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Clinical Study

Cost-effectiveness of microdiscectomy versus endoscopic discectomy for lumbar disc herniation

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ABSTRACT

BACKGROUND CONTEXT: Microdiscectomy is a standard technique for the surgical treatment of lumbar disc herniation (LDH). Endoscopic discectomy (ED) is another surgical option that has become popular owing to reports of shorter hospitalization and earlier return to work. No study has evaluated health care costs associated with lumbar discectomy techniques and compared cost-effectiveness.

PURPOSE: To assess the cost-effectiveness of four surgical techniques for LDH: microdiscectomy (MD), transforaminal endoscopic lumbar discectomy (TELD), interlaminar endoscopic lumbar discectomy (IELD), and unilateral biportal endoscopic discectomy (UBED).

STUDY DESIGN AND SETTING: Retrospective analysis.

PATIENT SAMPLE: Patients who underwent either MD or ED for primary LDH with 1-year follow-up between the ages of 20 and 60 years old.

OUTCOME MEASURES: Incremental cost-effectiveness ratio (ICER).

METHODS: Five hundred sixty-five patients aged 20−60 years who underwent treatment using one of the four surgical techniques with at least 1-year follow-up were reviewed. Health care costs were defined as the sum of direct and indirect costs. The former included the covered and uncovered costs of the National Health Insurance from operation to 1-year follow-up; indirect costs included costs incurred by work loss. Direct and indirect costs were evaluated separately. ICER was determined using cost/quality-adjusted life year (QALY). Health care costs and ICER were compared statistically among the four surgical groups. Cost-effectiveness was compared statistically between MD and ED.

RESULTS: One hundred fifty-seven patients who underwent TELD, 132 for IELD, 140 for UBED, and 136 for MD were enrolled. The direct costs of TELD, IELD, UBED, and MD were \$3,452.2±1,211.5, \$3,907.3±895.3, \$4,049.2±1,134.6, and \$4,302.1±1,028.9, respectively (p<.01). The indirect costs of TELD, IELD, UBED, and MD were \$574.5±495.9, \$587.8±488.3, \$647.4±455.6, and \$759.7±491.7, respectively (p<.01). The 1-year QALY gains were 0.208 for TELD, 0.211 for IELD, 0.194 for UBED, and 0.186 for MD. ICER (costs/QALY) was the highest for MD (\$34,840.4±25,477.9, p<.01). Compared with MD, ED saved an additional net of \$8,064 per QALY (p<.01). There was no significant difference in the ICERs among the three endoscopic techniques.

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CONCLUSIONS: ED was more cost-effective compared with MD at 1-year follow up.

Keywords: Cost-effectiveness; Endoscopic discectomy; Incremental cost-effectiveness ratio; Microdiscectomy; Quality-adjusted life year

Introduction

Microdiscectomy is a standard technique for the surgical treatment of lumbar disc herniation. Since 1980 [1], different types of endoscopic discectomy, such as transforaminal endoscopic lumbar discectomy (TELD) and interlaminar endoscopic lumbar discectomy (IELD), have been introduced and evolved [1]. Unilateral biportal endoscopic discectomy (UBED) has been recently introduced using a two portal system, with one portal for the endoscope and another for the entry of surgical instruments, similar to joint arthroscopy [2,3]. This technique, although not a full-endoscopic discectomy, combines the advantages of standard open and endoscopic spinal surgery. Endoscopic discectomy has become more popular with surgeons and patients as it is associated with lesser postoperative pain, shorter hospital stays and earlier returns to work [4−6]. No study has been conducted to evaluate health care costs associated with lumbar discectomy techniques and compare cost-effectiveness. The purpose of this study was to compare total hospital costs among microdiscectomy and three different endoscopic techniques and to analyze cost-effectiveness using the incremental cost-effectiveness ratio (ICER).

Methods

After obtaining approval for this study from our Institutional Review Board (2017-W06), written informed consent was obtained from patients. Consecutively, 598 patients aged between 20 and 60 years underwent discectomy from January 2016 to December 2016. All patients presented with sciatica and back pain that did not improve with conservative treatment for a minimum of 6 weeks. They underwent plain radiography, magnetic resonance imaging (MRI), and computed tomography (CT). Patients who had an obvious disc herniation were included in this study. They had the nerve root compression corresponding to the dermatomal distribution of the radicular pain. The exclusion criteria included multilevel disc herniations, recurrent disc herniation, spondylolisthesis, more than moderate spinal stenosis, and instability.

Six experienced surgeons performed the surgeries. Patients had scheduled and unscheduled outpatient clinic visits at postoperative 1 month, 3 months, 6 months, and 1 year. The need for physical therapy or medication was decided based on patient's status. If the visual analog scale (1−10) for the back or leg pain was more than 5, the patient was generally referred to a pain center for nerve root block, epidural steroid injection, or medial branch block. Three independent doctors and three nurses reviewed patients' records and radiological data (MRI, CT, and radiography). We enrolled only patients who underwent follow-up for more than 12 months after surgery. We reviewed medical records to evaluate data on operative procedures, anesthesia time, operative time, use of patient-controlled anesthesia (PCA), hospital stay duration, revision surgery of operative level, medications, physical therapy, epidural nerve block for remaining symptoms or worsening previous symptoms, readmission hospital stay, and CT or MRI findings for deterioration of previous symptoms.

Clinical and functional outcomes were assessed using the Oswestry disability index (ODI) and short-form health survey (SF-6D) scores preoperatively and 1 year postoperatively. The SF-36 scores were converted to SF-6D scores to calculate the quality-adjusted life year (QALY) gained. Costs were defined as the sum of the direct costs that were included in the covered and uncovered costs of the National Health Insurance (NHI) and the indirect costs. Direct costs can be defined as the sum of primary hospital costs associated with surgery and secondary hospital costs associated with postoperative course managements and unexpected events 2 weeks after surgery. In particular, primary hospital cost was defined as the sum of the costs associated with operation, surgical equipment (disposable radiofrequency probe, hemostatic agent, antiadhesive agent, etc.), anesthesia, hospital stay including meals, nursing care, laboratory work, postoperative intravenous PCA, physical therapy and/or medication, and radiological examination including CT and MRI. Secondary hospital cost was defined as the sum of the costs associated with reoperation: anesthesia for reoperation, postoperative intravenous pain control for reoperation and readmission, readmission hospital stay, and nursing care, laboratory work, physical therapy and/or medication, radiological examination (including CT/MRI for remaining symptoms or worsening of previous symptoms), and nerve block for remnant symptoms or worsening of previous symptoms. Indirect costs included the costs incurred by work loss. Work loss costs = {days of hospitalization + (the number of hospital visits × $^1/_3$)} × the employment rate by gender and age group × average daily wages. We applied the 2016−2017 average annual wages and employment rate of the authors' country to calculate work loss cost by age and sex according to data released by the country statistics of the authors. Cost-effectiveness was compared by QALY and ICER using total health care costs and patient reported outcome. The QALY was determined by the change in utility between baseline and 1 year. The ICER of endoscopic discectomy (ED) was assessed by (Cost $_{ED}$-Cost $_{MD}$)/(QALY $_{ED}$−QALY $_{MD}$).

Statistical analysis

Four different groups of continuous variables were analyzed using analysis of variance. Categorical variables were examined by chi-square test. Differences between two groups were analyzed using independent *t* test. All statistical analyses were performed with R for Windows (R Foundation for Statistical Computing, Vienna, Austria), and the statistical significance was set at p<.05. Health care costs and QALY gained were compared statistically among the four surgical groups. Cost-effectiveness was compared statistically between MD and ED.

Surgical techniques

Microdiscectomy (Fig. 1A), TELD (Fig. 1B), and IELD (Fig. 1C) have been described previously [6−10].

Unilateral biportal endoscopic discectomy

The procedure was performed under epidural anesthesia or general anesthesia. Cranial and caudal entry points were located 1 cm above and below the target lesion. Each entry point was located 1 cm lateral to the target lesion [2,11]. The cranial entry point was mostly used as the endoscopic portal, whereas the caudal entry point was mostly used as the working portal (Fig. 1D and E). After fascia opening and blunt muscle-splitting dissection, serial dilators were inserted. After removal of the dilators, an arthroscope (CONMED Linvatec, NY, USA) was inserted into the endoscopic portal. Following complete exposure of the lower lamina and ligamentum flavum in the targeted interlaminar space, an ipsilateral partial laminotomy was performed under magnified endoscopic vision, using a 3.5-mm drill with soft tissue protection and Kerrison punches. The endoscopic anatomical view was very similar to the microscopic view of a posterior unilateral laminotomy [2,3,11]. The ipsilateral ligamentum flavum was removed until full mobilization of the lateral border of the nerve root was achieved. Discectomy could be performed after retraction of the nerve root. The herniated disc materials were then removed using pituitary forceps.

Results

Patient population

A total of 726 consecutive patients underwent lumbar discectomy during the study period, and 565 (94.5%) of the 598 patients were enrolled in the study considering age. Thirty-three patients were lost to follow-up. A total of 157 patients for TELD, 132 for IELD, 140 for UBED, and 136 for MD were finally included. The mean ages (years) were 45.5±14.1 for patients who underwent TELD, 49.0±13.7 for patients who underwent IELD, 49.1±14.8 for patients who underwent UBED, and 47.9±14.1 for patients who underwent MD. There were no differences in age and sex between the groups (Table 1).

Operative times were 46.3±15.3 minutes in TELD, 65.5±37.3 minutes in IELD, 75.5±40.5 minutes in UBED, and 70.8±29.4 minutes in MD. Hospital stay durations were 3.6±5.7 days in TELD, 5.7±4.5 in IELD, 5.8±3.8 in UBED, and 8.7±3.7 in MD. Operative time and hospital stay duration were significantly different (p<.01 and p<.01, respectively; Table 2).

Clinical outcomes

The ODI improvements in patients who underwent TELD, IELD, UBED, and MD were 40.2±15.2, 41.0±17.1, 37.4±11.4, and 35.9±14.1, respectively (p<.01). The 1-year QALY gained were 0.208±0.079 with TELD, 0.212±0.088 with IELD, 0.194±0.059 with UBED, and 0.186±0.073 with MD (p<.01). Reoperation and readmission rates showed no significant differences among the four groups (Table 3).

Cost-utility analysis

The primary hospital costs averaged $2,997.8 for TELD, $3,629.3 for IELD, $3,642.4, for UBED, and $3,926.2 for MD (p<.01; Table 4). Costs of operation, surgical equipment, anesthesia, hospital stay, laboratory work, nursing care, and intravenous PCA use differed significantly among the four groups (p<.01). There were no significant differences in secondary hospital cost (p>.05; Table 5). Direct cost and indirect cost of MD were higher than those for the three endoscopic techniques (p<.01). The overall hospital cost for TELD ($4,026.8) was the lowest among the four groups (p<.01). The cost per QALY was $24,873.4 for TELD, $28,226.8 for IELD, $27,517.3 for UBED, and 34,840.4 for MD (p<.01; Table 6). Compared with MD, TELD saved a net $9,967. One-year QALY gained of ED was 0.203±0.074 and that of MD was 0.186±0.073. There was significant difference between the two groups (p<.01). ED saved $8,063.5 per QALY compared with MD. The ICER of ED was −$36,016.6 (Table 7).

Discussion

In the United States, 500,000 lumbar discectomy surgeries have been performed annually [12]. The total costs of low back pain in the United States exceed $100 billion per year [13]. According to the Spine Patient Outcomes Research Trial for lumbar disc herniation, although surgery costs ($27,273) were higher than medical interventional costs ($13,135), cost per QALY of surgery ($34,355) was lower than that of medical interventional treatment

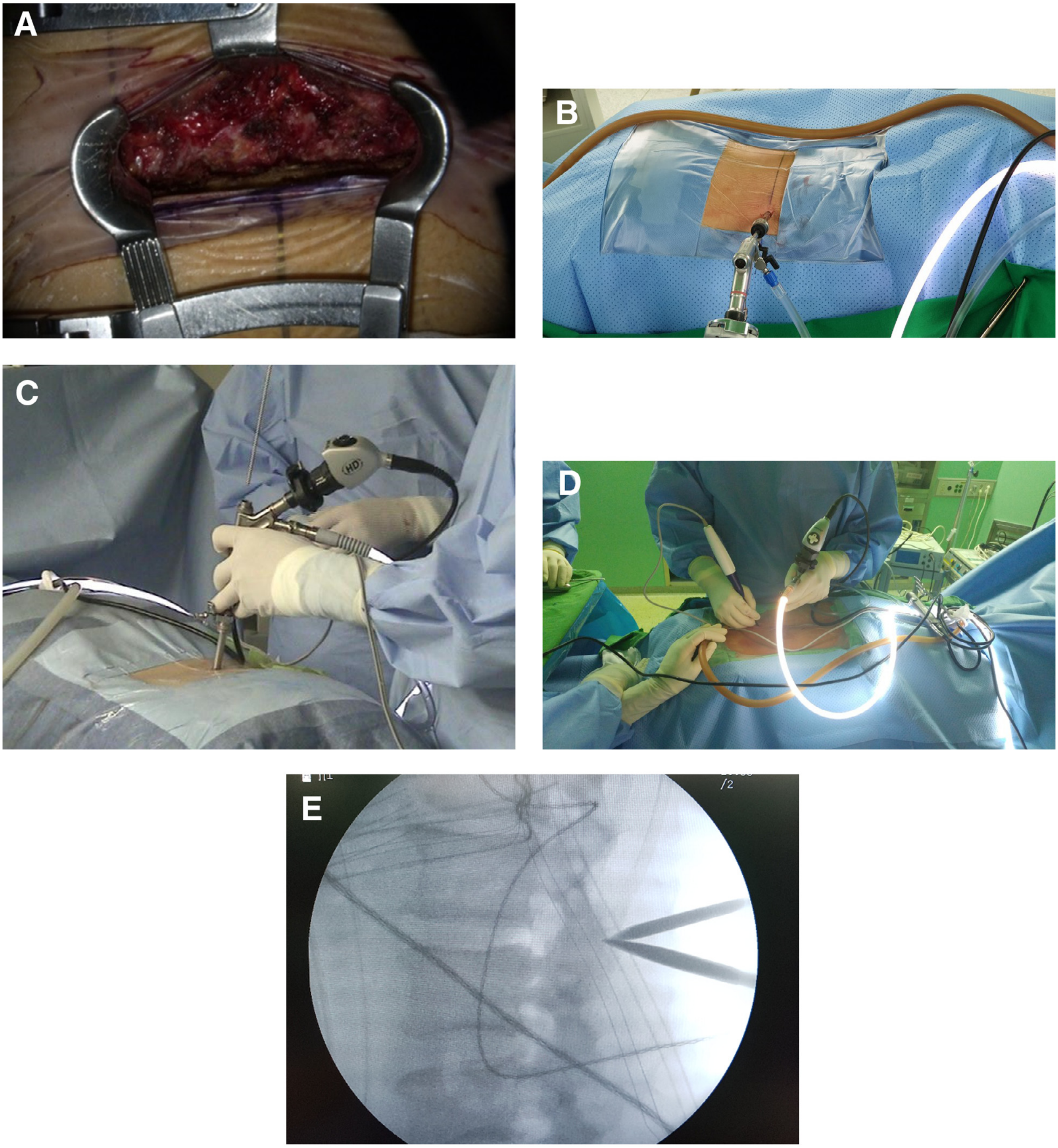

Fig. 1. Intraoperative photos and radiographs of surgical techniques.
(A) Lamina is exposed using a muscle retractor after subperiosteal muscle detachment for microdiscectomy.
(B) Procedure of transforaminal endoscopic lumbar discectomy (TELD).
(C) Procedure of interlaminar endoscopic lumbar discectomy (IELD).
(D) Procedure of unilateral biportal endoscopic discectomy (UBED).
(E) Triangulation with the endoscopic portal (cranial) and working portal (caudal) in UBED.

($69,403) [14]. Surgery contributes tenfold to improvements in the quality of life and is more cost-effective than medical interventional treatment. Surgical treatment is regarded as cost-effective when willingness to pay per gained QALY is between $50,000 and $100,000 [15−18].

Cost-utility analysis

Primary hospital costs depend on surgical techniques, anesthesia technique, and hospital stay length. TELD is associated with the lowest primary hospital costs. MD,

Table 1
Demographic data for four surgical techniques

	TELD	IELD	UBED	MD	p value
No. of patients	157	132	140	136	
Age (SD)	45.5 (14.1)	49 (13.7)	49.1 (14.8)	47.9 (14.1)	ns
Sex (M:F)	109:48	78:54	89:51	94:42	ns
Level					
L1−L2	2 (1.3%)	0	0	0	
L2−L3	10 (6.4%)	2 (1.5%)	4 (2.9%)	4 (2.9%)	
L3−L4	25 (15.9%)	8 (6.1%)	8 (5.7%)	7 (5.1%)	<.01
L4−L5	79 (50.3%)	61 (46.2%)	88 (62.9%)	79 (58.1%)	
L5−S1	41 (26.1%)	61 (46.2%)	40 (28.6%)	46 (33.8%)	

TELD, transformainal endoscopic lumbar discectomy; IELD, interlaminar endoscopic lumbar discectomy; UBED, unilateral biportal endoscopic discectomy; MD, microdiscectomy.

Table 2
Operative time and hospital stay duration for four surgical techniques

	TELD	IELD	UBED	MD	p
Operative time(mins)	46.3 (15.3)	65.5 (37.3)	75.5 (40.5)	70.8 (29.4)	<.01
Hospital stay (days)	3.6 (5.7)	5.7 (4.5)	5.8 (3.8)	8.7 (3.7)	<.01

Table 3
Clinical outcomes at the 1-year follow-up

	TELD	IELD	UBED	MD	p
ODI improvement (SD)	40.2 (15.2)	41.0 (17.1)	37.4 (11.4)	35.9 (14.1)	<.01
QALY gained (SD)	0.208 (0.079)	0.211 (0.088)	0.194 (0.059)	0.186 (0.073)	<.01
Re-operation rate (n)	7.6% (12)	5.3% (7)	6.4% (9)	6.6% (9)	ns
Readmission rate (n)	9.6% (15)	7.6% (10)	7.9% (11)	8.1% (11)	ns

ODI, Oswestry disablitiy index; QALY, quality adjusted life years.

Table 4
Primary hospital costs for four surgical techniques

	TELD	IELD	UBED	MD	p value
Operation	$458.9	$458.9	$458.9	$687.3	<.01
Surgical equipment	$1,124.1	$1,362.5	$1,292.8	$1,179.8	<.01
Radiology (including MRI/CT)	$432.5	$444.1	$455.1	$438.4	ns
Anesthesia	$0.0	$113.3	$122.1	$117.0	<.01
Hospital stay (including meal)	$450.7	$590.8	$634.6	$726.5	<.01
Laboratory work	$84.8	$83.5	$92.9	$92.4	<.01
Nursing care	$311.0	$407.6	$437.9	$501.2	<.01
Use of patient-controlled anesthesia	$36.4	$69.3	$43.2	$72.9	<.01
Medication/physical therapy	$44.3	$50.1	$45.7	$48.4	ns
Primary hospital cost	$2,997.8	$3,629.3	$3,642.4	$3,926.2	<.01

IELD, and UBED were performed under general anesthesia or spinal and/or epidural anesthesia, whereas TELD was done using only a local anesthetic (0.5%−1% lidocaine). Anesthesia technique affects hospital cost in anesthesia complication incidences, postoperative care requirements, and hospital stay duration [19,20]. TELD technique directly accesses herniated disc without injuring lamina, facet joint, and ligamentum flavum. TELD is the least invasive technique in terms of injury on the back muscle and laminar and ligamentous structures [9]. IELD and UBED have smaller skin incision length and lesser iatrogenic paraspinal muscle injury with muscle splitting technique than MD [9]. Differences in surgical approach and anesthesia affect hospital costs and postoperative pain control. Although there

Table 5
Secondary hospital costs for four surgical techniques

	TELD	IELD	UBED	MD	p value
Reoperation and anesthesia	$77.1	$54.0	$66.0	$34.8	ns
Readmission hospital stay	$45.5	$52.3	$57.0	$55.5	ns
Nursing care	$30.9	$28.5	$37.3	$38.3	ns
Nerve block	$102.5	$62.3	$69.6	$80.6	ns
Laboratory work & radiology (MRI/CT)	$132.9	$115.7	$121.0	$106.1	ns
Medication/physical therapy	$57.9	$51.8	$48.4	$54.1	ns
Secondary hospital cost	$454.5	$371.6	$406.8	$376.0	ns

were no significant differences in reoperation and readmission rates among the four groups, TELD was likely to be higher than the other groups. After discectomy, the cost of nerve block and CT and/or MRI in TELD was also higher than in other techniques. Considering surgical technique, MD, UBED, and IELD can achieve disc removal and posterior decompression, which includes removal of the partial lamina, medial facet joint, and ligamentum flavum. This posterior decompression may provide additional space in case of swelling of the nerve root during the postoperative state. According to NHI data, the cumulative reoperation rates of discectomy were 7.4% at 1 year, 10.5% at 3 years, and 13.4% at 5 years. There was no significant difference in reoperation rate within 90 days between open discectomy and endoscopic discectomy [21]. Our data also revealed similar reoperation rates.

Although open discectomy has been regarded as a standard technique, MD has been advocated for better visualization and minimizing incision size using a microscope [22,23]. Compared with MD, TELD has better perioperative data including length of hospital stay and operation time and less blood loss, muscle damage, and postoperative incisional pain [9]. Two-year follow-up data demonstrated that TELD is associated with less low back pain compared with MD and microendoscopic discectomy [5]. MD tends to have more days of hospitalization, which leads to a rise in direct costs compared with endoscopic discectomy. In addition, the tendency to have more days of hospitalization might cause the working days of patients to decrease, with their work loss costs being higher than those of endoscopic discectomy. The hospital cost of endoscopic discectomy is 0.88-fold smaller than that of microdiscectomy. The cost of endoscopic discectomy reduced to 23.1% compared with

Table 7
Incremental cost effectiveness ratio (ICER) between endoscopic discectomy (ED) and open microdiscectomy (MD)

	ED (429)	MD (136)	p
Direct costs	$3,806.4 (1,137.5)	$4,302.1 (1,028.9)	<.01
Indirect costs	$607.2 (478.4)	$759.8 (491.7)	<.01
Overall costs	$4,413.6 (1,404.2)	$5,061.9 (1,247.5)	<.01
QALY gained	$0.203 (0.074)	$0.185 (0.073)	<.01
Cost ($)/QALY	$26,776.9 (22,421.3)	$34,840.4 (25,477.9)	<.01
ICER	−$36,016.6		
Operation	$458.9 (0.0)	$687.3 (0.0)	<.01
Surgical equipment	$1,251.7 (274.1)	$1,179.8 (0.0)	<.01
Radiology (MRI/CT)	$510.1 (8.8)	$512.2 (10.2)	NS
Laboratory work	$87.7 (8.4)	$92.4 (3.9)	<.01
Nursing care	$386.2 (227.9)	$501.2 (176.0)	<.01
Anesthesia	$89.0 (67.8)	$121.7 (20.9)	<.01
Hospital stay	$582.4 (343.6)	$755.8 (265.4)	<.01
Use of patient-controlled anesthesia	$49.29 (38.8)	$75.8 (5.4)	<.01
Medication/physical therapy	$52.6 (73.4)	$54.1 (70.8)	NS
Nerve block	$82.0 (153.5)	$83.4 (172.5)	NS
Reoperation	$17.5 (99.7)	$10.4 (47.9)	NS
Readmission	$44.7 (195.9)	$57.8 (268.4)	NS
Rechecking radiology (MRI/CT)	$100.1 (257.1)	$104.6 (264.6)	NS
Readmission- nursing care	$28.9 (128.8)	$38.3 (178.0)	NS

ICER, incremental cost effectiveness ratio.

MD per 1 QALY gained. ED achieved approximately $8,064 per QALY cost-saving in lumbar disc surgery. However, there was no difference in 1-year cost/QALY among the three endoscopic techniques.

MIS versus conventional spine surgery

There were a few studies about cost-effectiveness of minimally invasive spinal (MIS) discectomy and/or decompression. Between tubular discectomy and conventional microdiscectomy, there was no significant difference in health-care costs and QALY [24]. In multilevel spinal stenosis, cost and QALY gained were similar between MIS decompression and open hemilaminectomy although MIS approach improved short-term recovery [25]. Cost-utility analysis reported that MIS fusion was less costly and achieved greater QALY gained between MIS fusion and open fusion [26,27]. MIS fusion reduced significant costs of surgical site infections. McGirt et al. reported cost

Table 6
Health care costs and costs per QALY (quality adjusted life year)

	TELD	IELD	UBED	MD	p
Direct costs	$3,452.2 (1,211.5)	$3,907.3 (895.3)	$4,049.2 (1134.6)	$4,302.1 (1,028.9)	<.01
Indirect costs	$574.5 (495.9)	$587.8 (488.3)	$647.5 (455.6)	$759.8 (491.7)	<.01
Overall costs	$4,026.8 (1,538.2)	$4,495.1 (1,219.2)	$4,696.6 (1,318.0)	$5,061.9 (1,247.5)	<.01
Costs/QALY	$24,873.4 (19,663.7)	$28,226.8 (33,064.6)	$27,517.3 (15,360.0)	$34,840.4 (25,477.9)	<.01

savings of $4,000 per 100 MIS surgeries for l-level and $38,400 per 100 MIS surgeries for 2-level surgery [26].

Limitations

The bias among the groups could not be overcome entirely in this retrospective study although more than 100 patients were enrolled in each group with similar age and sex. This study had relatively short-term clinical results and overall costs within 1-year follow-up. According to the literature, for simple decompression for disc herniation and spinal stenosis, clinical improvements after 3 months had reached its approximate final value [28,29]. Direct costs in the authors' country were approximately 5-fold lower than those in the United States. Also, NHI mostly covers medical costs. The reason for the long hospital stays in this study is due to low-cost of hospitalization related to insurance and cultural differences about the use of a multi-patient room.

Conclusions

Although both MD and ED are cost-effective surgical treatments at least in the authors' country, our data demonstrate that ED is more cost-effective compared to MD. There is no difference in cost-effectiveness among TELD, IELD, and UBED.

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