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HEALTH SERVICES RESEARCH

# Increased Volume of Lumbar Surgeries for Herniated Intervertebral Disc Disease and Cost-Effectiveness Analysis

*A Nationwide Cohort Study*

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**Study Design.** Retrospective cohort study of a nationwide database.

**Objective.** The primary objective was to summarize the use of surgical methods for lumbar herniated intervertebral disc disease (HIVD) at two different time periods under the national health insurance system. The secondary objective was to perform a cost-effectiveness analysis by utilizing incremental cost-effectiveness ratio (ICER).

**Summary of Background Data.** The selection of surgical method for HIVD may or may not be consistent with cost effectiveness under national health insurance system, but this issue has rarely been analyzed.

**Methods.** The data of all patients who underwent surgeries for HIVD in 2003 (n = 17,997) and 2008 (n = 38,264) were retrieved. The surgical methods included open discectomy (OD), fusion surgery, laminectomy, and percutaneous endoscopic lumbar discectomy (PELD). The hospitals were classified as tertiary-referral hospitals (≥300 beds), medium-sized hospitals (30–300 beds), or clinics (<30 beds). ICER showed the difference in the mean total cost per 1% decrease in the reoperation probability among surgical methods. The total cost included the costs of the index surgery and the reoperation.

**Results.** In 2008, the number of surgeries increased by 2.13-fold. The number of hospitals increased by 34.75% (731 in 2003 and 985 in 2008). The proportion of medium-sized hospitals increased from 62.79% to 70.86%, but the proportion of surgeries performed at those hospitals increased from 61.31% to 85.08%. The probability of reoperation was highest after laminectomy (10.77%), followed by OD (10.50%), PELD (9.20%), and fusion surgery (7.56%). The ICERs indicated that PELD was a cost-effective surgical method. The proportion of OD increased from 71.21% to 84.12%, but that of PELD decreased from 16.68% to 4.57%.

**Conclusion.** The choice of surgical method might not always be consistent with cost-effectiveness strategies, and a high proportion of medium-sized hospitals may be responsible for this change.

**Key words:** cost-benefit analysis, discectomy, endoscope, hospital, intervertebral disc, lumbar vertebra, reoperation, spine, surgery.

**Level of Evidence:** 4

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Surgical treatment is recommended for cases of symptomatic lumbar herniated intervertebral disc disease (HIVD) that are intractable to nonsurgical treatment.[1–3] In recent years, the number of spinal surgeries

for lumbar HIVD performed each year has increased.[4] Of several surgical methods used, open discectomy (OD) is the standard, and fusion surgery, laminectomy, and percutaneous endoscopic lumbar discectomy (PELD) are other options.[2,3,5–10] The selection of the surgical method might largely depend on clinical and radiological outcomes. Currently, clinical efficacy and economic responsibility are simultaneously considered to facilitate sustainable resource use.[11] The number of spine surgeries has increased with the development of new technologies and surgical instruments.[4,12] Given the increasing number of surgeries performed, it is unclear whether the surgical methods used are the most cost-effective ones.[2,3,13]

In Korea, all citizens are beneficiaries of the national health insurance system (NHIS).[9,10,14] All nationwide inpatient and outpatient data regarding disease and services (*i.e.*, procedures and operations) are coded and registered in the National Health Insurance Corporation (NHIC) database and the Health Insurance Review and Assessment Service (HIRA), thereby enabling population-based studies.[9,10,14]

The primary question of the present study was "Are the surgical methods selected for lumbar HIVD the most cost-effective ones?" To address this question, the choice of surgical method used for indexes surgery in 2003 and in 2008 was analyzed. For the cost-effectiveness analysis, the incremental cost-effectiveness ratio (ICER) was used to evaluate the difference in the mean cost per 1% change in the reoperation probability among surgical methods.[15,16]

## MATERIALS AND METHODS

### Data Source

The HIRA national database was used to create a cohort of all Korean patients who underwent surgery for HIVD in either 2003 or 2008.[9,10,14,15] The disease codes were standardized based on the international classification of diseases, 10th version (ICD-10). In Korea, "fee for service" is the traditional reimbursement system. The procedure codes were standardized by the NHIC and HIRA to file claims for medical fees to the NHIC. All hospitals in Korea follow the standardized codes of diseases and procedures for reimbursement. Nearly all hospitals in Korea honor the following benefit standards of the NHIC for reimbursement: intractable painful sciatica from a disc herniation despite nonsurgical treatment for at least 6 weeks if HIVD is not accompanied by neurological deficits.[9,10] However, the selection of surgical method was at the discretion of the surgeon.[9,10] The total direct costs (which are covered by the NHIS during admission and clinical visits) are recorded in the HIRA database. The HIRA and the institutional review board approved the review and analysis of the data (H-1403-125-568).

### Study Groups

To identify the surgical methods performed at the two different time periods, all the patients who had undergone lumbar spinal surgery in 2003 or 2008 were identified from the HIRA database. The surgical methods included OD, laminectomy, fusion surgery, and PELD. In 2003 and 2008, 47,316 and 93,032 patients, respectively, underwent surgery for lumbar HIVD (Figure 1A and B). We excluded patients who had also undergone lumbar spinal surgery during the preceding 5 years or 1 year from the group of patients in 2003 or 2008, respectively. Patients who were young (younger than 20 years) or who had been diagnosed with a fracture, neoplasm, or infection were also excluded. Consequently, 17,997 patients from 2003 and 38,264 patients from 2008 were included in the present analysis (Figure 1A and B). The patient characteristics are described in Table 1 and are summarized as the means ± standard deviations for continuous variables and as frequencies (proportions) for categorical variables.

### Endpoints and Follow-up

The data were taken from the statistical population, and we followed all patients for 5 years *via* unique encrypted resident registration numbers in accordance with Korean privacy laws; the minimum follow-up period was 5 years for all

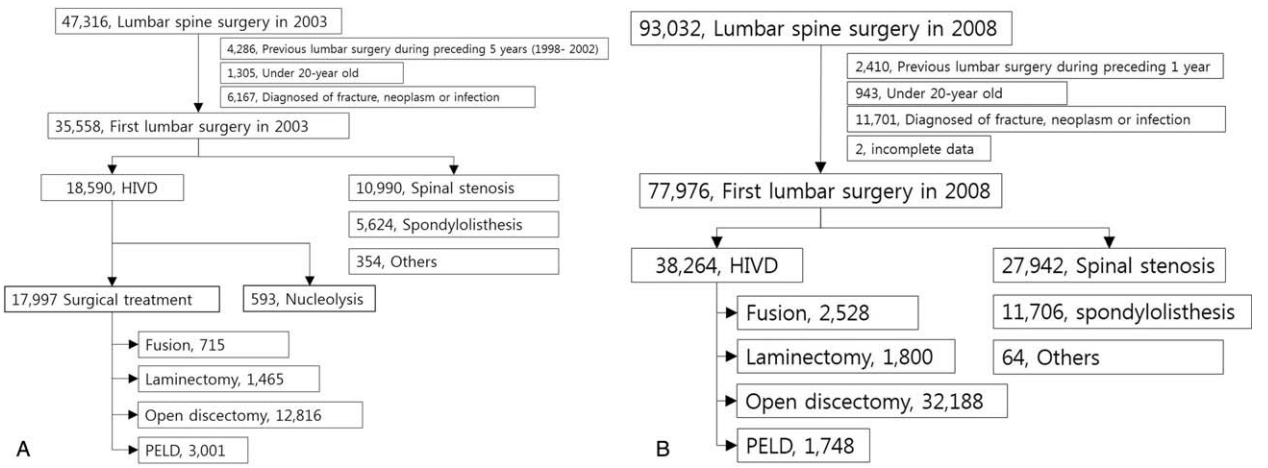


**Figure 1.** Patient flow diagram. **A**, Patients who underwent lumbar surgery in 2003. **B**, Patients who underwent lumbar surgery in 2008. HIVD indicates herniated intervertebral disc disease; PELD, percutaneous endoscopic lumbar discectomy.

**TABLE 1. Characteristics of Patients**

| Surgical Methods | 2003 (n = 17, 997) Number (%) | 2008 (n = 38.264) Number (%) |
|---|---|---|
| Open discectomy | 12,816 (71.21) | 32,188 (84.12) |
| Fusion | 715 (3.97) | 2528 (6.61) |
| Laminectomy | 1465 (8.14) | 1800 (4.70) |
| PELD | 3001 (16.68) | 1748 (4.57) |
| Age | | |
| 18–29 | 3488 (19.38) | 4909 (12.83) |
| 30–39 | 4376 (24.32) | 7871 (20.57) |
| 40–49 | 4786 (26.59) | 9588 (25.06) |
| 50–59 | 2907 (16.15) | 7357 (19.23) |
| 60–69 | 1936 (10.76) | 5763 (15.6) |
| 70- | 504 (2.80) | 2776 (7.25) |
| Mean ± SD | 42.58 ± 13.51 | 46.98 ± 14.61 |
| Sex | | |
| Male | 10,923 (60.69) | 22,666 (59.24) |
| Female | 7074 (39.31) | 15,598 (40.76) |
| Diabetes | 2233 (12.41) | 3879 (10.14) |
| Osteoporosis | 2112 (11.74) | 2511 (6.56) |
| Comorbidities | 10,223 (56.80) | 15,423 (40.31) |
| Type of hospital | | |
| Tertiary-referral hospitals | 3627 (20.15) | 4059 (10.61) |
| General hospitals | 4797 (26.65) | 9370 (24.49) |
| Hospitals | 6238 (34.66) | 23,187 (60.60) |
| Clinics | 3335 (18.53) | 1648 (4.31) |

*PELD indicates percutaneous endoscopic lumbar discectomy; SD, standard deviation.*

patients.[9,10,14] An event was defined as the occurrence of any type of second lumbar surgery with the disease code of lumbar degenerative disease during the follow-up period. The surgical method for the second lumbar surgery included OD, fusion surgery, laminectomy and PELD. Because detailed surgical levels were not noted in the claim data, the second surgery included operations at both the index and lumbar levels.[9] Censoring occurred when patients were deceased or reached the final follow-up period without surgery.[9]

## Statistical Analyses: Probability of Reoperation

The probability of reoperation after each surgical method at postoperative 5 years was calculated using the Kaplan-Meier method. All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC), and significance was defined as $P < 0.05$ (two-tailed). Medical comorbidity was assessed according to the "ICD-9-CM and ICD-10 Coding Algorithms for Charlson Comorbidities" proposed by Quan *et al*.[16] If the primary or secondary diagnoses listed at any hospital visit in the year of surgery included certain disease codes, then the patient was regarded as having a comorbidity.[9,10,14] Hospitals were classified based on their size and capacity as tertiary-referral hospitals (≥300 beds), general hospitals (100–300 beds), hospitals (30–100 beds), or clinics (<30 beds).[9,14] The number of hospitals that requested reimbursement for lumbar spinal surgery was determined from claim data in 2003 and 2008, and those hospitals were considered to have performed spinal surgeries (spine hospitals).

## Incremental Cost-Effectiveness Ratio

The ICER represents the additional cost for one unit of health benefit gained.[7,17–20] The value of the additional cost was measured as the willingness to pay (WTP) per unit of health benefit gained by the health provider or customer.[21] The benefit can be measured in terms of life-years, quality-adjusted life-years (QALY) or the incidence of a specific disease.[7,17,22] The ICER is used to evaluate health interventions (such as drugs or surgical methods) and help policy makers allocate health care resources.[18] The ICER value is used as a threshold for WTP.[7,18,21] If the WTP value is lower than the ICER value, the health intervention is not regarded as cost effective.[7,18,21] In the present study, health benefit was measured as the decrement in the probability of reoperation, and the ICER was defined as the difference in the average total cost among surgical methods divided by the difference in the probability of reoperation.[2,21,23] The reference surgical method was OD. For example, the ICER of fusion surgery was calculated as follows:

$$\text{ICER of fusion surgery} = \frac{(\text{cost of fusion surgery}) - (\text{cost of OD})}{(\text{reoperation probability of fusion surgery}) - (\text{reoperation probability of OD})}$$

In the present study, the ICER value represents the additional cost of a 1% change in the reoperation probability. Four scenarios were considered: (1) more costly with a higher

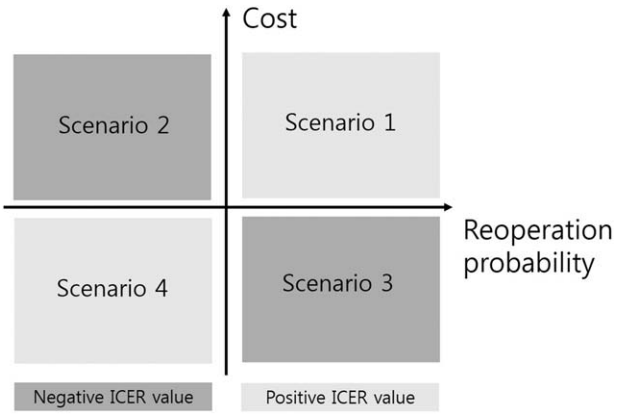


**Figure 2.** Cost-effectiveness plane. There are four scenarios. The ICER values are positive for scenarios 1 and 4 and as negative for scenario 2 and 3. Scenario 4 describes the most cost-effective surgical method. ICER indicates incremental cost-effectiveness ratio.

reoperation probability, (2) more costly with a lower reoperation probability, (3) less costly with a higher reoperation probability, and (4) less costly with a lower reoperation probability (Figure 2). The ICER value was positive for scenarios 1 and 4 and negative for scenarios 2 and 3. Scenario 4 corresponded to the most cost-effective surgical method. However, WTP needed to be considered for scenario 2.

The cost included the direct costs of both the index surgery and the reoperation (second surgery) based on the claim data. The cost of the index surgery was retrieved from the database.[24] However, the cost of the reoperation varied depending on the surgical method used for the reoperation. To calculate the cost of the reoperation, the costs of each surgical method used for reoperation were multiplied by the occurrence of each surgical method during reoperation and summed. The following example is provided for illustration. After OD, reoperation was performed with fusion surgery in a% of patients, laminectomy in b%, OD in c%, and PELD in d%. The average costs of reoperation were A for fusion surgery, B for laminectomy, C for OD, and D for endoscopic discectomy. The average total cost of OD for 5 years was then calculated as follows.

$$\text{Average total cost} = \text{cost of index OD} + \frac{(A \times a + B \times b + C \times c + D \times d)}{100}$$

All costs were adjusted to 2015 prices using health care-specific inflation indices (Korean Statistical Information Service; www.kosis.kr).

## RESULTS

### Reoperation

The reoperation probabilities during the 5-year follow-up period were 8.06% in 2003 and 11.26% in 2008, with an average of 10.24% (Table 2). The probability of reoperation was highest after laminectomy (10.77%), followed by OD (10.50%), PELD (9.20%), and fusion surgery (7.56%) (Table 3). OD was the most common reoperation surgical method after OD and PELD (62.63% and 54.95% of reoperations, respectively); however, fusion surgery was the most common surgical method after fusion surgery or laminectomy (54.44% and 42.05% of reoperations, respectively) (Table 3).

### Choice of Surgical Method

The number of surgeries increased by 2.13-fold between 2003 and 2008 (Table 1). Patients aged between 30 and 59 years accounted for approximately 65% of patients, and the percentage was similar for 2003 and 2008. The total number of all types of hospitals increased by 34.75% between 2003 and 2008 (Table 4). The numbers of general hospitals and hospitals increased by 34.21% and 64.68%, respectively. The proportions of medium-sized hospitals (general hospitals and hospitals) were 62.79% (459/731) in 2003 and 70.86% (698/985) in 2008. However, the proportions of surgeries according to hospital type did not show increases similar to those of the hospital proportions (Table 4). In 2003, 61.31% (11,035/17,997) of surgeries were performed at general hospitals and hospitals; however, in 2008, 85.08% (32,557/38,264) of surgeries were performed at general hospitals and hospitals.

The selection of surgical method for index surgeries also changed between 2003 and 2008 (Table 4). OD was the most common surgical technique in both 2003 and 2008, but the proportion of OD increased from 71.21% in 2003 to 84.12% in 2008. Among OD surgeries, 58.84% (7542/12,816) were performed at general hospitals and hospitals in 2003, whereas 86.03% (27,692/32,188) were performed at these hospitals in 2008. The proportion of fusion surgery

**TABLE 2. Occurrence of Reoperation**

| Postoperative Time | 2003 | | 2008 | | Total | |
|---|---|---|---|---|---|---|
| | Cumulative Number | Cumulative % | Cumulative Number | Cumulative % | Number | Cumulative % |
| <1 mo | 69 | 0.38 | 240 | 0.63 | 309 | 0.55 |
| 1–3 mo | 184 | 1.02 | 663 | 1.73 | 847 | 1.51 |
| 3 mo–1 yr | 425 | 2.36 | 1604 | 4.20 | 2029 | 3.61 |
| 1–2 yr | 687 | 3.83 | 2431 | 6.37 | 3118 | 5.56 |
| 2–3 yr | 953 | 5.32 | 3087 | 8.10 | 4040 | 7.21 |
| 3–4 yr | 1200 | 6.70 | 3741 | 9.83 | 4941 | 8.83 |
| 4–5 yr | 1440 | 8.06 | 4277 | 11.26 | 5717 | 10.24 |

**TABLE 3. Surgical Methods for Reoperation**

| | Number of Patients | | Reoperation Probability (%)* | Surgical Method for Reoperation | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | First Surgery | Reoperation | | Open Discectomy | Occurrence Rate (%)† | Fusion | Occurrence Rate (%)† | Laminectomy | Occurrence Rate (%)† | PELD | Occurrence Rate (%)† |
| 2003 | | | | | | | | | | | |
| Open discectomy | 12,816 | 1105 | 8.17 | 609 | 4.75 | 360 | 2.81 | 55 | 0.43 | 81 | 0.63 |
| Fusion | 715 | 44 | 5.99 | 9 | 1.26 | 28 | 3.92 | 7 | 0.98 | 0 | 0 |
| Laminectomy | 1465 | 133 | 8.4 | 39 | 2.66 | 62 | 4.23 | 32 | 2.18 | 0 | 0 |
| PELD | 3001 | 246 | 7.92 | 124 | 4.13 | 66 | 2.20 | 15 | 0.5 | 41 | 1.37 |
| 2003 Total | 17,997 | 1528 | 8.06 | 781 | 4.34 | 516 | 2.87 | 109 | 0.61 | 122 | 0.68 |
| 2008 | | | | | | | | | | | |
| Open discectomy | 32,188 | 3880 | 11.43 | 2513 | 7.81 | 1004 | 3.12 | 297 | 0.92 | 66 | 0.21 |
| Fusion | 2528 | 215 | 8 | 68 | 2.69 | 113 | 4.47 | 32 | 1.27 | 2 | 0.08 |
| Laminectomy | 1800 | 238 | 12.71 | 106 | 5.89 | 94 | 5.22 | 37 | 2.06 | 1 | 0.06 |
| PELD | 1748 | 209 | 11.39 | 126 | 7.21 | 38 | 2.17 | 21 | 1.2 | 24 | 1.37 |
| 2008 total | 38,264 | 4542 | 11.26 | 2813 | 7.35 | 1249 | 3.26 | 387 | 1.01 | 93 | 0.24 |
| Total‡ | | | | | | | | | | | |
| Open discectomy | 45,004 | 4985 | 10.50 | 3122 | 6.94 (62.63)§ | 1364 | 3.03 (27.36) | 352 | 0.78 (7.06) | 147 | 0.33 (2.95) |
| Fusion | 3243 | 259 | 7.56 | 77 | 2.37 (29.73) | 141 | 4.35 (54.44) | 39 | 1.20 (15.06) | 2 | 0.06 (0.77) |
| Laminectomy | 3265 | 371 | 10.77 | 145 | 4.44 (39.08) | 156 | 4.78 (42.05) | 69 | 2.11 (18.60) | 1 | 0.03 (0.27) |
| PELD | 4749 | 455 | 9.20 | 250 | 5.26 (54.95) | 104 | 2.19 (22.86) | 36 | 0.76 (7.91) | 65 | 1.37 (14.29) |
| Total | 56,261 | 6070 | 10.24 | 3594 | 6.39 (59.21) | 1765 | 3.14 (29.08) | 496 | 0.88 (8.17) | 215 | 0.38 (3.54) |

**Reoperation probabilities were calculated using a survival analysis and are different from rates.*

*†The denominator is the number of patients in first surgery.*

*§Percentage among reoperation.*

*‡Total of 2003 and 2008.*

*PELD indicates percutaneous endoscopic lumbar discectomy.*

**TABLE 4. Surgical Method According to Hospital Type**

| | Total (%) | Tertiary Referral Hospitals (%) | General Hospitals (%) | Hospitals (%) | Clinics (%) |
|---|---|---|---|---|---|
| 2003 | | | | | |
| Open discectomy | 12,816 (71.21) | 3067 (84.56) | 4048 (84.39) | 3494 (56.01) | 2207 (66.18) |
| Fusion | 715 (3.97) | 117 (3.23) | 221 (4.61) | 319 (5.11) | 58 (1.74) |
| Laminectomy | 1465 (8.14) | 300 (8.27) | 202 (4.21) | 157 (2.52) | 806 (24.17) |
| PELD | 3001 (16.68) | 143 (3.94) | 326 (6.80) | 2268 (36.36) | 264 (7.92) |
| 2003 Total | 17,997 (100) | 3627 (100) | 4797 (100) | 6238 (100) | 3335 (100) |
| Number of hospitals | 731 | 42 (5.75)* | 190 (26.00)* | 269 (36.80)* | 230 (31.46)* |
| 2008 | | | | | |
| Open discectomy | 32,188 (84.12) | 3049 (75.12) | 7496 (80.00) | 20,196 (87.10) | 1447 (87.80) |
| Fusion | 2528 (6.61) | 649 (15.99) | 859 (9.17) | 922 (3.98) | 98 (5.95) |
| Laminectomy | 1800 (4.70) | 228 (5.62) | 483 (5.15) | 1007 (4.34) | 82 (4.98) |
| PELD | 1748 (4.57) | 133 (3.28) | 532 (5.68) | 1062 (4.58) | 21 (1.27) |
| 2008 Total | 38,264 (100) | 4059 (100) | 9370 (100) | 23,187 (100) | 1648 (100) |
| Number of hospitals | 985 | 43 (4.37)* | 255 (25.89)* | 443 (44.97)* | 244 (24.77)* |
| Pooled† | | | | | |
| Open discectomy | 45,004 (79.99) | 6116 (79.57) | 11,544 (81.49) | 23,690 (80.51) | 3654 (73.33) |
| Fusion | 3243 (5.76) | 766 (9.97) | 1080 (7.62) | 1241 (4.22) | 156 (3.13) |
| Laminectomy | 3265 (5.80) | 528 (6.87) | 685 (4.84) | 1164 (3.96) | 888 (17.82) |
| PELD | 4749 (8.44) | 276 (3.59) | 858 (6.06) | 3330 (11.32) | 285 (5.72) |
| 2003 and 2008 total | 56,261 (100) | 7686 (100) | 14,167 (100) | 29,425 (100) | 4983 (100) |

**Total of 2003 and 2008.*
*†Proportion of each type of hospital among all spine hospitals*
*PELD indicates percutaneous endoscopic lumbar discectomy*

increased from 3.97% in 2003 to 6.61% in 2008, and the increase was similar for all types of hospitals. However, the proportion of PELD decreased from 16.68% in 2003 to 4.57% in 2008. The proportion of PELD in hospitals decreased markedly from 36.36% in 2003 to 4.58% in 2008. Regarding PELD surgeries, 86.43% (2594/3001) and 91.19% (1594/1748) were performed at medium-sized hospitals in 2003 and 2008, respectively. Overall, 78.29% (35,234/45,004) of ODs, 71.57% (2321/3243) of fusion surgeries and 88.19% (4188/4749) of PELD surgeries were performed at medium-sized hospitals.

### Incremental Cost-Effectiveness Ratio

The average direct costs were greater in 2008 than in 2003, particularly with regard to fusion surgery and laminectomy (Table 5). Fusion surgery was more costly than OD and had a lower probability of reoperation (Scenario 2, Figure 2). Laminectomy was in Scenario 1. PELD was less costly than OD and had a lower reoperation probability (Scenario 4). The ICER results showed that PELD was the cost-effective surgical method with respect to reducing reoperation probability. However, the small difference in the probability of reoperation between PELD and OD might have inflated the ICER.[23]

## Discussion

The primary question of the present study was "Are the surgical methods selected for lumbar HIVD the most cost-effective ones?" The ICER showed that PELD was the most cost-effective surgical method; however, the surgeries performed were inconsistent with a cost-effective strategy. The proportion of medium-sized hospitals (30–300 beds) increased from 62.79% in 2003 to 70.86% in 2008, but the proportion of surgeries performed at those hospitals increased from 61.31% in 2003 to 85.08% in 2008. The high proportion of medium-sized hospitals may have been responsible for this pattern.

### Choice of Surgical Method

The increasing general population, especially the increasing aging population, might have been responsible for increase in the number of operations between 2003 and 2008: the number of people older than 20 years increased by 6.3% (from 36,186,130 in 2003 to 38,496,861 in 2008), and the number of people between 30 and 59 years old increased by 7.8% (from 21,484,321 in 2003 to 23,165,464 in 2008; Korean Statistical Information Service, www.kosis.kr). However, these population increases do not explain why the number of surgeries increased by 113% between 2003 and 2008 years. Various factors may have contributed to the increased number of surgeries, such as improvements in instrumentation, surgical techniques, anesthesia techniques, and supportive care; the influence of key opinion leaders; and financial incentives to hospitals and surgeons.[4,25–27] Although detailed information regarding these factors was not available from the registered data, the increase in the proportion of surgeries in medium-sized hospitals was notable. The increase in the proportion of surgeries (from 61.31% to 85.08%) performed at medium-sized hospitals

**TABLE 5. Incremental Cost-Effectiveness Ratio**

| | Average Total Cost ($)* | Cost of First Operation ($) | Cost of Reoperation ($)† | Reoperation Probability (%)‡ | ICER ($/%)§ |
|---|---|---|---|---|---|
| 2003 | | | | | |
| Open discectomy | 2064 | 1811 | 253 | 8.17 | |
| Fusion | 3637 | 3433 | 204 | 5.99 | −722 |
| Laminectomy | 2128 | 1841 | 287 | 8.4 | 278 |
| Percutaneous endoscopic discectomy | 1563 | 1332 | 231 | 7.92 | 2004 |
| 2008 | | | | | |
| Open discectomy | 2262 | 1878 | 384 | 11.43 | |
| Fusion | 4937 | 4632 | 305 | 8 | −780 |
| Laminectomy | 2719 | 2266 | 453 | 12.71 | 357 |
| Percutaneous endoscopic discectomy | 1643 | 1275 | 368 | 11.39 | 15,475 |
| Pooled | | | | | |
| Open discectomy | 2204 | 1859 | 345 | 10.5 | |
| Fusion | 4648 | 4368 | 280 | 7.56 | −831 |
| Laminectomy | 2459 | 2075 | 384 | 10.77 | 944 |
| Percutaneous endoscopic discectomy | 1600 | 1311 | 289 | 9.2 | 465 |

*Average total cost added the cost of first operation and the cost of reoperation. All costs were inflated to 2015 prices using the healthcare-specific inflation indices.

†To calculate the cost of reoperation, the cost of each surgical method in reoperation was multiplied by the occurrence rate of each surgical method and summed.

‡Reoperation probabilities were calculated with the Kaplan-Meier method

§Incremental cost-effectiveness ratio (ICER) is defined as the difference in average total costs between surgical methods, divided by the difference in reoperation rate.

was greater than the increase in the proportion (from 62.79% to 70.86%) of medium-sized hospitals. The increased number of general hospitals and hospitals may have been responsible for this pattern.

The benefit standards of the NHIC and HIRA did not change between 2003 and 2008, and the surgical indications were similar throughout the 5-year period. Although the ICER showed that PELD was cost effective, the surgical method most often performed was not PELD but OD. A detailed analysis was not possible with the current data, but the balloon effect of modified strictness in applying the benefit standards might explain this phenomenon.[28] If the standards for the reimbursement of a specific surgical method (*e.g.*, PELD) become stricter, then the number of surgeries with more lenient standards might increase. This phenomenon might affect medium-sized hospitals. Although the selection of surgical method was at the discretion of the surgeon, it might be indirectly controlled by NHIS, and this may lead to the high dissatisfaction rate among physicians.[29]

### Cost-Effectiveness Analysis

Because cost effectiveness drives policies and health care reforms, accurate measurements of real-world effectiveness are of the utmost importance.[30] The value of cost was judged by WTP per gained QALY. For example, the Spinal Patient Outcomes Research Trial indicated that surgical treatment was more costly than nonoperative treatments; the mean difference in total cost was $14,137 (95% CI: $11,737–$16,770).[2] However, surgical treatment was considered cost effective because WTP per gained QALY was between $50,000 and $100,000.[2,11,21]

## LIMITATIONS

This study had several limitations. First, the registered data indicated only direct costs; indirect costs, such as missed work and medical fees for noncovered services, were not considered in this study.[29] The direct cost of OD in South Korea ($1,643) is 6- to 8-fold lower than the cost in other countries ($10,311–$12,901), and the direct cost of PELD is lower than that of OD.[3,31,32] In Korea, medical fees for noncovered services represent approximately 35% of medical costs, and the actual direct total costs can be estimated as the total cost * (100/65).[22] When the actual direct costs were estimated, the direct costs in Korea were still approximately 5-fold lower than those in the USA. As with most cost-effectiveness studies, specific dollar values might not be equivalent among studies and WTP considering the benefits and risks of each surgical method in different countries may lead to different results.[11,33] Moreover, the present ICER was not based on quality of life, but based on reoperation probability. These factors limit the generalizability of the present study's results. Second, because the present evaluation was based on an observational design and not a randomized controlled trial,[2] the selection of surgical methods was not uniform among surgeons or institutions. Moreover, the present study did not control for clinical or radiological factors. Such factors might influence the selection of surgical methods and the probability of reoperation. Third, different washout periods may have inflated the number of surgeries in 2008. An electronic data interchange (EDI) system was established in 2003, and data from the previous period were incomplete. The registration rate in EDI was 95.2% in 2003 and 99.9% in 2008. Typically, a 1-year washout period is

recommended to trace past medical history, but the washout period for the 2003 cohort was 5 years because of incomplete EDI records in the previous period.[26,27]

Nevertheless, the present study analyzed the selection of different surgical methods at two different time periods under NHIS and provided a cost-effectiveness analysis from a statistical population. The results might be helpful for health service planners, particularly those in countries with (or with plans to have) similar NHISs.

## CONCLUSION

The choice of surgical method is not always in accordance with cost-effectiveness strategies. Although the present results were obtained from a single country and therefore are limited with regard to generalizability, the present information should be of interest to health service planners, particularly those in countries with (or with plans to have) similar NHISs.[33]

### ➢ Key Points

- ❑ The selection of surgical method for lumbar HIVD may or may not follow cost-effectiveness under the NHIS.
- ❑ The data of all patients who underwent a first surgery for HIVD in 2003 (n = 17,997) and 2008 (n = 38,264) were analyzed.
- ❑ PELD was cost-effective surgical method in reducing reoperation probability.
- ❑ However, the proportion of PELD decreased from 16.68% to 4.57%, whereas that of OD increased from 71.21% to 84.12%.
- ❑ The choice of surgical method might not always be consistent with cost-effectiveness strategies in NHIS.

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