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Reasons for Transfer and Subsequent Outcomes Among Patients Undergoing Elective Spine Surgery at an Orthopedic Specialty Hospital

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Original Article

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ABSTRACT

Objective: To evaluate the reasons for transfer as well as the 90-day outcomes of patients who were transferred from a high-volume orthopedic specialty hospital (OSH) following elective spine surgery.

Materials and Methods: All patients admitted to a single OSH for elective spine surgery from 2014 to 2021 were retrospectively identified. Ninety-day complications, readmissions, revisions, and mortality events were collected and a 3:1 propensity match was conducted.

Results: Thirty-five (1.5%) of 2351 spine patients were transferred, most commonly for arrhythmia (n = 7; 20%). Thirty-three transferred patients were matched to 99 who were not transferred, and groups had similar rates of complications (18.2% vs. 10.1%; P = 0.228), readmissions (3.0% vs. 4.0%; P = 1.000), and mortality (6.1% vs. 0%; P = 0.061).

Conclusion: Overall, this study demonstrates a low transfer rate following spine surgery. Risk factors should continue to be optimized in order to decrease patient risks in the postoperative period at an OSH.

Keywords: Specialty hospital, spine surgery, transfer

INTRODUCTION

Specialty hospitals have become increasingly common in the era of cost-effective healthcare.[1] Since the 1990s, the number of surgical specialty hospitals has more than tripled.[2] Specialty hospitals offer many of the advantages in patient experience that exist in ambulatory surgical centers, but they also have the additional benefit of standard inpatient postoperative services which reduce the economic burden of healthcare relative to general hospitals.[3]

Although the orthopedic specialty hospital (OSH) often provides efficient care and healthcare value, one concern is their inability to address intraoperative and postoperative medical complications. This may ultimately necessitate patients requiring transfer to a hospital that can provide higher acuity care.[4] While the low transfer rate found amongst orthopedic subspecialties (<1%) may not generate significant cause for concern, patients who required higher-level of care transfer had worse outcomes as defined by greater 90-day medical complications and readmission

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rates in an arthroplasty study.[5] Thus, it is unclear if certain patients or surgeries are poor candidates for OSHs given their potential risk for transfer.

Previous literature suggests lumbar fusions performed at an OSH have equivalent 90-day outcomes when compared to generalized hospitals. Moreover, these patients also had a reduced length of stay and decreased operative time when compared to a tertiary referral center.[6] While lumbar fusions may therefore be safe when performed at an OSH in properly selected patients, no study has evaluated the rate of tertiary referral center transfer rates from an OSH among this patient population. Therefore, the purpose of this study is to (1) summarize the reasons for transfer to a tertiary referral center from an OSH after spine surgery and (2) to determine if a difference exists in 90-day outcomes between patients who are transferred to a tertiary care center and nontransferred patients.

MATERIALS AND METHODS

After institutional review board approval, all patients admitted to one OSH for an elective spine surgery were identified between January 2014 and December 2021. Informed consent was waived due to the retrospective nature of the study. The specialty hospital has both inpatient and outpatient capabilities, with surgeons performing procedures in spine, joint replacement, and other orthopedic subspecialties. Features include specialized nursing, physical therapy, anesthesia, and internal medicine, with in-house and/or on-call physicians. Patient selection for the OSH consists of strict exclusion criteria: (1) American Society of Anesthesiologists (ASA) score of 4 or nonstable 3, (2) patients younger than 12 years old, (3) automatic implantable cardioverter defibrillator, (4) personal or family history of malignant hyperthermia, (5) end-stage renal disease on dialysis, (6) positive pregnancy test, and (7) body mass index (BMI) >40. Patients without any of these exclusions are eligible for surgery at the specialty hospital at the discretion of the operating surgeon and anesthesiologist.

All patients transferred from the specialty hospital to a tertiary care center were identified, yielding 35 patients. Demographics, procedure information, and reason for transfer were identified for each patient, along with outcomes of their transfer, including admission and subsequent procedure or intensive care unit admission. Two patients were excluded after descriptive analysis: 1 case was abandoned before completion of the procedure due to a loss of intraoperative motor signals and 1 anterior lumbar interbody fusion (ALIF) due to a lack of controls for the propensity match. A 3-to-1 propensity match of transferred patients to nontransferred controls was performed based on age, sex, BMI, Elixhauser comorbidity index, procedure, levels decompressed or fused, and cut-to-close operative time. Complications, readmissions, and mortality within 90 days of surgery were collected for all transferred and nontransferred patients via chart review.

Statistical analysis

Standard descriptive statistics were reported for patient demographics, including proportions and means with standard deviation. Differences in demographic characteristics for categorical variables were compared using either the Fisher's exact test or Pearson Chi-square. Sample means between the two groups were compared using a parametric independent-samples *t*-test. For all analyses, $P < 0.05$ was considered statistically significant. All statistical analyses were performed using RStudio (Version 1.3.1073-1, RStudio, Inc., Boston, MA, USA).

RESULTS

In total, 2351 procedures were performed at the specialty hospital between January 2014 and December 2021. During this time, 35 patients (1.5%) were transferred. The transfer group was composed of 10 (28.6%) anterior cervical discectomy and fusions (ACDF), 7 (20%) posterior lumbar decompressions (PLD), 6 (17.1%) PLD and fusions (PLDF), and 10 (28.6%) transforaminal lumbar interbody fusions (TLIF). Only one patient was transferred who underwent either ALIF or posterior cervical fusion. Less than 1% (0.64%) of all simple lumbar decompressions, 3.1% of lumbar fusions, and 1.6% of all cervical fusions were transferred. When stratified by technique, patients undergoing PLDF without interbody placement had the highest transfer rate (4.6%), followed by TLIF (2.5%), ACDF (1.8%), and PLD (0.6%). Patients needing transfer also had a significantly greater operative duration (150.8 min vs. 102.3 min, $P < 0.0001$). There were no significant differences in baseline patient characteristics, including age, sex, BMI, or comorbidity burden [Table 1].

Arrhythmia ($n = 7$; 20%) was the most common reason for transfer. After arrhythmia, hypoxia, and respiratory failure were the most common reasons for transfer ($n = 3$; 8.6%). All remaining reasons for transfer had an incidence of two or less cases. All patients who were transferred were admitted except one patient who was discharged after a syncopal workup after falling and hitting their head [Table 2].

Among matched patients, age, sex, BMI, Elixhauser, procedure, levels decompressed or fused, and cut to close time were similar between groups [Table 3]. A similar percent

Table 1: Unmatched cohort characteristics

	Transferred (*n*=35), *n* (%)	Not transferred (*n*=2316), *n* (%)	*P*
Age	57.2 (15.3)	53.5 (13.5)	0.122
Sex			
Male	20 (57.1)	1355 (58.5)	0.871
Female	15 (42.9)	961 (41.5)	
BMI	28.7 (5.4)	28.8 (5.2)	0.846
Elixhauser	0.85 (1.23)	0.61 (0.91)	0.451
Procedure			
ACDF	10 (28.6)	615 (26.7)	0.001*
PCF	1 (2.9)	69 (3.0)	
PLD	7 (20.0)	1095 (47.3)	
PLDF	6 (17.1)	124 (5.4)	
TLIF	10 (28.6)	393 (17.0)	
ALIF	1 (2.9)	20 (0.86)	
Levels decompressed or fused	1.45 (0.67)	1.33 (0.60)	0.238
Operative duration	150.8 (77.6)	102.3 (54.8)	<0.001*

BMI – Body mass index; ACDF – Anterior cervical discectomy and fusions; PCF – Posterior cervical fusion; PLD – Posterior lumbar decompression; PLDF – PLD and fusion; TLIF – Transforaminal lumbar interbody fusion; ALIF – Anterior lumbar interbody fusion

Table 2: Reason for transfer from specialty hospital

Transfer reason	Number of patients*, *n* (%)	Procedure or ICU, *n* (%)
Arrhythmia	7 (20.0)	0
Hypoxia	3 (8.6)	0
Respiratory failure	3 (8.6)	2 (66)
Altered mental status	2 (5.7)	1 (50)
Ileus	2 (5.7)	0
Motor signal changes	2 (5.7)	2 (100)
Pain management	2 (5.7)	0
Weakness	2 (5.7)	0
Anemia	1 (2.9)	0
Chest pain	1 (2.9)	0
Coded	1 (2.9)	1 (100)
Dural tear	1 (2.9)	1 (100)
DVT	1 (2.9)	0
Dysphagia	1 (2.9)	0
Epidural hematoma	1 (2.9)	1 (100)
Heart failure exacerbation	1 (2.9)	0
IVC vein tear	1 (2.9)	1 (100)
Pneumonia	1 (2.9)	1 (100)
Syncope	1 (2.9)	0
UTI	1 (2.9)	0

*All patients who were transferred were admitted to the receiving hospital except for one patient with syncope. DVT – Deep vein thrombosis; IVC – Inferior vena cava; UTI – Urinary tract infection; ICU – Intensive care unit

of patients in the transfer group experienced complications within 90-day of surgery compared to patients in the nontransfer group (18.2% vs. 10.1%; $P = 0.228$). Ninety-day readmissions were also similar between groups (3.0% vs. 4.0%; $P = 1.000$). One patient in the transfer group (initially transferred for cerebrospinal fluid leak and possible infection) was readmitted for a dural tear and underwent revision decompression with a dural repair. In the group without transfer, there were four total readmissions: Two for postoperative infections, one for an esophageal perforation following ACDF, and one for a revision decompression due to recurrent symptoms 75 days following the initial procedure. Ninety-day mortality was greater in the transfer group wherein two (6.1%) died compared to none in the group without transfers; however, this did not reach statistical significance ($P = 0.061$) [Table 4].

DISCUSSION

Specialty hospitals allow for streamlined spine care with dedicated staff and strict protocols to help reduce length of stay and hospital-acquired conditions while still providing a limited offering of inpatient postoperative services that ambulatory surgery centers cannot provide.[3] However, prior studies investigating outcomes of extremity arthroplasty surgeries at OSHs demonstrate conflicting findings regarding rates of transfer to higher levels of care. Given the inability of OSHs to independently address many significant complications, understanding the nature of transfers to general hospitals after spine surgery is critical to surgeons and their patients. The most common reason for transfer in this study was arrhythmia. Overall, the transfer rate of patients treated with spine surgery at this specialty hospital was low at 1.5%. When the transferred patient group was compared to the nontransfer group, there was a significant difference in procedure type and operative duration but not demographic characteristics. There were no significant differences in surgical outcomes.

Previous literature has reported varying transfer rates from OSHs. Padegimas *et al*. reported a transfer rate of 2.2% in a cohort of 136 patients undergoing shoulder arthroplasty at an OSH.[7] The three causes of transfer in their cohort were cardiopulmonary in nature (pulmonary embolism work-up, hypotension, and pneumonia).[7] In an analysis of outcomes between outpatient and ambulatory ACDF, an extremely low transfer rate of 0.8% was found.[8] However, their analysis only included patients with an American Society of Anesthesiologists (ASA) class I or II.[8] Among patients undergoing lumbar fusion surgery, the transfer rate is believed to be closer to 2%, although the cohort was much smaller and this only amounted to 2 patients; one for sequential syncopal events and one for a small bowel obstruction.[6] In a recent publication, D'Amore *et al*. reported on the largest cohort of OSH transfers ($n = 46$) demonstrating a 0.62% transfer rate after total knee arthroplasty (TKA) or total hip arthroplasty (THA). Authors in that series reported

Table 3: Matched cohort characteristics

	Transferred (*n*=33), *n* (%)	Not transferred (*n*=99), *n* (%)	*P*[a]
Age	57.2 (15.3)	55.9 (12.8)	0.641
Sex			
Male	19 (57.6)	56 (56.6)	0.919
Female	14 (42.4)	43 (43.4)	
BMI	28.7 (5.4)	28.9 (5.2)	0.818
Elixhauser	0.85 (1.23)	0.91 (1.09)	0.789
Procedure			
ACDF	10 (30.3)	31 (31.3)	0.981
PLD	7 (21.2)	18 (18.2)	
PLDF	6 (18.2)	20 (20.2)	
TLIF	10 (30.3)	30 (30.3)	
Levels decompressed or fused			
1	21 (63.6)	56 (56.6)	0.834
2	9 (27.3)	33 (33.3)	
3	3 (9.1)	10 (10.1)	
Operative duration	148.5 (76.6)	145.3 (67.8)	0.822

BMI – Body mass index; ACDF – Anterior cervical discectomy and fusions; PLD – Posterior lumbar decompression; PLDF – PLD and fusion; TLIF – Transforaminal lumbar interbody fusion

Table 4: Outcomes of matched cohort

	Transferred (*n*=33), *n* (%)	Not transferred (*n*=99), *n* (%)	*P*[a]
90-day complications	6 (18.2)	10 (10.1)	0.228
90-day readmissions	1 (3.0)	4 (4.0)	1.000
90-day mortality	2 (6.1)	0	0.061

that the most common indication for transfer was arrhythmia, chest pain, and hypotension.[5]

The present study adds to prior literature by assessing the largest cohort of spine surgeries performed at a specialty hospital ($n = 2351$), resulting in the largest cohort of spine surgery transfers ($n = 35$) for analysis. The low overall transfer rate of 1.5% likely reflects the ability for a large specialty hospital optimize patients preoperatively and appropriately select patients who will not require higher acuity care.[9] In addition, the center's implementation of a nurse navigator program, which has demonstrated reduced episode-of-care costs, may significantly reduce the need for transfer by facilitating effective communication preoperatively. Authors have speculated that this is due to preprocedural screening and improved patient communication conferred by having dedicated nurse navigators.[10]

In this patient cohort, two patients were transferred for ileus and one patient was transferred for syncope. However, the most common reason for transfer was arrhythmia, which was present in 7 of the transferred patients in this population, 20% of the total cohort. The current literature demonstrates a 1% rate of newly diagnosed atrial fibrillation arrhythmia after major noncardiac surgery, which is much higher than the rate seen in this cohort.[11] The next most common reasons for transfers were hypoxia and respiratory failure, each of which accounted for the transfer of three patients (8.6%, each). These three most common issues are cardiorespiratory issues that can have potentially life-threatening consequences if not treated appropriately. Specialty hospitals do not have the same level of intensive care offered at a tertiary medical center. Moreover, these cardiopulmonary issues warrant transfer to avoid the significant clinical deterioration that may go undertreated at a specialty hospital. In the setting of spine surgery, the incidence of cardiac events is as high as 6.7% and respiratory events as high as 9%.[12,13] However, this patient cohort demonstrated a much lower rate of cardiac and respiratory events, which emphasizes the importance of preoperative optimization and cardiac clearance. As a standard, all patients who undergo spine surgery at this OSH must undergo preoperative cardiac evaluation and clearance. Strict OSH policies regarding patient optimization are needed to minimize these risks and potential transfers.

Several studies have also assessed the surgical outcomes associated with lumbar spine surgery at specialty hospitals. In an analysis of unplanned 90-day readmissions in 2,860 patients in a tertiary care orthopedic hospital, Avinash *et al*. showed a readmission rate of 3.32%.[14] In their study, the most common cause of readmission was surgical site infection, accounting for 44.21% of all 90-day readmissions.[14] McCormack *et al*. similarly reported a 30-day readmission rate of 3.8% following spine surgery at a OSH.[15] However, others have reported 30-day readmissions rates over 9.0%.[16] When evaluating complication rates among patients transferred after surgery at an OSH, D'Amore *et al*. demonstrated that there was a significantly higher rates of medical complications.[5] However, our study found no difference in rates of 90-day complications or 90-day readmissions for patients requiring transfer versus those who did not, when accounting for patient and surgical differences. This indicates adequate management of complications requiring transfer at our specialty hospital, suggesting that surgery at our OSH is safe for our patients. Currently no literature exists evaluating preoperative protocols in predicting patient outcomes at an OSH. Our OSH's criteria may therefore serve as a foundation for other centers seeking to establish criteria to reduce complication and transfer rates. Our OSH's strict criteria for patients to be eligible for surgery may be safely implemented at other specialty hospitals to help meet the increased surgical demand while also providing safe specialty care.

However, close inspection of our results reveals there may be a potential increase in mortality associated with surgical

transfers from OSHs that did not reach statistical significance. D'Amore *et al*. previously did not demonstrate any increase in 90-day mortality in either patients transferred to higher levels of care or those who were not transferred after TKA or THA at an OSH.[5] However, given the inherent difference in procedural risk associated with spine surgery versus extremity surgery, a direct comparison between D'Amore *et al.* and the present study is likely insufficient.[5] Spine surgery presents complex risks to patients including severe complications and mortality. It is intuitive that patients with severe complications that elevate to needing a transfer are more likely to experience mortality events than patients with an uncomplicated surgery. However, it is unclear whether these rare mortality events may have occurred even if the index surgery was performed at a large tertiary care center. Because of the extremely low incidence of transferred patients, there is an impetus for future research with a larger number of transferred patients to determine if spine surgery at OSHs causes an increase in mortality compared to patients with complications of comparable severity at a tertiary care center.

An increased operative time has been reported to be predictive of worse surgical outcomes.[6] Our study demonstrated that a longer operative duration was predictive of need for transfer. Patients with a prolonged operative duration are more likely to require more intensive care and are more likely to have experienced a complication during surgery.[17,18] Moreover, these complications may lead to greater postoperative disability and subsequent complications, such as venous thromboembolic events,[18-20] although these were not identified as a common cause of transfer in our study. In addition, those who received certain procedures, such as PLDF and TLIF, had significantly higher rates of transfer. These may likely reflect the baseline differences in patient populations and indications for each procedure. A prior systematic review and meta-analysis demonstrated similar complication rates among patients undergoing TLIF and ALIF.[21] Another study of 1-and 2-level lumbar fusions similarly identified no difference in complication rates between TLIF, ALIF, and PLDF.[22] Bateman *et al*. demonstrated that the complication rate associated with ALIF is 14.1%,[23] which may be a higher risk procedure due to the severe complications unique to the approach including injury to the peritoneum or the great vessels. In our cohort, the lower risk of transfer in patients undergoing ALIF may be a result of more careful patient selection. However, our OSH has since stopped performing ALIFs, in order to avoid major catastrophic events. Our data remains unclear as to whether these procedures pose inherent risks to patients when performed at specialty hospitals, and further studies are needed to examine this finding.

One potential limitation of this study is its retrospective nature, although the prospective tracking of complications and readmissions decreases the potential that data was accidentally omitted. In the future, studies should collect prospective data on spine transfers at OSHs. Another future area of study could include a comparison of outcomes to similarly matched patients treated in a general hospital. This comparison may provide more useful information regarding the benefits of OSHs, including the monetary impact of OSH to acute care hospital transfers. A second potential limitation is the generalizability of the results. Our OSH always has a well-organized preoperative optimization protocol along with inpatient medical provider coverage. Because of these factors, the overall transfer rate may be lower than what might be expected at other OSH institutions, depending on their policies. In addition, because our OSH has close ties with a tertiary care facility, with providers practicing at both facilities, outcomes of transferred patients may only be generalizable to other specialty hospitals who establish these optimized care networks.

CONCLUSION

Overall, this study demonstrates a low transfer rate (1.5%) of patients from an OSH to an acute care hospital. The most common reason for transfer was cardiopulmonary in nature. Certain procedures, such as ACDF and PLD, may be ideal for performing at OSH while other surgeries with longer duration may be better suited for hospitals with more ancillary support. There was no difference in 90-day outcomes of transferred patients when compared to patients that did not require transfer. Risk factors before OSH surgery should continue to be optimized in order to decrease the risk to patients in the immediate postoperative period.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Leider M, Campbell R, Boyce J, Tjoumakaris F. Orthopaedic specialty hospitals compared with general hospitals: A systematic review of demographic, clinical, and financial parameters. JBJS Rev 2021;9:e20.
2. Carey K, Burgess JF Jr., Young GJ. Specialty and full-service hospitals: A comparative cost analysis. Health Serv Res 2008;43:1869-87.
3. Schneider JE, Miller TR, Ohsfeldt RL, Morrisey MA, Zelner BA, Pengxiang Li. The economics of specialty hospitals. Med Care Res Rev 2008;65:531-53.
4. Cram P, Vaughan-Sarrazin MS, Wolf B, Katz JN, Rosenthal GE. A comparison of total hip and knee replacement in specialty and general hospitals. J Bone Joint Surg Am 2007;89:1675-84.

5. D'Amore T, Blaber O, Magnuson JA, Sutton RM, Haag T, Krueger CA. Orthopedic specialty hospital reasons for transfer and subsequent outcomes. J Arthroplasty 2022;37:819-23.
6. Kreitz TM, Tarazona D, Padegimas EM, Foltz C, Kepler CK, Anderson DG, *et al.* Comparison of short-term outcomes after lumbar fusion between an orthopedic specialty hospital and tertiary referral center. Spine (Phila Pa 1976) 2019;44:652-8.
7. Padegimas EM, Zmistowski BM, Clyde CT, Restrepo C, Abboud JA, Lazarus MD, *et al.* Length of stay after shoulder arthroplasty-the effect of an orthopedic specialty hospital. J Shoulder Elbow Surg 2016;25:1404-11.
8. Adamson T, Godil SS, Mehrlich M, Mendenhall S, Asher AL, McGirt MJ. Anterior cervical discectomy and fusion in the outpatient ambulatory surgery setting compared with the inpatient hospital setting: Analysis of 1000 consecutive cases. J Neurosurg Spine 2016;24:878-84.
9. Courtney PM, West ME, Hozack WJ. Maximizing physician-hospital alignment: Lessons learned from effective models of joint arthroplasty care. J Arthroplasty 2018;33:1641-6.
10. Phillips JL, Rondon AJ, Vannello C, Fillingham YA, Austin MS, Courtney PM. A nurse navigator program is effective in reducing episode-of-care costs following primary hip and knee arthroplasty. J Arthroplasty 2019;34:1557-62.
11. Bhave PD, Goldman LE, Vittinghoff E, Maselli J, Auerbach A. Incidence, predictors, and outcomes associated with postoperative atrial fibrillation after major noncardiac surgery. Am Heart J 2012;164:918-24.
12. Guyot JP, Cizik A, Bransford R, Bellabarba C, Lee MJ. Risk factors for cardiac complications after spine surgery. Evid Based Spine Care J 2010;1:18-25.
13. Imposti F, Cizik A, Bransford R, Bellabarba C, Lee MJ. Risk factors for pulmonary complications after spine surgery. Evid Based Spine Care J 2010;1:26-33.
14. Avinash M, Renjith KR, Shetty AP, Sharma V, Kanna RM, Rajasekaran S. Unplanned readmissions after spine surgery: A single-center prospective analysis of a 90-day model in 2,860 cases. Asian Spine J 2020;14:43-50.
15. McCormack RA, Hunter T, Ramos N, Michels R, Hutzler L, Bosco JA. An analysis of causes of readmission after spine surgery. Spine (Phila Pa 1976) 2012;37:1260-6.
16. Deyo RA, Mirza SK, Martin BI, Kreuter W, Goodman DC, Jarvik JG. Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults. JAMA 2010;303:1259-65.
17. Kim BD, Hsu WK, De Oliveira GS Jr., Saha S, Kim JY. Operative duration as an independent risk factor for postoperative complications in single-level lumbar fusion: An analysis of 4588 surgical cases. Spine (Phila Pa 1976) 2014;39:510-20.
18. Kim JY, Khavanin N, Rambachan A, McCarthy RJ, Mlodinow AS, De Oliveria GS Jr., *et al.* Surgical duration and risk of venous thromboembolism. JAMA Surg 2015;150:110-7.
19. Piper K, Algattas H, DeAndrea-Lazarus IA, Kimmell KT, Li YM, Walter KA, *et al.* Risk factors associated with venous thromboembolism in patients undergoing spine surgery. J Neurosurg Spine 2017;26:90-6.
20. Tran KS, Issa TZ, Lee Y, Lambrechts MJ, Nahi S, Hiranaka C, *et al.* Impact of prolonged operative duration on postoperative symptomatic venous thromboembolic events after thoracolumbar spine surgery. World Neurosurg 2023;169:e214-20.
21. Teng I, Han J, Phan K, Mobbs R. A meta-analysis comparing ALIF, PLIF, TLIF and LLIF. J Clin Neurosci 2017;44:11-7.
22. Lambrechts MJ, Siegel N, Heard JC, Karamian BA, Dambly J, Baker S, *et al.* Trends in single-level lumbar fusions over the past decade using a national database. World Neurosurg 2022;167:e61-9.
23. Bateman DK, Millhouse PW, Shahi N, Kadam AB, Maltenfort MG, Koerner JD, *et al.* Anterior lumbar spine surgery: A systematic review and meta-analysis of associated complications. Spine J 2015;15:1118-32.