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Efficacy of endoscopic decompression surgery for treatment of lumbar spinal stenosis

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ABSTRACT

Background: The overall aim of this study was to assess the effectiveness of endoscopic decompression for outcomes in patients with lumbar spinal stenosis (LSS).

Methods: We conducted a retrospective cohort, single-institution study of n = 139 patients from 2019 to 2022 who underwent endoscopic decompression for LSS. The primary outcome was improvement of Oswestry Disability Index (ODI) between baseline and 12-month follow-up.

Results: In the present sample (n = 139) the average age was 57.6 years (SD = 17.4, with even distribution of men (49%) vs. women (51%). In patients with LSS, lumbar disc herniation was the most common diagnosis in 49 patients followed by lumbar radiculopathy in 25 patients. Lumbar radicular pain was the 3rd most common diagnosis in 21 patients with all other diagnosis listed in Table S1. There was a significant improvement (i.e., decrease) in ODI following endoscopic decompression (mean change: −8.3, 95% CI: −9.4, −7.2, $P < 0.001$, Fig. 1). Prior lumbar spine surgery ($P = 0.048$), BMI ($P = 0.053$), and age ($P = 0.022$) were associated with changes in ODI. Nearly half (47%) of the sample had prior lumbar spine surgery. Those with prior lumbar spine surgery (−7.5, 95% CI: −8.3, −6.6) showed less improvement than those without prior lumbar spine surgery (−9.1, 95% CI: −10.9, −7.2, Fig. 2). For BMI, 23% had normal BMI while 24% were overweight and 53% were obese. Patients with normal BMI (−10.3, 95% CI: −13.4, −7.2) showed greater improvements compared to overweight (−7.9, 95% CI: −9.4, −6.4) and obese (−7.6, 95% CI: −9.0, −6.3, Fig. 3) patients. Patients under 40 years old (−10.2, 95% CI: −13.6, −6.8) showed greater improvements in ODI compared to those 40 years and older (−7.8, 95% CI: −8.6, −6.8, Fig. 4).

Conclusions: In patients with lumbar spinal stenosis, endoscopic decompression was associated with reduced disability. Patients with no prior lumbar spine surgery, normal BMI, and who were under 40 years old showed greater improvements.

1. Introduction

Lumbar spinal stenosis (LSS) is a degenerative disease of the lumbar spine which presents with intermittent neurogenic claudication and cramping as well as possible muscle weakness of the legs. It is estimated that approximately 11% of older adults in the United States have symptomatic lumbar spinal stenosis, while more than 20% of adults older than 60 years of age have evidence of stenosis which does not require treatment [1]. Lumbar spinal stenosis is often recognized as being a major contributor to back pain and impairment due to spinal canal narrowing. Other precipitating factors for impairment in LSS involve narrowing of intervertebral foramina and lateral recess. This disease may go without symptoms for a long duration as skeletal, muscular, and neural physiology compensates for the deranged axial alignment and progressively increasing compression of neural structures, but this ultimately results in chronic pain and disability with

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difficulty of ambulation [2]. While lumbar spinal stenosis may initially be treated with lifestyle modifications, nonsteroidal anti-inflammatory drugs, physiotherapy, and epidural injections these conservative management strategies are often limited and do not provide an adequate relief of pain and improvement in functionality in advanced cases. Traditionally, open decompression has been the gold standard for the treatment of lumbar spinal stenosis [3]. However, recent advancement with full endoscopic surgery has demonstrated advantages in minimizing soft tissue trauma, maintaining spinal architecture, and preservinglimi spinal stability by limiting bony resection thereby ensuring better patient outcomes in terms of early recovery and rehabilitation, minimal postoperative hospital course, and faster return to work [4].

While full endoscopic surgical decompression for lumbar spinal stenosis has demonstrated promising results, the evidence for indications and efficacy for such a procedure during the postoperative period still is in its early stages. In our study, a cohort of patients who underwent endoscopic decompression for lumbar spinal stenosis with failed conservative management inclusive of pharmacotherapy and physical therapy were assessed retrospectively with the aim of determining patient outcomes in terms of efficacy through pain scores, Oswestry Disability Index (ODI), visual analog scale (VAS) of pain from 0 to 10, Patient-Reported Outcomes Measurement Information System (PROMIS-29) scores, functional movement, and quality of life. We have developed a preliminary criterion of which patients would most benefit from full endoscopic decompression based on age, prior surgical exposure, and body habitus.

2. Materials and methods

This is a retrospective cohort study of 139 patients who underwent endoscopic decompression for various conditions leading to lumbar spinal stenosis. The sample consisted of both male and female patients 18 years and older, who had successfully undergone endoscopic decompression from July 2019 to December 2021 for treatment of neurogenic claudication under the care of the University of Florida Health network. Selection criteria for endoscopic decompression were at the attending surgeon's discretion. Criteria included symptomatic presentation of neurogenic claudication due to pathologies listed in Table S1. Patients' electronic medical record data, including ICD 10 & CPT codes, were obtained through Epic Systems. This included both patients that did or did not undergo prior intervention such as prior back surgery, pharmacotherapy (NSAIDs, Opioids, SSRIs, and SNRIs), and physical therapy. Our sample excluded patients (n = 1) who did not complete endoscopic decompression due to procedural complications like excessive bleeding. Intra-operative and post-operative surgical complications were also examined within a 1-year time frame. This study was deemed Exempt (Category 4) by the University of Florida Institutional Review Board (IRB#: 202102880). We observed post-operative follow-up data ranging from a few weeks to 1 year. Three procedures were classified: PROC 1 stands for any combinations of endoscopic decompression of the central spinal canal and/or lateral recess and/or neuroforamina by debulking of intervertebral disc, resection of lamina, facet joint, ligamentum flavum, facet cysts, or scar tissue from previous spine surgeries. PROC 2 stands for resection of branch of spinal nerve(s) outside the spinal canal. PROC 3 stands for resection of L5 transverse process and/or sacral ala along with pseudo joint at L5-S1. We evaluated both preoperative and postoperative VAS of back pain, ODI, and PROMIS-29 data. Minimally clinically important change (MCIC) was considered 2 pts for VAS and 10 pts for ODI [5]. Additionally, as per previous work, we examined % of patients who achieved a "patient acceptable symptom state" (PASS), defined as ≤ 22 on ODI [6]. The charts were examined for adverse events using specific keywords to identify any instances of complications or adverse outcomes associated with these surgeries. By searching for terms like "dural tear," "bleeding," "hematoma," "infection", "fluid leak", "nerve injury", "paralysis", "numbness" & "weakness", we were looking for any occurrences of these complications and assess their frequency and severity.

For descriptive statistics, continuous measures were summarized with means and standard deviations or medians and interquartile ranges. Categorical measures were summarized as frequencies and percentages. Rates of patients achieving MCIC for VAS pain and ODI were calculated as percentages with exact binomial confidence intervals. The change in proportion of patients achieving PASS in ODI was calculated with a z-test to compare two proportions. To evaluate change in ODI, VAS pain, and PROMIS-29 a paired-t-test was used, calculating mean change with 95% confidence intervals (95% CI). To examine various factors on change, linear regression modeling was used. In these models, preprocedural outcome measurement was included as an independent variable and postprocedural outcome measurements were dependent variables. This created a "residual change score" and thus any statistically significant effects of factors of interest in regression modeling were interpreted as affecting change in outcome. Age and BMI were analyzed as both continuous and categorical variables. Age associations were stratified between <40 years and 40+ years, to compare younger-aged adults with middle-aged and older adults, since LSS is a degenerative disease. BMI was stratified as normal (<24.9) overweight (25–29.9) and obese (30+). $P < 0.05$ was considered statistically significant.

3. Results

The present study includes n = 139 patients who underwent endoscopic decompression procedures. Table 1 reports patient characteristics. The average age was 57.6 ± 17.5 with nearly equal representation of men and women. Half of the sample had a reported smoking history and had an average BMI of 31.1 ± 7.3. Nearly half the sample (47%) had prior lumbar spine surgery and 28% received multilevel surgical procedure. Prior to the procedure, 16% of patients reported ODI score already at PASS cutoff. A total of 7 complications were noted from the key words search in the chart: three patients had small incidental dural tears (<0.5 cm) & four patients had persistent symptoms which were attributed to MRI confirmation of incomplete decompression.

Table 1
Patient characteristics and preoperative measurements (n = 139).

Measure	Summary
Age, mean years ± SD	57.6 ± 17.5
Sex, n (%)	
Women	71/138 (51%)
Men	68/139 (49%)
BMI, mean ± SD	31.1 ± 7.3
Smoking history, n (%)	70/139 (50%)
Prior lumbar spine surgery, n (%)	65/139 (47%)
Preprocedural ODI PASS, n (%)	22/139 (15%)
Radiological assessment, n (%)	
MRI only	9/139 (6%)
MRI with X-ray and/or CT	130/139 (94%)
Operative time, mean minutes ± SD	129 ± 67
Operative levels, n (%)	
L1-L2	2/138 (1%)
L2-L3	9/138 (7%)
L3-L4	41/138 (30%)
L4-L5	95/138 (69%)
L5-S1	31/138 (22%)
Endoscopic decompression procedure, n (%)	
PROC 1	119/139 (86%)
PROC 2	18/139 (13%)
PROC 3	2/139 (1%)

Note: SD = standard deviation; ODI PASS→ patient acceptable symptom state for Oswestry Disability Index (≤22).

3.1. Oswestry Disability Index (ODI)

Following the procedure, 30% (41/139, 95%CI: 22%–39%) achieved the MCIC (10 pt decrease) for ODI. Moreover, 32% (44/139) of patients achieved PASS in ODI, which was a significant improvement from procedural rates (z = 4.2538, p < 0.001, Fig. 1). There was significant overall improvement in mean ODI before and after their procedures (mean difference: −8.3, 95% CI: −9.4, −7.2, $P < 0.001$, Fig. 2A). Prior lumbar spine surgery ($P = 0.048$), BMI ($P = 0.053$), and age ($P = 0.022$) were associated with change in ODI. Nearly half (47%) of the sample had prior back surgery. Those with prior lumbar spine surgery (−7.5, 95% CI: −8.3, −6.6) showed less improvement than those without prior surgery (−9.1, 95% CI: −10.9, −7.2, Fig. 2B). For BMI, 23% had normal BMI while 24% were overweight and 53% were obese. Patients under 40 years old (−10.2, 95% CI: −13.6, −6.8) showed greater improvements in ODI compared to those 40 years and older (−7.8, 95% CI: −8.6, −6.8, Fig. 2C). Patients with normal BMI (−10.3, 95% CI: −13.4, −7.2) showed greater improvements compared to overweight (−7.9, 95% CI: −9.4, −6.4), and obese (−7.6, 95% CI: −9.0, −6.3, Fig. 2D) patients. There were no statistically significant effects on change in ODI due to sex ($P = 0.780$), smoking ($P = 0.499$), type of radiological assessment ($P = 0.410$), operative time ($P = 0.988$), number of operative levels ($P = 0.503$), and procedure ($P = 0.993$) (Supp Fig. S1).

3.2. Visual analog scale (VAS)

Following the procedure, 96% (134/139, 95%CI: 92%–99%) achieved the MCIC (2 pt decrease) for VAS. Mean VAS pain scores significantly improved before and after the procedure (mean difference: −3.7, 95% CI: −3.9, −3.4, $P < 0.001$, Fig. 3A). The type of radiological assessment ($P < 0.001$) and procedure type ($P = 0.015$) were associated with change in VAS pain scores. Patients with only MRI assessment showed greater pain improvements (−5.2, 95% CI: −6.6, −3.8) compared to those with multiple types of radiological assessments, e.g., MRI with either X-ray, computerized tomography (CT), or both (−3.6, 95% CI: −3.8, −3.3, Fig. 3B). Patients undergoing PROC 1 had greater pain improvements (−3.8, 95% CI: −4.1, −3.5) compared to those undergoing PROC 2 and PROC 3 procedures (−3.0, 95% CI: −3.5, −2.4, Fig. 3C). There were no statistically significant effects on change in VAS pain due to prior back surgery ($P = 0.809$), age ($P = 0.466$), sex ($P = 0.147$), BMI ($P = 0.873$), smoking ($P = 0.114$), operative time ($P = 0.720$), and number of operative levels ($P = 0.503$) (Supp Fig. S2).

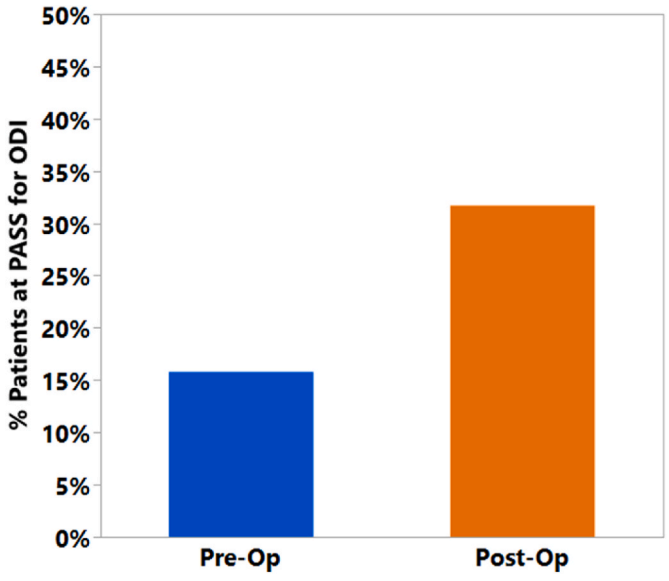

Fig. 1. Proportion of patients at "patient acceptable symptom state" (PASS), defined as ≤ 22 on Oswestry Disability Index (ODI), prior to and following decompression procedure.

3.3. Patient-Reported Outcomes Measurement Information System (PROMIS-29)

PROMIS-29 scores were collected in a smaller subset of patients (n = 67) and improved from before to after the procedure (mean difference: +2.5, 95% CI: +0.7, +4.2, $P = 0.007$, Fig. 4A). Men (+4.3, 95% CI: +1.2, +7.3) showed greater improvement on PROMIS-29 scores compared to women (+1.0, 95% CI: −1.0, +3.1). There were significant sex differences in PROMIS-29 improvement ($P = 0.029$, Fig. 4B). There were no statistically significant effects on change in PROMIS-29 due to prior back surgery ($P = 0.829$), age ($P = 0.206$), BMI ($P = 0.292$), smoking ($P = 0.210$), operative time ($P = 0.199$), number of operative levels ($P = 0.257$), and procedure ($P = 0.637$) (Supp Fig. S3).

4. Discussion

Endoscopic decompression is a minimally invasive surgical procedure for definitive treatment of various lumbar spinal conditions with the advantages of reduced surgical trauma, faster postoperative recovery, and earlier return to work timespan [7]. Our study supports these findings but also expands on the indications for performing this procedure.

Patients showed improvements in ODI, VAS, and PROMIS-29 scores after the procedure. This data supports findings from prior studies examining the efficacy of endoscopic decompression in the treatment of LSS [8,9]. Currently, endoscopic decompression involves any combinations of techniques that involve decompression via resection of lamina, facet joint, ligamentum flavum, facet cysts, scar tissue from earlier spine surgeries, or debulking of intervertebral disc [4,10]. Similar methods were used in our "endoscopic decompression" procedure, and our results show greater efficacy of the methods (PROC 1) compared to the resection of spinal nerves (PROC 2), L5 transverse process, or the sacral ala (PROC 3) in reducing postoperative VAS pain scores (Fig. 2C).

Overall, endoscopic decompression was associated with improvement in pain scores postoperatively. This agrees with prior studies that have shown efficacy of endoscopic decompression for treatment of neurogenic pain compared to non-operative management [1]. Our study further builds on this by examining specific parameters in which the procedure was effective. However, improvements were not uniform amongst all variables. Specifically, endoscopic decompression was less effective in reducing ODI scores in patients with prior back surgery who were over the age of 40 and had a BMI ≥40. Earlier studies have proven that endoscopic decompression procedures have greater risks of complications in older patients with more severe disease, including recurrence of LSS, persistent pain of the lumbosacral or lower extremity, dural tear, incomplete decompression, surgical site infection, epidural hematoma, and intraoperative posterior neck pain [4,10]. In our analysis of 139 patients, it was determined that there were no reports of epidural hematoma, cerebrospinal fluid leak, nerve injury, weakness, paralysis or surgical site infections. Three patients had small incidental dural tears (<0.5 cm) which were immediately recognized and treated with fibrin glue. There were no spinal fluid leaks or nerve root damage reported in those patients. Four patients had persistent symptoms which were attributed to MRI confirmation of incomplete decompression.

VAS pain scores indicate that prior radiological assessment with MRI alone is associated with greater efficacy and may be the only imaging modality needed for surgical planning and for the procedure, which would ultimately reduce the cost burden to the patient and insurance companies in surgical planning, treatment, and management. This finding has not been reported in the literature thus far. However, depending on the complexity, severity, and progression of the spinal disease, patients with more advanced or complicated stenosis may require more imaging prior to surgical treatment to rule out any

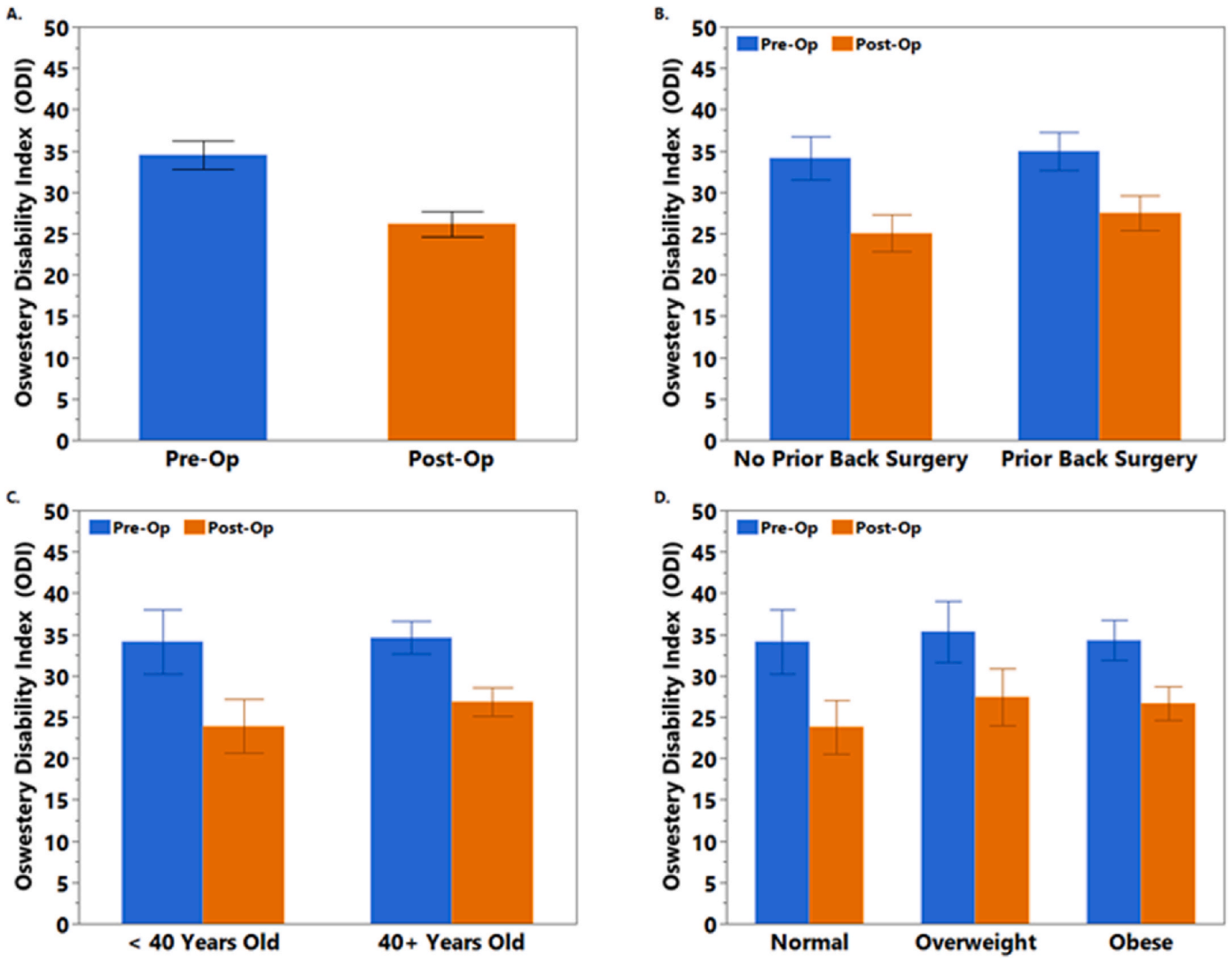

Fig. 2. Change in Oswestry Disability Index (ODI) following endoscopic decompression procedure in total sample (A) and stratified by prior back surgery (B), age (C), and BMI (D) with 95% confidence intervals.

instability or other contraindications of a minimally invasive procedure. This finding is limited by the fact that only 9 patients from our study fell into this category of using MRI alone. There were likely additional factors that influenced the decision to use MRI without secondary imaging such as CT and X-ray, some of which could be confounding this finding, leading to the appearance of a difference in outcome. Further studies that specifically use imaging modalities as an independent variable would need to be conducted to say definitively that the use of imaging is associated with a change in outcomes.

The results from this study indicate that endoscopic decompression is a practical treatment choice for many patients with a diagnosis of lumbar spinal stenosis. This is especially true for patients who are under 40 years old, have no prior history of back surgery, and are within the normal BMI range (18.5–24.9 kg/m^2); patients with these characteristics have shown the greatest improvement in function as measured by ODI. The conventional surgical approach utilizes open lumbar decompression with or without lumbar fusion and they have a relatively elevated risk for postoperative complications as well as longer recovery periods [4]. Comparatively, endoscopic decompression can be done with minimal tissue trauma and bone resection and with lower complication rates due to its less invasive nature. If adopted on a broad scale, endoscopic decompression could save patients a considerable amount of physical pain, preserve their spinal architecture while minimizing any spinal instability, improve their quality of life, and reduce employment absence, all while minimizing the financial burden on the healthcare system in treating patients with chronic pain. Endoscopic decompression surgeries may also be helpful in helping to address the opioid epidemic in the United States for patients experiencing chronic pain by providing direct interventional nonopioid therapy [11].

Many of the results of our study were limited by patient size; at the time this study was completed, we had an N = 139. These patients were at a single, large academic institution with catchment to a specific patient demographic. Performing this study at other sites with a different patient population would not only increase patient numbers & diversity but can also reveal other factors which may affect the outcomes and benefits of this type of surgery. These additional data points can include prior interventional pain therapies such as therapeutic facet injections, epidural steroid injections, radio frequency neurotomies, and medial branch blocks, done before or after the surgery. The lack of data on these types of procedures namely, epidural steroid injections and facet joint injections was a limitation of this study and would have revealed further insight to the outcomes and value of the endoscopic procedure. Furthermore, as a non-consecutive retrospective analysis, the study's design is inherently susceptible to selection bias, incomplete records, uncontrolled confounding variables, and potential changes in practices over time. Despite efforts to mitigate these biases by defining clear

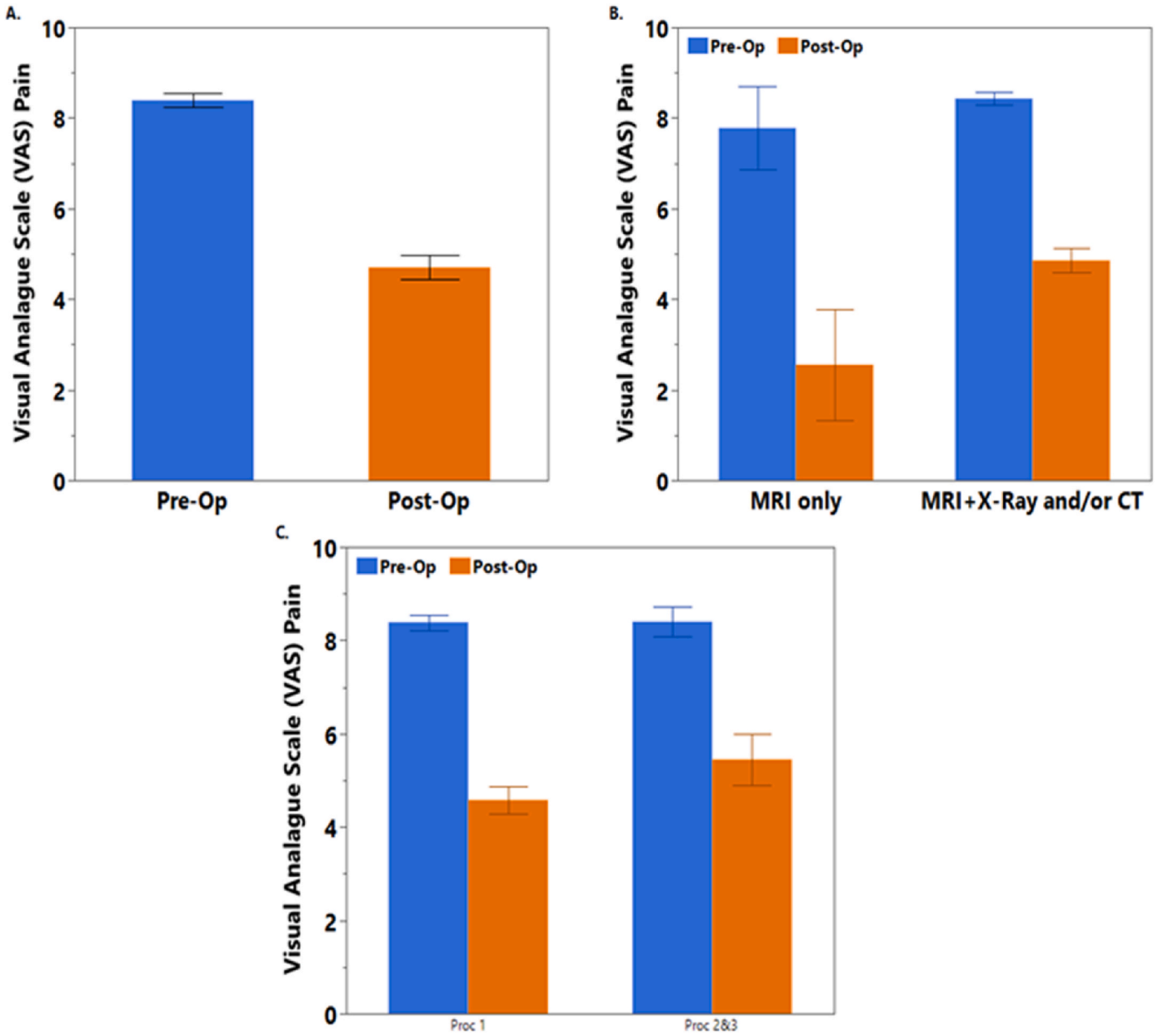

Fig. 3. Change in visual analog scale (VAS) pain scores following endoscopic decompression procedure in total sample (A) and stratified by radiological assessment (B) and procedure (C), with 95% confidence intervals. PROC 1 stands for any combinations of endoscopic decompression of the central spinal canal and/or lateral recess and/or neuroforamina by debulking of intervertebral disc, resection of lamina, facet joint, ligamentum flavum, facet cysts, or scar tissue from earlier spine surgeries. PROC 2 stands for resection of branch of spinal nerve(s) outside the spinal canal. PROC 3 stands for resection of L5 transverse process and/or sacral ala along with pseudojoint at L5-S1).

inclusion criteria and focusing on a within-subject design, future research with prospective or randomized control design with a robust sensitivity analysis would improve the validity of the current study. Another limitation of our study is that our follow-up period was 12 months; future analyses should aim to assess the benefits of endoscopic decompression beyond this period. Furthermore, future investigations should assess the advantages and risks of endoscopic decompression for patients above the age of 40 and with greater than normal BMIs, as these patients are at a greater risk of developing lower back pain [12].

Despite these limitations, our study reports benefit for performing endoscopic decompression to treat LSS. To directly compare endoscopic decompression against more commonly used surgical methods, future studies should be directed at conducting randomized control trials, or an equivalent retrospective review, that assign patients with LSS to full endoscopic decompression or to the current gold standard of open decompression methods, such as lumbar laminectomy. Additionally, further study aimed at subgroup analysis, stratified by indication, may further elucidate situations where endoscopic decompression may be more efficacious.

5. Conclusions

In our study, endoscopic decompression has been illustrated to be an effective procedure in improving the quality of life for patients diagnosed with LSS. When assessing changes in ODI scores, we found greater improvements in LSS patients a) without prior back surgery, b) with a normal BMI, and c) were under 40 years of age. These results show that endoscopic decompression should be the surgery of choice in those patients who fit the above criteria. The added benefit of endoscopic decompression is due to its minimally invasive approach, which has

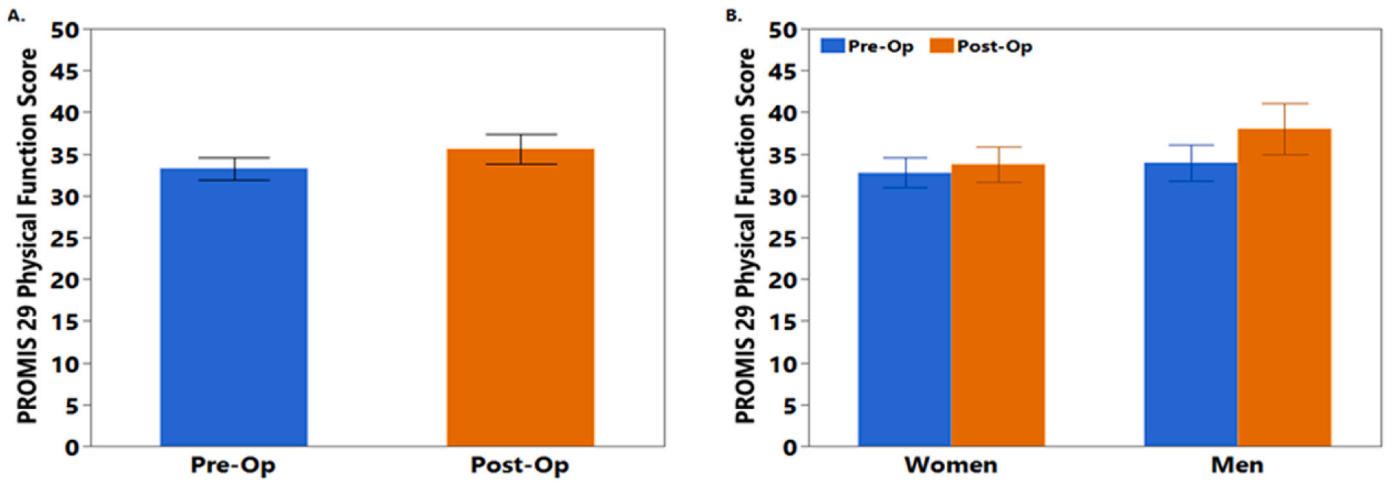

Fig. 4. Change in PROMIS-29 physical function scores following endoscopic decompression procedure in total sample (A) and stratified by sex (B), with 95% confidence intervals.

been shown to promote quicker recovery and reduce intra- and post-operative complications. Future research should focus on endoscopic decompression in patients above the age of 40 and with above-average BMIs since a greater proportion of LSS patients are within those groups. As this was a retrospective single-center study, future work can better study this intervention by incorporating a larger sample size with follow-up periods greater than 12 months.

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Reprints

Reprints will not be available from the authors.

Author contributions

DPS collected data, contributed to analysis, contributed to writing, organized research structure, led team collaboration, taught medical students. CG, JT, WP, AS, AB collected data, contributed to writing, participated in team collaboration. TV conceived, designed, and performed the analysis, contributed to writing. S.K. project PI; contributed to writing, contributed to data analysis.

Declaration of competing interest

The authors declare no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.inpm.2024.100391.

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