Does the microendoscopic technique reduce mortality and major complications in patients undergoing lumbar discectomy? A propensity score–matched analysis using a nationwide administrative database

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OBJECTIVE Although minimally invasive spinal surgery has recently gained popularity, few nationwide studies have compared the adverse events that occur during endoscopic versus open spinal surgery. The purpose of this study was to compare perioperative complications associated with microendoscopic discectomy (MED) and open discectomy for patients with lumbar disc herniation.

METHODS The authors retrospectively extracted from the Diagnosis Procedure Combination database, a national inpatient database in Japan, data for patients admitted between July 2010 and March 2013. Patients who underwent lumbar discectomy without fusion surgery were included in the analysis, and those with an urgent admission were excluded. The authors examined patient age, sex, Charlson Comorbidity Index, body mass index, smoking status, blood transfusion, duration of anesthesia, type of hospital, and hospital volume (number of patients undergoing discectomy at each hospital). One-to-one propensity score matching between the MED and open discectomy groups was performed to compare the proportions of in-hospital deaths, surgical site infections (SSIs), and major complications, including stroke, acute coronary events, pulmonary embolism, respiratory complications, urinary tract infection, and sepsis. The authors also compared the hospital length of stay between the 2 groups.

RESULTS A total of 26,612 patients were identified in the database. The mean age was 49.6 years (SD 17.7 years). Among all patients, 17,406 (65.4%) were male and 6422 (24.1%) underwent MED. A propensity score–matched analysis with 6040 pairs of patients showed significant decreases in the occurrence of major complications (0.8% vs 1.3%, $p = 0.01$) and SSI (0.1% vs 0.2%, $p = 0.02$) in patients treated with MED compared with those who underwent open discectomy. Overall, MED was associated with significantly lower risks of major complications (OR 0.62, 95% CI 0.43–0.89, $p = 0.01$) and SSI (OR 0.29, 95% CI 0.09–0.87, $p = 0.03$) than open discectomy. There was a significant difference in length of hospital stay (11 vs 15 days, $p < 0.001$) between the groups. There was no significant difference in in-hospital mortality between MED and open discectomy.

CONCLUSIONS The microendoscopic technique was associated with lower risks for SSI and major complications following discectomy in patients with lumbar disc herniation.

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KEY WORDS lumbar disc herniation; minimally invasive surgery; endoscopic surgery; mortality; complication; surgical site infection

ABBREVIATIONS BMI = body mass index; CCI = Charlson Comorbidity Index; DPC = Diagnosis Procedure Combination; ICD-10 = *International Classification of Diseases, 10th Revision*; MED = microendoscopic discectomy; SSI = surgical site infection.

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ENDOSCOPIC spinal surgery was developed as a minimally invasive spinal surgery. Microendoscopic discectomy (MED) was originally developed in 1997 for the treatment of lumbar disc herniation,⁹ and since then, microendoscopic surgery techniques have been used for the treatment of several spinal disorders, including foraminal stenosis and disorders at the level of the spinal cord (i.e., cervical and thoracic spine), with favorable outcomes.^{2,10,15,19,21,22,25,41} Several studies have demonstrated that endoscopic discectomy is associated with less invasiveness than open discectomy, with comparable clinical outcomes.^{11–14,30,32–35,37} However, because these studies involved small numbers of patients in single institutions, it remains unclear whether MED is truly a safer technique than open discectomy. Despite the clinical importance of understanding the risk for adverse surgical comorbidities, few nationwide studies have examined these issues by directly comparing MED and open discectomy. The purpose of this study was to compare the mortality and morbidities in patients with lumbar disc herniation who had been treated using MED and open discectomy based on a propensity score–matched analysis of data obtained from a nationwide administrative database in Japan.

Methods

Data Source

We used data abstracted from the Japanese Diagnosis Procedure Combination (DPC) database, the details of which have been described previously.^{4–7,17,24} Briefly, the database includes administrative claims data and discharge abstract data from approximately 1000 hospitals across Japan. All 82 academic hospitals are obliged to contribute to the database, but the participation of community hospitals is voluntary. Approximately 50% of all acute-care inpatients in Japan were included in the DPC database in 2011. The database includes the following information: patient age and sex; main diagnoses; surgical procedures; comorbidities that were already present at admission and complications that occurred after admission, recorded using *International Classification of Diseases, 10th Revision* (ICD-10) codes; length of stay; and in-hospital death. Surgical procedures are coded using original Japanese codes. The DPC database clearly differentiates between preoperative comorbidities and postoperative complications. Informed patient consent for inclusion in this study was waived because of the anonymous nature of the data. The study was approved by the institutional review board of The University of Tokyo.

Patient Selection and Data

We extracted from the database data for patients admitted between July 2010 and March 2013. We included patients who underwent lumbar discectomy without fusion surgery. Patients requiring urgent admission were excluded. Patients who underwent surgery under local anesthesia were also excluded. The following details were examined: patient age and sex; body mass index (BMI); smoking status; Charlson Comorbidity Index (CCI); blood transfusion; duration of anesthesia; type of hospital (academic or nonacademic); and hospital volume (average annual num-

ber of patients undergoing discectomy at each hospital). The CCI can quantify the prognosis of patients enrolled in a large cohort and is widely used to measure case-mix administrative data. The index is based on a point-scoring system (from 0 to 40) for the presence of specific associated diseases. Quan and colleagues²⁹ have provided a validated chart showing how individual comorbidities correspond to a set of ICD-10 codes. Based on their protocol, each ICD-10 code associated with a comorbidity was converted into a score, and the scores were summed for each patient to determine the CCI.

Outcomes

The clinical outcomes evaluated were in-hospital death, major complications, and surgical site infection (SSI). Major complications included stroke (ICD-10 codes I60–I64), acute coronary events (I21–I24), pulmonary embolism (I26), respiratory complications (pneumonia [J12–J18], postoperative respiratory disorders [J95], or respiratory failure [J96]), urinary tract infection (J95), acute renal failure (N17), and sepsis (A40, A41).

In this study, SSI was defined as cases that were coded as SSI (T813, T814) and required additional surgical intervention following the index discectomy.

Statistical Analysis

To describe the patient demographic data, categorical variables were summarized as the number and proportion, and continuous variables were summarized as the mean and standard deviation (SD). We compared patient demographic data between the MED and open discectomy groups in the unmatched and propensity score–matched groups using the standardized difference. An absolute standardized difference > 0.1 was considered to indicate significant imbalance of a baseline covariate.¹

Propensity Score Matching

To adjust for measured confounding factors, we performed propensity score matching.⁸ To estimate propensity scores, we fitted a logistic regression model for the receipt of MED as a function of patient demographic and hospital factors, including patient age, sex, CCI, BMI, smoking status, duration of anesthesia, blood transfusion, type of hospital, and hospital volume. The C-statistic for evaluating the goodness of fit was calculated. Each patient in the MED group was matched with a patient in the open discectomy group with the closest estimated propensity score within a specified range (≤ 0.2 of the pooled SD of the estimated logits) using the nearest-neighbor method without replacement.

Fisher's exact test was used to compare the proportions of SSI, at least 1 major complication, and in-hospital death between the propensity-matched pairs of the MED and discectomy groups. The Mann-Whitney U-test was used to compare the median length of hospital stay between the propensity-matched pairs. Univariate logistic regression analysis for the propensity-matched population was performed to estimate the odds ratio (OR) and 95% confidence interval (CI) of the MED group with reference to the open discectomy group for SSI and at least 1 major

complication. The threshold for significance was set at $p < 0.05$. All statistical analyses were conducted using SPSS version 20.0 (IBM Corp.).

Results

A total of 26,612 patients were identified in the database. The mean age was 49.6 years (SD 17.7 years), and 17,406 patients (65.4%) were male. The median length of hospital stay was 15 days (IQR 11–20 days). Among all patients, 6422 patients (24.1%) underwent MED and 20,190 patients (75.9%) underwent open discectomy. By one-to-one propensity score matching, 6040 pairs were selected. The C-statistic for goodness of fit was 0.683.

Table 1 shows the patient demographic data in the unmatched and propensity score–matched groups. In the unmatched group, patients with a younger age, lower CCI, treatment in an academic hospital, and admission to a high-volume hospital were more likely to undergo MED. After propensity score matching, the distributions of the patient backgrounds were closely balanced between the MED group and the open discectomy group.

Table 2 shows the proportions of in-hospital death, at least 1 major complication, SSI, and median length of stay in the unmatched and propensity score–matched groups. Fisher's exact test for the propensity score–matched groups showed no significant difference for in-hospital mortality

TABLE 1. Demographic data in the unmatched and propensity score–matched groups

Parameter	Unmatched Group			Propensity Score–Matched Group		
	MED	Open Discectomy	Standardized Difference*	MED	Open Discectomy	Standardized Difference*
No. of patients	6422	20,190		6040	6040	
Male sex (%)	4218 (65.7)	13,188 (65.3)	0.01	3941 (65.2)	3919 (64.9)	0.01
Patient age in yrs (%)						
≤29	1179 (18.4)	2619 (13.0)	0.15	1060 (17.5)	1151 (19.1)	−0.00
30–39	1430 (22.3)	3771 (18.7)	0.09	1315 (21.8)	1328 (22.0)	−0.01
40–49	1222 (19.0)	3428 (17.0)	0.05	1138 (18.8)	1153 (19.1)	−0.01
50–59	931 (14.5)	3110 (15.4)	−0.03	905 (15.0)	874 (14.5)	0.01
60–69	941 (14.7)	3730 (18.5)	−0.10	914 (15.1)	886 (14.7)	0.01
≥70	719 (11.2)	3532 (17.5)	−0.18	708 (11.7)	648 (10.7)	0.03
CCI (%)						
0	6048 (94.2)	18,308 (90.7)	0.13	5672 (93.9)	5681 (94.1)	−0.01
1	166 (2.6)	746 (3.7)	−0.06	164 (2.7)	177 (2.9)	−0.01
≥2	208 (3.2)	1136 (5.6)	−0.12	204 (3.4)	182 (3.0)	0.02
BMI in kg/m ² (%)						
<18.5	320 (5.0)	987 (4.9)	0.00	300 (5.0)	303 (5.0)	0.00
18.5–23	2622 (40.8)	8001 (39.6)	0.02	2433 (40.3)	2431 (40.2)	0.00
23–25	1403 (21.8)	4312 (21.4)	0.01	1313 (21.7)	1289 (21.3)	0.01
25–30	1575 (24.5)	5272 (26.1)	−0.04	1510 (25.0)	1520 (25.2)	−0.01
>30	413 (6.4)	1323 (6.6)	−0.01	395 (6.5)	408 (6.8)	−0.01
Unknown (%)	89 (1.4)	295 (1.5)	−0.01	89 (1.5)	89 (1.5)	0.00
Smoking status (%)						
Smoker	2325 (36.2)	7470 (37.0)	0.02	2164 (35.8)	2075 (34.4)	0.03
Nonsmoker	3497 (54.5)	10,880 (53.9)	0.01	3280 (54.3)	3347 (55.4)	−0.02
Data missing/unknown	600 (9.3)	1840 (9.1)	0.01	596 (9.9)	618 (10.2)	−0.01
Blood transfusion (%)	12 (0.2)	100 (0.5)	−0.05	12 (0.2)	13 (0.2)	0.00
Duration of anesthesia in min (%)†						
≤120	1570 (24.8)	5583 (28.2)	−0.08	1337 (22.5)	1246 (20.8)	0.04
121–180	2801 (44.3)	8541 (43.2)	0.02	2680 (45.1)	2649 (44.3)	0.02
181–240	1395 (22.1)	3761 (19.0)	0.08	1373 (23.1)	1494 (25.0)	−0.04
241–300	400 (6.3)	1231 (6.2)	0.00	394 (6.6)	424 (7.1)	−0.02
301–360	97 (1.5)	382 (1.9)	−0.03	97 (1.6)	107 (1.8)	−0.02
≥361	61 (1.0)	272 (1.4)	−0.04	61 (1.0)	63 (1.1)	−0.01
Teaching hospital (%)	1179 (18.4)	2854 (14.1)	0.12	1176 (19.5)	1285 (21.3)	−0.04
Hospital vol (no./yr [SD])	69.1 (64.0)	41.7 (48.6)	0.48	59.1 (50.7)	55.2 (59.3)	0.07

* An absolute standardized difference of > 0.1 indicates significant imbalance of a baseline covariate.

† Data were missing for some patients: 6324 for the unmatched MED group and 19,770 for the unmatched open discectomy group.

TABLE 2. Rates of in-hospital death, major complications, SSI, and length of stay in the unmatched and propensity score–matched groups

Parameter	Unmatched Group (no. [%])		p Value	Propensity Score–Matched Group (no. [%])		p Value
	MED	Open Discectomy		MED	Open Discectomy	
No. of patients	6422	20,190		6040	6040	
In-hospital death	1 (0.0)	9 (0.0)	0.47	1 (0.0)	1 (0.0)	1.00
At least 1 major complication	48 (0.7)	314 (1.6)	<0.001	47 (0.8)	76 (1.3)	0.009
Stroke	4 (0.1)	15 (0.1)	1.00	3 (0.0)	0 (0.0)	0.25
Acute coronary events	28 (0.4)	169 (0.8)	0.001	28 (0.5)	40 (0.7)	0.14
Pulmonary embolism	0 (0.0)	3 (0.0)	1.00	0 (0.0)	1 (0.0)	1.00
Respiratory complications	5 (0.1)	35 (0.2)	0.10	5 (0.1)	6 (0.1)	1.00
Urinary tract infection	8 (0.1)	79 (0.4)	0.001	8 (0.1)	23 (0.4)	0.01
Sepsis	1 (0.0)	7 (0.0)	0.69	1 (0.0)	2 (0.0)	1.00
SSI	4 (0.1)	53 (0.3)	0.003	4 (0.1)	14 (0.2)	0.02
Median length of stay in days	11	16	<0.001	11	15	<0.001

between the MED and open discectomy groups (0.0% vs 0.0%, $p = 1.00$). Patients in the MED group exhibited a significantly lower risk of major complications (0.8% vs 1.3%, $p = 0.01$) and SSI (0.1% vs 0.2%, $p = 0.02$) than patients in the open discectomy group. There was a significant difference in the median length of stay (11 vs 15 days for MED and open discectomy, respectively, $p < 0.001$) between the 2 groups.

Table 3 shows the results of logistic regression analysis for the occurrence of major complications and SSI. The MED group was significantly less likely to have major complications (OR 0.62, 95% CI 0.43–0.89, $p = 0.01$) and SSI (OR 0.29, 95% CI 0.09–0.87, $p = 0.03$) than the open discectomy group.

Discussion

The main finding of this study was that patients treated using MED experienced lower rates of postoperative SSI and major complications than patients treated with open discectomy, even after adjustment for the measured confounders using propensity score matching. The analysis of a nationwide database enabled us to investigate a large number of samples and to evaluate the magnitude and impact of surgical techniques on major postoperative complications.

Microendoscopic surgery for lumbar disc herniation was developed with the concept of preserving posterior elements (i.e., paraspinal muscles) as much as possible. Several previous randomized control studies comparing MED with open surgery have shown favorable postoperative outcomes following MED.^{11,12,14,30,32,33,39} Although surgical skills, such as hand–eye coordination, are required, MED could become the standard surgical treatment

method for patients with lumbar disc herniation. However, previous reports were insufficient to conclude that MED shows superiority in terms of postoperative complications as compared with open discectomy because of the small sample sizes involved.

MED was thought to be a safer and less invasive surgical technique than open discectomy. Previous reports have shown that patients undergoing MED experience fewer indicators of surgical invasiveness than those undergoing open discectomy.^{13,23,34,35,36,40} Markers of invasiveness include postoperative elevations in serum levels of inflammatory markers and muscle enzymes,^{13,34,36} irritation of nerve roots using intraoperative neuromonitoring,^{35,40} and muscle damage by axial MRI.²³ However, if postoperative complications often occurred, it would be concluded that endoscopic surgery is no longer a safe procedure, despite its lower invasiveness. Matsumoto and colleagues¹⁸ reported the complication rates for endoscopic spinal surgery in a nationwide retrospective study. In their series, which included discectomy, laminectomy, fenestration, and fusion surgery, the incidence of surgery-related complications (e.g., dural injury) was 2.1%. One advantage of the present study was the study design using open discectomy as a comparable reference. Another advantage was including treated patients from multiple calendar years, while the study by Matsumoto and colleagues only evaluated patients treated in 2007. To the best of our knowledge, the present study is the first to compare postoperative complications between MED and open discectomy procedures for the treatment of lumbar disc herniation while adjusting for patient characteristics using propensity score matching. Our results suggest that the microendoscopic technique is safer and less invasive for the treatment of patients

TABLE 3. Logistic regression analyses for the occurrence of major complications and SSI in the propensity score–matched group

Procedure	At Least 1 Major Complication			SSI		
	OR	95% CI	p Value	OR	95% CI	p Value
Open discectomy	Reference			Reference		
MED	0.62	0.43–0.89	0.009	0.29	0.09–0.87	0.03

with lumbar disc herniation, as demonstrated by a lower risk of SSI and major complications.

Data in the present study are consistent with those in previous reports evaluating minimally invasive techniques.^{20,26,28,38} In a retrospective study using an administrative database, McGirt and colleagues²⁰ reported that their minimally invasive technique was associated with a decrease in the incidence of SSI following 2-level posterior/transforaminal lumbar interbody fusion. O'Toole and colleagues postulated several possible reasons for the lower risk of SSI associated with minimally invasive surgery: reduced exposure of deep tissue, preventive effect of a tubular retractor for local contamination, smaller incisions, and reduced dead space in the surgical site after closure.²⁶ These advantages of minimally invasive techniques can apply to MED, although we were unable to identify the possible reasons for the reduced SSI risk in our study. Further analyses designed to investigate the pathomechanism of the lower invasiveness of MED are warranted.

This study also showed that the average length of hospital stay was significantly shorter for patients undergoing MED than for patients undergoing open discectomy, which was consistent with previous reports.^{11,14,30} However, the average length of hospital stay in the present study (11 days in patients treated via MED) was longer than those in previous reports, which ranged from 1 to 2 days.^{3,9,227,32,37} According to the Organization for Economic Cooperation and Development Health Statistics 2014, the national average length of hospital stay in Japan was 17.2 days, which was much longer than those in other countries (<http://www.oecd.org/els/health-systems/oecd-health-statistics-2014-frequently-requested-data.htm>). In Japan, hospitals often provide both early postoperative care and subsequent rehabilitation in a single hospitalization. We believe that the longer hospitalization in the present study can provide more precise information on postoperative comorbidities reflecting surgical invasiveness.

This study has several limitations. First, the study was based on a retrospective observational design, and the treatment assignment was not random. Although measured confounders were adjusted by the propensity score analyses, the results may still be biased by unmeasured confounders. Second, the coded diagnoses may be less accurate than the diagnoses recorded in prospective studies because of possible misclassification or underreporting. However, we believe that the rate of miscoding was relatively low in the DPC database because the attending physicians recorded the diagnoses. Third, the DPC database does not provide detailed clinical information such as the surgeons' technical proficiency, size of disc herniation, detailed surgical procedure (e.g., use of a microscope in open discectomy), and detailed surgery-related complications (e.g., durotomy). Finally, we were unable to obtain data regarding mortality and complications that occurred after discharge; therefore, the long-term mortality and morbidities could not be evaluated.

Conclusions

The present study suggests that the microendoscopic technique reduces the risk for SSI and major complications following discectomy in patients with lumbar disc

herniation. Microendoscopic surgery can be a safer and less invasive procedure than open surgery.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Ohya. Acquisition of data: Ohya, Oichi, Matsui, Fushimi. Analysis and interpretation of data: Ohya, Yasunaga. Drafting the article: Ohya. Critically revising the article: Oshima, Chikuda. Reviewed submitted version of manuscript: Chikuda, Tanaka. Statistical analysis: Ohya, Yasunaga. Administrative/technical/material support: Matsui, Fushimi, Yasunaga. Study supervision: Tanaka.

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