Trends in isolated lumbar spinal stenosis surgery among working US adults aged 40–64 years, 2010–2014

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OBJECTIVE Recommendations for the surgical treatment of isolated lumbar spinal stenosis (LSS) (i.e., in the absence of concomitant scoliosis or spondylolisthesis) are unclear. The aims of this study were to investigate trends in the surgical treatment of isolated LSS in US adults and determine implications for outcomes.

METHODS The authors analyzed inpatient and outpatient claims from the Truven Health Analytics MarketScan Commercial Claims and Encounters Database for 20,279 patients aged 40–64 years who underwent surgery for LSS between 2010 and 2014. Only patients with continuous 12-month insurance coverage after surgery were included. The rates of decompression with arthrodesis versus decompression only and of simple (1- or 2-level, single-approach) versus complex (> 2-level or combined-approach) arthrodesis were analyzed by year and geographic region. These trends were further analyzed with respect to complications, length of hospital stay, payments made to the hospital, and patient discharge status. Statistical significance was set at $p < 0.05$.

RESULTS The proportion of patients who underwent decompression with arthrodesis compared with decompression only increased significantly and linearly from 2010 to 2014 (OR 1.08; 95% CI 1.06–1.10). Arthrodesis was more likely to be complex rather than simple with each subsequent year (OR 1.4; 95% CI 1.33–1.49). This trend was accompanied by an increased likelihood of postoperative complications (OR 1.11; 95% CI 1.02–1.21), higher costs (payments increased by a mean of US\$1633 per year; 95% CI 1327–1939), and greater likelihood of being discharged to a skilled nursing facility as opposed to home (OR 1.11; 95% CI 1.03–1.20). The South and Midwest regions of the US had the highest proportions of patients undergoing arthrodesis (48% and 42%, respectively). The mean length of hospital stay did not change significantly ($p = 0.324$).

CONCLUSIONS From 2010 to 2014, the proportion of adults undergoing decompression with arthrodesis versus decompression only for the treatment of LSS increased, especially in the South and Midwest regions of the US. A greater proportion of these fusions were complex and were associated with more complications, higher costs, and a greater likelihood of being discharged to a skilled nursing facility.

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KEYWORDS complex fusion; hospital payments; lumbar spinal stenosis; outcomes; trends

AFTER the introduction of pedicle screw fixation in the early 1990s, surgery for lumbar spinal stenosis (LSS) became the fastest-growing surgery.^{5,22} Spinal stenosis subsequently became the most common indication for spinal surgery in elderly patients.¹ From 2000 to 2014, the estimated national cost of LSS surgery increased from \$1.8 to \$8.2 billion as surgery for LSS rose from 0.2% to 0.3% of all inpatient procedures performed in the US (<https://hcupnet-archive.ahrq.gov>).

Patients with isolated LSS (i.e., in the absence of concomitant scoliosis or spondylolisthesis) can be treated nonoperatively using various modalities, including pain medication, physical therapy, and epidural steroid injections. Patients can also undergo decompressive spinal surgery with or without arthrodesis.⁴ It is well established that at mid- to long-term follow-up, surgical decompression is associated with clinical outcomes superior to those achieved with nonoperative therapy.^{1,14,18,24} However, the choice of

ABBREVIATIONS CCI = Charlson Comorbidity Index; ICD-9 = *International Classification of Diseases, Ninth Revision*; LSS = lumbar spinal stenosis; SNF = skilled nursing facility; USD = US dollar

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surgical procedure is a matter of debate. Although decompression with arthrodesis reduces the motion of spinal segments that may cause pain, its use in isolated LSS has not been shown to produce superior outcomes to decompression alone and is generally not recommended in that particular setting.^{2,7,15,16,20} Furthermore, arthrodesis has been associated with a higher rate of major postoperative complications, longer hospital stay, and greater use of health care resources compared with decompression alone.^{2,6,17} Previous studies have shown that the decision to perform arthrodesis is determined largely by surgeon preference¹⁰ and that it varies by geographic region.¹³

Despite a lack of evidence to support its use and the undesirable effects it may cause, the use of arthrodesis for LSS treatment in the US for patients aged ≥ 65 years has risen substantially in recent years.⁶ A similar trend has been observed in patients aged > 18 years in Australia.¹⁷ However, it is unclear whether the trend toward an increased rate of arthrodesis for LSS is happening in working-age patients in the US and whether this potential increase in the number of complex procedures has similar adverse associations. Patients aged 40–64 years constitute a large proportion of the US workforce. Their share of the gross domestic product was estimated to be 30% in 2010.¹² Hence, more accurate assessment of the risks and benefits of arthrodesis for isolated LSS in this population may have far-reaching economic consequences.

Our goals were to identify temporal trends in the following: 1) the incidence of surgery for isolated LSS; 2) the type of surgery performed; 3) the complexity of LSS procedures; 4) the length of hospital stay, postoperative complication rates, and discharge status after surgical treatment of LSS, as well as the costs of surgical treatment of LSS; and 5) geographic variations in the type of surgery performed for LSS.

Methods

This research does not qualify as human subjects research and is subsequently exempt from institutional review board approval.

Patient Sample

Our patient sample was derived from inpatient and outpatient claims between 2010 and 2014 from the Truven Health Analytics MarketScan Commercial Claims and Encounters Database, which includes data on commercially insured members < 65 years of age. We included patients > 40 years of age with continuous 12-month insurance coverage after surgery. The *International Classification of Diseases, Ninth Revision* (ICD-9) code 724.02 was used to identify patients who underwent surgery for “spinal stenosis of the lumbar region” as the only principal diagnosis. We excluded patients with concomitant diagnoses such as scoliosis or spondylolisthesis.

Surgery Incidence and Type

The incidence of surgery was calculated as the proportion of patients who underwent LSS surgery to the total number of eligible enrollees during each 1-year period. Surgery was categorized as decompression only (ICD-9

code 03.09 or 80.51) or decompression with fusion (code 81.06, 81.07, 81.08, 81.63, or 81.64).

Complications and Discharge Status

Inpatient medical complications were the following: cardiopulmonary resuscitation (ICD-9 code 9393 or 9960), endotracheal intubation (code 9604), cardiopulmonary arrest (code 4275 or 9971), acute myocardial infarction (code 410), respiratory failure (code 51881), pulmonary embolism (code 41511), pneumonia (code 482), stroke (code 99702), and wound infection or dehiscence (code 9981, 9983, 9985, or 8622). Patients were categorized as being discharged to home or to a skilled nursing facility (SNF).

Regional Analysis

Geographical regions were assigned according to the location of patient residence. They were divided into the 4 geographic regions used by the US Census Bureau: Northeast (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York, and Pennsylvania); Midwest (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin); South (Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia); and West (Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming).

Payments and Length of Hospital Stay

To estimate the use of health care resources, we analyzed payments made to the hospitals (as opposed to charges) in US dollars (USD) and the length of postoperative hospital stay in days. Inflation rates were adjusted according to the consumer price index, and all dollars were subsequently expressed in 2014 USD equivalents.

Statistical Analysis

Changes during the 5-year period in the characteristics and outcomes of patients who underwent surgery for LSS were assessed using multivariate regression models controlling for patient age and sex. Student t-tests were used to compare group means, and chi-square tests were used to compare proportions. Given the large sample size, care must be taken when interpreting statistically significant but not clinically important results. Statistical significance was set at $p < 0.05$. Statistical analyses were performed using Stata software, version 15 (StataCorp LP).

Results

Patient Sample

The annual incidence of LSS surgery (per 1000 people) ranged from a low of 1.2 in 2014 to a high of 1.8 in 2011 and 2012 (Table 1). In total, 20,279 patients underwent surgery for LSS and were included in the study. The mean ($\pm$ SD) patient age was 56 ± 6 years, and 9001 patients (44%) were women. The proportion of women versus men undergoing LSS surgery did not change significantly over

TABLE 1. Surgery type and incidence data by year for 20,279 patients who underwent surgery for LSS

Parameter	No. (%) [*]	Incidence [†]
Decompression only		
2010	2897 (61)	
2011	3003 (61)	
2012	2841 (61)	
2013	1885 (58)	
2014	1357 (51)	
Overall	11,983 (59)	
Decompression w/ arthrodesis		
2010	1887 (40)	
2011	1919 (39)	
2012	1830 (39)	
2013	1368 (42)	
2014	1292 (49)	
Overall	8296 (41)	
Overall surgery incidence		
2010		1.7
2011		1.8
2012		1.8
2013		1.5
2014		1.2
Overall		1.6

Data from the Truven Health Analytics MarketScan Commercial Claims and Encounters Database, 2010–2014.

* Complex fusions were those involving a combined anteroposterior approach and/or > 2 spinal levels. Percentages represent the proportion of complex fusions out of the total number of fusions performed.

† Per 1000 eligible enrollees during each 1-year period. Annual enrollment was 2.75 million in 2010, 2.76 million in 2011, 2.67 million in 2012, 2.12 million in 2013, and 2.20 million in 2014.

time ($p = 0.082$). Similarly, the mean Charlson Comorbidity Index (CCI) values were similar throughout the study period ($p = 0.319$). Although there was a statistically significant decrease in age over time, this difference was not clinically important (differences were -0.12 , -0.19 , and -0.06 , $p < 0.001$)

Surgery Incidence and Type

Of the 20,279 patients, 8296 (41%) underwent decompression with arthrodesis (Table 1). Compared with patients who underwent decompression only, patients who underwent decompression with arthrodesis were more likely to be women (51% vs 40%, $p < 0.001$) (Table 2). The proportion of patients who underwent decompression with arthrodesis as opposed to decompression only increased significantly over time (OR 1.08, $p < 0.001$) (Fig. 1). Similarly, arthrodesis was more likely to be complex rather than simple with each subsequent year (OR 1.4; 95% CI 1.33–1.49).

Complications and Discharge Status

During the study period, there was a significant increase in the likelihood of having a postoperative medical

TABLE 2. Characteristics and outcomes of patients who underwent decompression only ($n = 11,983$) or decompression with arthrodesis ($n = 8296$) for LSS

Parameter	Mean $\pm$ SD	No. of Patients (%)	p Value
Patient characteristics			
Age, yrs			
Decompression only	57 $\pm$ 6		
Decompression w/ arthrodesis	56 $\pm$ 6		<0.001
Female sex			
Decompression only		4743 (40)	
Decompression w/ arthrodesis		4258 (51)	<0.001
CCI score			
Decompression only	0.46 $\pm$ 0.82		
Decompression w/ arthrodesis	0.43 $\pm$ 0.80		0.074
Outcomes			
Complication			
Decompression only		145 (1.2)	
Decompression w/ arthrodesis		156 (1.9)	<0.001
Length of hospital stay, days			
Decompression only	2.3 $\pm$ 2.6		
Decompression w/ arthrodesis	3.5 $\pm$ 3.5		<0.001
Discharge to SNF			
Decompression only		171 (1.4)	
Decompression w/ arthrodesis		211 (2.5)	<0.001
Payment, USD			
Decompression only	14,000 $\pm$ 13,000		
Decompression w/ arthrodesis	48,000 $\pm$ 35,000		<0.001

Data from the Truven Health Analytics MarketScan Commercial Claims and Encounters Database, 2010–2014.

complication (OR 1.11, $p = 0.013$) (Table 3). Similarly, the likelihood of being discharged to an SNF as opposed to home also increased significantly over time (OR 1.11, $p = 0.005$). Compared with decompression only, decompression with arthrodesis was associated with significantly higher rates of inpatient complications (1.9% vs 1.2%, $p < 0.001$) and discharge to an SNF (2.5% vs 1.4%, $p < 0.001$) (Table 2).

Geographic Variation

The proportion of patients who underwent decompression with arthrodesis versus decompression only for isolated LSS differed significantly by US geographic region ($p < 0.001$). The regions with the highest proportion of patients undergoing decompression with arthrodesis were the Midwest (42%) and South (48%), whereas the regions

FIG. 1. Proportion of 20,279 patients aged 40–64 years who underwent surgical decompression for LSS whose treatment also included arthrodesis. This proportion increased significantly and linearly during the 5-year study period.

with the lowest rates of arthrodesis were the Northeast (36%) and West (31%). After controlling for age, sex, and CCI, patients were significantly more likely to undergo arthrodesis if they resided in the Midwest (OR 1.3, $p < 0.001$) or the South (OR 1.6, $p < 0.001$) compared with the Northeast (Fig. 2).

Payments and Length of Hospital Stay

Mean hospital payments for LSS surgery increased significantly by a mean of US\$1633 per year (95% CI 1327–1939, $p < 0.001$) (Table 3) and were higher by almost fourfold for patients who underwent decompression with arthrodesis versus decompression only (\$48,000 $\pm$ \$35,000 vs \$14,000 $\pm$ \$13,000, $p < 0.001$) (Table 2).

Mean length of hospital stay did not change significantly during the study period ($p = 0.187$) (Table 3); however, it was significantly longer for patients who underwent decompression with arthrodesis versus those who underwent decompression alone (3.5 ± 3.5 vs 2.3 ± 2.6 days, $p < 0.001$) (Table 2).

Discussion

In our sample of US adults aged 40–64 years, the likelihood of undergoing arthrodesis for isolated LSS increased significantly from 2010 to 2014. These changes were accompanied by rising medical costs, higher complication rates, and increased rates of discharge to an SNF.

In 2010, Deyo et al.⁶ reported an increase in the proportion of complex fusions among the US elderly population from 2002 to 2007. Our results similarly reflect a rise in the proportion of complex procedures for LSS in patients aged 40–64 years. A similar trend in the adult Australian population between 2003 and 2013 has been reported.¹⁷

It is unclear what is causing the increase in the proportion of complex surgeries. We hypothesize that contributing factors may be financial incentives that are part of a changing physician reimbursement system, the influence of key opinion leaders, and the marketing of new surgical devices.⁵ A worsening of patients' disease state over time or a change in disease severity seems implausible because the same ICD-9 diagnosis code for isolated LSS was used throughout the study.

The treatment approach for degenerative disease of the lumbar spine varies substantially by surgeon and specialty.^{9,10} However, complex procedures in the elderly are associated with high costs, complication rates, and readmission rates.⁶ Although it might be plausible that younger patients better tolerate complex procedures, our results show that patients aged 40–64 years who underwent arthrodesis had significantly longer hospital stays, higher rates of inpatient complications, and higher payments by the insurance provider.

During the 5-year study period, the age, sex, and CCI of patients who underwent surgery for LSS did not change in a clinically important manner. However, patients who underwent decompression with arthrodesis were more likely to be women. The influences of patient sex on procedure choice remain unclear. The higher likelihood of undergoing arthrodesis for female patients may be supported by the notion that these decisions are based on surgeon preference, patient expectations, and cultural factors, as well as a possibly higher association of instability with LSS that might have been underestimated by ICD-9 coding.¹⁹

The type of procedure performed for LSS in the US elderly population has been shown to differ by geographic location.^{3,23} Weinstein et al.²³ reported that arthrodesis rates among elderly patients were highest in many Mid-

TABLE 3. Outcomes by year for 20,279 patients who underwent surgery for LSS

Outcome by Year	No. (%)	Mean ± SD	Change From 2010 to 2014		
			OR (95% CI)*	β (95% CI)*	p Value
Complication					
2010	59 (1.2)		1.11 (1.02 to 1.21)		0.013
2011	74 (1.5)				
2012	56 (1.2)				
2013	65 (2.0)				
2014	47 (1.8)				
Overall	301 (1.5)				
Length of hospital stay, days					
2010		2.8 ± 3.4		0.02 (−0.01 to 0.05)	0.187
2011		2.7 ± 2.8			
2012		2.7 ± 3.2			
2013		2.9 ± 3.0			
2014		2.9 ± 3.0			
Overall		2.3 ± 2.6			
Discharge to SNF					
2010	84 (1.8)		1.11 (1.03 to 1.20)		0.005
2011	81 (1.6)				
2012	83 (1.8)				
2013	67 (2.1)				
2014	67 (2.5)				
Overall	382 (1.9)				
Payment, USD					
2010		26,000 ± 28,000		1633 (1327 to 1939)	<0.001
2011		27,000 ± 30,000			
2012		27,000 ± 28,000			
2013		31,000 ± 30,000			
2014		32,000 ± 35,000			
Overall		28,000 ± 30,000			

Data from the Truven Health Analytics MarketScan Commercial Claims and Encounters Database, 2010–2014.

* Adjusted for patient age and sex.

west and Southern states compared with the Northeast and the West. Our results support that finding in a younger population. Interestingly, the higher rates of arthrodesis in the South and Midwest compared with the West and Northeast were reported in 1994,²² and this trend seems to persist. There is no evidence that the indication for surgery and subsequently the type of procedure performed varied by geographic location.

Given that patient and surgeon preferences have been shown to vary by geographic location,^{8,21} we believe that local training and variations in physician-patient interactions may have contributed to this variability.

This study has potential limitations, including those inherent in a retrospective design. We analyzed administrative claims data in which ICD-9 diagnostic and procedure codes were used, and such codes may lack the clinical specificity to represent disease states accurately. However, we believe that using the same ICD-9 codes consistently throughout the study addresses this limitation because it is unlikely that the same code would reflect more com-

plex indications for surgery over time. Furthermore, we were unable to determine whether discharge to an SNF represented a change in living status or whether a given patient resided in an SNF before surgery. Another potential limitation is the use of payments as a proxy estimate of costs rather than assessing costs directly in the health care setting. Nevertheless, this is the first study to assess the trend and certain aspects of the associated burden of the surgical treatment of LSS in the working-age US population. We believe that these results identify an important trend in this age group in which outcomes can be very consequential.

Conclusions

Our results suggest a trend toward higher rates of arthrodesis and complex procedures for the treatment of isolated LSS, especially in the South and Midwest of the US. These surgeries were associated with more complications, higher payments, and a longer hospital stay. Given the lack

FIG. 2. Odds of undergoing decompression with arthrodesis for LSS by US region, using the Northeast region as the referent and adjusting for age, sex, and CCI. Error bars indicate 95% CI. Data from Truven Health Analytics MarketScan Commercial Claims and Encounters Database for 2010–2014.

of strong recommendations for the treatment of this disease,¹⁶ further prospective studies and a thorough review of the current guidelines¹¹ are needed to define a new and clearer standard of care.

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Conception and design: Raad, Skolasky, Riley. Acquisition of data: Raad, Donaldson. Analysis and interpretation of data: Raad, Skolasky. Drafting the article: Raad, Donaldson. Critically revising the article: Sciubba, Neuman, Kebaish, El Dafrawy. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Skolasky. Statistical analysis: Raad. Administrative/technical/material support: Raad, Donaldson. Study supervision: Skolasky.

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