



Original Article

## Trends in lumbar interbody fusion: A study of American Board of Orthopedic Surgery (ABOS) candidate data

Sean Childs<sup>1</sup>, Wajeeh Bakhsh<sup>1</sup>, Caroline Thirukumaran<sup>2</sup>, Sanford Emery<sup>3</sup>, Paul Rubery<sup>2</sup>, Addisu Mesfin<sup>4</sup>

Departments of <sup>1</sup>Orthopaedic Surgery and <sup>2</sup>Orthopaedics, University of Rochester, Rochester, New York, <sup>3</sup>Department of Orthopaedic Surgery, West Virginia University, Morgantown, West Virginia, <sup>4</sup>Department of Orthopaedic Surgery, Medstar Orthopaedic Institute, Washington, DC, United States.

E-mail: Sean Childs - schilds3@gmail.com; Wajeeh Bakhsh - wbakhsh@gmail.com; Caroline Thirukumaran - caroline.thirukumaran@urmc.rochester.edu; Sanford Emery - semery@hsc.wvu.edu; Paul Rubery - paul\_rubery@urmc.rochester.edu; \*Addisu Mesfin - amesfin@gmail.com



\*Corresponding author:

Addisu Mesfin,  
Department of Orthopaedic  
Surgery, Medstar Orthopaedic  
Institute, Washington, DC,  
United States.

amesfin@gmail.com

Received: 13 June 2023

Accepted: 08 November 2023

Published: 15 December 2023

DOI

10.25259/SNI\_502\_2023

Quick Response Code:



### ABSTRACT

**Background:** There has been an increase in posterior-based interbody fusions over the past two decades. Our objective was to evaluate trends in interbody fusion use among the American Board of Orthopedic Surgery (ABOS) Part II candidates.

**Methods:** The ABOS database from 2003 to 2012 was queried for common procedural terminology (CPT) codes indicating lumbar interbody fusion (22,558 anterior lumbar interbody fusion [ALIF] and 22,630 and 22,633 posterior lumbar interbody fusion [PLIF] or transforaminal lumbar interbody fusion [TLIF]). Trends in the use of interbody fusion technique, associated complications, and geographical variation were evaluated. We also queried utilization of the anterior and posterior interbody fusions by the International Classification of Diseases-9 code.

**Results:** 6841 interbody fusion cases were identified (2329 ALIF and 4512 PLIF/TLIF). There was a significantly higher use of PLIF/TLIF than ALIF over the study period ( $P < 0.001$ ). As compared to patients in the Midwest, those in the Northwest had significantly higher odds of undergoing PLIF/TLIF (odds ratio [OR]: 4.79, 95% confidence interval [CI]: 3.61–6.35,  $P < 0.001$ ), and those in the Southwest had significantly lower odds of PLIF/TLIF (OR: 0.81, 95% CI: 0.69–0.95,  $P = 0.01$ ). The overall complication rate was 22.2% ( $n = 1,519$ ). Vascular-related complications were significantly higher among patients undergoing ALIF (31 vs. 1,  $P < 0.001$ ), while those undergoing TLIF/PLIF were more likely to experience unspecified medical complications. On multivariate analysis, patients undergoing PLIF/TLIF had lower odds of experiencing a complication ( $P = 0.03$ , OR 0.87, CI 95%).

**Conclusion:** Over the 10-year study period, there has been a significantly increased rate of posterior interbody fusion among candidates taking part II ABOS examination.

**Keywords:** American Board of Orthopedic Surgery (ABOS), Anterior lumbar interbody fusion (ALIF), Complications, Lumbar interbody fusion, Transforaminal lumbar interbody fusion (TLIF), Trends

### INTRODUCTION

Degenerative conditions of the lumbar spine are common. Spinal stenosis is a significant cause of disability, particularly in the elderly population.<sup>[1-3]</sup> In addition to being a common indication for spinal surgery, the prevalence of lumbar stenosis is expected to increase significantly over the next decade.<sup>[4]</sup>

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Interbody fusion with instrumentation is often used to address lumbar stenosis. The interbody device allows for load bearing and maintains the foraminal height.<sup>[6]</sup> Evolution in interbody fusion techniques has provided spinal surgeons with a variety of options regarding surgical approach, fixation strategy, and graft materials.<sup>[5,7,8]</sup> Existing options include posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), lateral interbody fusion (LIF), oblique lumbar interbody fusion (OLIF), and anterior lumbar interbody fusion (ALIF) approaches, each with their risks and benefits.

The objective of this study was to evaluate the trends in the use of lumbar interbody devices for the treatment of lumbar spinal pathology as well as their associated complications among candidates for part II of the American Board of Orthopedic Surgery (ABOS) examination over ten years.

## MATERIALS AND METHODS

### Data source

In the United States, the ABOS confers board certification on orthopedic surgeons. Surgical cases performed during a predetermined 6-month period are submitted for review. The data submitted for each case includes International Classification of Diseases (ICD) codes, CPT codes, patient age and gender, geographical region of the surgeon's practice, surgical complications, fellowship training of the surgeon, and a brief verbal description of the procedure and indications. These cases are entered into a secure database maintained on behalf of the ABOS by Data Harbor Solutions (Hinsdale, Illinois). This de-identified data is the subject of our study and has been used in other previous work.

### Study cohort

The ABOS database was queried for cases of lumbar interbody fusion using the CPT codes 22,558 ALIF, 22,630 PLIF, and 22,633 TLIF between 2003 and 2012. As the CPT code for transforaminal interbody fusion was combined with that for PLIF (CPT 22630) after 2012, these two procedures were grouped for the analysis portion of this study. Surgeon's geographical location, associated ICD-9 codes, and perioperative complications were gathered.

### Key variables

The outcomes of interest were the rates of each surgery type (computed as the number of surgeries per 100 surgeons), the type of surgery (specified as a categorical variable with ALIF and PLIF/TLIF categories), and whether or not a complication was reported (specified as a yes/no variable). The independent variables of interest were the geographic location (categorized as regions of the United States),

principal diagnosis (categorized based on the listed ICD code), and the year of surgery. Our analytic models also controlled for covariates such as age and gender that were likely to confound the association of interest.

### Statistical analysis

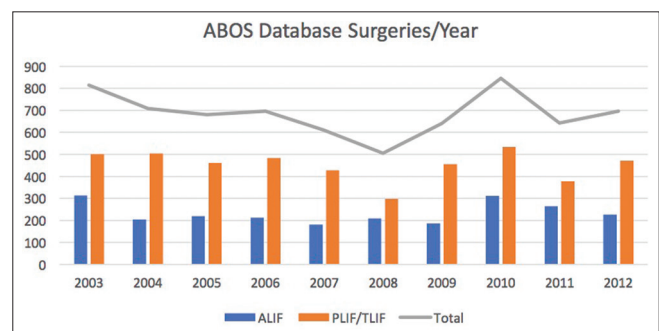
The proportions of lumbar spinal pathology treated with ALIF (CPT 22558) and posterior/transforaminal interbody fusion (CPT 22,530 and CPT 22,633) were determined. We used Chi-square tests and student *t*-tests to test differences in the distribution of key variables across the surgical groups. We constructed multivariable logistic regression models to examine whether the geographic location and principal diagnosis were significant predictors of the type of surgery and the risk of complications. The statistical significance was set at  $P < 0.05$ .

## RESULTS

From 2003 to 2012, orthopedic surgeons taking the ABOS part II examination submitted 6841 cases of lumbar interbody fusion. Of the cases submitted, a total of 2329 (34%) cases were ALIFs, and 4512 (66%) were performed from a posterior approach. There was a significantly higher rate of PLIF/TLIF compared to ALIF during the study ( $P < 0.01$ ) [Figure 1].

### Regional variations

Anterior-based lumbar interbody fusion was found to be reported most frequently by surgeons practicing in the Southwest ( $n = 675$ ), followed by surgeons in the Midwest region ( $n = 472$ ) of the United States. Anterior-based interbody fusion was reported least frequently by surgeons in the Northwest ( $n = 77$ ) and Southeast ( $n = 270$ ) regions. PLIF was reported most frequently by surgeons practicing in the Southern ( $n = 861$ ) and Northeast regions ( $n = 808$ ). As compared to patients in the Midwest, those in the Northwest had significantly higher odds of undergoing PLIF/TLIF (odds ratio [OR]: 4.79, 95% confidence interval [CI]: 3.61–6.35,



**Figure 1:** Trends in type of interbody fusion use. ABOS: American board of orthopaedic surgery, ALIF: Anterior lumbar interbody fusion, PLIF: Posterior lumbar interbody fusion, TLIF: Transforaminal lumbar interbody fusion.

$P < 0.001$ ) and those in the Southwest had significantly lower odds of PLIF/TLIF (OR: 0.81, 95% CI: 0.69–0.95,  $P = 0.01$ ).

### Common diagnoses

The five most commonly listed ICD-9 codes were as follows: spinal stenosis of the lumbar region without neurogenic claudication (724.02), degeneration of lumbar/lumbosacral intervertebral disc (722.52), acquired spondylolisthesis (738.4), thoracic or lumbosacral neuritis/radiculitis (724.4), and displacement of thoracic/lumbar intervertebral disc without myelopathy (722.1). As compared to patients with degenerative disc disease (722.52), patients with

ICD-9 diagnoses of lumbar stenosis (724.02) underwent significantly higher numbers of PLIF/TLIF when compared to ALIF (2135 vs. 601;  $P < 0.01$ ) and were at greater odd of undergoing this procedure ( $P < 0.001$ , OR 2.33, CI 95%: 2.02–2.68).

### Complications [Table 1]

The overall complication rate for the study cohort was 22% ( $n = 1,519$ ). The five most common reported complications were as follows: unspecified surgical complications ( $n = 462$ ), infection ( $n = 176$ ), nerve palsy/injury ( $n = 162$ ), wound dehiscence ( $n = 93$ ), and implant failure ( $n = 60$ ). There were no significant differences in the rates of these complications between patients undergoing PSIF/TLIF or ALIF ( $P > 0.05$ , [Table 1]). Vascular-related complications were recorded for one patient undergoing PSIF/TLIF, while 31 patients undergoing ALIF had a statistically greater risk of sustaining a vascular complication ( $P < 0.01$ ).

### DISCUSSION

Degenerative lumbar conditions are a common source of disability and societal economic burden. Lumbar spinal decompression and interbody fusion have become an increasingly common procedure in these patients and has been shown to yield good results. Few studies have examined the trends in surgical approaches used during interbody fusion among recent orthopedic graduates as well as their associated complications and economic burden [Table 2].

Our study reveals that during our 10-year study period, there was a significantly higher use of PLIF/TLIF when compared with ALIF among candidates taking part II ABOS examination. There were significant geographic differences

**Table 1:** Complications by procedure type

Complication	ALIF (n)	PLIF/TLIF	P value
Surgical Unspecified	142	320	<b>0.01</b>
Infection	61	115	0.71
Nerve Palsy/Injury	56	106	0.58
Wound Dehiscence	38	55	0.28
Implant Failure	11	49	<b>0.02</b>
Hemorrhage	25	33	<b>0.01</b>
Bone Fracture	24	28	0.13
Vascular Injury	31	1	<b>&lt;0.01</b>
Non Union/Delayed Union	6	6	0.48
Implant Fracture	4	7	0.95
Wound Healing Delay	6	3	0.87
Limb Ischemia	7	1	<b>0.01</b>
Implant Malfunction	4	3	0.95
Spinal Cord Injury	1	6	0.53
Hematoma/Seroma	4	3	0.93

ALIF: Anterior lumbar interbody fusion, PLIF: Posterior lumbar interbody fusion, TLIF: Transforaminal lumbar interbody fusion, Bold items: Statistically significant ( $p < 0.05$ )

**Table 2:** Summary of large studies comparing lumbar interbody fusion outcomes and complications.

Author/Journal	Number of patients	Study design	Study period	Interbody type	Complications
Bae et al. Spine 2013	73,773	Database (Nationwide inpatient sample)	2004-2009	N/A	Avg. Inpatient mortality (12.6%)
Kepler et al. Spine 2014	5,639 (22% with interbody)	Database (ABOS)	1999-2011	N/A	5% wound complication 1.5% implant related complications
Oezel L et al. World Neurosurgery 2022	49,895	Database (NSQIP)	2009-2013; 2015-2019	PLIF/TLIF (n=34,560) ALIF/LLIF (n=15,245)	Decrease in post-op complications, blood transfusion in 2015-2019 group compared to 2009-2013
Katz et al. Spine 2019	26,336	Database (NSQIP)	2005-2015	PLIF/TLIF (n=18,063) ALIF/LLIF (n=8,273)	-15.5% higher morbidity in PLIF/TLIF -re-operation & readmission similar in both groups

ALIF: Anterior lumbar interbody fusion, PLIF: Posterior lumbar interbody fusion, TLIF: Transforaminal lumbar interbody fusion, NSQIP: National surgical quality improvement program, ABOS: American board of orthopaedic surgery, N/A: Not available

in the use of surgical approaches for lumbar interbody fusion as well, with the Northwest and Southeast having the highest levels of PLIF/TLIF use while the southwest had the lowest. Lumbar stenosis and degenerative spondylolisthesis diagnoses were associated with the highest rates of PLIF/TLIF among part II ABOS candidates during the study period. In addition, there was a 22% rate of complications reported by candidates during this study period. Vascular-related complications were significantly higher among patients with ALIF. In addition, patients undergoing PLIF/TLIF were also found to have significantly lower odds of experiencing a complication within the perioperative or postoperative time course.

## CONCLUSION

We found that posterior interbody fusion is more commonly performed than anterior interbody fusion among orthopedic spinal surgeons taking part II of the ABOS certification exam during our 10-year study period. Complications were found to be lower among patients undergoing PLIF/TLIF, and vascular-related complications were found to be significantly higher among patients undergoing anterior interbody fusion.

## Ethical approval

Due to the deidentified nature of the database with no patient or surgeon identifiers present, an IRB approval was not obtained.

## Declaration of patient consent

Patient's consent was not required as there are no patients in this study.

## Financial support and sponsorship

Nil.

## Conflicts of interest

Addisu Mesfin: Travel/lodging: Medtronic, NuVasive.

## Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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**How to cite this article:** Childs S, Bakhsh W, Thirukumaran C, Emery S, Rubery P, Mesfin A. Trends in lumbar interbody fusion: A study of American Board of Orthopedic Surgery (ABOS) candidate data. *Surg Neurol Int.* 2023;14:426. doi: 10.25259/SNI\_502\_2023

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