Minimally invasive versus open transforaminal lumbar interbody fusion: comparison of clinical outcomes among obese patients

Clinical article

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Objective. Minimally invasive (MI) transforaminal lumbar interbody fusion (TLIF) has been demonstrated in previous studies to offer improvement in pain and function comparable to those provided by the open surgical approach. However, comparative studies in the obese population are scarce, and it is possible that obese patients may respond differently to these two approaches. In this study, the authors compared the clinical benefit of open and MI TLIF in obese patients.

Methods. The authors conducted a retrospective cohort study based on review of electronic medical records at a single institution. Eligible patients had a body mass index (BMI) ≥ 30 kg/m², were ≥ 18 years of age, underwent single-level TLIF between 2007 and 2011, and outcome was assessed at a minimum 6 months postoperatively. The authors categorized patients according to surgical approach (open vs MI TLIF). Outcome measures included postoperative improvement in visual analog scale (VAS), Oswestry Disability Index (ODI), estimated blood loss (EBL), and hospital length of stay (LOS).

Results. A total 74 patients (21 open and 53 MI TLIF) were studied. Groups had similar baseline characteristics. The median BMI was 34.4 kg/m² (interquartile range 31.6–37.5 kg/m²). The mean follow-up time was 30 months (range 6.5–77 months). The mean improvement in VAS score was 2.8 (95% CI 1.9–3.8) for the open group (n = 21) and 2.4 (95% CI 1.8–3.1) for the MI group (n = 53), which did not significantly differ (unadjusted, p = 0.49; adjusted, p = 0.51). The mean improvement in ODI scores was 13 (95% CI 3–23) for the open group (n = 14) and 15 (95% CI 8–22) for the MI group (n = 45), with no significant difference according to approach (unadjusted, p = 0.82; adjusted, p = 0.68). After stratifying by BMI (< 35 kg/m² and ≥ 35 kg/m²), there was still no difference in either VAS or ODI improvement between the approaches (both unadjusted and adjusted, p > 0.05). Complications and EBL were greater for the open group than for the MI group (p < 0.05).

Conclusions. Obese patients experienced clinically and statistically significant improvement in both pain and function after undergoing either open or MI TLIF. Patients achieved similar clinical benefit whether they underwent an open or MI approach. However, patients in the MI group experienced significantly decreased operative blood loss and complications than their counterparts in the open group.

Minimally invasive (MI) transforaminal lumbar interbody fusion (TLIF) was introduced as a means of limiting adjacent tissue injury.10 Limited randomized13,24 and observational1,19,20,22,28,38,40,45,45 data have suggested that long-term pain reduction, functional improvement, fusion rates, and operative complications may be similar in the two approaches, although postoperative pain, blood loss, and hospital length of stay (LOS) appear to be increased in open TLIFs. The effects of an MI approach compared with open approach are poorly characterized among obese patients.
Outcomes for MI and open TLIF in obese patients

Studying the obese population is crucial, given that over one-third of the United States’ population is obese. Obese patients may be at greater risk for complications, pose unique technical operative challenges of increased complexity, and may have a different association between operative approach and clinical outcomes than those of nonobese patients. Existing studies generally either neglect to report the body mass index (BMI) of their patient population or else include patients with mean BMIs in the nonobese range. Therefore, our understanding of the optimal surgical approach in obese patients remains incomplete.

In the current study, we tested whether pain or functional outcomes differ according to whether obese patients undergo an open TLIF or an MI TLIF. We hypothesized that, consistent with the nonobese populations studied thus far, similar improvements in pain and disability would be seen in obese patients.

Methods

Approval was obtained from the University of Michigan Institutional Review Board prior to performing this study.

Study Design

We performed a retrospective cohort study. For the study’s main comparison, patients were categorized according to whether they underwent an open or MI TLIF according to operative notes documented in the electronic medical record.

Patient Population

Patients who underwent open or MI TLIF between 2007 and 2011 at a single institution were retrospectively identified through the use of electronic medical records. Eligible patients had a BMI ≥ 30 kg/m² (the current standard accepted definition of obesity), were ≥ 18 years of age, underwent a single-level TLIF, and had a clinical outcomes assessment of at least 6 months postoperatively. The MI TLIF technique used in these patients has been previously described in the literature.

Data Collection and Outcomes Assessment

Data regarding patient demographics and medical history, including age at the time of surgery, sex, and medical history, were recorded. Relevant medical history including diabetes mellitus, coronary artery disease, hypertension, renal disease, and anemia was confirmed via electronic health records if the patient had ever had a diagnosis of a chronic health condition documented either in the preoperative assessment or previous clinical notes. Renal disease was defined as having a preoperative creatinine of greater than 1.3 mg/dl in men and greater than 1.1 mg/dl in women. Anemia was defined as a preoperative hemoglobin level less than 13.5 g/dl in men and less than 12 g/dl in women. Details regarding the TLIF included the operative date, surgical indication, and lumbar level that was surgically treated.

The primary outcomes of interest included changes in visual analog scale (VAS) and Oswestry Disability Index (ODI) scores. Each scale was administered both preoperatively and postoperatively. If patients did not return for scheduled follow-up, they were contacted by mail or telephone to determine clinical outcomes and asked a standard set of questions. Postoperative values were subtracted from preoperative values to determine postoperative improvement, which was recorded as a positive value. The ODI is a 10-item scale measuring low back–related functional disability with 6 response categories for each question. Each item scores from 0 to 5, which is transformed into a 0–100 scale. The VAS is scored from 0 (no pain) to 10 (worst imaginable pain).

Secondary outcomes included hospital LOS, estimated blood loss (EBL), and perioperative complications. The LOS is defined as days from admission to hospital discharge. We determined EBL from operative reports. Complications were assessed by searching intraoperative reports in addition to inpatient and outpatient notes in the electronic health record up to 30 days postoperatively. Specific complications were identified by reviewing electronic health record documentation and confirmed using standard diagnostic definitions. Standard definitions of complications for urinary tract infection, myocardial infarction, respiratory dysfunction, pneumonia, urinary retention, and sepsis were based on published literature to reduce bias. Excessive EBL was defined as greater than 1.5 L.

Statistical Analysis

Descriptive data were analyzed using univariate analysis. Continuous variables were described using mean and 95% CI or by median and interquartile range (IQR). Categorical variables were described using frequencies. Continuous variables were compared between our 2 groups using 2-sample Student t-test or by matched pair t-test when comparing individual score changes. Categorical variables were compared using chi-square test or Fisher exact test.

To account for potential confounders, we performed a propensity score analysis to adjust for factors related to surgical approach. We generated predicted probabilities of undergoing an MI approach using a logistic regression, with MI TLIF as the outcome and with age, BMI, sex, diabetes mellitus, coronary artery disease, renal disease, hypertension, anemia, antidepressant use, smoking status, surgeon, and diagnosis as predictors. Linear regression with VAS and ODI outcomes were fit, with the covariate of interest being MI TLIF, adjusted for predicted probability.

A p value < 0.05 was considered significant in this study. All statistical analyses were performed using SAS software, version 9.3 (SAS Institute).

Results

We identified 425 patients who underwent a TLIF at our institution from 2007 to 2011. Of these, 74 met inclusion criteria for our study. Baseline characteristics were similar between the open (n = 21) and MI (n = 53) groups (Table 1). The median BMI was 34.4 kg/m² (IQR 31.6–37.5 kg/m²).
In the open-TLIF group, all 21 patients (100%) had both a preoperative and postoperative VAS score with which to calculate VAS improvement. Fourteen (67%) of 21 patients had a preoperative ODI score, 26 (100%) of 26 had a postoperative ODI score, and thus 14 (67%) of 21 had both preoperative and postoperative scores with which to calculate an ODI improvement.

Among the MI TLIF group, all 53 patients (100%) had VAS improvement scores available. Forty-five of (85%) 53 patients had a preoperative ODI score available, 53 (100%) of 53 had a postoperative ODI score available, and thus, 45 (85%) of 54 had an improvement score available.

The overall median follow-up duration was 25 months (IQR 16–44 months). The mean follow-up time was 28 months (range 7–64 months) for the open group and 31 months (range 6–77 months) for the MIS group (p = 0.44).

Both VAS and ODI score results are displayed in Figs. 1 and 2 and summarized in Table 2 according to surgical approach. The mean postoperative VAS scores were 3.9 (95% CI 3.2–5.4) for the open group and 4.7 (95% CI 3.9–5.4) for the MI group (Fig. 1 upper), which did not significantly differ according to surgical approach (unadjusted, p = 0.61; adjusted for propensity score, p = 0.68).

The mean postoperative improvement in VAS score compared with preoperative score (Fig. 1 lower) was 2.8 (95% CI 1.9–3.8) for the open group and 2.4 (95% CI 1.8–3.1) for the MI group (unadjusted, p = 0.49; adjusted, p = 0.51).

The mean postoperative ODI score (Fig. 2 upper) was 0.89 (95% CI 0.75–1.03). The mean postoperative improvement in ODI score (Fig. 2 lower) was 2.8 (95% CI 2.0–3.5) for the open group and 2.1 (95% CI 1.3–2.9) for the MI group (unadjusted, p = 0.02; adjusted, p = 0.08).

Fig. 3 and Table 3 depict analysis stratified by the class of obesity. After stratifying by BMI (< 35 kg/m² and ≥ 35 kg/m²), the mean follow-up time, mos (n = 65) and then to those with at least 24 months (n = 40) of postoperative follow-up.

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The overall median follow-up duration was 25 months (IQR 16–44 months). The mean follow-up time was 28 months (range 7–64 months) for the open group and 31 months (range 6–77 months) for the MIS group (p = 0.44).

Both VAS and ODI score results are displayed in Figs. 1 and 2 and summarized in Table 2 according to surgical approach. The mean postoperative VAS scores were 4.3 (95% CI 3.2–5.4) for the open group and 4.7 (95% CI 3.9–5.4) for the MI group (Fig. 1 upper), which did not significantly differ according to surgical approach (unadjusted, p = 0.61; adjusted for propensity score, p = 0.68).

The mean postoperative improvement in VAS score compared with preoperative score (Fig. 1 lower) was 2.8 (95% CI 1.9–3.8) for the open group and 2.4 (95% CI 1.8–3.1) for the MI group (unadjusted, p = 0.49; adjusted, p = 0.51). The mean postoperative ODI score (Fig. 2 upper) was 0.89 (95% CI 0.75–1.03). The mean postoperative improvement in ODI score (Fig. 2 lower) was 2.8 (95% CI 2.0–3.5) for the open group and 2.1 (95% CI 1.3–2.9) for the MI group (unadjusted, p = 0.02; adjusted, p = 0.08).

Fig. 3 and Table 3 depict analysis stratified by the class of obesity. After stratifying by BMI (< 35 kg/m² and ≥ 35 kg/m²), the mean follow-up time, mos (n = 65) and then to those with at least 24 months (n = 40) of postoperative follow-up.

Discussion

Foley et al. first described the MI TLIF, which utilizes tubular retractors inserted serially via a muscle-splitting approach to reduce soft-tissue injury as an alternative to the traditional open approach. Subsequently, MI TLIF was demonstrated to be safe and feasible. Recent meta-analyses of subsequent studies have suggested that MI TLIF produces comparable outcomes in terms of radiographic fusion and improvements in pain and functional outcomes.

A number of studies have compared outcomes for obese and nonobese patients after TLIF. For example, in one of the largest series, Djurasovic et al. reported ODI score improvement of approximately 15, which did not differ between obese and nonobese groups in a minimum follow-up of 2 years. Obese patients had a slightly higher risk of postoperative wound infection. Other studies have suggested no clear relationship between BMI and pain outcomes following lumbar surgery. However, such studies cannot directly inform the optimal surgical approach in the obese population because they compare...
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the effect of BMI on outcomes within a given operation, not the effect of surgical approach on outcomes for obese patients.

Wang et al. performed one of the few existing studies comparing pain and functional outcomes after MI TLIF or open TLIF among overweight or obese patients. They found higher VAS scores within 2 days of surgery in the open group, which is consistent with other studies not restricted by BMI, suggesting increased use of patient-controlled analgesia in the immediate postoperative setting in open procedures. However, the effect disappeared at latest follow-up (mean 3 years), at which point VAS and ODI scores were similar after open and MI TLIF groups. Wang and colleagues’ results suggested that ultimate outcome is similar for open and MI operations among the overweight or obese group. However, a key limitation of their study was that their mean BMI was not in the obese range (mean 28.9 ± 3.2 [± SEM]), so it is not possible to draw conclusions about obese patients from their study. We have therefore built upon their results by including only truly obese patients, which to our knowledge has not been previously reported. Wang and colleagues also did not control for comorbidities or any potential confounders, which we have done using propensity scores.

Studies have compared open and MI TLIFs in populations regardless of BMI. In light of the fact that observational data on surgical outcomes may be subject to substantial selection bias and residual confounding, limited randomized data do exist. Wang and colleagues randomized 79 patients to an MI TLIF or open-TLIF group with at least 2 years of follow-up. In the MI group, ODI was significantly better at 3 and 6 months postoperatively, which attenuated with time, and VAS did not differ significantly at any point between the 2 groups. Interestingly, they also incorporated multimodal data to evaluate soft-tissue damage; they detected more favorable electrophysiological amplitude and frequency and MRI T2 relaxation times in the sacrospinalis muscle to suggest less soft-tissue damage associated with the MI approach, despite similar creatine phosphokinase isoenzyme levels. Although no party was blinded to the intervention and the authors do not list the number of patients screened for the study to assist the reader in evaluating selection bias, such data may offer the least-biased available insight into the relationship between surgical approach and outcomes, not accounting for BMI.
In another study, Shunwu et al.\textsuperscript{34} quasi-randomized 62 patients with an average BMI of 23 to undergo MI or open TLIF according to odd versus even calendar date admitted for surgery. Although the authors claim that MI TLIF yielded superior postoperative VAS and ODI scores, their results do not suggest a difference between groups at any given time point, so their conclusion should be interpreted cautiously. Aside from pain and functional outcomes, these randomized studies did demonstrate improvements in EBL, time to ambulation and discharge, and time undergoing fluoroscopy to various degrees among the MI groups. Therefore, even though the 2 operations likely produced similar outcomes, MI TLIF did boast several advantages.

Observational data derived from retrospective\textsuperscript{1,5,19,31,40} and prospective\textsuperscript{22,32,44} cohort studies lead to similar conclusions. Meta-analysis of such studies failed to detect any clear difference in pain or functional improvements between MI and open approaches;\textsuperscript{36} both approaches demonstrated clinically meaningful benefit for which magnitudes were consistent with our findings in all studies included. An important limitation of such analysis, particularly retrospective studies, is that existing studies rarely report the percentage of patients in each group who were excluded due to missing VAS or ODI data. This invites selection bias if the reasons for missing data are related to either operation or outcome. The open approach was superior to MI TLIF in terms of x-ray exposure (average 41 seconds less), while the MI approach was superior in terms of intraoperative blood loss (219 ml less) and LOS (2.7 days less). Neither approach was superior in terms of complication or reoperation rates, although it may be difficult to draw

**TABLE 2:** Mean postoperative VAS and ODI scores and indicator of improvement according to surgical approach

<table>
<thead>
<tr>
<th>Score</th>
<th>Open TLIF (95% CI)</th>
<th>MI TLIF (95% CI)</th>
<th>Unadjusted p Value</th>
<th>Adjusted p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>postop</td>
<td>4.3 (3.2–5.4)</td>
<td>4.7 (3.9–5.4)</td>
<td>0.61</td>
<td>0.68</td>
</tr>
<tr>
<td>difference</td>
<td>2.8 (1.9–3.8)</td>
<td>2.4 (1.8–3.1)</td>
<td>0.49</td>
<td>0.51</td>
</tr>
<tr>
<td>ODI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>postop</td>
<td>45 (36–54)</td>
<td>44 (37–51)</td>
<td>0.82</td>
<td>0.26</td>
</tr>
<tr>
<td>difference</td>
<td>13 (3–23)</td>
<td>15 (8–22)</td>
<td>0.82</td>
<td>0.68</td>
</tr>
</tbody>
</table>

* Adjusted for propensity score including age, sex, BMI, diabetes mellitus, coronary artery disease, hypertension, renal disease, anemia, smoking status, antidepressant use, surgeon, and primary diagnosis.
definitive conclusions from these studies because limited sample sizes created odds ratios with confidence intervals of sometimes hundred-fold widths. Another meta-analysis has suggested excellent and similar fusion rates for both approaches, exceeding 90%. Our study suggests that the lack of association between operative approach and clinical patient-centered outcomes may hold for obese patients, consistent with studies performed in the nonobese population. We found a significant improvement in both postoperative pain and functional status comparable with those reported in the literature. While our study contains a relatively small sample size, the results suggest that the lack of association between operative approach and outcomes may persist among obese patients.

![Fig. 3. Bar graphs demonstrating postoperative improvement in VAS (upper) and ODI (lower) scores stratified by BMI for open versus MI TLIF. Error bars represent 95% confidence intervals.](image)

**TABLE 3: Postoperative improvement in VAS and ODI scores stratified by BMI**

<table>
<thead>
<tr>
<th>BMI Status</th>
<th>Open TLIF (95% CI)</th>
<th>MI TLIF (95% CI)</th>
<th>Unadjusted p Value</th>
<th>Adjusted p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI &lt;35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAS improvement</td>
<td>3.0 (1.7–4.2)</td>
<td>2.2 (1.1–3.2)</td>
<td>0.33</td>
<td>0.50</td>
</tr>
<tr>
<td>ODI improvement</td>
<td>15 (2–28)</td>
<td>8 (–2 to 18)</td>
<td>0.38</td>
<td>0.49</td>
</tr>
<tr>
<td>BMI ≥35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAS improvement</td>
<td>2.6 (0.6–4.6)</td>
<td>2.6 (1.8–3.5)</td>
<td>0.94</td>
<td>0.88</td>
</tr>
<tr>
<td>ODI improvement</td>
<td>6 (–9 to 21)</td>
<td>21 (11–31)</td>
<td>0.29</td>
<td>0.95</td>
</tr>
</tbody>
</table>

* Adjusted for propensity score including age, sex, BMI, diabetes mellitus, coronary artery disease, hypertension, renal disease, anemia, smoking status, antidepressant use, surgeon, and primary diagnosis.
sample size in each stratum, we did not detect a difference in the relationship between surgical approach and clinical outcomes according to obesity class. Furthermore, consistent with the literature suggesting that perioperative complication rates, as well as EBL, may also be lower for the MI approach,\textsuperscript{18} our study underscores these findings in the MI cohort in the obese population.

Taken together, our results indicate that both surgical approaches similarly benefit obese patients. An MI TLIF may offer more net salutary benefits aside from pain and functional outcomes. The MI approach may therefore overall be a reasonable and even superior alternative to the open approach in this population.

Limitations and Strengths

Our study may suffer from a number of limitations. As one that provides retrospective nonrandomized data, it may suffer from residual confounding. However, to address confounding we used a propensity score to adjust for covariates potentially associated with the decision to pursue MIS versus open surgery, including comorbidities, age, sex, surgeon, and diagnosis. We restricted the study to include those with at least 6 months of clinical follow-up. We believe this was a clinically meaningful amount of follow-up time. Furthermore, our mean and median follow-up times both exceeded 2 years, and the range extended up to 77 months. Moreover, the results were quantitatively similar when we restricted them to the 40 patients with follow-up of at least 2 years. We did not collect data on radiographic lumbar fusion. However, since this was a clinical outcomes study, we believe that pain and functional outcomes are a more meaningful focus than surrogate radiographic results. Furthermore, the limited data available have not yet shown a clear association between radiographic fusion and outcomes.\textsuperscript{2,30} Selection bias may occur due to missing data. Indeed, 20% of patients did not have a preoperative ODI score with which to calculate an ODI improvement score. However, 100% of patients had complete VAS data, and 100% of patients had postoperative ODI scores, which therefore would not be victim to selection bias. Outcomes were not all assessed using the same mode of communication or in the same setting. However, patients were all administered the same standardized questionnaires so we believe responses were elicited consistently. Although our study

TABLE 4: Estimated blood loss and LOS*

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Open TLIF (IQR)</th>
<th>MI TLIF (IQR)</th>
<th>Unadjusted p Value</th>
<th>Adjusted p Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>median EBL in mL</td>
<td>450 (300–1000)</td>
<td>100 (100–200)</td>
<td>0.009</td>
<td>0.003</td>
</tr>
<tr>
<td>median LOS in days</td>
<td>3 (3–4)</td>
<td>2 (2–4)</td>
<td>0.056</td>
<td>0.13</td>
</tr>
</tbody>
</table>

* Boldface indicates statistical significance.
† Adjusted for propensity score including age, sex, BMI, diabetes mellitus, coronary artery disease, hypertension, renal disease, anemia, smoking status, antidepressant use, surgeon, and primary diagnosis.

TABLE 5: Complications*

<table>
<thead>
<tr>
<th>Complications</th>
<th>Open TLIF (n = 21)</th>
<th>MI TLIF (n = 53)</th>
<th>Unadjusted p Value</th>
<th>Adjusted p Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>overall‡</td>
<td>11</td>
<td>9</td>
<td>0.008</td>
<td>0.005</td>
</tr>
<tr>
<td>cardiopulmonary‡</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0.97</td>
</tr>
<tr>
<td>atrial fibrillation§</td>
<td>0 (0%)</td>
<td>1 (2%)</td>
<td>1</td>
<td>0.97</td>
</tr>
<tr>
<td>surgical‡</td>
<td>9</td>
<td>3</td>
<td>0.001</td>
<td>0.0006</td>
</tr>
<tr>
<td>durotomy§</td>
<td>3 (14%)</td>
<td>2 (4%)</td>
<td>0.13</td>
<td>0.02</td>
</tr>
<tr>
<td>K-wire fracture§</td>
<td>0 (0%)</td>
<td>1 (2%)</td>
<td>1</td>
<td>0.97</td>
</tr>
<tr>
<td>excessive blood loss§</td>
<td>5 (24%)</td>
<td>0 (0%)</td>
<td>0.001</td>
<td>0.95</td>
</tr>
<tr>
<td>seroma§</td>
<td>1 (5%)</td>
<td>0 (0%)</td>
<td>0.28</td>
<td>0.94</td>
</tr>
<tr>
<td>infectious‡</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>0.37</td>
</tr>
<tr>
<td>urinary tract infection§</td>
<td>0 (0%)</td>
<td>2 (4%)</td>
<td>1</td>
<td>0.96</td>
</tr>
<tr>
<td>pneumonia§</td>
<td>0 (0%)</td>
<td>1 (2%)</td>
<td>1</td>
<td>0.97</td>
</tr>
<tr>
<td>wound infection§</td>
<td>1 (5%)</td>
<td>0 (0%)</td>
<td>0.28</td>
<td>0.95</td>
</tr>
<tr>
<td>other‡</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0.52</td>
</tr>
<tr>
<td>ileus§</td>
<td>0 (0%)</td>
<td>1 (2%)</td>
<td>1</td>
<td>0.58</td>
</tr>
<tr>
<td>urinary retention§</td>
<td>1 (5%)</td>
<td>1 (2%)</td>
<td>0.49</td>
<td>0.56</td>
</tr>
</tbody>
</table>

* Boldface indicates statistical significance.
† Adjusted for age, sex, BMI, diabetes mellitus, coronary artery disease, hypertension, renal disease, anemia, smoking status, antidepressant use, surgeon, and primary diagnosis.
‡ Total number of complications.
§ Number of patients (% of patients).
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was performed at a single institution, there is no reason for us to believe that our results do not generalize to the institutional experience of others.

Our study also has a number of strengths. Our study had long-term follow-up of patients up to a maximum 77 months, with an average follow-up exceeding 2 years. We also had a homogeneous patient population in whom single-level operations were performed at a single institution. We were able to compare pre- and postoperative scores of both pain and disability to evaluate important surgical outcomes; the patient’s subjective improvement in pain and function. We also adjusted for important demographics information using propensity scores to reduce confounding.

Conclusions

Obese patients experienced clinically and statistically significant improvement in both pain and function after undergoing MI and open TLIFs. These results are comparable to those obtained in nonobese studied patient populations.

Disclosure

Dr. Park reports being a consultant for Globus Medical and Medtronic and receiving royalties from Globus Medical. Dr. La Marca reports being a consultant for Globus Medical and Biomet and receiving royalties from Globus Medical.

Author contributions to the study and manuscript preparation include the following. Concept and design: Park, La Marca. Acquisition of data: all authors. Analysis and interpretation of data: Terman, Yee, Lau, Khan. Drafting the article: Terman, Yee, Lau. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Park. Statistical analysis: Terman, Yee, Lau, Khan. Study supervision: Park, La Marca.

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