

Biportal Endoscopic Approach for Lumbar Degenerative Disease in the Ambulatory Outpatient vs Inpatient Setting: A Comparative Study

Don Young Park, Thomas E. Olson, Alexander Uphill-Brown, Babapelumi Adejuyigbe, Akash A. Shah, William L. Sheppard, Cheol Wung Park and Dong Hwa Heo

Int J Spine Surg published online 28 September 2023
<https://www.ijssurgery.com/content/early/2023/10/17/8545>

This information is current as of July 27, 2024.

Email Alerts Receive free email-alerts when new articles cite this article. Sign up at:
<http://ijssurgery.com/alerts>

Biportal Endoscopic Approach for Lumbar Degenerative Disease in the Ambulatory Outpatient vs Inpatient Setting: A Comparative Study

DON YOUNG PARK, MD¹; THOMAS E. OLSON, MD¹; ALEXANDER UPFILL-BROWN, MD¹;
BABAPELUMI ADEJUYIGBE, BS¹; AKASH A. SHAH, MD¹; WILLIAM L. SHEPPARD, MD¹; CHEOL WUNG PARK,
MD, PhD²; AND DONG HWA HEO, MD, PhD³

¹UCLA Department of Orthopedic Surgery, David Geffen School of Medicine at UCLA, Los Angeles, CA, USA; ²Department of Neurosurgery, Woori Hospital, Daejeon, South Korea; ³Department of Neurosurgery, Harrison Spinartus Hospital Chungdam, Seoul, South Korea

ABSTRACT

Background: Biportal spinal endoscopy is increasingly utilized for lumbar disc herniations and lumbar stenosis. The objective was to investigate the safety and effectiveness of the technique in the outpatient vs inpatient setting.

Methods: This is a comparative study of consecutive patients who underwent biportal spinal endoscopy by a single surgeon at a single institution. Demographics, surgical complications, and patient-reported outcomes were prospectively collected and retrospectively analyzed. Statistics were calculated among treatment groups using unpaired *t* test and χ^2 analysis where appropriate. Statistical significance was determined as $P < 0.05$.

Results: Eighty-four patients were included, 58 (69.0%) as outpatient, 26 (31.0%) as inpatient. Mean follow-up was 7.5 months. Statistically significant differences in age, American Society of Anesthesiologists classification, and Charleston Comorbidity Index scores were reported between cohorts, with younger and healthier patients undergoing outpatient surgery ($P < 0.0001$). Outpatients were more likely to have discectomies while inpatients were more likely to have decompressions for stenosis. No significant differences in postoperative complications were found between groups.

Both cohorts demonstrated significant improvement in visual analog scale (VAS) back and leg pain scores and Oswestry Disability Index scores ($P < 0.001$). Outpatients had significantly lower postoperative VAS back pain ($P = 0.001$) and Oswestry Disability Index scores ($P = 0.004$) at 5–8 weeks compared with inpatients, but there was no significant difference for VAS leg pain scores at all time points between the cohorts.

Conclusions: Early results demonstrate that biportal spinal endoscopy can safely and effectively be performed in both inpatient and outpatient settings.

Clinical Relevance: Outpatient biportal spinal endoscopy can be performed successfully in well selected patients, which may reduce the financial burden of spine surgery to the U.S. healthcare system.

Level of Evidence: 3.

Endoscopic Minimally Invasive Surgery

Keywords: biportal spinal endoscopy, endoscopic spine surgery, minimally invasive spine surgery, outpatient, inpatient, ambulatory surgery center

INTRODUCTION

Biportal spinal endoscopy has recently developed into an effective minimally invasive technique for treating lumbar disc herniations and lumbar stenosis.^{1–6} The technique utilizes water-based irrigation, which allows for excellent visualization through the endoscope.⁷ The endoscope is introduced through a viewing portal incision, which is separated from the working portal incision where surgical instruments are introduced.⁸ The endoscope and surgical instruments are triangulated at the spinal anatomy to perform the surgery.^{9,10} Due to the separation of the viewing portal and working portal, the surgeon has greater flexibility and versatility

to perform the surgery. The existing literature thus far, including systematic reviews and meta-analyses, has demonstrated successful clinical outcomes with low complication rates.^{11–16} However, these studies have been completed outside the United States, as biportal spinal endoscopy has only recently been introduced in the United States.

Outpatient spine surgery is also rapidly developing and expanding in the United States with the advancement of minimally invasive techniques, which allow patients to undergo spine surgery with reduced pain and faster recovery.¹⁷ As a result of exorbitant health care expenditures in the United States and the repercussion of the COVID-19 pandemic, particular attention has been

placed on shifting spine surgery from the traditional inpatient hospital setting into the outpatient setting to reduce costs.¹⁸ Lumbar discectomies and decompressions for stenosis are among the most commonly performed surgeries in the United States and have been successfully performed in the outpatient setting.^{19,20}

Due to the minimally invasive nature of biportal spinal endoscopy, the technique can be readily applied to the outpatient setting. Appropriate patient selection is important for successful implementation of the technique, especially in ambulatory surgery centers (ASCs) that do not allow for more than a 23-hour stay postoperatively. This is the first study in the United States to examine the early clinical results of biportal spinal endoscopy to treat common lumbar pathologies. In addition, no prior studies have investigated biportal spinal endoscopy when performed in either the outpatient or inpatient setting. We sought to identify the proper diagnoses, procedures, and patient populations that would benefit from biportal spinal endoscopy in the outpatient vs inpatient setting.

METHODS

Consecutive patients undergoing biportal spinal endoscopy by a single surgeon at a tertiary care university hospital in the United States were included in this study. The study was a prospectively collected, retrospectively analyzed study design and was IRB-approved (UCLA IRB#22-001674). All patients provided written informed consent, which was stored in the electronic medical record. Inclusion criteria consisted of all primary biportal endoscopic spine surgeries in the lumbar spine starting with the initiation of the study period in October 2021 for the diagnosis of lumbar disc herniation, lumbar stenosis, and lumbar synovial facet cyst causing stenosis requiring surgery for lumbar radiculopathy. Exclusion criteria included any revision surgery and any surgery for the diagnosis of spinal instability, infection, tumor, or trauma. Patients were divided between those undergoing surgery in an outpatient setting and those undergoing surgery in the inpatient setting. Patients were selected for the outpatient setting based on their American Society of Anesthesiologists (ASA) classification score. The policy at this institution mandates that any patient with an ASA score of 3 or above (out of 5) does not qualify for surgery in an ASC.

All patients in the outpatient cohort underwent surgery either at an ASC or in the hospital setting with same day discharge as outpatient status. Patients in the inpatient cohort underwent surgery with a planned

inpatient admission into the hospital. Additionally, patients requiring overnight stay were admitted to the hospital as inpatient status and thus included in the inpatient cohort. The ASC at this institution does not permit overnight stay and any surgery that may require overnight stay must be performed at the hospital. Biportal endoscopic spine surgery was performed as previously described in prior publications for all patients in the study.^{3,5,6} Depending on the pathology, lumbar discectomy and/or decompression was performed utilizing the biportal endoscopic technique. All cases in both cohorts had postoperative drains placed at the end of the surgery as a part of the study protocol. In addition, placing postoperative drains is a part of the surgeon's practice for biportal surgery to reduce the risk of epidural hematoma. The drains were removed prior to discharge home for the outpatient cohort or on postoperative day 1 for the inpatient cohort.

All patients completed previously validated patient-reported outcomes (PROs) of the visual analog scale (VAS) score for back and leg pain and the Oswestry Disability Index (ODI) at the initial preoperative visit and at each subsequent postoperative visit. All patients were also required to report any postoperative complications, including neurological changes such as recurrent pain, radicular symptoms, and motor weakness, at all points in the follow-up period. The follow-up intervals were 6 weeks, 3 months, 6 months, and 1 year after surgery. Patients were contacted by members of the study team via telehealth visits if there were any missed follow-up intervals for up to 2 years following the index procedure. Patient's demographic and perioperative data, complications, and PROs were prospectively collected and stored in a secure institutional database. Certain aspects of the demographic data were retrospectively collected for the purposes of this study such as body mass index (BMI), ASA, and Charleston Comorbidity Index (CCI) scores.

Statistical Methods

The primary outcomes were postoperative complications and changes in PROs. Demographic and surgical data were also compared between inpatient and outpatient groups. Analyses were performed using a 2-tailed Student's *t* test after ensuring normal distributions. For skewed, nonparametric distributions, continuous variables are presented as medians and interquartile ranges and analyzed using the Wilcoxon rank-sum test, if paired, or the Mann-Whitney rank-sum tests if unpaired. χ^2 tests were used for categorical analysis, with Yates' continuity correction applied. Visual inspection and the

Shapiro-Wilk test were used to assess for normality, with $P < 0.10$ for the latter indicative of non-normally distributed data. If the data were normally distributed, 95% CIs were estimated using SE. When data were nonparametric, medians and 95% CIs were generated using 1000 bootstrapped samples. Where appropriate, Bonferroni correction was used to adjust for multiple testing. Statistical analyses were performed using R 3.6.0 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Eighty-four patients were identified as having met inclusion criteria. Of these, 58 (69%) were performed in the outpatient setting, while 26 (31%) were performed in the inpatient setting. Of the outpatients, 4 patients stayed overnight and left the following morning (6.9%). The mean follow-up was 7.5 months with no difference between inpatient and outpatient settings ($P = 0.397$). Compared with patients undergoing inpatient surgery, patients undergoing surgery in the outpatient setting were younger (mean age 53.9 vs 73.6 years, $P < 0.0001$) and had lower ASA classifications (ASA > 2 in 22% vs 73%, $P < 0.0001$) and levels of medical comorbidity (mean CCI 1.5 vs 3.9, $P < 0.0001$). BMI did not vary between cohorts (Table 1, $P = 0.93$). Inpatient cases were associated with a higher surgical drain output (Table 1, $P < 0.0001$). No significant differences were observed in intraoperative blood loss (Table 1, $P = 0.21$) or surgical duration, although inpatient cases tended to be longer (adjusted $P = 0.096$).

The cases performed included 67 single-level and 17 two-level decompressive procedures spanning from L1 to S1, with no statistically significant differences between the 2 cohorts in the number of levels (1 vs 2) or the distribution of the specific levels addressed (Table 2). The most common levels were L4 to L5 and L5 to S1. Those undergoing decompression in the outpatient setting were more likely to have a diagnosis of disc herniation, whereas those in the inpatient setting were more likely to be diagnosed with lumbar spinal stenosis ($P = 0.0001$, Table 2).

No significant differences were detected with postoperative complications between the 2 cohorts such as transient postoperative radiculitis, weakness, wound complications, or reherniation during the postoperative follow-up period (Table 3). All cases of transient postoperative radiculitis resolved by the 6-week point postoperatively with conservative treatment. There was 1 case of postoperative weakness with grade 4/5 extensor hallucis longus weakness in each cohort that resolved with physical therapy and rehabilitation. Postoperative magnetic resonance imaging (MRI) for these cases revealed a small epidural hematoma and did not require reoperation.

PROs improved significantly from preoperative to most recent follow-up in both groups (Figure 1). In the inpatient cohort, median ODI scores improved from 23 to 6 ($P < 0.0001$), median VAS back scores improved from 5 to 2 ($P = 0.000147$), and median VAS leg scores improved from 7 to 0 ($P < 0.0001$; Table 4). In the outpatient cohort, median ODI scores improved from 18.5 to 2 ($P < 0.0001$), median VAS back scores

Table 1. Demographic characteristics of patients undergoing biportal endoscopic lumbar surgery.

Variable	Statistic	Outpatient	Inpatient	Total	P Value ^a
		(n = 58)	(n = 26)	(N = 84)	
Female	N (%)	14 (24%)	11 (42%)	25 (30%)	0.15
Age (yrs)	Mean (SD)	53.9 (15.5)	73.6 (8.2)	60.0 (16.4)	< 0.0001
	Median (Range)	57.5 (24–81)	71.5 (57–89)	65 (24–89)	
BMI (kg/m ²)	Mean (SD)	27.6 (5.0)	27.7 (3.6)	27.6 (4.6)	0.92
	Median (Range)	26.7 (19.8–38.5)	27.4 (22.0–36.9)	27 (19.8–38.5)	
ASA score	N > 2 (%)	13 (22%)	19 (73%)	2.3 (0.6)	< 0.0001
	Median (Range)	2 (1–3)	3 (2–3)	2 (1–3)	
Charlson Comorbidity Index	Mean (SD)	1.5 (1.5)	3.9 (1.7)	2.2 (1.9)	< 0.0001
	Median (Range)	1.5 (0–6)	3.5 (1–8)	2 (0–8)	
Surgery Duration (min)	Mean (SD)	116 (42)	146 (51)	125 (47)	0.012
	Median (Range)	105 (63–253)	135 (66–227)	108 (63–253)	
Length of Stay (days)	Mean (SD)	0.1±0.3	1.6±0.9	0.5±0.9	< 0.0001
	Range	0–1	1–4	0–4	
Estimated Blood Loss (mL)	Median (IQR)	0 (0–0)	0 (0–8)	0 (0–0)	0.21
	Median (Range)	0 (0–35)	0 (0–30)	0 (0–35)	
Total Drain Output (mL)	Median (IQR)	30 (14–51)	80 (50–134)	35 (25–80)	< 0.0001
	Median (Range)	30 (0–235)	80 (30–505)	35 (0–505)	

Abbreviations: ASA, American Society of Anesthesiologists; IQR, interquartile range.

^aAdjusted threshold for statistical significance $P < 0.0063$.

Table 2. Surgical features of patients undergoing biportal endoscopic lumbar surgery.

Variable	Outpatient	Inpatient	Total	P Value ^a
	n = 58	n = 26	N = 84	
Number of levels				
1 Level	51 (88%)	16 (62%)	67 (80%)	0.013
2 Levels	7 (12%)	10 (38%)	17 (20%)	
Levels addressed ^b				
L1–2	1 (2%)	1 (3%)	2 (2%)	0.170
L2–3	6 (9%)	2 (6%)	8 (8%)	
L3–4	9 (14%)	11 (31%)	20 (20%)	
L4–5	32 (49%)	18 (50%)	50 (50%)	
L5–S1	17 (26%)	4 (11%)	21 (21%)	
Primary diagnosis				
Stenosis	26 (45%)	24 (92%)	50 (60%)	0.0001
Disc herniation	32 (55%)	2 (8%)	34 (40%)	
Primary procedure				
Discectomy	32 (55%)	2 (8%)	34 (40%)	0.0001
Laminotomy/decompression	26 (45%)	24 (92%)	50 (60%)	

^aAdjusted threshold for statistical significance, $P < 0.0125$.

^bTotal number of levels addressed was 65 for outpatients, 36 for inpatients, and 101 for all patients.

improved from 5 to 0 ($P < 0.0001$), and median VAS leg scores improved from 7 to 0 ($P < 0.0001$; Table 4). Statistically significant differences between the cohorts were observed at the 5-to-8-week interval for VAS back scores (Figure 1B; $P = 0.0013$, threshold $P < 0.01$) and ODI scores (Figure 1A; $P = 0.0036$) with the inpatient cohort demonstrating higher levels of back pain and disability at short-term follow-up.

The overall amount of improvement in PROs between inpatient and outpatient cohorts was similar (Figure 2). ODI score decreased by an average of 14.8 points in outpatients and 14.5 in inpatients ($P = 0.880$; Figure 2A), while VAS back scores decreased by an average of 4.2 in outpatients and 2.9 in inpatients ($P = 0.046$, threshold $P < 0.0167$) and VAS leg score decreased by an average of 5.7 in outpatients and 5.0 in inpatients ($P = 0.410$; Figure 2B and C).

DISCUSSION

Biportal spinal endoscopy is an emerging minimally invasive technique with successful clinical outcomes in the treatment of common lumbar pathologies.^{1–6} Multiple systematic reviews and meta-analyses have demonstrated significant improvement in pain and disability with low complication rates with the technique.^{11–16} Given the recent introduction of biportal

spinal endoscopy in the United States, no prior studies have investigated the clinical results of the technique when performed in the United States. In South Korea where the technique was developed and advanced, most patients are admitted to the hospital with inpatient status after surgery. Due to the drastically disparate health care milieu and the financial pressures in the United States, especially after the COVID-19 pandemic, outpatient spine surgery is rapidly becoming attractive for properly selected patients due to cost savings and efficiencies.¹⁸ Given the sheer volume of patients undergoing lumbar discectomies and decompressions in the United States, shifting to the outpatient setting could greatly reduce spine surgery expenditures. Biportal spinal endoscopy can readily be applied in the outpatient setting due to the minimally invasive nature of the surgery.

This is the first study conducted in the United States to demonstrate successful implementation of biportal spinal endoscopy in the outpatient setting with properly selected patients. The patients in the outpatient cohort were younger and healthier and had significantly lower ASA and CCI scores than the inpatient cohort. More discectomies were performed in the outpatient setting, and more unilateral laminotomy for bilateral decompression (ULBD) cases were performed in the inpatient setting. However,

Table 3. Complications following biportal endoscopic lumbar surgery.

Complication	Outpatient	Inpatient	Total	P Value
	(n = 58)	(n = 26)	(N = 84)	
Postoperative radiculitis	10 (17%)	5 (19%)	15 (17.9%)	>0.99
Postoperative weakness	1 (1.7%)	1 (3.8%)	2 (2.4%)	>0.99
Wound drainage	1 (1.7%)	0 (0.0%)	1 (1.2%)	>0.99
Reherniation	1 (1.7%)	1 (3.8%)	2 (2.4%)	>0.99

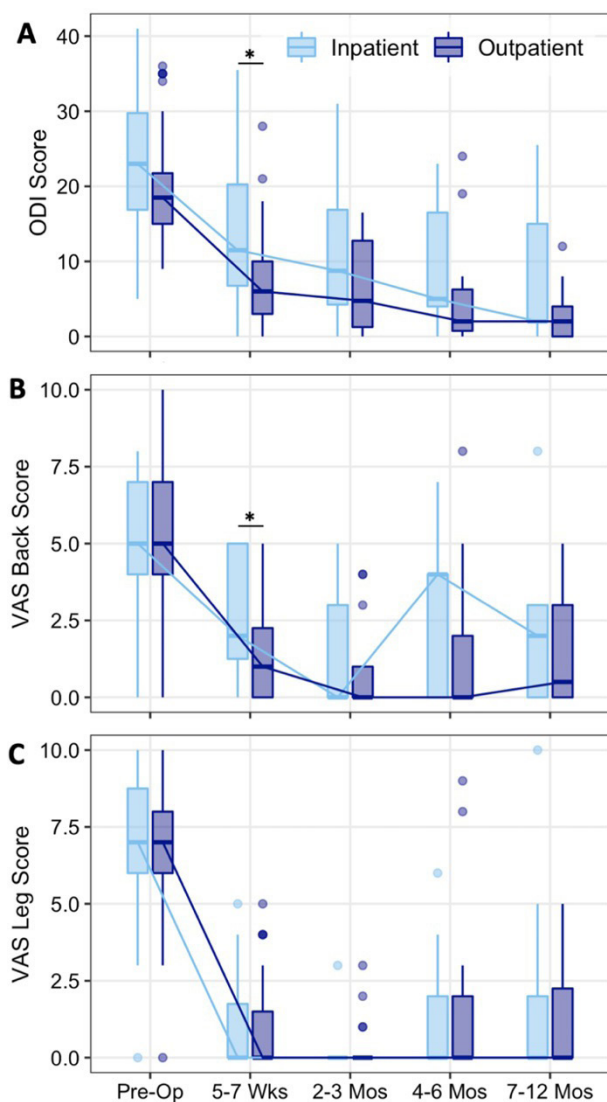


Figure 1. Trend in patient-reported outcomes across different perioperative time points for (A) Oswestry Disability Index score, (B) visual analog scale (VAS) back pain score, and (C) VAS leg pain score. Figures represent box plots with median and interquartile range highlighted. Star (*) indicates statistically significant difference between inpatient and outpatient scores at a particular time point after adjusting for multiple testing ($P < 0.01$). Nonparametric Mann-Whitney U test performed at all time points after confirming non-normal distribution.

there were similar numbers of ULBD cases between the cohorts with 20 outpatient and 24 inpatient cases. With increasing age, medical comorbidities, and progressive disease, surgery may be more complex, requiring multilevel decompression in the inpatient setting. This likely contributed to the increase in surgical duration and hospital stay, which in turn affected the surgical drain duration and drain output as patients stayed in the hospital longer. Despite the increasing complexity, both cohorts demonstrated significant improvement in PROs postoperatively.

Performing biportal spinal endoscopy in the outpatient setting did not increase the risk for complications as there were no differences between the cohorts. The transient postoperative radiculitis was treated medically with medications such as nonsteroidal anti-inflammatory drugs and/or oral steroids, and radiculitis had resolved by the 6-week follow-up point for all patients. This radiculitis may be due to the inflammation of the neural elements and may be associated with an epidural hematoma. In a study by Kim et al, the authors obtained postoperative MRI scans in 39 patients undergoing biportal spinal endoscopy and found that the radiographic rate of epidural hematoma was 24.7%.²¹ However, only 2 (5.13%) required revision surgery due to the epidural hematoma. In our study, there was one case of postoperative weakness in each cohort. Postoperative MRIs in both cases demonstrated a small epidural hematoma that resolved with physical therapy.

When examining the VAS and ODI results of both cohorts, the VAS back pain scores improved more with an average 4.2-point reduction for the outpatient cohort vs 2.9-point reduction for the inpatient cohort. Although there were no statistically significant differences in the degree of improvement between the cohorts, the absolute point difference may reflect the chronic nature of lumbar spondylosis associated with older patients. As the degenerative process progresses with age, the etiology of back pain can be multifactorial with multilevel involvement as compared with single-level disc herniations or lumbar stenosis in younger patients. While not statistically significant, median starting ODI value was higher in inpatients (23 vs 19), and this may reflect the more chronic and advanced disease in the older inpatients. The overall improvement in ODI was similar between groups. Finally, the improvement of VAS leg scores was significant and equivalent with both cohorts, demonstrating a profound improvement in preoperative radiculopathy.

Previous studies comparing the biportal and microscopic techniques have demonstrated clinical equivalency, with the biportal technique having less back pain in the short term but no difference in outcomes or complications.^{22,23} A recent multicenter randomized controlled noninferiority trial by Park et al compared biportal endoscopic and open microscopic discectomy and demonstrated lower early surgical site pain within the first 48 hours in the biportal group with lower creatinine phosphokinase ratios, reflecting less muscle and soft tissue

Table 4. Patient-reported outcomes before and after surgery for patients undergoing biportal endoscopic surgery, median values (range).

Measure	Outpatient	Inpatient	Total	P Value ^a
	(n = 58)	(n = 26)	(N = 84)	
Preoperative				
ODI	18.5 (9–36)	23 (5–41)	20 (5–41)	0.021
VAS back	5 (0–10)	5 (0–8)	5 (0–10)	0.99
VAS leg	7 (0–10)	7 (0–10)	7 (0–10)	0.42
Postoperative				
ODI	2 (0–28)	6 (0–25.5)	4 (0–28)	0.044
VAS back	0 (0–8)	2 (0–8)	0 (0–8)	0.020
VAS leg	0 (0–8)	0 (0–10)	0 (0–10)	0.42
Change				
ODI	14.5 (–14–36)	16.0 (–3.5–35)	15 (–14–36)	0.88
VAS back	4 (–4–10)	3 (–2–8)	4 (–4–10)	0.046
VAS leg	6 (0–9)	6 (–3–9)	6 (–3–9)	0.41

Abbreviations: ODI, Oswestry Disability Index; VAS, visual analog scale.
^aAdjusted threshold for statistical significance $P < 0.0167$

collateral damage.²³ The authors found that biportal endoscopy was noninferior to open microscopic techniques in terms of ODI scores at 12-month follow-up with no differences in clinical outcomes and complication rates. Another randomized controlled trial performed by the same study group investigated biportal endoscopic ULBD with open microscopic techniques for lumbar stenosis and again found no difference in pain scores, ODI, EQ-5D, and pain-DETECT scores up to 12 months after surgery.²⁴

When comparing biportal and uniportal endoscopic techniques, Heo et al demonstrated greater radiographic decompression with biportal ULBD as compared with uniportal on postoperative MRI scans, but this difference did not translate into clinical differences, as there were no differences in clinical outcomes or complications.²⁵ Our results correlate well with the existing published literature that biportal spinal endoscopy is indeed safe and

effective in treating common lumbar pathologies and can be successfully applied in both the inpatient and outpatient settings depending on patient-specific factors and characteristics.

The limitations of this study include the small sample size and short duration of follow-up, which may influence the results of the study. However, our results corroborate well with previously published studies. Patients who qualify for outpatient are inherently different in many respects than patients who require inpatient surgery, contributing to selection bias. The study design incorporated the prospective collection of patient data with retrospective analysis, which can introduce bias. However, the study was designed at the inception to investigate biportal spinal endoscopy in the outpatient and inpatient settings with PROs, operative, and complication data collected prospectively. Only certain elements of the demographic data such as BMI, ASA score, and CCI

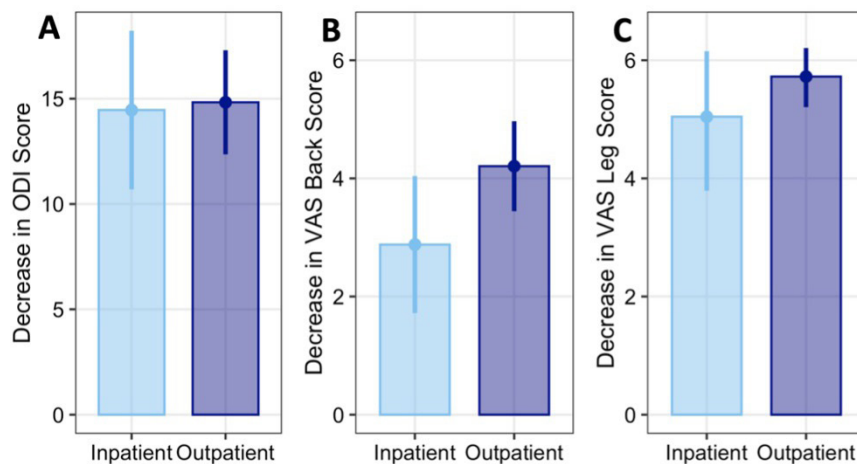


Figure 2. Absolute difference in patient-reported outcomes between preoperative and most recent follow-up for (A) Oswestry Disability Index (ODI) score, (B) visual analog scale (VAS) back pain score, and (C) VAS leg pain score. No differences between change in inpatient and outpatient scores after adjusting for multiple testing were significant ($P < 0.017$). Bars represent 95% CIs.

were collected and analyzed retrospectively. Therefore, the central results of this study, that biportal spinal endoscopy was clinically safe and effective in both the outpatient and inpatient settings, were investigated prospectively, limiting the bias inherent in the retrospective aspect of the study.

CONCLUSION

In this study, we demonstrated that biportal spinal endoscopy was both safe and effective when performed in the outpatient and inpatient settings. This is the first comparative cohort study performed in the United States on biportal spinal endoscopy, and we demonstrated improved clinical outcomes with low complication rates in the short term. We demonstrated that properly selected patients with common lumbar pathologies can safely undergo this procedure in the outpatient setting. Older patients with more medical comorbidities would be better candidates of the technique in the inpatient setting with similar clinical outcomes and safety profile.

REFERENCES

1. Soliman HM. Irrigation endoscopic discectomy: a novel percutaneous approach for lumbar disc prolapse. *Eur Spine J*. 2013;22(5):1037–1044. doi:10.1007/s00586-013-2701-0
2. Torudom Y, Dilokhuttakarn T. Two portal percutaneous endoscopic decompression for lumbar spinal stenosis: preliminary study. *Asian Spine J*. 2016;10(2):335–342. doi:10.4184/asj.2016.10.2.335
3. Hwa Eum J, Hwa Heo D, Son SK, Park CK. Percutaneous biportal endoscopic decompression for lumbar spinal stenosis: a technical note and preliminary clinical results. *J Neurosurg Spine*. 2016;24(4):602–607. doi:10.3171/2015.7.SPINE15304
4. Kim J-E, Choi D-J, Park EJ. Clinical and radiological outcomes of foraminal decompression using unilateral biportal endoscopic spine surgery for lumbar foraminal stenosis. *Clin Orthop Surg*. 2018;10(4):439–447. doi:10.4055/cios.2018.10.4.439
5. Eun SS, Eum JH, Lee SH, Sabal LA. Biportal endoscopic lumbar decompression for lumbar disk Herniation and spinal canal stenosis: a technical note. *J Neurol Surg A Cent Eur Neurosurg*. 2017;78(4):390–396. doi:10.1055/s-0036-1592157
6. Heo DH, Kim JS, Park CW, Quillo-Olvera J, Park CK. Contralateral sublaminar endoscopic approach for removal of lumbar juxtafacet cysts using percutaneous biportal endoscopic surgery: technical report and preliminary results. *World Neurosurg*. 2019;122:474–479. doi:10.1016/j.wneu.2018.11.072
7. Simpson AK, Lightsey HM, Xiong GX, Crawford AM, Minaamide A, Schoenfeld AJ. Spinal endoscopy: evidence, techniques, global trends, and future projections. *Spine J*. 2022;22(1):64–74. doi:10.1016/j.spinee.2021.07.004
8. Choi CM, Chung JT, Lee SJ, Choi DJ. How I do it? Biportal endoscopic spinal surgery (BESS) for treatment of lumbar spinal stenosis. *Acta Neurochir (Wien)*. 2016;158(3):459–463. doi:10.1007/s00701-015-2670-7
9. Casey KF, Chang MK, O'Brien ED, et al. Arthroscopic microdiscectomy: comparison of preoperative and postoperative imaging studies. *Arthroscopy*. 1997;13(4):438–445. doi:10.1016/s0749-8063(97)90121-3
10. Kambin P, O'Brien E, Zhou L, Schaffer JL. Arthroscopic microdiscectomy and selective fragmentectomy. *Clin Orthop Relat Res*. 1998;(347):150–167.
11. Lin G-X, Huang P, Kotheeranurak V, et al. A systematic review of unilateral biportal endoscopic spinal surgery: preliminary clinical results and complications. *World Neurosurg*. 2019;125:425–432. doi:10.1016/j.wneu.2019.02.038
12. Pranata R, Lim MA, Vania R, July J. Biportal endoscopic spinal surgery versus microscopic decompression for lumbar spinal stenosis: a systematic review and meta-analysis. *World Neurosurg*. 2020;138:e450–e458. doi:10.1016/j.wneu.2020.02.151
13. Chen Z, Zhou H, Wang X, Liu Z, Liu W, Luo J. Complications of unilateral biportal endoscopic spinal surgery for lumbar spinal stenosis: a meta-analysis and systematic review. *World Neurosurg*. 2023;170:e371–e379. doi:10.1016/j.wneu.2022.11.019
14. Heo DH, Park DY, Hong HJ, Hong YH, Chung H. Indications, contraindications, and complications of biportal endoscopic decompressive surgery for the treatment of lumbar stenosis: a systematic review. *World Neurosurg*. 2022;168:411–420. doi:10.1016/j.wneu.2022.09.023
15. Li Y-S, Chen C-M, Hsu C-J, Yao Z-K. Complications of unilateral biportal endoscopic lumbar discectomy: a systematic review. *World Neurosurg*. 2022;168:359–368. doi:10.1016/j.wneu.2022.10.038
16. Park DY, Upfill-Brown A, Curtin N, et al. Clinical outcomes and complications after biportal endoscopic spine surgery: a comprehensive systematic review and meta-analysis of 3673 cases. *Eur Spine J*. 2023;32(8):2637–2646. doi:10.1007/s00586-023-07701-9
17. DelSole EM, Mankanji HS, Kurd MF. Current trends in ambulatory spine surgery: a systematic review. *J Spine Surg*. 2019;5(Suppl 2):S124–S132. doi:10.21037/jss.2019.04.12
18. Malik AT, Xie J, Retchin SM, et al. Primary single-level lumbar microdiscectomy/decompression at a free-standing ambulatory surgical center vs a hospital-owned outpatient department-an analysis of 90-day outcomes and costs. *Spine J*. 2020;20(6):882–887. doi:10.1016/j.spinee.2020.01.015
19. Dodo Y, Okano I, Kelly NA, et al. Risk factors for ambulatory surgery conversion to extended stay among patients undergoing one-level or two-level posterior lumbar decompression. *Spine (Phila Pa 1976)*. 2023;48(11):748–757. doi:10.1097/BRS.0000000000004621
20. Mooney J, Michalopoulos GD, Zeitouni D, et al. Outpatient versus inpatient lumbar decompression surgery: a matched noninferiority study investigating clinical and patient-reported outcomes. *J Neurosurg Spine*. 2022;1–13. doi:10.3171/2022.3.SPINE211558
21. Kim J-E, Choi D-J, Park EJ. Evaluation of postoperative spinal epidural hematoma after biportal endoscopic spine surgery for single-level lumbar spinal stenosis: clinical and magnetic resonance imaging study. *World Neurosurg*. 2019;126:e786–e792. doi:10.1016/j.wneu.2019.02.150
22. Park S-M, Kim G-U, Kim H-J, et al. Is the use of a unilateral biportal endoscopic approach associated with rapid recovery after lumbar decompressive laminectomy? A preliminary analysis of a prospective randomized controlled trial. *World Neurosurg*. 2019;128:e709–e718. doi:10.1016/j.wneu.2019.04.240
23. Park S-M, Lee H-J, Park H-J, et al. Biportal endoscopic versus microscopic discectomy for lumbar herniated

disc: a randomized controlled trial. *Spine J.* 2023;23(1):18–26. doi:10.1016/j.spinee.2022.09.003

24. Park S-M, Park J, Jang HS, et al. Biportal endoscopic versus microscopic lumbar decompressive laminectomy in patients with spinal stenosis: a randomized controlled trial. *Spine J.* 2020;20(2):156–165. doi:10.1016/j.spinee.2019.09.015

25. Heo DH, Lee DC, Park CK. Comparative analysis of three types of minimally invasive decompressive surgery for lumbar central stenosis: biportal endoscopy, uniportal endoscopy, and microsurgery. *Neurosurg Focus.* 2019;46(5):2019.2.FOCUS197. doi:10.3171/2019.2.FOCUS197

Funding: The authors received no financial support for the research, authorship, and/or publication of this article.

Declaration of Conflicting Interests: The first author, D.Y.P., is a strategic board member for Amplify Surgical, Inc., which manufactures the biportal endoscopic equipment used in this study. Other conflicts of interest for D.Y.P. include being a consultant

for Alphatec, Nuvasive, and Seaspine in the past 36 months. The remaining authors have no conflicts of interest.

IRB Approval: This study was IRB-approved (UCLA IRB#22-001674).

Corresponding Author: Don Young Park, UCLA Department of Orthopaedic Surgery, David Geffen School of Medicine at UCLA, 1250 16th St, Suite 3142, Santa Monica, CA 90404, USA; dypark@mednet.ucla.edu

Published 28 September 2023

This manuscript is generously published free of charge by ISASS, the International Society for the Advancement of Spine Surgery. Copyright © 2023 ISASS. To see more or order reprints or permissions, see <http://ijssurgery.com>.