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An Assessment of Nonoperative Management Strategies in a Herniated Lumbar Disc Population: Successes Versus Failures

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Abstract

Study Design: Retrospective cohort study.

Objective: To compare the utilization of conservative treatments in patients with lumbar intervertebral disc herniations who were successfully managed nonoperatively versus patients who failed conservative therapies and elected to undergo surgery (microdiscectomy).

Methods: Clinical records from adult patients with an initial herniated lumbar disc between 2007 and 2017 were selected from a large insurance database. Patients were divided into 2 cohorts: patients treated successfully with nonoperative therapies and patients that failed conservative management and opted for microdiscectomy surgery. Nonoperative treatments utilized by the 2 groups were collected over a 2-year surveillance window. "Utilization" was defined by cost billed to patients, prescriptions written, and number of units disbursed.

Results: A total of 277 941 patients with lumbar intervertebral disc herniations were included. Of these, 269 713 (97.0%) were successfully managed with nonoperative treatments, while 8228 (3.0%) failed maximal nonoperative therapy (MNT) and underwent a lumbar microdiscectomy. MNT failures occurred more frequently in males (3.7%), and patients with a history of lumbar epidural steroid injections (4.5%) or preoperative opioid use (3.6%). In a logistic multivariate regression analysis, male sex and utilization of opioids were independent predictors of conservative management failure. Furthermore, a cost analysis indicated that patients who failed nonoperative treatments billed for nearly double ($1718/patient) compared to patients who were successfully treated ($906/patient).

Conclusion: Our results suggest that the majority of patients are successfully managed nonoperatively. However, in the subset of patients that fail conservative management, male sex and prior opioid use appear to be independent predictors of treatment failure.

Keywords
lumbar, disc herniation, discectomy, disc, low back pain

Introduction

Low back pain is thought to affect more than 80% of people at some point during their lifetime making it one of the most prevalent medical conditions worldwide.[1,2] Morbidity from lumbar spine disease consistently accounts for the greatest source of years lived with disability in the United States and, as such, places a substantial burden on both patients and the workforce.[3,4] Expenditures associated with treating low back

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pain are estimated to be greater than $100 billion annually and have been demonstrated to be increasing faster than overall US health care costs.[5] Intervertebral disc disorders are a common cause of low back pain, with a herniated disc affecting an estimated 2% to 3% of the population at any given time.[5-7] Use of first-line conservative management strategies such as analgesic medications, steroid injections, and physical therapy usually results in symptomatic relief in over 90% of patients within 12 weeks of symptom onset.[7-10] While conservative management is often successful, the effectiveness and costs of prolonged use of maximal nonoperative therapy (MNT) in patients demonstrating no early clinical improvement is unclear.[8,11-13]

To this end, the aim of this study was to compare the utilization of conservative treatments in patients with a lumbar intervertebral disc herniation who were successfully managed nonoperatively versus patients who failed conservative therapies and elected to undergo surgery.

Methods

Data Source

The population was obtained from the Humana Ortho (HORTHO) insurance database, which includes over 20.9 million patient lives and encompasses both private/commercially insured and Medicare Advantage beneficiaries with orthopedic diagnoses. Patient records were accessed through a remote computer server maintained by PearlDiver (PearlDiver Technologies, Inc, Colorado Springs, CO). Clinical documents were queried using Current Procedural Terminology (CPT) codes, International Classification of Diseases (ICD) diagnosis and procedure codes, and generic drug codes specific to Humana.

Patient Sample

The base population consisted of adult patients ($\geq$19 years old) with a primary diagnosis of lumbar disc herniation. Patients were subsequently divided into 2 cohorts—a successful conservative therapy cohort and a cohort that failed nonoperative management and opted for surgery. The failed nonoperative treatment population was composed of patients who underwent a primary $\leq$3-level lumbar microdiscectomy procedure from 2007 to 2017. Only patients continuously active within the insurance system for at least 2 years prior to their microdiscectomy operation were included.

The successful nonoperative therapy cohort consisted of patients from the base population who did not undergo microdiscectomy surgery and were continuously active within the insurance system for at least 2 years following their primary lumbar disc herniation diagnosis.

Patients were excluded if they had a previous cervical or lumbar fusion surgery, or had a diagnosis of lumbosacral spinal fracture or malignancy. Both ICD-9 and ICD-10 codes were incorporated for each respective selection/exclusion diagnostic criteria, while CPT codes were utilized for the aforementioned procedures (Appendix A).

Medical Therapies

The use of conservative therapies within the 2 years prior to microdiscectomy surgery in the "failed" treatment group and within 2 years following diagnosis in the "successful" conservative management cohort was documented. Nonoperative treatments included nonsteroidal anti-inflammatory drugs (NSAIDs), opioid medications, muscle relaxants, lumbar epidural steroid injections (LESIs), physical therapy and occupational therapy sessions (PT/OT), and chiropractor treatments. Regarding prescription opioids, only oxycodone hydrochloride, hydrocodone/acetaminophen, and oxycodone/acetaminophen, the most commonly utilized formulations (prescribed in >80% of patients) were queried. Emergency department (ED) visits for which a lumbar disc herniation was recorded as the primary complaint were also collected. All imaging studies involving the lumbar spine including X-rays, computed tomography scans, and magnetic resonance imaging studies were captured. Generic drug codes and CPT codes were used to query medication and procedures use, respectively (Appendix B).

Nonoperative therapy utilization was characterized by average dollars spent ($US per patient), average number of documented prescriptions, and average number of units billed for. A "unit" consists of an individual pill, injection, therapy visit, ED visit, or imaging study. In addition to the averages, the utilization of each conservative treatment was normalized by the number of unique patients utilizing the respective therapy. The term "cost" represents the actual amount paid by insurers.

Baseline Demographics and Comorbidities

Patient demographic information including age, gender, geographical region, and ethnicity was collected. Patient age information was inherently binned into 5-year intervals as a privacy measure. Geographical region associations were to 1 of 4 distinct territories (Midwest, Northeast, South, and West), which are consistent with US Census Bureau guidelines and were derived from the location in which the insurance claim was filed. Additionally, ICD-9 and ICD-10 diagnosis codes were used to collect common patient comorbidities including obesity (body mass index $\geq$30 kg/m^2), type 2 diabetes mellitus, smoking status, atrial fibrillation, history of myocardial infarction, and chronic obstructive pulmonary disease (Appendix C).

Data Analysis

The primary objective was to compare the nonoperative treatment utilization in the cohort successfully managed with conservative treatments with the patients that failed medical management and elected to undergo microdiscectomy

Table 1. Characteristics Comparison of Lumbar Disc Herniation Population: Patients Successfully Treated Nonoperatively and Those That Failed MNT and Opted for Microdiscectomy Surgery, n (%).

Characteristic	Total lumbar disk herniation patients	Successful nonoperative treatment	Failed nonoperative treatment (microdiscectomy)	Failure rate (%)
Total	277 941	269 713	8228	3.0%
Male	120 731 (43.4%)	116 267 (43.1%)	4464 (54.3%)	3.7%
Female	157 210 (56.6%)	153 446 (56.9%)	3764 (45.7%)	2.4%
Geographical region breakdown				
Midwest	61 604 (22.2%)	59 511 (22.1%)	2093 (25.4%)	3.4%
Northeast	6105 (2.2%)	5957 (2.2%)	148 (1.8%)	2.4%
South	183 367 (66.0%)	178 167 (66.1%)	5200 (63.2%)	2.8%
West	26 865 (9.7%)	26 078 (9.7%)	787 (9.6%)	2.9%
Racial breakdown				
White	196 784 (70.8%)	191 716 (71.1%)	5068 (61.6%)	2.6%
Black	23 858 (8.6%)	23 551 (8.7%)	307 (3.7%)	1.3%
Asian	1095 (0.4%)	1070 (0.4%)	25 (0.3%)	2.3%
Hispanic	3948 (1.4%)	3921 (1.5%)	27 (0.3%)	0.7%
North American Native	456 (0.2%)	442 (0.2%)	14 (0.2%)	3.1%
Other	2546 (0.9%)	2487 (0.9%)	59 (0.7%)	2.3%
Unknown	49 254 (17.7%)	46 526 (17.3%)	2728 (33.2%)	5.5%
Preoperative comorbidities				
Obesity (BMI >30)	70 830 (25.5%)	68 933 (25.6%)	1897 (23.1%)	2.7%
Type 2 diabetes mellitus	97 418 (35.0%)	94 826 (35.2%)	2592 (31.5%)	2.7%
Myocardial infarction	6974 (2.5%)	6758 (2.5%)	216 (2.6%)	3.1%
Atrial fibrillation	28 290 (10.2%)	27 671 (10.3%)	619 (7.5%)	2.2%
Smoking	45 437 (16.3%)	43 875 (16.3%)	1562 (19.0%)	3.4%
COPD	32 981 (11.9%)	32 266 (12.0%)	715 (8.7%)	2.2%
Nonoperative therapy use				
NSAIDs	102 660 (36.9%)	98 972 (36.7%)	3688 (44.8%)	3.6%
Opioids	168 755 (60.7%)	162 745 (60.3%)	6010 (73.0%)	3.6%
Muscle relaxants	101 319 (36.5%)	97 255 (36.1%)	4064 (49.4%)	4.0%
LESI	91 456 (32.9%)	87 347 (32.4%)	4109 (49.9%)	4.5%
PT/OT sessions	100 117 (36.0%)	96 711 (35.9%)	3406 (41.4%)	3.4%
Chiropractor visits	43 460 (15.6%)	41 661 (15.4%)	1799 (21.9%)	4.1%
Lumbar spine imaging	118 065 (42.5%)	109 927 (40.8%)	8138 (98.9%)	6.9%
Emergency department visits	1768 (0.6%)	1387 (0.5%)	381 (4.6%)	21.5%

Abbreviations: MNT, maximal nonoperative therapy; BMI, body mass index; COPD, chronic obstructive pulmonary disorder; NSAID, nonsteroidal anti-inflammatory drug; LESI, lumbar epidural steroid injections; PT/OT, physical therapy and occupational therapy.

surgery. Comparisons between categorical parameters were made using χ^2 tests, with P values <.05 considered statistically significant findings. Independent predictors of conservative management failure were determined through a multivariate logistic regression analysis adjusting for patient age (reference: 50-54 years), gender (reference: Females), race (reference: Caucasian), geographic region (reference: Midwest), obesity, diabetes, smoking history, and opioid utilization. All statistical calculations were carried out in R (The R Project for Statistical Computing) within the PearlDiver platform.

Results

Patient Population

A total of 277 941 adult patients diagnosed with a lumbar herniated intervertebral disc comprised the base population. Demographically, there was a greater proportion of females (56.6%) and patients identifying as White (70.8%), Table 1. Geographically, the majority of patients resided in the Southern region (66.0%) followed by the Midwest region (22.2%), Table 1. The most prevalent comorbidities within the base population included diabetes (35.0%), obesity (25.5%), and smoking (16.3%), Table 1.

Failure Rate Comparison

There were 269 713 patients (97.0%) treated successfully with nonoperative management alone, while 8228 patients (3.0%) ultimately failed conservative measures and elected to have surgery, Table 1. High nonoperative therapy failure rates were observed in males (3.7%) and patients from the Midwest region (3.4%), Table 1. Similarly, smokers (3.4%) and patients with a history of myocardial infarction (3.1%) also had high nonoperative therapy failure rates, Table 1.

Table 2. Age Comparison of Lumbar Disc Herniation Population: Patients Successfully Treated Nonoperatively, and Those That Failed MNT and Opted for Microdiscectomy Surgery, n (%).

Age bracket	Total lumbar disc herniation patients	Successful nonoperative treatment	Failed nonoperative treatment (microdiscectomy)	Failure rate (%)
Total Patients	277 941	269 713	8228	3.0%
20 to 24	1113 (0.4%)	1044 (0.4%)	69 (0.8%)	6.2%
25 to 29	2042 (0.7%)	1947 (0.7%)	95 (1.2%)	4.7%
30 to 34	4230 (1.5%)	3980 (1.5%)	250 (3.0%)	5.9%
35 to 39	6667 (2.4%)	6343 (2.4%)	324 (3.9%)	4.9%
40 to 44	10 154 (3.7%)	9735 (3.6%)	419 (5.1%)	4.1%
45 to 49	14 628 (5.3%)	14 104 (5.2%)	524 (6.4%)	3.6%
50 to 54	20 902 (7.5%)	20 283 (7.5%)	619 (7.5%)	3.0%
55 to 59	25 257 (9.1%)	24 522 (9.1%)	735 (8.9%)	2.9%
60 to 64	25 175 (9.1%)	24 489 (9.1%)	686 (8.3%)	2.7%
65 to 69	57 160 (20.6%)	55 913 (20.7%)	1247 (15.2%)	2.2%
70 to 74	48 011 (17.3%)	46 295 (17.2%)	1716 (20.9%)	3.6%
75 to 79	32 141 (11.6%)	31 167 (11.6%)	974 (11.8%)	3.0%
80 to 84	18 757 (6.7%)	18 326 (6.8%)	431 (5.2%)	2.3%
85 to 89	4828 (1.7%)	4742 (1.8%)	86 (1.0%)	1.8%
90 and over	6876 (2.5%)	6823 (2.5%)	53 (0.6%)	0.8%

Abbreviation: MNT, maximal nonoperative therapy.

When assessing nonoperative management failure rates at the individual treatment level, patients utilizing muscle relaxants (4.0%), LESIs (4.5%), and those presenting to the ED for back pain or radiculopathy (21.5%) were associated with the highest conservative therapy failure rates. In fact, the utilization of each of the tracked therapies conferred a greater risk of treatment failure versus the average population failure rate (3.0%), Table 1. Looking at the age distribution, a greater percentage of patients from the surgery cohort (20.4%) were <50 years compared to the successful nonoperative management population (13.8%), Table 2.

Nonoperative Therapy Utilization

Comparing the costs associated with conservative therapies during the 2-year surveillance window, patients who failed nonoperative management billed for nearly double ($1718/patient) compared to patients who were successfully treated ($906/patient), Table 3. In the failed nonoperative management cohort, the greatest contributors to total costs included lumbar spine imaging (44.7%), and LESIs (35.5%), with opioid medications comprising 5.1%, Table 3.

When normalized by patient utilizing each respective therapy, the failed conservative management cohort spent more on LESIs (failed cohort: $1222.89/patient; successful cohort: $1040.73/patient), lumbar spine imaging (failed cohort: $777.26/patient; successful cohort: $384.77/patient), and ED visits (failed cohort: $756.93/patient; successful cohort: $522.79/patient), Table 4.

Predictors of Failed Nonoperative Therapy

In our multivariate regression analysis, male gender (odds ratio [OR]: 1.494 95% confidence interval [CI]: 1.428-1.564) and opioid utilization during the conservative therapy trial (OR: 2.723 95% CI: 2.526-2.939) were independent predictors of nonoperative treatment failure, Table 5. Compared to patients aged 50 to 54, individuals in the age bracket 70 to 74 (OR: 2.245 95% CI: 2.021-2.497) were the most likely age group to fail conservative management, Table 5. On a geographic basis, patients from the South (OR: 0.880 95% CI: 0.834-0.928) or West (OR: 0.886 95% CI: 0.813-0.965) were less likely to fail nonoperative therapies than patients from the Midwest.

Discussion

Herniated intervertebral disc disorders are a primary contributor to low back pain, and have inflicted a considerable cost to our society. While early conservative management strategies have been effective in most patients, the role for long-term utilization of these therapies is unclear. Therefore, we sought to compare the nonoperative therapy utilization in herniated lumbar disc patients successfully managed with nonoperative therapy with those who failed conservative management and opted for microdiscectomy.

In this retrospective study of 277 941 adult patients diagnosed with a herniated lumbar disc, we found that 97.0% were successfully managed nonoperatively, while 3.0% failed MNT and underwent a microdiscectomy procedure. A multivariate regression analysis determined that male gender and opioid utilization during the nonoperative therapy trial were independent predictors of conservative management failure in our cohort. Additionally, a cost analysis indicated that patients who failed nonoperative treatments billed for nearly twice as much compared to patients who were successfully treated (failed cohort: $1718/patient; successful cohort: $906/patient).

Table 3. Successful Versus Failed Nonoperative Therapy Cohort Comparison of Absolute Costs ($US), Prescriptions (Number of Prescriptions), and Units Dispensed (Number of Units) Associated With Conservative Management of Lumbar Disc Herniation, n (%).

Medical therapy	Successful nonoperative treatment	Failed nonoperative treatment (microdiscectomy)
Absolute MNT costs		
NSAIDs	$25 827 831 (10.6%)	$706 931 (5.0%)
Opioids	$47 091 356 (19.3%)	$726 804 (5.1%)
Muscle relaxants	$11 324 214 (4.6%)	$239 221 (1.7%)
LESIs	$90 904 826 (37.2%)	$5 024 874 (35.5%)
PT/OT	$11 207 667 (4.6%)	$351 186 (2.5%)
Chiropractor treatments	$15 057 726 (6.2%)	$472 714 (3.3%)
Lumbar spine imaging	$42 296 391 (17.3%)	$6 325 310 (44.7%)
ED visits[a]	$725 112 (0.3%)	$288 390 (2.0%)
Total costs	$244 435 123	$14 135 430
Absolute number of MNT prescriptions		
NSAIDs	420 276 (10.4%)	12 658 (9.2%)
Opioids	1 459 932 (36.2%)	34 824 (25.3%)
Muscle relaxants	632 552 (15.7%)	14 705 (10.7%)
LESIs	427 752 (10.6%)	19 391 (14.1%)
PT/OT	201 727 (5.0%)	5751 (4.2%)
Chiropractor treatments	583 431 (14.5%)	18 619 (13.5%)
Lumbar spine imaging	306 401 (7.6%)	31 384 (22.8%)
ED visits[a]	1836 (0.0%)	485 (0.4%)
Total prescriptions	4 033 907	137 817
Absolute number of MNT units		
NSAIDs	34 438 043 (16.2%)	948 111 (22.2%)
Opioids	126 223 513 (59.3%)	2 326 432 (54.4%)
Muscle relaxants	50 505 887 (23.7%)	931 982 (21.8%)
LESIs	583 474 (0.3%)	18 685 (0.4%)
PT/OT	197 041 (0.1%)	5459 (0.1%)
Chiropractor treatments	680 260 (0.3%)	17 742 (0.4%)
Lumbar spine imaging	293 465 (0.1%)	29 809 (0.7%)
ED visits[a]	1836 (0.0%)	485 (0.0%)
Total units	212 923 519	4 278 705

Abbreviations: MNT, maximal nonoperative therapy; NSAID, nonsteroidal anti-inflammatory drug; LESI, lumbar epidural steroid injections; PT/OT, physical therapy and occupational therapy; ED, emergency department.

[a]ED prescriptions are synonymous with ED visits.

Our findings are consistent with other studies describing the selection and costs of conservative therapies utilized in the management of this pathology. In a prospective observational study of 1417 patients, Cummins et al assessed the nonoperative medical resources used by patients with degenerative lumbar spine pathologies. Within the cohort diagnosed with a herniated disc (743 patients), greater than 40% had trialed physical therapy, anti-inflammatory medications, opioids, injections, and had been seen by a chiropractor. Moreover, the authors found that patients with a herniated disc were significantly more likely to visit the emergency department, utilize opioids, muscle relaxants, or antidepressants than patients with any other lumbar spine disorder analyzed.[14]

Due to the considerable costs associated with prolonged conservative therapy utilization, determining predictors of nonoperative treatment failure in patients with an intervertebral disc herniation is of significant interest. In a systematic review of 14 studies, Verwoerd et al found evidence that higher baseline leg pain serves as a predictor of surgical management in patients with sciatica. Among other variables analyzed, the results demonstrated no association between age, gender, body mass index, or smoking status with nonoperative treatment prognosis. However, the authors determined that the current body of evidence is clinically, methodologically, and statistically heterogeneous, limiting the ability to identify potential prognostic factors in nonsurgically treated sciatica[15] In our current study of over a 250 000 patients with symptomatic disc herniations, we identified male gender and chronic opioid use as independent predictors of failing nonoperative management and undergoing a microdiscectomy procedure.

While the subset of patients with intervertebral disc herniation who failed medical management in our cohort is low (3.0%), it is important to recognize that the consequences of prolonged trials of MNT are not trivial. A common methodology used to evaluate the value of different treatment modalities is the incremental cost-effectiveness ratio (ICER).[16-18] This ratio is defined as the cost difference between 2 therapies divided by the difference in their efficacy, thus facilitating comparisons between 2 potential interventions on the basis

Table 4. Successful Versus Failed Nonoperative Therapy Cohort Comparison of Normalized Costs ($US per Patient), Prescriptions (Number of Prescriptions per Patient), and Units Dispensed (Number of Units per Patient) Associated With Conservative Management of Lumbar Disc Herniation. Normalization Is by Number of Patient Utilizing Respective Nonoperative Therapy.

Medical therapy	Successful nonoperative treatment	Failed nonoperative treatment (microdiscectomy)
Normalized MNT costs		
NSAIDs	$260.96	$191.68
Opioids	$289.36	$120.93
Muscle relaxants	$116.44	$58.86
LESIs	$1040.73	$1222.89
PT/OT	$115.89	$103.11
Chiropractor treatments	$361.43	$262.76
Lumbar spine imaging	$384.77	$777.26
ED visits[a]	$522.79	$756.93
Normalized number of MNT prescriptions		
NSAIDs	4.2	3.4
Opioids	9.0	5.8
Muscle relaxants	6.5	3.6
LESIs	4.9	4.7
PT/OT	2.1	1.7
Chiropractor treatments	14.0	10.3
Lumbar spine imaging	2.8	3.9
ED visits[a]	1.3	1.3
Normalized number of MNT units		
NSAIDs	348.0	257.1
Opioids	775.6	387.1
Muscle relaxants	519.3	229.3
LESIs	6.7	4.5
PT/OT	2.0	1.6
Chiropractor treatments	16.3	9.9
Lumbar spine imaging	2.7	3.7
ED visits[a]	1.3	1.3

Abbreviations: MNT, maximal nonoperative therapy; NSAID, nonsteroidal anti-inflammatory drug; LESI, lumbar epidural steroid injections; PT/OT, physical therapy and occupational therapy; ED, emergency department.
[a]ED prescriptions are synonymous with ED visits.

Table 5. Logistic Regression Results[a]

Characteristic	OR	CI—2.5%	CI—97.5%
Age			
Age 20-24	1.390	1.057	1.798
Age 25-29	1.029	0.813	1.288
Age 30-34	1.366	1.163	1.599
Age 35-39	1.199	1.037	1.384
Age 40-44	1.147	1.004	1.308
Age 45-49	1.117	0.988	1.263
Age 55-59	1.145	1.023	1.283
Age 60-64	1.253	1.116	1.408
Age 65-69	1.315	1.181	1.466
Age 70-74	2.245	2.021	2.497
Age 75-79	1.907	1.701	2.140
Age 80-84	1.465	1.278	1.679
Age 85-89	1.153	0.902	1.456
Age 90+	0.510	0.378	0.673
Gender			
Male	1.494	1.428	1.564
Race			
Asian	0.950	0.620	1.384
Black	0.553	0.491	0.621
Hispanic	0.309	0.205	0.445
North American Native	1.352	0.754	2.218
Other	0.904	0.684	1.169
Unknown	2.711	2.528	2.908
Geographic region			
Northeast	0.894	0.750	1.057
South	0.880	0.834	0.928
West	0.886	0.813	0.965
Additional regression characteristics			
Obesity (BMI >30)	0.903	0.859	0.949
Type 2 DM	0.842	0.800	0.885
Smoker	1.002	0.949	1.058
Opioid use during conservative therapy	2.723	2.526	2.939

Abbreviations: OR, odds ratio; CI, confidence interval; BMI, body mass index; DM, diabetes mellitus.
[a]Dependent variable—Nonoperative therapy failure (microdisectomy) cohort; Independent variables—Age, gender, race, geographical region, obesity (BMI >30), diabetes, smoker, and opioid use during conservative therapy. Note that age 50-54, female gender, Caucasian race, and Midwest region are used for the multivariate baseline comparison group for age, gender, race, and region, respectively.

of cost per quality-adjusted life-year (QALY) gained.[16] The comparative value of surgical versus long-term nonoperative treatment for a herniated disc has been previously examined. In a 4-year cost-effectiveness analysis comparing surgery to conservative treatment of degenerative lumbar spine conditions, Tosteson et al found that the ICER for discectomy surgery to repair a herniated disc was $20 600/QALY gained relative to nonoperative management over the 4-year period.[17] This is well below the upper limit for high-value interventions in the United States, typically set at $50 000/QALY.[19,20]

Conversely, the comparative effectiveness of different nonoperative therapies versus each other, or to placebo, remains unclear based on a lack of high-quality studies. However, evidence suggests that extended courses of MNT in patients with a herniated disc who do not demonstrate early improvement may be of little value. In a cohort of patients with a lumbar herniated disc who remained symptomatic after 6 weeks of conservative treatment, Parker et al found that continuation of medical management for 2 additional years did not lead to a minimally clinically important difference in any outcome including Numeric Rating Scales for leg or back pain, Oswestry Disability Index, Short Form 12-item physical or mental health surveys, or Zung Self-Rating Depression Scale. The 2-year costs of treatment (direct costs) plus costs due to missed work (indirect costs) averaged $7097 per patient in the herniated disc cohort.[11] Considering the minimal improvement in these patients, this indicates a high ICER for prolonged MNT. Analogous to the aforementioned studies, we found almost a 2-fold costs difference between use of conservative therapies in patients who eventually underwent surgery compared to patients successfully treated nonoperatively. As these surgical patients likely experienced a limited treatment effect from conservative care, this provides further evidence that the ICER for prolonged MNT may be high. Identifying surgical candidates earlier in the treatment process is a potential source of cost-savings and is therefore of interest to both payers and providers.

Limitations

The results and implications of this analysis must be interpreted within the setting of its limitations. The insurance database used to assemble the study population for this investigation is composed solely of Medicare Advantage beneficiaries as well as private/commercially insured patients. Medicaid patients were therefore not captured in our study. Only services billed to an insurance provider were included in our analysis; hence, the utilization metrics reported are likely an underestimate, as over-the-counter medications and therapies omitted from insurance coverage were not included in our study. Additionally, while data within large patient registries is free from many biases inherent to studies where data is collected by the investigators, there have been reports suggesting that errors may exist in these types of databases.[21-23]

Most important, the robust insurance database utilized in this investigation lacks clinical context and individual diagnostic information. This has the potential to affect our results, as it is possible that patients who failed nonoperative management and underwent a microdiscectomy may have had more severe baseline symptoms. It is also likely that our cohorts were biased by patients who were poor surgical candidates and not offered operative management. Specifically, the regression analysis suggests that patients with comorbid obesity or diabetes were more likely to be treated successfully with nonoperative management strategies, when the lumbar spine literature indicates the contrary.[24,25] The more likely explanation behind this observation is the fact that patients with these comorbidities are more prone to infections and less likely to benefit from operative management, and were therefore less likely to be offered surgery in the first place.

Despite the aforementioned limitations, our retrospective study comprising over 270 000 patients identified substantial differences in the utilization patterns and associated costs of nonoperative therapies trialed by patients with a lumbar herniated disc who were successfully treated conservatively versus those who failed nonoperative care and underwent a microdiscectomy surgery.

Conclusion

The results of this study suggest the majority of patients diagnosed with a herniated lumbar disc are successfully managed nonoperatively. However, in the subset of patients that fail conservative management, male gender and prior opioid use are independent predictors of treatment failure.

Appendix A

CPT, ICD-9, and ICD-10 Diagnosis and Procedure Codes for Inclusion and Exclusion Criteria.

Inclusion/exclusion criteria	CPT, ICD-9, and ICD-10 codes
Inclusion diagnosis codes	ICD-9-D: ICD-9-D-72 210, ICD-9-D-72 211 ICD-10-D: ICD-10-D-M5126, ICD-10-D-M5127, ICD-10-D-M5124, ICD-10-D-M5125
Inclusion procedure codes	CPT: CPT-63 030, CPT-63 035
Exclusion diagnosis codes	ICD-9-D: ICD-9-D-8055, ICD-9-D-8056, ICD-9-D-8057, ICD-9-D-8058, ICD-9-D-8059, ICD-9-D-1702, ICD-9-D-1706 ICD-10-D: ICD-10-D-S32009B, ICD-10-D-S3210XA, ICD-10-D-S3210XB, ICD-10-D-S322XXB, ICD-10-D-S322XXA, ICD-10-D-S129XXA, ICD-10-D-S22009A, ICD-10-D-S32009A, ICD-10-D-S3210XA, ICD-10-D-S322XXA, ICD-10-D-S129XXA, ICD-10-D-S22009B, ICD-10-D-S32009B, ICD-10-D-S3210XB, ICD-10-D-S322XXB, ICD-10-D-C412, ICD-10-D-C414
Exclusion procedure codes	CPT: CPT-22 595, CPT-22 600, CPT-22 842, CPT-22 554, CPT-22 630, CPT-22 632, CPT-22 612, CPT-22 614

Abbreviations: CPT, Current Procedural Terminology; ICD, International Classification of Diseases.

Appendix B

Humana Generic Drug Codes and CPT Codes for Preoperative Medical Therapies of Interest.

Inclusion medications	Humana generic drug code
Opioids	GENERIC_DRUG: GENERIC_DRUG-100 055, GENERIC_DRUG-101 802, GENERIC_DRUG-106 030, GENERIC_DRUG-106 414, GENERIC_DRUG-100 504, GENERIC_DRUG-101 215, GENERIC_DRUG-100 548, GENERIC_DRUG-101 126
Nonsteroidal anti-inflammatory drugs	GENERIC_DRUG: GENERIC_DRUG-100 494, GENERIC_DRUG-100 050, GENERIC_DRUG-100 195, GENERIC_DRUG-100 435, GENERIC_DRUG-100 882, GENERIC_DRUG-108 744, GENERIC_DRUG-100 109, GENERIC_DRUG-100 453, GENERIC_DRUG-100 558, GENERIC_DRUG-100 034, GENERIC_DRUG-100 893, GENERIC_DRUG-101 005, GENERIC_DRUG-108 896, GENERIC_DRUG-104 073, GENERIC_DRUG-100 440, GENERIC_DRUG-101 093, GENERIC_DRUG-100 707, GENERIC_DRUG-104 484, GENERIC_DRUG-101 721, GENERIC_DRUG-100 293, GENERIC_DRUG-100 764, GENERIC_DRUG-100 928, GENERIC_DRUG-105 205
Muscle relaxants	GENERIC_DRUG: GENERIC_DRUG-100 716, GENERIC_DRUG-100 541, GENERIC_DRUG-100 347, GENERIC_DRUG-102 033, GENERIC_DRUG-100 028, GENERIC_DRUG-101 474, GENERIC_DRUG-100 183, GENERIC_DRUG-110 360, GENERIC_DRUG-100 892, GENERIC_DRUG-100 944, GENERIC_DRUG-100 785, GENERIC_DRUG-100 417
Lumbar epidural spinal injections	CPT: CPT-62 311, CPT-62 319, CPT-64 483, CPT-64 484
Physical therapy/ occupational therapy	CPT: CPT-4018F, CPT-97 003, CPT-97 004, CPT-G0129, CPT-G8990, CPT-G8991, CPT-G8992, CPT-G8993, CPT-G8994, CPT-G8995, CPT-S9129, CPT-97 001, CPT-97 002, CPT-S8990, CPT-S9131
Chiropractor	CPT: CPT-98 940, CPT-98 941, CPT-98 942
Lumbar spine imaging	CPT: CPT-72 148, CPT-72 149, CPT-72 158, CPT-72 131, CPT-72 132, CPT-72 133, CPT-72 069, CPT-72 080, CPT-72 100, CPT-72 110, CPT-72 114, CPT-72 120, CPT-72 265, CPT-72 270, CPT-72 295

Abbreviation: CPT, Current Procedural Terminology.

Appendix C

ICD-9 and ICD-10 Diagnosis Codes for Baseline Comorbidities.

Comorbidity	Diagnosis codes
Obesity (BMI ≥30)	ICD-9-D: ICD-9-D-V8530, ICD-9-D-V8531, ICD-9-D-V8532, ICD-9-D-V8533, ICD-9-D-V8534, ICD-9-D-V8535, ICD-9-D-V8536, ICD-9-D-V8537, ICD-9-D-V8538, ICD-9-D-V8539, ICD-9-D-V8541, ICD-9-D-V8542, ICD-9-D-V8543, ICD-9-D-V8544, ICD-9-D-V8545, ICD-9-D-27 800, ICD-9-D-27 801
	ICD-10-D: ICD-10-D-Z6830, ICD-10-D-Z6831, ICD-10-D-Z6832, ICD-10-D-Z6833, ICD-10-D-Z6834, ICD-10-D-Z6835, ICD-10-D-Z6836, ICD-10-D-Z6837, ICD-10-D-Z6838, ICD-10-D-Z6839, ICD-10-D-Z6841, ICD-10-D-Z6842, ICD-10-D-Z6843, ICD-10-D-Z6844, ICD-10-D-Z6845, ICD-10-D-E6601, ICD-10-D-E6609, ICD-10-D-E668, ICD-10-D-E669
Type 2 diabetes mellitus	ICD-9-D: ICD-9-D-24 900, ICD-9-D-24 901, ICD-9-D-24 910, ICD-9-D-24 911, ICD-9-D-24 920, ICD-9-D-24 921, ICD-9-D-24 930, ICD-9-D-24 931, ICD-9-D-24 940, ICD-9-D-24 941, ICD-9-D-24 950, ICD-9-D-24 951, ICD-9-D-24 960, ICD-9-D-24 961, ICD-9-D-24 970, ICD-9-D-24 971, ICD-9-D-24 980, ICD-9-D-24 981, ICD-9-D-24 990, ICD-9-D-24 991, ICD-9-D-25 000, ICD-9-D-25 001, ICD-9-D-25 002, ICD-9-D-25 003, ICD-9-D-25 010, ICD-9-D-25 011, ICD-9-D-25 012, ICD-9-D-25 013, ICD-9-D-25 020, ICD-9-D-25 021, ICD-9-D-25 022, ICD-9-D-25 023, ICD-9-D-25 030, ICD-9-D-25 031, ICD-9-D-25 032, ICD-9-D-25 033, ICD-9-D-25 040, ICD-9-D-25 041, ICD-9-D-25 042, ICD-9-D-25 043, ICD-9-D-25 050, ICD-9-D-25 051, ICD-9-D-25 052, ICD-9-D-25 053, ICD-9-D-25 060, ICD-9-D-25 061, ICD-9-D-25 062, ICD-9-D-25 063, ICD-9-D-25 070, ICD-9-D-25 071, ICD-9-D-25 072, ICD-9-D-25 073, ICD-9-D-25 080, ICD-9-D-25 081, ICD-9-D-25 082, ICD-9-D-25 083, ICD-9-D-25 090, ICD-9-D-25 091, ICD-9-D-25 092, ICD-9-D-25 093, ICD-9-D-3572
	ICD-10-D: ICD-10-D-E0800, ICD-10-D-E0801, ICD-10-D-E0810, ICD-10-D-E0811, ICD-10-D-E0821, ICD-10-D-E0822, ICD-10-D-E0829, ICD-10-D-E08311, ICD-10-D-E08319, ICD-10-D-E08321, ICD-10-D-E08329, ICD-10-D-E08331, ICD-10-D-E08339, ICD-10-D-E08341, ICD-10-D-E08349, ICD-10-D-E08351, ICD-10-D-E08359, ICD-10-D-E0836, ICD-10-D-E0839, ICD-10-D-E0840, ICD-10-D-E0841, ICD-10-D-E0842, ICD-10-D-E0843, ICD-10-D-E0844, ICD-10-D-E0849, ICD-10-D-E0851, ICD-10-D-E0852, ICD-10-D-E0859, ICD-10-D-E08610, ICD-10-D-E08618, ICD-10-D-E08620, ICD-10-D-E08621, ICD-10-D-E08622, ICD-10-D-E08628, ICD-10-D-E08630, ICD-10-D-E08638, ICD-10-D-E08641, ICD-10-D-E08649, ICD-10-D-E0865, ICD-10-D-E0869, ICD-10-D-E088, ICD-10-D-E089, ICD-10-D-E1010, ICD-10-D-E1011, ICD-10-D-E1021, ICD-10-D-E1022, ICD-10-D-E1029, ICD-10-D-E10311, ICD-10-D-E10319, ICD-10-D-E10321, ICD-10-D-E10329, ICD-10-D-E10331, ICD-10-D-E10339, ICD-10-D-E10341, ICD-10-D-

(continued)

Appendix C. (continued)

Comorbidity	Diagnosis codes
	E10349, ICD-10-D-E10351, ICD-10-D-E10359, ICD-10-D-E1036, ICD-10-D-E1039, ICD-10-D-E1040, ICD-10-D-E1041, ICD-10-D-E1042, ICD-10-D-E1043, ICD-10-D-E1044, ICD-10-D-E1049, ICD-10-D-E1051, ICD-10-D-E1052, ICD-10-D-E1059, ICD-10-D-E10610, ICD-10-D-E10618, ICD-10-D-E10620, ICD-10-D-E10621, ICD-10-D-E10622, ICD-10-D-E10628, ICD-10-D-E10630, ICD-10-D-E10638, ICD-10-D-E10641, ICD-10-D-E10649, ICD-10-D-E1065, ICD-10-D-E1069, ICD-10-D-E108, ICD-10-D-E109, ICD-10-D-E1100, ICD-10-D-E1101, ICD-10-D-E1121, ICD-10-D-E1122, ICD-10-D-E1129, ICD-10-D-E11311, ICD-10-D-E11319, ICD-10-D-E11321, ICD-10-D-E11329, ICD-10-D-E11331, ICD-10-D-E11339, ICD-10-D-E11341, ICD-10-D-E11349, ICD-10-D-E11351, ICD-10-D-E11359, ICD-10-D-E1136, ICD-10-D-E1139, ICD-10-D-E1140, ICD-10-D-E1141, ICD-10-D-E1142, ICD-10-D-E1143, ICD-10-D-E1144, ICD-10-D-E1149, ICD-10-D-E1151, ICD-10-D-E1152, ICD-10-D-E1159, ICD-10-D-E11610, ICD-10-D-E11618, ICD-10-D-E11620, ICD-10-D-E11621, ICD-10-D-E11622, ICD-10-D-E11628, ICD-10-D-E11630, ICD-10-D-E11638, ICD-10-D-E11641, ICD-10-D-E11649, ICD-10-D-E1165, ICD-10-D-E1169, ICD-10-D-E118, ICD-10-D-E119, ICD-10-D-E1300, ICD-10-D-E1301, ICD-10-D-E1310, ICD-10-D-E1311, ICD-10-D-E1321, ICD-10-D-E1322, ICD-10-D-E1329, ICD-10-D-E13311, ICD-10-D-E13319, ICD-10-D-E13321, ICD-10-D-E13329, ICD-10-D-E13331, ICD-10-D-E13339, ICD-10-D-E13341, ICD-10-D-E13349, ICD-10-D-E13351, ICD-10-D-E13359, ICD-10-D-E1336, ICD-10-D-E1339, ICD-10-D-E1340, ICD-10-D-E1341, ICD-10-D-E1342, ICD-10-D-E1343, ICD-10-D-E1344, ICD-10-D-E1349, ICD-10-D-E1351, ICD-10-D-E1352, ICD-10-D-E1359, ICD-10-D-E13610, ICD-10-D-E13618, ICD-10-D-E13620, ICD-10-D-E13621, ICD-10-D-E13622, ICD-10-D-E13628, ICD-10-D-E13630, ICD-10-D-E13638, ICD-10-D-E13641, ICD-10-D-E13649, ICD-10-D-E1365, ICD-10-D E1369, ICD-10-D-E138, ICD-10-D-E139
Myocardial infarction	ICD-9-D: ICD-9-D-41 000, ICD-9-D-41 001, ICD-9-D-41 002, ICD-9-D-41 010, ICD-9-D-41 011, ICD-9-D-41 012, ICD-9-D-41 020, ICD-9-D-41 021, ICD-9-D-41 022, ICD-9-D-41 030, ICD-9-D-41 031, ICD-9-D-41 032, ICD-9-D-41 040, ICD-9-D-41 041, ICD-9-D-41 042, ICD-9-D-41 050, ICD-9-D-41 051, ICD-9-D-41 052, ICD-9-D-41 080, ICD-9-D-41 081, ICD-9-D-41 082, ICD-9-D-41 090, ICD-9-D-41 091, ICD-9-D-41 092, ICD-9-D-41 181 ICD-10-D: ICD-10-D-I2101, ICD-10-D-I2102, ICD-10-D-I2109, ICD-10-D-I2111, ICD-10-D-I2119, ICD-10-D-I2121, ICD-10-D-I2129, ICD-10-D-I213, ICD-10-D-I214, ICD-10-D-I220, ICD-10-D-I221, ICD-10-D-I222, ICD-10-D-I228, ICD-10-D-I229, ICD-10-D-I230, ICD-10-D-I231, ICD-10-D-I232, ICD-10-D-I233, ICD-10-D-I234, ICD-10-D-I235, ICD-10-D-I236
Atrial fibrillation	ICD-9-D: ICD-9-D-42 731 ICD-10-D: ICD-10-D-I480, ICD-10-D-I481, ICD-10-D-I482, ICD-10-D-I4891
Smoking	ICD-9-D: ICD-9-D-3051 ICD-10-D: ICD-10-D-Z720
COPD	ICD-9-D: ICD-9-D-49 120, ICD-9-D-49 121, ICD-9-D-49 122, ICD-9-D-49 320, ICD-9-D-49 321, ICD-9-D-49 322 ICD-10-D: ICD-10-D-J440, ICD-10-D-J441, ICD-10-D-J449

Abbreviations: CPT, Current Procedural Terminology; ICD, International Classification of Diseases; BMI, body mass index; COPD, chronic obstructive pulmonary disease.

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