DOI: 10.5137/1019-5149.JTN.24318-18.1
Received: 23.07.2018 / Accepted: 27.07.2018
Published Online: 28.07.2019

Turk Neurosurg 29(5):643-650, 2019

Original Investigation

A Simple Cost-Effectiveness Analysis of Bilateral Decompression via Unilateral Approach versus Instrumented Total Laminectomy and Fusion for Lumbar Spinal Stenosis

Ali Erhan KAYALAR[1], Mehmet Resid ONEN[1], Aydin GERILMEZ[2], Sait NADERI[1]

[1]University of Health Sciences, Umraniye Training and Research Hospital, Department of Neurosurgery, Istanbul, Turkey
[2]University of Health Sciences, Haydarpaşa Numune Training and Research Hospital, Department of Neurosurgery, Istanbul, Turkey

Corresponding author: Ali Erhan KAYALAR ✉ draekayalar@gmail.com

ABSTRACT

AIM: To compare the clinical and economic results of two different surgical approaches (bilateral decompression via unilateral approach and instrumented total laminectomy and fusion) in the treatment of lumbar spinal stenosis.

MATERIAL and METHODS: The clinical, surgical, and economic aspects of 100 surgically treated patients with lumbar spinal stenosis were retrospectively reviewed.

RESULTS: Decompression was performed at 158 levels in 100 patients. The most commonly decompressed levels were L4-5 and L3-4. Significant difference was observed between pre- and postoperative visual analog scale scores in both groups ($p<0.05$). In Group 1 (instrumented total laminectomy and fusion), the mean surgery cost was 2539.2 USD (mean procedure cost: 1440.1 USD, mean implant cost: 1099.2 USD). In Group 2 (bilateral decompression via unilateral approach) the mean surgery cost was 998.5 USD. The cost difference was significant ($p<0.05$).

CONCLUSION: Both instrumented total laminectomy and fusion and bilateral decompression via unilateral approach performed with and without stabilization showed similar clinical results in patients with lumbar spinal stenosis. However, the cost of surgery was found to be 2.5-fold higher in the instrumented total laminectomy and fusion group. This study supports the concept that minimally invasive spine surgery is cost-effective.

KEYWORDS: Cost effectiveness, Economy, Lumbar spinal stenosis, Surgery

ABBREVIATIONS: BDUA: Bilateral decompression via unilateral approach, **CT:** Computed tomography, **MISS:** Minimally invasive spinal surgery, **MRI:** Magnetic resonance imaging, **LSS:** Lumbar spinal stenosis, **VAS:** Visual analog scale

■ INTRODUCTION

Lumbar spinal stenosis (LSS) may occur as a result of facet joint and ligamentum flavum hypertrophy, disc degeneration, spinal instability, or a combination of these conditions. In cases without overt instability, neurogenic claudication is the main symptom. The aim of surgical treatment is to eliminate symptoms by sufficiently decompressing the neural elements within the spinal canal. Commonly used modalities for microsurgical treatment are laminectomy (24,32), unilateral laminotomy, bilateral laminotomy, and open door laminoplasty (5). Depending on the extent of decompression, the addition of fusion and stabilization has become more common recently as well. Furthermore, minimally invasive procedures, such as microsurgical or endoscopic decompression and bilateral decompression via unilateral approach (BDUA), have become more common (2,8,11,18). BDUA was first described by Young

Ali Erhan KAYALAR : 0000-0001-5717-5889
Mehmet Resid ONEN : 0000-0003-4353-9068
Aydin GERILMEZ : 0000-0002-5945-4547
Sait NADERI : 0000-0002-6784-4270

et al (36). In this procedure, the facet joints and contralateral neural arch are protected, which decreases scar formation as well as the risk of iatrogenic instability. The aim of the present study was to compare the surgical results and economic costs of instrumented total laminectomy and fusion and BDUA.

MATERIAL and METHODS

Clinical, surgical, and economic aspects of 100 patients with LSS who underwent surgical intervention were retrospectively reviewed.

Inclusion and Exclusion Criteria

The primary indication for surgery in this study was neurogenic claudication with or without radicular pain associated with a radiological evidence of LSS. Radiological examination included lumbar magnetic resonance imaging (MRI), computed tomography (CT), dynamic lumbar radiographs, and in selected patients, scoliosis radiographs. Patients with concomitant disorders, such as inflammation, malignancy, degenerative spondylolisthesis, sagittal imbalance, and instability, were excluded from the study.

Patient Classification

Patients were classified into two groups: Group 1 consisted of cases who underwent total laminectomy, transpedicular stabilization, and posterolateral fusion; Group 2 consisted of patients who underwent BDUA. Leg pain of the patients was evaluated preoperatively and at 8 months postoperatively with a visual analog scale (VAS) using the VAS improvement rate [(preoperative VAS score – postoperative VAS score)/(preoperative VAS score) × 100]. In addition, the two groups were compared in terms of operation time, volume of bleeding, length of hospitalization, complications, and economic cost. The mean follow-up period was 16 ± 6 months.

Surgical Procedure

Instrumented Total Laminectomy and Fusion

All operations were performed under general anesthesia with the patient in the prone position. After fluoroscopy for level localization, a midline skin incision was made and subcutaneous dissection was performed to the lumbosacral fascia, exposing the level(s) of interest and one level above and below. The lumbosacral fascia was opened in the midline and the paravertebral muscles were subperiosteally stripped from the vertebral column bilaterally; a wide dissection was performed to visualize the transverse processes at all levels. First, transpedicular polyaxial screws were placed in each necessary pedicle under fluoroscopic guidance. Then total laminectomy was performed using Kerrison rongeurs and a high-speed drill under microscopic guidance. Following the decompression, the screw system was fixed with rods. Autogenous bone graft was used for fusion. The bone grafts were placed on and between the transverse processes (Figure 1A-D).

BDUA

All operations were performed under general anesthesia with the patient in the prone position and all stages of the operation were performed using a surgical microscope. Entry was performed with a midline skin incision of approximately 2-3 cm, depending on the number of levels to be decompressed. The procedure was started on the symptomatic side or the side with greater stenosis on the radiographic studies in cases without radiculopathy. After subcutaneous dissection, the lumbosacral fascia was opened in the midline and the paravertebral muscles were stripped subperiosteally off the vertebral column. A Taylor retractor was placed lateral to the facet joint at the level where decompression was to be applied, and a weight of 500 g was attached. Using a high-speed drill, the upper and lower laminae were removed as far as the free edge of the hypertrophic ligamentum flavum, and the base of the spinous process was removed. Then, by tilting the operating table, the microscope angle was changed to be able to see the contralateral side. With this maneuver, an angle of approximately 60°-70° was achieved and thus good visualization was obtained. At this point, the contralateral ligamentum flavum was excised (Figure 2A-D).

Statistical Analysis

All statistical analyses were performed using SPSS for Windows 10.0. Descriptive statistical methods (mean, standard deviation) were used for data summarization. For quantitative data, the Wilcoxon sign test was used to compare parameters with non-normal distribution. For qualitative data, comparisons were performed using the Chi-square and McNemar tests. The results were evaluated at a confidence interval of 95% with statistical significance defined as $p<0.05$.

RESULTS

Demographics

There were 50 patients in Group 1 (42 females and 8 males, mean age 56.22 years), and 50 patients in Group 2 (36 females and 14 males, mean age 58.44 years). There was no significant age difference between groups ($p>0.05$).

Surgery Levels

Decompression was performed at 158 levels in 100 patients. The most commonly decompressed levels were L4-5 and L3-4. In Group 1, single level decompression was performed in 27 patients and multisegmental decompression in 23 patients (mean 1.56 levels), whereas single level was performed in 24 patients and multisegmental in 26 patients in Group 2 (mean 1.56 levels). In Group 1, decompression was performed at a total of 78 levels (L2-3 in 6 patients, L3-4 in 21, L4-5 in 40, and L5-S1 in 11). In Group 2, decompression was performed at a total of 80 levels (L2-3 in 6 patients, L3-4 in 27, L4-5 in 44, and L5-S1 in 3) (Figure 3).

Leg Pain Evaluation

A significant improvement in the degree of leg pain as a result of surgical decompression was found in all patients. The preoperative mean VAS score decreased from 7.96 ± 1.08 to 2.88 ± 0.5 in Group 1, and from 7.7 ± 1.6 to 2.74 ± 0.3 in Group 2. The difference between preoperative and postoperative VAS scores was statistically significant in both

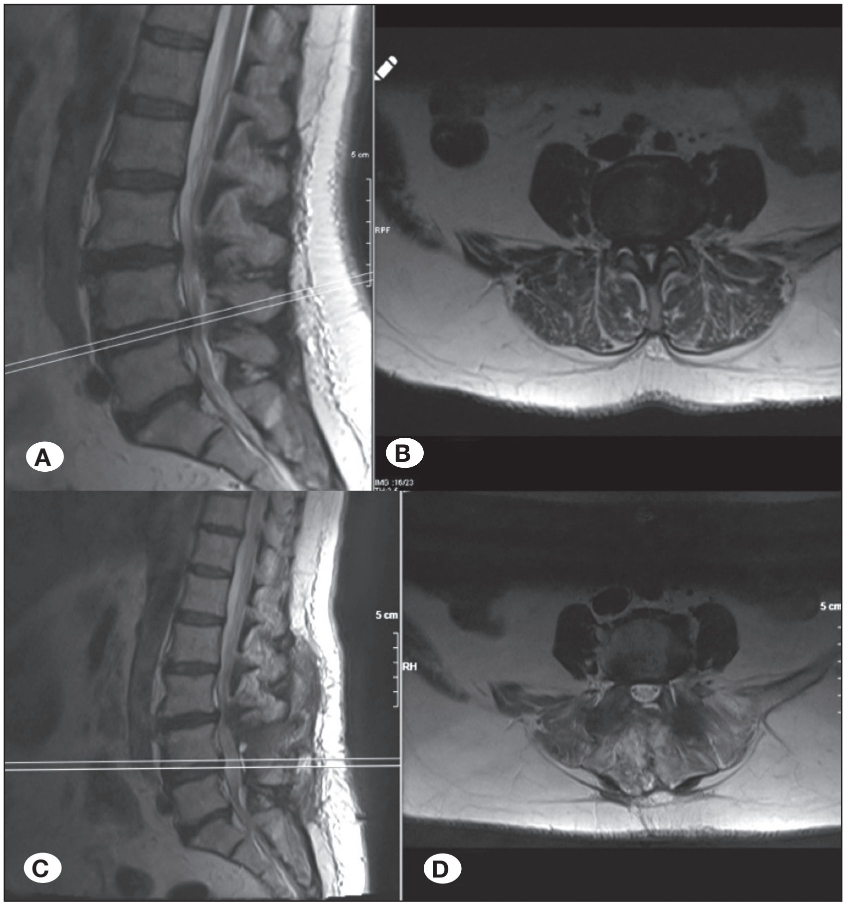

Figure 1: Preoperative **(A,B)** and postoperative **(C,D)** sagittal and axial T2W-MR images of a case with L4-5 lumbar spinal stenosis who underwent L4 total laminectomy with L4-L5 pedicle screw instrumentation.

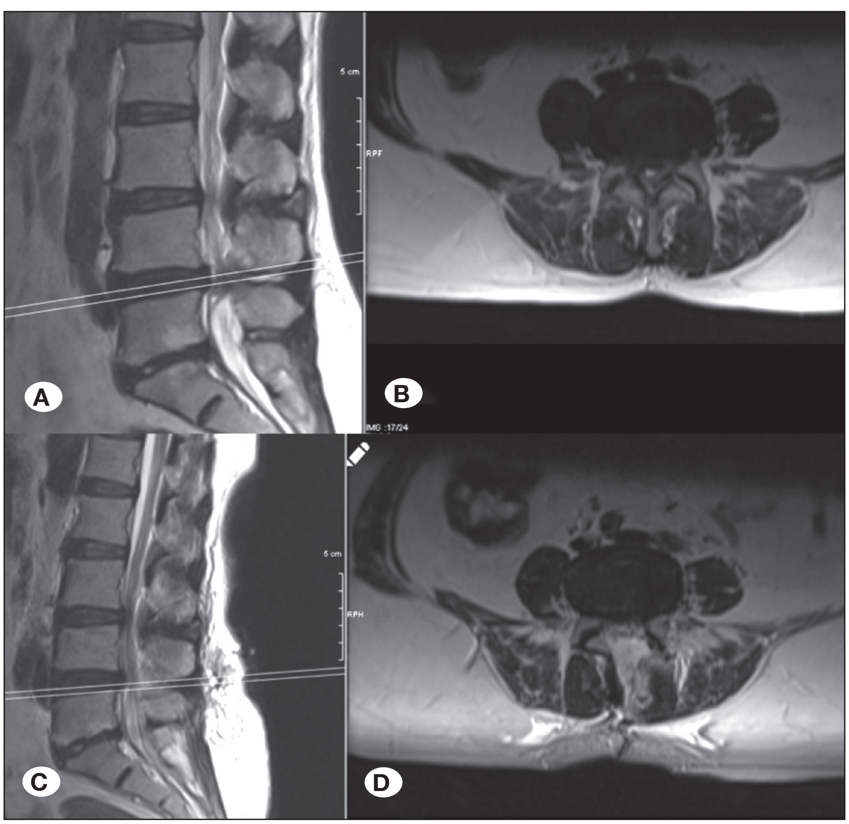

Figure 2: Preoperative **(A,B)** and postoperative **(C,D)** sagittal and axial T2W-MR images of a case with L4-5 lumbar spinal stenosis who underwent bilateral decompression via unilateral approach.

groups (p=0.000). The VAS improvement rate was 63.8% in Group 1 and 64.4% in Group 2 (Figure 4).

Operating Time

The operating time (time from initial incision to final skin closure) was 186 ± 75 minutes in Group 1 and 75.4 ± 30 minutes in Group 2. The observed difference was statistically significant (p<0.05). We ignored all the periods of time lost in monitoring after intubation, arterial catheterization, attaching the catheter, positioning the patient, and positioning for preoperative fluoroscopy imaging and postoperative supine positioning, and late and early awakening.

Length of Hospitalization

Mean duration of postoperative hospitalization was 2.8 days in Group 1, and 1.2 days in Group 2. The observed difference between groups was statistically significant (p<0.05). In addition, we found that as the number of levels that underwent decompression increased, the length of hospitalization also increased.

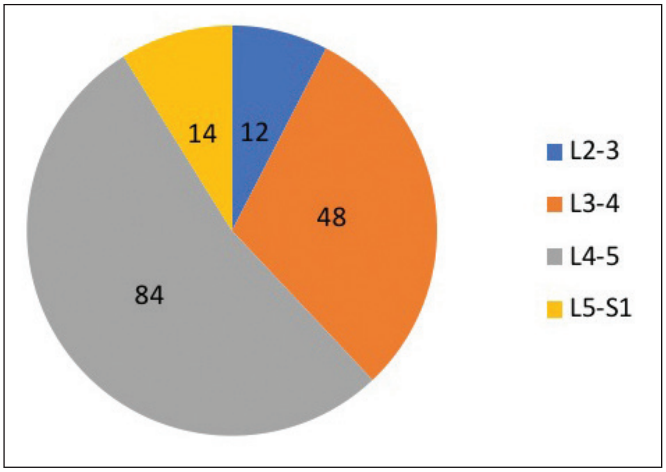

Figure 3: Number of levels operated on according to the pathological level.

Blood Loss

Blood loss was 400 ± 85 mL in Group 1 and 90 ± 35 mL in Group 2. The observed difference was statistically significant (p<0.05).

Cost Analysis

In Group 1, the mean cost of surgery was 1440.1 USD and the mean implant cost was 1099.2 USD, for a mean total cost of 2539.2 USD. In Group 2, the mean cost of surgery was 998.5 USD. The difference between groups was statistically significant (p<0.05). All cost analysis data are presented in Table I.

Complications

During long-term follow-up in Group 1, adjacent segment disease developed in one patient, who then underwent further decompression and extension of the fusion and instrumentation. In Group 2, a dural tear occurred in one patient that was repaired with sutures and fibrin glue; no cerebrospinal fluid fistula developed during follow-up. Radicular complaints recurred during long-term follow-up in two patients who then underwent additional microdiscectomy.

■ DISCUSSION

This study showed the effectiveness of both laminectomy with fusion and BDUA in the surgical treatment of LSS and confirmed that BDUA is associated with lower cost, shorter postoperative hospitalization, and less blood loss than total laminectomy and fusion. The aim of surgery in LSS is improvement in neurogenic claudication and relief of pain. The standard treatment for spinal stenosis is total or hemilaminectomy. However, such a decompression may be associated with disruption of the supraspinous and interspinous ligament complexes, as well as disruption of the facet joints, leading to spinal instability (9,24,25,28,30,34). Therefore, the addition of instrumented fusion to decompression by many surgeons has become common practice (7,13). BDUA was developed

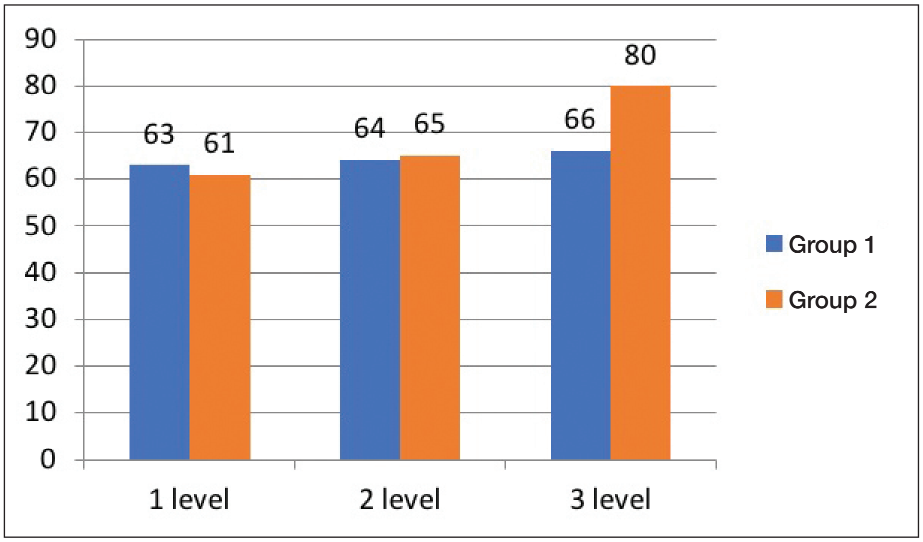

Figure 4: Preoperative – postoperative VAS changes according to the number of levels decompressed.

Table I: Comparison of the Results Between the Two Groups

	Number of cases	Pain relief (VAS)		Length of Hospital Stay (days)	Blood Loss (mL)	Operation time (min)	Cost analysis (US Dollar)
		Preoperative	Postoperative				
Group I	50 (42 F; 8 M)	7.96 ± 1.08	2.88 ± 0.5	2.8	400 ± 85	186 ± 75	1440.1
Group II	50 (36 F; 14 M)	7.7 ± 1.6	2.74 ± 0.3	1.2	90 ± 35	75.4 ± 30	2539.2
Statistical Analysis		p>0.05		**p<0.05**	**p<0.05**	**p<0.05**	**p<0.05**

to minimize instability due to iatrogenic ligament and facet joint disruption, and has become an effective alternative. By protecting a significant proportion of the facet joints and ligaments, the BDUA technique reduces the risk of instability, thus the addition of instrumented fusion to the procedure may not be needed. Previous studies have reported good short-term, mid-term, and long-term clinical results with BDUA (12,17,27,29,34). However, as the follow-up period became longer, the success rate decreased. Cavusoglu et al. reported a 94% patient satisfaction rate and 96% recovery rate in a study of BDUA patients with an 18–24 month follow-up period (4). In a study by Yaman et al. that compared the clinical and radiological results of classic laminectomy and BDUA at 6 and 12 months after surgery, no difference was found between the two procedures in terms of leg pain VAS scores, whereas back pain VAS scores of the BDUA patients were significantly lower (35). A randomized clinical study by Mobbs et al. that compared BDUA with open decompression in 79 patients found that BDUA was as effective as open decompression in terms of improvement in Oswestry Disability Index scores (6). Similarly, in a study by Park et al. ipsilateral and contralateral canal decompression using unilateral laminectomy were compared; the VAS improvement rate was 75.4% on the ipsilateral side and 73.7% on the contralateral side. The slight difference was not statistically significant (19). These studies and others suggest that BDUA is effective in the surgical treatment of LSS in terms of unilateral and contralateral leg pain and low back pain. In the current study, no statistically significant difference was found between Group 1 and Group 2 with respect to postoperative leg VAS scores, suggesting that the BDUA procedure is as successful as classic laminectomy in relieving leg pain. Back pain VAS scores of the BDUA patients were lower. We believe that this is due to less muscle stripping and retraction and preservation of the spinous processes and interspinous and supraspinous ligament complexes. The current study also showed that BDUA was associated with less blood loss, which agrees with previously published studies by Cavusoglu et al. (4), and Krut'ko (14). Less back pain and less blood loss are two advantages of BDUA in LSS surgery.

Other advantages associated with BDUA are shorter hospitalization time and lower cost. Although these advantages have been reported in many studies, debate remains regarding whether minimally invasive spinal surgery (MISS) is more cost-effective than open surgery. This is because MISS techniques may require initial capital expenditures for imaging (C-arm, or O-arm) and the surgery itself (microscope, robotics, endoscope, and microinstruments). However, after initial expenditures, MISS techniques are associated with shorter hospitalization and faster return to work, resulting in better overall cost effectiveness in the long-term. Most cost-related studies have reported the costs of fusion techniques and confirmed the superiority of minimally invasive interbody fusion in terms of hospitalization rate, anesthesia time, and lower direct hospital costs. However, there are also several studies on the economic aspects of purely decompressive procedures (3,10, 16,22,23,26,33). Udeh et al. compared laminectomy and minimally invasive decompression and reported that minimally invasive decompression was more cost-effective (43,760 USD vs. 125,985 USD) (31). Parker et al. compared conservative care, laminectomy, and interspinous spacer in the treatment of LSS and reported that laminectomy was more cost-effective than both interspinous spacer and conservative care (20-22). In other studies, the cost of decompression was compared with the cost of decompression and instrumented fusion. Kuntz et al. compared the costs and benefits of laminectomy alone to laminectomy plus lumbar fusion for patients with degenerative lumbar spondylolisthesis and LSS. As a result, they reported cost effectiveness of laminectomy alone when compared with decompression with instrumented fusion (15). A similar result was noted by Alvin et al., who reported that decompression with instrumented fusion was inferior to decompression alone in terms of cost effectiveness 1 year after surgery in patients with grade I degenerative spondylolisthesis (1). Our cost-related findings are in line with the previously reported results, however our study is limited, as a more detailed cost-effectivity analysis could not be performed.

■ CONCLUSION

Laminectomy with fusion and BDUA for LSS have comparable clinical results after surgery, but BDUA is superior in terms of cost effectiveness (Table II). BDUA was found to be more cost-effective due to its lesser surgical cost, shorter hospital stay, and reduced need for transfusion.

Table II: Summary of the Previously Published (2012 – 2016) Literature

Comparison	Author	Year	Result
MISS vs. Open TLIF	Parker et al.	2012	MIS-TLIF allows patients to leave the hospital sooner, achieve narcotic independence sooner, and return to work sooner than open-TLIF. In our experience, MIS- versus open-TLIF is a cost reducing technology in the surgical treatment of medically refractory low-back and leg pain from grade I lumbar spondylolisthesis.
MISS vs. Open TLIF	Parker et al.	2014	MIS-TLIF may represent a valuable and cost-saving advancement from a societal and hospital perspective.
MISS vs. Open TLIF	Singh et al.	2014	MIS-TLIF technique demonstrated significant reductions of operative time, LOS, anesthesia time, VAS scores, and EBL compared with the open technique. This reduction in perioperative parameters translated into lower total hospital costs over a 60-day perioperative period.
MAS tubular discectomy with conventional md, minimal access TLIF versus open TLIF, and multilevel hemilaminectomy via MAS versus open approach.	Lubelski et al.	2014	The included cost-effectiveness studies generally supported no significant differences between open surgery and MAS lumbar approaches. Much of the evidence lacked details on methodology for modeling, related assumptions, justification of economic model chosen, and sources and types of included costs and consequences. The follow-up periods were highly variable, indirect costs were not frequently analyzed or reported, and many of the studies were conducted by a single group, thereby limiting generalizability. Prospective studies are needed to define differences and optimal treatment algorithms.
Circumferential fusions vs. posterolateral fusions	Ghogawala et al. (Guideline update)	2014	Recent costanalyses have demonstrated the long-term benefits of circumferential fusions over posterolateral fusions (This study showed an incremental savings of $49,306 per QALY following a circumferential fusion compared with a posterolateral fusion.)
MIS TLIF vs. OS TLIF	Vertuani et. al.	2015	MISS is a more cost-effective surgical procedure for lumbar spinal fusion in comparison with traditional OS in both the United Kingdom and Italy
Conservative care (CC) vs. laminectomy (DS) vs. the interspinous spacer	Parker et al.	2015	DS was more cost effective than spacer and CC
MI-TLIF vs. open-TLIF	Phan et al.	2015	Reduced perioperative costs, length of stay, and blood loss for minimally invasive compared with open surgical approaches for TLIF (weighted mean difference (WMD) $2820 61%)
Laminectomy vs. MISS	Udeh et al.	2015	MISS was more cost effective 43.760 S vs. 125.985 S
TLIF vs. PSF	Carreon et al.	2016	At a cost per QALY threshold of $100,000 and using SF-6D–based QALYs, the authors found that TLIF would be cost-prohibitive compared with PSF at a surgical cost of $4830 above that of PSF. However, with EQ-5D–based QALYs, TLIF would become cost-prohibitive at an increased surgical cost of $2960 relative to that of PSF. With the 2014 US per capita gross domestic product of $53,042 as a more stringent cost-effectiveness threshold, TLIF would become cost-prohibitive at surgical costs $2562 above that of PSF with SF-6D–based QALYs or at a surgical cost exceeding that of PSF by $1570 with EQ-5D–derived QALYs.

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