Operative and Nonoperative Treatment Approaches for Lumbar Degenerative Disc Disease Have Similar Long-Term Clinical Outcomes Among Patients with Positive Discography

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Key words
- Degenerative disc disease
- Discogram
- Discography
- Fusion
- Lumbar
- Outcomes
- Spine
- Surgery

Abbreviations and Acronyms
- BMI: Body mass index
- DDD: Degenerative disc disease
- HRQOL: Health-related quality of life
- MCS: Mental component score
- MRI: Magnetic resonance imaging
- NRS: Numerical rating scale
- ODI: Oswestry disability index
- PCS: Physical component score
- SF-12: Short form-12

OBJECTIVE: It remains unclear whether fusion for lumbar degenerative disc disease with positive discography produces better outcomes compared with nonoperative treatment. The aim of this study was to compare outcomes of patients with discography-concordant lumbar degenerative disc disease electing for fusion versus nonoperative treatment.

METHODS: We retrospectively reviewed consecutive patients with back pain and concordant lumbar discogram who were offered fusion. Follow-up questionnaires included pain score, Oswestry disability index, short form-12, and satisfaction scale. Patients were stratified based on whether they elected for fusion or nonoperative treatment.

RESULTS: Overall follow-up was 48% (96/200). Patients lacking follow-up were slightly older ($P = 0.021$) and less likely to be smokers ($P = 0.013$). Between patients with and without follow-up, there were no significant differences in pain score at initial visit, body mass index, or gender ($P \geq 0.40$). The 96 patients for whom follow-up was obtained included 53 in the operative and 43 in the nonoperative groups. At baseline, there were no significant differences between these groups based on age, pain score, body mass index, smoking, or gender ($P \geq 0.25$). Mean follow-up was 63 months for operative and 58 months for nonoperative patients ($P = 0.20$). The mean pain score at last follow-up improved significantly for operative and nonoperative patients ($P < 0.001$). At follow-up, operative and nonoperative groups did not differ significantly with regard to pain scores, Oswestry disability index, short form-12, or satisfaction scale.

CONCLUSIONS: Comparison of long-term outcomes for patients with back pain and concordant discography did not demonstrate a significant difference in outcome measures of pain, health status, satisfaction, or disability based on whether the patient elected for fusion or nonoperative treatment.

INTRODUCTION

Chronic back pain, with an annual prevalence of 15%–45%, results in enormous health-related expenditure without a consistent improvement in physical, mental, and functional health-related outcomes (32). Chronic low back pain has been attributed to degenerative disc disease (DDD) in a subset of patients, and provocative discography has been proposed as a decision-making guide to better select patients who could potentially benefit from interventional/surgical procedures for relief of back pain thought to be secondary to DDD (31). Discography involves injection of a “contrast” material into the disc space to provide information on disk morphology and to assess whether the injection elicits a “provoked” pain response. Although morphologic alterations may be readily appreciated on discography, their presence alone does not necessarily implicate the disc as a pain generator (1, 31, 33). As a result, considerable importance is given to the provoked pain response, which, when reported by the patient to be similar to their symptomatic pain, is considered as evidence of a symptomatic disk. There is extensive debate in the spine literature with regard to discography, with some of the major concerns being a high false-positive rate of the provoked pain response in asymptomatic and symptomatic individuals (5, 7, 8, 24, 40, 52). However, a recent meta-analysis of false-positive studies using the International Spine Intervention Society standard suggested that discography has a specificity of 0.94, after setting certain patient selection criteria (52).
Multiple studies have tried to determine the correlation between discography results and treatment outcomes (9, 10, 20, 26, 30, 37, 46, 51). The results have been inconsistent, with variable outcomes regarding pain, functionality, and quality of life. The question whether surgery should be performed for back pain relief for those with a positive discogram still remains without a clear answer. Some investigators recommend surgical intervention after a positive discogram only for patients who also have associated abnormal magnetic resonance imaging (MRI) findings (37-39). The controversy is further compounded by recent translational and clinical evidence documenting damage and progression of disc degeneration as a result of dye injection as part of the discography procedure (6, 21, 22, 25).

Interpretation of evidence regarding efficacy of presurgical discography becomes difficult with divergent views among various investigators.

Our objective in the present study was to assess the long-term clinical outcomes of patients with a positive, concordant lumbar discogram who were offered spinal fusion and either accepted or declined this surgical treatment. Our hypothesis was that, compared with the patients electing for nonoperative treatment, the patients treated with lumbar fusion would have better health-related quality of life (HRQOL) and satisfaction scores at long-term follow-up.

METHODS

This study was a retrospective review of consecutive patients who were referred for a diagnostic lumbar discography procedure between 2003 and 2009 at a single institution (Thomas Jefferson University, Philadelphia, Pennsylvania, USA). Inclusion criteria for the present study were symptoms of axial low back pain, attempted conservative therapy for a minimum of 6 weeks, and a one level or a two adjacent level positive discogram that was concordant with lumbar DDD based on MRI. All patients expressed interest in surgery and felt to be surgical candidates before obtaining discography. Patients presenting with discogenic back pain along with other surgical indications (e.g., spondylolisthesis, tumor, infection, and stenosis, and patients who had undergone previous lumbar decompression/discectomy or a previous lumbar fusion) were excluded. In general, a discogram was ordered after documentation of abnormal MRI findings, and surgery (instrumented lumbar fusion) was subsequently offered to those who had a one level or a two adjacent level positive discogram that was concordant with lumbar DDD based on MRI scans. Patients who declined surgical intervention were generally offered nonoperative treatment modalities, including physical therapy, epidural injections, and medications. Before study initiation, internal review board approval was obtained through Thomas Jefferson University Medical Center.

For patients meeting inclusion criteria, medical records from initial presentation were reviewed, and extracted information included patient age, gender, body mass index (BMI), smoking status, surgical dates if surgery was performed, and baseline back pain numerical rating scale (NRS) score. The NRS score ranged from 0 to 10, with 0 representing no pain and 10 representing the most unbearable pain. This information was collected as part of the standard medical record.

For the present study, patients were contacted by telephone and/or mail and asked to complete disability and functionality questionnaires including Oswestry disability index (ODI) (18), satisfaction scale (14, 29), and the short-form-12 (SF-12) surveys (48). Patients who provided incomplete information, denied a telephone interview, or could not be contacted were not included in the present study. Baseline parameters were compared between patients for whom follow-up was achieved and those for whom follow-up could not be obtained to assess for potential confounding factors related to follow-up.

The satisfaction scale includes six questions regarding satisfaction with the overall result of the back operation, including pain relief, walking ability, ability to do housework or employment, and strength in the lower extremities and steadiness in an upright posture (14, 29). These questions are each scored on a 4-point scale: 1 (very satisfied), 2 (somewhat satisfied), 3 (somewhat dissatisfied), and 4 (very dissatisfied). The satisfaction scale score is obtained by summing the score for each answered question and dividing by the number of answered questions. Thus, the final score can range from one to four.

Baseline demographics and NRS pain scores, as well as outcomes scores at follow-up, were compared between the patients treated with lumbar fusion versus those who declined surgical treatment. Because patients who initially declined surgical treatment could subsequently elect for surgical treatment, we chose to analyze the data using two different approaches. For the first data analysis approach, patients were classified into the operative and nonoperative groups based on the initial management plan; specifically, patients were classified as operative only if they underwent lumbar fusion within 6 months of the initial evaluation and discography. All other patients were classified into the nonoperative group, including those who elected for lumbar fusion more than 6 months after initial evaluation. For the second data analysis approach, patients were classified into the operative group if they were treated with lumbar fusion at any point between the time of initial evaluation and the time of last follow-up. Only patients who had not undergone lumbar fusion as of the time of last follow-up were classified into the nonoperative group.

Statistical Analysis

Frequency distributions and summary statistics were calculated for all clinical, operative, and radiographic variables. For categorical variables, cross-tabulations were generated, and the Fisher’s exact or Pearson χ² test was used to compare distributions. For continuous variables, t-tests were used to investigate differences between subsets of patients classified by categorical data. Multiple regression analyses were performed using each of the outcomes measures (NRS pain score, ODI, SF-12 mental component score [MCS], SF-12 physical component score [PCS], and satisfaction score) as a dependent variable and patient demographic and clinical parameters as independent variables. Statistical tests were two-sided, and P < 0.05 was considered statistically significant. All data recorded were analyzed by R version 2.15.2 software (R Foundation for Statistical Computing, Vienna, Austria; available at: http://www.r-project.org/).
RESULTS

Baseline Comparisons Between the Patient Groups with and without Follow-Up

A total of 200 patients were identified who met baseline inclusion criteria and were offered surgical treatment (lumbar fusion). Of these 200 patients, follow-up was obtained for 96 (48%), including 53 (55%) of the 96 total patients treated with lumbar fusion and 43 (41%) of the total 104 patients in the nonoperative group (based on initial management plan). Compared with patients for whom follow-up could not be obtained, those with follow-up were slightly older (mean age, 47.1 years vs. 43.9 years; \(P = 0.021\)) (Table 1) and were less likely to be smokers (28.1% vs. 45.2%; \(P = 0.013\)). The patients with and without follow-up did not differ significantly with regard to NRS pain score at initial visit (\(P = 0.62\)), BMI (\(P = 0.05\)), proportion with single-level versus two-level positive discogram (\(P = 1.0\)), or gender (\(P = 0.40\)) (Table 1).

Baseline Comparison Between Operative and Nonoperative Patients with Follow-Up

Based on initial management approach, the 96 patients for whom follow-up was obtained included 53 (55%) in the operative group and 43 (45%) in the nonoperative group. At baseline, there were no significant differences identified between the two groups with regard to age, NRS pain score, BMI, proportion with single level versus two-level positive discogram, smoking, or gender (Table 2). In each group, the mean age at baseline was 47 years, the mean pain score was approximately 8 of 10, and approximately 50% of the patients were men.

Clinical Outcomes Comparisons Between Operative and Nonoperative Patients

The mean length of follow-up obtained was 63 months (standard deviation, 21 months; range, 26–111 months) for the 53 operative patients and was 58 months (standard deviation, 19 months; range, 30–100 months) for the 43 nonoperative patients. The length of follow-up between these groups did not differ significantly (\(P = 0.20\)). Compared with baseline values, the mean NRS pain score at last follow-up improved significantly for both the operative patients (7.8–3.6; \(P < 0.001\)) and the nonoperative patients (8.0–4.4; \(P < 0.001\)). At follow-up, the operative and nonoperative patient groups did not differ significantly with regard to NRS pain scores (\(P = 0.29\)), ODI (\(P = 0.80\)), satisfaction scale (\(P = 0.08\)), SF-12 PCS (\(P = 0.22\)), or SF-12 MCS (\(P = 0.25\)) (Table 3).

Separate multiple regression analyses were performed with each of the outcome measures assessed at follow-up serving as a dependent variable and baseline demographic and clinical parameters as explanatory variables (Table 4). Smoking demonstrated a significant negative impact on ODI, SF-12 MCS, SF-12 PCS, and the satisfaction scale, and higher BMI had a significant negative impact on the satisfaction scale score. Notably, whether patients underwent lumbar fusion or pursued nonoperative care was not a significant factor for any of the outcome measures. The remaining parameters, including age, gender, one-level versus two-level positive discography, baseline NRS pain score, and length of follow-up, were also not significant explanatory factors for any of the outcome measures (Table 4). Not only were they not statistically significant, but also the confidence interval for each parameter indicates values too small to have clinical impact.

Analyses Accounting for Patients Who Sought Delayed Lumbar Fusion

Of the 43 patients who elected for nonoperative treatment at baseline and did not undergo lumbar fusion within 6 months of initial evaluation and discography, 15 (35%) ultimately underwent lumbar fusion at some point between 6 months after initial evaluation and last follow-up. The mean length of time between initial evaluation and lumbar fusion for these 15 patients was 18 months (range, 6–47 months). To assess whether these 15 patients, who converted to operative care, impacted the outcomes comparisons between the operative and nonoperative patient groups, all analyses were repeated with the operated patients redefined as patients treated with lumbar fusion at any point between the time of initial evaluation and last follow-up. In essence, this transferred the 15 patients who converted from nonoperative to operative care into the operative treatment group.

The resulting operative (\(n = 68\)) and nonoperative (\(n = 28\)) treatment groups did not significantly differ at baseline with regard to the parameters listed in Table 2, except for a modest but significant difference in the percentage of men in the operative (67.9%) compared with the nonoperative (42.6%) groups (\(P = 0.042\)). At follow-up the operative and nonoperative groups did not differ significantly with regard to NRS pain score (\(P = 0.25\)), ODI (\(P = 0.97\)), satisfaction scale (\(P = 0.10\)), SF-12 PCS (\(P = 0.41\)), or SF-12 MCS (\(P = 0.43\)). Multiple regression analyses demonstrated the same significant explanatory factors for each outcomes measure as those shown in Table 4.

DISCUSSION

Discography was first introduced by Lindblom (28) as an imaging procedure to

| Table 1. Demographic Variables and Baseline Pain Scores for the Entire Cohort of 200 Patients with Low Back Pain and a Positive Lumbar Discogram, Stratified Based on Whether Follow-Up Was Obtained |
|---|---|---|---|---|---|
| Follow-Up | Value | Mean (SD) | Number of Patients (%) | P | 
| Age (years) | No (n = 104) | Yes (n = 96) | 43.9 (9.9) | 47.1 (9.4) | 0.021 |
| NRS pain score at initial visit | No (n = 104) | Yes (n = 96) | 8.0 (1.1) | 7.9 (1.0) | 0.62 |
| BMI | No (n = 104) | Yes (n = 96) | 28.3 (5.0) | 28.2 (5.7) | 0.95 |
| Single-level positive discogram* | No (n = 104) | Yes (n = 96) | 44 (42.3) | 41 (42.7) | 1.0 |
| Smokers | No (n = 104) | Yes (n = 96) | 47 (45.2) | 27 (28.1) | 0.013 |
| Number of men | No (n = 104) | Yes (n = 96) | 59 (56.7) | 48 (50) | 0.40 |

NRS pain score ranges from 0 to 10, with 0 representing no pain and 10 representing the most unbearable pain. SD, standard deviation; NRS, numeric rating scale; BMI, body mass index.

*Remaining patients had a positive discogram at two adjacent levels.
Table 2. Demographic Variables and Baseline Pain Scores for the 96 Patients with Low Back Pain and Positive Discogram for Whom Follow-Up Was Obtained, Stratified Based on Whether or Not Lumbar Fusion Was Performed as Part of Initial Management Plan (within 6 months of positive discogram)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of Patients</th>
<th>Mean (SD) or Number of Patients (%)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonoperative</td>
<td>43</td>
<td>47.3 (10.0)</td>
<td>0.87</td>
</tr>
<tr>
<td>Operative</td>
<td>53</td>
<td>47.0 (8.9)</td>
<td></td>
</tr>
<tr>
<td>NRS pain score at initial visit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonoperative</td>
<td>43</td>
<td>8.0 (1.2)</td>
<td>0.41</td>
</tr>
<tr>
<td>Operative</td>
<td>53</td>
<td>7.8 (0.9)</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonoperative</td>
<td>43</td>
<td>27.9 (6.6)</td>
<td>0.64</td>
</tr>
<tr>
<td>Operative</td>
<td>53</td>
<td>28.5 (4.9)</td>
<td></td>
</tr>
<tr>
<td>Single-level positive discogram*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonoperative</td>
<td>43</td>
<td>17 (39.5%)</td>
<td>0.88</td>
</tr>
<tr>
<td>Operative</td>
<td>53</td>
<td>24 (45.3%)</td>
<td></td>
</tr>
<tr>
<td>Smokers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonoperative</td>
<td>43</td>
<td>15 (34.9%)</td>
<td>0.25</td>
</tr>
<tr>
<td>Operative</td>
<td>53</td>
<td>12 (22.6%)</td>
<td></td>
</tr>
<tr>
<td>Number of men</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonoperative</td>
<td>43</td>
<td>23 (53.5%)</td>
<td>0.68</td>
</tr>
<tr>
<td>Operative</td>
<td>53</td>
<td>25 (47.2%)</td>
<td></td>
</tr>
</tbody>
</table>

NRS pain score ranges from 0 to 10, with 0 representing no pain and 10 representing the most unbearable pain. SD, standard deviation; NRS, numeric rating scale; BMI, body mass index.

*Remaining patients had a positive discogram at two adjacent levels.

Table 3. Comparison of Clinical Outcome Measures at Follow-Up Between Operative and Nonoperative Groups, with the Operative Group Defined as Those Treated with Lumbar Fusion Performed as Part of Initial Management Plan (within 6 months of positive discogram)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of Patients</th>
<th>Mean (SD) or Number of Patients (%)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRS pain score at follow-up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonoperative</td>
<td>43</td>
<td>4.4 (2.7)</td>
<td>0.29</td>
</tr>
<tr>
<td>Operative</td>
<td>53</td>
<td>3.6 (3.0)</td>
<td></td>
</tr>
<tr>
<td>Oswestry disability index</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonoperative</td>
<td>43</td>
<td>34.2 (19.3)</td>
<td>0.80</td>
</tr>
<tr>
<td>Operative</td>
<td>53</td>
<td>35.3 (25.5)</td>
<td></td>
</tr>
<tr>
<td>Satisfaction scale (1—4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonoperative</td>
<td>43</td>
<td>2.3 (0.9)</td>
<td>0.08</td>
</tr>
<tr>
<td>Operative</td>
<td>53</td>
<td>1.9 (1.0)</td>
<td></td>
</tr>
<tr>
<td>SF-12 PCS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonoperative</td>
<td>43</td>
<td>43.8 (7.1)</td>
<td>0.22</td>
</tr>
<tr>
<td>Operative</td>
<td>53</td>
<td>45.7 (8.0)</td>
<td></td>
</tr>
<tr>
<td>SF-12 MCS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonoperative</td>
<td>43</td>
<td>48.7 (9.9)</td>
<td>0.25</td>
</tr>
<tr>
<td>Operative</td>
<td>53</td>
<td>46.1 (11.9)</td>
<td></td>
</tr>
</tbody>
</table>

Pain score ranges from 0 to 10, with 0 representing no pain and 10 representing the most unbearable pain. SD, standard deviation; NRS, numeric rating scale; SF, Short Form; PCS, physical component score; MCS, mental component score.

visualize the herniated nucleus pulposus in the 1940s. At present, discography is used by some physicians as a diagnostic test to help determine whether a patient with back pain with degenerative disk disease may be a candidate for surgical intervention. According to Derby et al. (12), a positive discogram is determined by the following criteria: a pain severity more than 6/10, which is concordant with the patient’s presenting pain, a pressure limit of less than 50 psi, a grade 3 annular tear, and a control disc with pain severity less than 6/10. All patients in our study met these defined criteria and were offered surgery for their discogenic pain. The results of our study demonstrate significantly improved pain scores at follow-up for both the operative and nonoperative treatment groups and do not demonstrate a significant difference for standardized outcomes measures of pain, generalized health status, satisfaction, or disability between the two groups. Collectively, these findings do not support our initial hypothesis, which compared with the patients electing for nonoperative treatment the patients treated with lumbar fusion would have better HRQOL and satisfaction scores at long-term follow-up.

It is important to appropriately interpret and apply the findings of the present study as these data only reflect lumbar fusion for DDD. Spinal fusion is commonly used to treat several other conditions, including traumatic spinal injuries, spondylolisthesis, spinal deformities, spine tumors, and spinal instability created by the need for aggressive bony decompression. The present study does not apply to these conditions, and many other reports address the application and effectiveness of spinal fusion for these conditions (3, 4, 11, 35, 42–45, 49, 50, 53).

Treatment options for low back pain that is attributed to DDD are varied and may include physical therapy, epidural injections, intradiscal electrothermal therapy, nucleoplasty, and surgery. However, each of these treatments has mixed results reported in the literature, with inconclusive evidence regarding functional outcomes. A systematic review of five randomized controlled trials comparing lumbar fusion surgery to nonoperative care for low back pain demonstrated that fusion may not be more effective than a structured rehabilitation program (17, 34). Surgical management also comes with associated risk such as junctional degeneration (17), pseudarthrosis, and need for reoperation (15).

Clinical utility of a positive discogram is a controversial topic. Multiple studies have
examined the role of surgery for patients with discogram-concordant pain. In a study conducted by Colhoun et al.\(^\text{[10]}\), the surgical outcomes of patients who had surgery after a discogram were assessed. Of the 137 patients who had a positive discogram, they reported that 99% had a sustained and significant benefit after surgical treatment. In contrast, among the 25 patients who did not have provocation of symptoms during the discogram, only 52% had a sustained and significant benefit after surgical treatment. Another study determined surgery for discogram-positive back pain to have satisfactory outcomes if associated with a solid artherososis\(^\text{[51]}\). Knox and Chapman\(^\text{[26]}\) reported that a single-level anterior lumbar interbody fusion, when performed for discogenic back pain, only improved outcomes in 53% of the patients. In another study that compared patients who underwent surgery for discogenic back pain, with and without a presurgical screening discography, there was no significant difference in the degree of improvement in ODI scores between the groups\(^\text{[30]}\).

In a retrospective study, Smith et al.\(^\text{[46]}\) assessed outcomes of patients with documented single-level discogenic pain with a positive discogram who were considered candidates for surgery but chose conservative therapy and reported improvements in pain and disability scores in 60% of these patients at a mean follow-up of 4.9 years. This latter study is consistent with the present study, in which patients with a positive discogram who elected for nonsurgical treatment also experienced, on average, significant clinical improvement at long-term follow-up.

There have also been studies indicating that this procedure could potentially harm the patient. Studies have suggested that discography can cause accelerated disc degeneration. For example, Gruber et al.\(^\text{[23]}\) demonstrated that the radiocontrast dye used for discography may have deleterious effects affecting viability of human disc cells.

Multivariate analyses in the present study suggest that smoking significantly negatively impacts HRQOL as assessed by ODI, SF-12 MCS, SF-12 PCS, and satisfaction scale score. This is consistent with previous studies in which smoking has been linked to poorer surgical outcomes for cervical spine procedures\(^\text{[36]}\) and for lumbar spinal procedures\(^\text{[13, 27, 41, 45, 47]}\), including instrumented and non-instrumented. In addition, in the present study, increased BMI was associated with poorer satisfaction scale scores, but was not significantly associated with other outcome measures, including NRS pain score, ODI, SF-12 MCS, or SF-12 PCS. This is consistent with previous studies suggesting that obese patients, surgically treated for degenerative lumbar disease, do not have poorer pain, disability and general health outcomes compared with nonobese patients\(^\text{[2, 16, 19]}\), but contrasts with the study of Gepstein et al.\(^\text{[19]}\), in which patient satisfaction was assessed and did not appear to be impacted by obesity. Smith et al.\(^\text{[45]}\) reported on factors that distinguished between the best and worst outcomes for adult spinal deformity surgery, and among the few factors that distinguished these groups were smoking and BMI.

The primary limitations of the present study include the retrospective design and the modest follow-up rate of approximately 59%. However, except for a modest difference in mean patient age and

differences in smoking rates, the patient groups for which follow-up was and was not achieved were similar. Because this was a retrospective evaluation, there were no preoperative ODI or SF-12 scores available, but the baseline NRS pain scores suggest that the operative and nonoperative groups had similar preoperative pain levels. In addition, although the operative and nonoperative patients demonstrated similar outcomes measures at last follow-up, our data do not permit assessment of the time course over which these improvements occurred. It is possible that patients in either the operative or nonoperative groups may have achieved improvement faster.

A key strength of the present study is that all patients were evaluated and cared for by the same physiatrist. In addition, analyses were performed using two approaches (with patients grouped based on initial operative versus nonoperative management plan and with patients grouped based on whether surgery was or was not performed at any point before the last follow-up).

CONCLUSIONS

The present study provides comparison of long-term outcomes for patients with low back pain and a positive concordant discography and who either elected for or against lumbar fusion. The results of our study demonstrate significantly improved pain scores at follow-up for the operative and nonoperative treatment groups and do not demonstrate a significant difference for standardized outcome measures of pain, generalized health status, satisfaction, or disability. Collectively, these findings do not support our initial hypothesis comparing the patients electing for nonoperative treatment and the patients treated with lumbar fusion, which group would have better HRQOL and satisfaction scores at long-term follow-up.

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 Conflict of interest statement: Approval for the present study was obtained through the institutional review board of Thomas Jefferson University. Justin S. Smith is a consultant for Medtronic, Biomet, Globus; received honoraria for teaching Medtronic, Biomet; Research study group support: Depuy. Christopher Shaffrey is a consultant, patent for Biomet; received royalties, patent from Medtronic; is a consultant for Depuy; got grant funding from NH and DOD. Alexander Vaccaro received Health Care Entity Relationships and Investments from the following companies: Replication Therapy / Stock / Stock Option Ownership Interests; DePuy / Receipt of Royalty Payments; Medtronic / Receipt of Royalty Payments; Stryker Spin / Receipt of Royalty Payments; Institutional / Educational Grant; Biomet Spin / Receipt of Royalty Payments; Globus / Receipt of Royalty Payments; Stock / Stock Option Ownership Interests; K-2 Medical / Stock / Stock Option Ownership Interests; Paradigm Spin / Stock / Stock Option Ownership Interests; Stout Medical / Consulting/Independent Contractor, Stock / Stock Option Ownership Interests; Aesculap / Receipt of Royalty Payments; Medtronic / Stock / Stock Option Ownership Interests; Computational Biodynamics / Stock / Stock Option Ownership Interests; Thoracic Spine Technologies / Stock / Stock Option Ownership Interests; Spineology / Stock / Stock Option Ownership Interests; Small Bone Innovations / Stock / Stock Option Ownership Interests; NuCore / Stock / Stock Option Ownership Interests; Cross Current / Stock / Stock Option Ownership Interests; Syndicom / Stock / Stock Option Ownership Interests; In Vivo / Stock / Stock Option Ownership Interests; Flagship Surgical / Stock / Stock Option Ownership Interests; Advanced Spinal Intellectual Properties / Stock / Stock Option Ownership Interests; Cytokinetics / Stock / Stock Option Ownership Interests; Bovon Orthopedics / Stock / Stock Option Ownership Interests; Electrobore / Stock / Stock Option Ownership Interests; Naviscan / Receipt of Royalty; Electrocore / Stock / Stock Option Ownership Interests; Fluoropharma / Stock / Stock Option Ownership Interests; R.S.I. / T.I. / Gerson Lehrman Group / Consulting/Independent Contractor; Guidepoint Global / Consulting/Independent Contractor; Medacorp / Consulting/Independent Contractor; Cerapedics / Institutional / Educational Grant; Rothman Institute and Related Properties / Stock / Stock Option Ownership Interests; AO Spine / Service on Scientific Advisory Board/Directors/Service on Committees; Innovative Surgical Design / Consulting/Independent Contractor, Service on Scientific Advisory Board/Board of Directors/Service on Committees, Stock / Stock Option Ownership Interests; Association of Collaborative Spine Research / Service on Scientific Advisory Board/Board of Directors/Service on Committees; Spine / Service on Scientific Advisory Board/Board of Directors/Service on Committees, Stock / Stock Option Ownership Interests; Gurusrinham Sathu, Ken Bode, David Gentdelberg, Mitchell Maltenfort, David Ibrahimi have nothing to disclose.

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