Elderly Patients Have Similar Outcomes Compared to Younger Patients After Minimally Invasive Surgery for Spinal Stenosis

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Published online: 4 December 2013
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Abstract

Background Older patients undergo surgery for lumbar spinal stenosis in great numbers, but as a result of substantial diagnostic and surgical heterogeneity, the impact of age on results after surgery is poorly defined.

Questions/purposes We compared groups of patients younger and older than 70 years with relative clinical and surgical homogeneity to determine differences in (1) interval improvement in Oswestry Disability Index (ODI)

at 6 weeks, 6 months, and 12 months postoperatively and (2) perioperative adverse events.

Methods We performed a subgroup analysis of an ongoing prospective observational study. Patients were divided based primarily on age (younger than 70 years [$n = 68$] and 70 years or older [$n = 41$]) and secondarily on procedure (minimally invasive decompression alone or decompression and instrumented fusion). With the exception of age and American Society of Anesthesiologists status, the two age groups were similar ($p > 0.3$) in baseline demographics and ODI. Mean pre- and postoperative ODI were compared between groups at 6 weeks, 6 months, and 12 months. Perioperative adverse events were also compared.

Results At all time intervals, both younger and older patients demonstrated ($p = 0.05$ to < 0.001) improvements in ODI. At the 1-year mark, no differences in ODI were demonstrated between the younger and older patients for decompression only (21 versus 26 [$p = 0.29$]) or decompression and fusion (19 versus 18 [$p = 0.97$]). Interval improvement in ODI was not different between younger and older patients at any time point for decompression only (6 weeks: -18 versus -20 [$p = 0.66$]; 6 months: -21 versus -17 [$p = 0.41$]; 12 months: -21 versus -15 [$p = 0.29$]) or decompression and fusion (6 weeks: -11 versus -12 [$p = 0.58$]; 6 months: -21 versus -22 [$p = 0.69$]; 12 months: -23 versus -27 [$p = 0.97$]). There were no differences in perioperative adverse events between groups ($p = 0.67$).

Conclusions When clinical and surgical heterogeneity is minimized, improvements in terms of disability as measured by the ODI and the frequency of adverse events after surgery in elderly patients with lumbar spinal stenosis are comparable to those of younger patients. For patients with focal lumbar spinal stenosis, age alone should not dissuade us from considering surgical intervention if otherwise indicated.

One of the authors (YRR) certifies that he or she, or a member of his or her immediate family, has received or may receive payments or benefits, during the study period, an amount of USD 10,000 to 100,000 from Medtronic (Memphis, TN, USA). Funding for this project was received from the Toronto General and Western Hospital Foundation, Minimal Access Ambulatory Spine Surgery Research and Education Program (Toronto, Ontario, Canada).

All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research* editors and board members are on file with the publication and can be viewed on request.

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Level of Evidence Level III, therapeutic study. See Instructions for Authors for a complete description of levels of evidence.

Introduction

As the post-World War II population ages, the percentage of the population older than 70 years continues to grow, placing increasing focus on degenerative conditions and chronic disease [9]. The incidence of clinically significant lumbar spinal stenosis, an age-related, degenerative condition of the spine that results in considerable disability among the elderly, is on the rise [9, 17, 18, 23]. Often dismissed as simply a normal part of aging, symptoms may eventually become quite severe or even disabling [26]. Additionally, the increasing economic burden of treating this age-related pathology further highlights the need to optimize effective treatment strategies in the management of this growing surgical demographic.

When indicated, surgical treatment of neurogenic claudication due to lumbar spinal stenosis with or without spondylolisthesis significantly improves health-related quality of life [21, 22, 27, 30]. However, many elderly patients significantly suffering from lumbar spinal stenosis may be marginalized and not considered candidates for surgery due to ageism, medical comorbidities, and/or subjective impressions (from the patient and/or the surgeon) of a patient's risk or outcome after spinal surgery [23]. Deyo et al. [6] have previously demonstrated an almost three times greater risk of postoperative complications in patients 75 years or older compared with patients younger than 40 years, with complex procedures having disproportionately higher complication rates. Unfortunately, significant clinical, diagnostic, and surgical heterogeneity exists in the literature; thus, the isolated impact of age on outcome remains unclear [3, 7, 17, 26]. In this regard, the consistent and reduced exposure-related morbidity associated with minimally invasive spine surgery has been proposed as potentially beneficial in the elderly [9, 10, 23].

We therefore compared groups of patients younger and older than 70 years with relative clinical and surgical homogeneity to determine differences in (1) interval improvement in Oswestry Disability Index (ODI) at 6 weeks, 6 months, and 12 months postoperatively and (2) perioperative adverse events.

Patients and Methods

We conducted a subgroup analysis of an ongoing prospective observational study of consecutive patients from a single institution, operated on by a single surgeon. Patients

were divided based primarily on age (younger than 70 years and 70 years or older) and secondarily on procedure (minimally invasive decompression alone or decompression and instrumented fusion). All surgical procedures were performed between January 2008 and December 2010 by the senior author (YRR). Preoperative baseline characteristics including age, sex, BMI, American Society for Anesthesiologists (ASA) physical status score, and presence of degenerative spondylolisthesis were recorded.

Inclusion criteria were patients presenting with neurogenic claudication (leg-dominant pain with standing and walking relieved by forward flexion) secondary to degenerative lumbar spinal stenosis with or without degenerative spondylolisthesis undergoing either minimally invasive microdecompression (one to two levels) or minimally invasive decompression and instrumented fusion (one to two levels) [24], using techniques described in more detail below. Patients were excluded if they had nondegenerative stenosis, scoliosis of greater than 10°, age of less than 50 years, any other diagnoses causing radiculopathy (eg, herniated disc, isolated synovial cyst, trauma, tumor, or infections), or degenerative disc disease as a primary diagnosis. In addition, patients lost to followup or those with missing primary data (ODI) at 1 year (ie, had data at later time points) were excluded.

One hundred nine patients fulfilled our inclusion criteria, 68 in the younger group and 41 in the older group (Table 1). This represented 81% (109 of 135 patients) undergoing surgical treatment for the eligible diagnoses during the period in question by the study surgeon (YRR). Of the 26 patients not analyzed, 19% ($n = 13$ missing 1-year data, $n = 4$ lost to followup) were younger than 70 years and 18% ($n = 6$ missing 1-year data, $n = 3$ lost to followup) were 70 years or older ($p = 0.89$). Comparatively, there was no difference in the primary outcome measure at baseline between these 26 patients and the 109 analyzed (ODI: 43 versus 42, respectively [$p = 0.70$]).

Table 1. Baseline characteristics in the two age groups

Characteristic	< 70 years ($n = 68$)	≥ 70 years ($n = 41$)	p value
Age (years)*	57.0 $\pm$ 10.0	75.0 $\pm$ 4.1	< 0.01
Female sex (%)	44	43	0.89
BMI*	28.8 $\pm$ 5.0	27.8 $\pm$ 5.5	0.38
Mean ASA grade	2	3	0.012
Presence of degenerative spondylolisthesis (%)	51	56	0.48
Day surgery case (%)	59	54	0.47

* Values are expressed as mean $\pm$ SD; ASA = American Society of Anesthesiologists.

The mean age was 57.0 years for those younger than 70 years and 75.0 years for those 70 years or older ($p = 0.001$). Sex ($p = 0.89$), BMI ($p = 0.38$), presence of spondylolisthesis ($p = 0.48$), and day surgery case ($p = 0.47$) were not different between age groups (Table 1). There was a greater number of patients in the younger group with an ASA of 1 and a greater number in the older group with an ASA of 3 ($p = 0.012$).

All patients with claudication, with no or manageable low-back pain, with no obvious dynamic instability (increase in spondylolisthesis or lateral listhesis by ≥ 5 mm demonstrated on supine to standing or flexion-extension imaging), and with or without static spondylolisthesis (up to Grade I) underwent decompression alone [11, 19]. All patients with back pain equal to or greater than leg pain, greater than 5 mm of motion, or Grade II or greater spondylolisthesis underwent decompression and fusion. The technique of microdecompression involved a bilateral decompression from a unilateral approach using a fixed tubular retractor system (METRx®; Medtronic, Memphis, TN, USA) that has been described previously [11, 19]. Minimally invasive fusion involved a paramedian muscle-splitting approach with a transforaminal lumbar interbody fusion using a tubular retractor and percutaneous pedicle screws (Sextant®; Medtronic) [11, 19]. All patients undergoing decompression and fusion were admitted for at least 1 day of monitoring in hospital. Patients undergoing decompression only were discharged on the day of surgery unless patient medical comorbidity dictated otherwise. Admission to hospital after decompression was required in 4.4% of the younger patients and 17% of the older patients ($p = 0.03$). This was due to medical status and/or living status (alone with no support system). The postoperative protocol (mobilization and progressive low-impact and low-back exercises as tolerated) was the same for all patients regardless of age and no bracing was utilized.

In the younger group, 40 patients underwent decompression only and 28 patients underwent decompression and fusion. In the older group, 28 patients underwent decompression only and 13 patients underwent decompression and fusion. Intraoperative data including blood loss and hospital length of stay (LOS) were recorded for each patient. For all procedures, mean blood loss was 50.9 mL for the younger group and 62.6 mL for older group ($p = 0.52$). For patients requiring admission, mean hospital LOS was 1.5 days (range, 1–3 days) in the younger group and 2.7 days (range, 1–9 days) in the older group ($p = 0.23$) after decompression only and 4.3 days (range, 1–9 days) in younger group and 5.5 days (range, 4–15 days) in older group ($p = 0.37$) after decompression and fusion.

All patients undergoing spine surgery underwent a preoperative anesthesia assessment with other medical

assessments (eg, cardiology) and preoperative optimization as deemed necessary by anesthesiology. All insulin-dependent diabetic patients were routinely seen by endocrinology for perioperative diabetic control. Postoperative assessment and intervention by medical or other consulting services were on a case-by-case basis.

ODI Version 2 assessments were administered in a standard written format during clinic visits preoperatively and at 6 weeks, 6 months, and 12 months after surgery. Differences in the degree of interval recovery were assessed by comparing relative improvement in ODI at 6 weeks, 6 months, and 12 months for each group.

Adverse events were defined as any event due to medical or surgical intervention leading to patient harm or requiring additional monitoring or treatment and were captured using the validated Spine Adverse Events Severity System as previously described [20]. We classified adverse events using the Adverse Event Severity Classification, where Grade 1 events result in no or minimal treatment or effect on LOS, Grade 2 events require treatment and/or increased LOS (3–7 days) but are not associated with long-term sequelae, Grade 3 events require treatment and/or increased LOS (> 7 days) and are associated with long-term sequelae, and Grade 4 events result in death [20].

For all analysis noted above and below in the Results section, we used Student's *t*-tests to determine statistical significance for continuous variables (applying the Shapiro-Wilk normality test, change in ODI followed a normal distribution) and chi-square tests to determine significance for categorical variables. We considered *p* values of less than 0.05 significant. Microsoft® Excel® (2008) (Microsoft Corp, Redmond, WA, USA) and SAS® Version 9.3 for Windows® (SAS Institute, Inc, Cary, NC, USA) were used for all statistical analyses.

Results

Both younger and older patients showed similar improvement in ODI postoperatively at all time intervals compared to baseline, with no difference in the degree of improvement between the young and elderly. No differences in ODI were found between age groups at each of the measured time intervals (Table 2, Fig. 1). Similarly, when younger and older patients were subdivided according to procedure, there were no differences between younger and older patients at any interval time period for decompression alone (baseline: 43 versus 41 [$p = 0.73$]; 6 weeks: -18 versus -20 [$p = 0.66$]; 6 months: -21 versus -17 [$p = 0.41$]; 12 months: -21 versus -15 [$p = 0.29$]) (Fig. 2) or decompression and fusion (baseline: 42 versus 45 [$p = 0.57$]; 6 weeks: -11 versus -12 [$p = 0.58$];

Table 2. Pre- and postoperative ODI at 6 weeks, 6 months, and 12 months after surgery

Procedure	Age (years)	Baseline ODI (points)	6 weeks		6 months		12 months	
			ODI (points) (Δ)*	p value [†]	ODI (points) (Δ)*	p value [†]	ODI (points) (Δ)*	p value [†]
Decompression	< 70 (n = 40)	43	24 (−18) [−25, −11] (p < 0.001)	0.66 [−6, 13]	21 (−21) [−27, −14] (p < 0.001)	0.41 [−12, 6]	21 (−21) [−27, −15] (p < 0.001)	0.29 [−14, 2]
	≥ 70 (n = 28)	41	21 (−20) [−28, −15] (p < 0.001)		24 (−17) [−24, −11] (p < 0.001)		26 (−15) [−21, −10] (p < 0.001)	
Decompression and fusion	< 70 (n = 28)	42	30 (−11) [−16, −1] (p = 0.026)	0.58 [−10, 16]	21 (−21) [−28, −14] (p < 0.001)	0.69 [−21, 19]	19 (−23) [−30, −15] (p < 0.001)	0.97 [−13, 21]
	≥ 70 (n = 13)	45	34 (−12) [−23, −0.1] (p = 0.048)		24 (−22) [−39, −1] (p = 0.040)		18 (−27) [−42, −11] (p = 0.0032)	

* Δ = change from baseline, with 95% CI in brackets and p value (one-sample t-test); [†] between-group comparisons (two-sample t-test), with 95% CI for differences in means in brackets; ODI = Oswestry Disability Index.

6 months: −21 versus −22 [p = 0.69]; 12 months: −23 versus −27 [p = 0.97]) (Fig. 3). At the 1-year mark, the changes in ODI for younger patients after decompression only or decompression and fusion were −21 (95% CI, −27, −15) (p < 0.001) and −23 (95% CI, −30, −15) (p < 0.001), respectively (Table 2). For older patients, the changes in ODI after decompression only and decompression and fusion were −15 (95% CI, −21, −10) (p < 0.001) and −27 (95% CI, −42, −11) (p = 0.0032), respectively (Table 2).

At 1 year, there were no differences in the number of adverse events between younger and older patients. Seven of the 68 patients (10%) in the younger group had an adverse event, compared to five of 41 patients (12%) in the older group (p = 0.67) (Table 3).

Discussion

The goal of minimally invasive surgery is to limit tissue injury and improve postoperative recovery [1, 8, 9, 12, 13, 15, 16, 23]. This may be especially beneficial in the elderly population where operative morbidity and decreased postoperative mobility can increase surgical risk [9, 10]. Although others have looked at the influence of age on complications and clinical results after spine surgery, heterogeneity in surgical procedures and diagnoses makes interpretation of these data challenging. We therefore determined, in a relatively homogeneous patient population, the influence of age on disability and adverse events after spine surgery.

There are several limitations to this study. It is a subgroup analysis of patients from a prospective study designed to evaluate a wide array of outcomes after surgery for degenerative spinal diagnoses and not the specific end points in this study. Also, followup was limited to 1 year; thus, there may be differential deterioration in ODI between groups over time. This cohort represents only 80% of consecutive patients meeting our inclusion criteria; however, there was no differential loss to followup or missing data at 1 year between groups, which tends to offset this limitation. Furthermore, there was no difference in the baseline ODI between those included and excluded for missing data. It is possible that some longer-term complications or deterioration in outcomes or differential reoperation rates may present in a delayed fashion [28, 29]. Although our groups were homogeneous regarding surgical procedure and clinical presentation, combining patients with and without degenerative spondylolisthesis (although equally represented between groups) introduces a degree of diagnostic heterogeneity. Furthermore, our results are specific to the selection criteria and procedures described herein; therefore, these findings are not generalizable to all

Fig. 1 A graph shows the ODI scores in younger and older patients at baseline, 6 weeks, 6 months, and 12 months. Values are shown as mean $\pm$ SD; p values are shown for between-group comparisons.

No significant differences were found between groups at each of the measured time intervals.

Fig. 2 A graph shows the interval improvement in disability as reflected by relative change in mean ODI at 6 weeks, 6 months, and 12 months for younger and older patients after decompression only. Values are shown as mean $\pm$ SD; p values are shown for between-group comparisons. No significant differences were found between groups at 6 weeks, 6 months, and 12 months.

Fig. 3 A graph shows interval improvement in disability as reflected by relative change in mean ODI at 6 weeks, 6 months, and 12 months for younger and older patients after decompression and fusion. Values are shown as mean $\pm$ SD; p values are shown for between-group comparisons. No significant differences were found between groups at 6 weeks, 6 months, and 12 months.

practices. Finally, due to limited sample sizes particularly when groups were subdivided by procedure type, the study is underpowered to state absolute differences with regard to hospital LOS or admission rates, although the general trends reported here may be valuable. Our initial prestudy power analysis demonstrated that a sample size of 40 in each group would be sufficient to detect a 12.8-point ODI difference, which would support a minimal clinically significant difference in ODI [4]. Furthermore, we did not delineate very elderly patients (older than 80 years) from elderly patients; it is possible that patients in their ninth

decade may have increased surgical morbidity not captured by this study.

Our results demonstrated that in a consistently selected cohort where exposure-related surgical morbidity was equal, improvement in patient-reported disability was comparable in younger and older patients pre- and post-operatively as measured by ODI. In a similar comparative study, Thornes et al. [25] reported on 100 patients undergoing more conventional open decompression and decompression and fusion for lumbar spinal stenosis. Stratifying age at 65 years, the authors reported that age

Table 3. Adverse events in the two age groups

Age group	Number of patients with adverse events	Adverse events
< 70 years	7 (10.2%)	Ileus (Grade 1) Cardiac failure (Grade 2) Urinary retention (Grade 2) Delirium (Grade 2) Postoperative neuropathic pain (Grade 3) Hematoma (Grade 3) Pulmonary embolism (Grade 3)
≥ 70 years	5 (12.2%)	Superficial wound infection (Grade 2) Urinary tract infection × 2 (Grade 2) Urinary retention (Grade 2) Other (Grade 2)
p value	0.67	

did not significantly impact improvement in symptoms, function, and health-related quality of life at 1 year. In a noncomparative study, Rosen et al. [23] reported no major complications and significant improvement in ODI and SF-36 scores in their series of 57 patients with a mean age of 81 years undergoing minimally invasive decompression for lumbar spinal stenosis.

Our study also demonstrated that the elderly can expect similar interval improvements in disability as compared to their younger counterparts. In an elderly cohort undergoing minimally invasive lumbar spinal decompression, Rosen et al. [23] performed a longitudinal analysis to determine the durability of postoperative changes in the outcome scores. They found that ODI decreased 5.1 points per month for the first 3 months with no further change after 3 months. However, no younger control group was present and complication rates in decompression with fusion were not investigated. Although we did not conduct a formal rate of recovery analysis, our results suggested that recovery times between the elderly and young were similar.

Considerable variability in adverse events after surgical management of lumbar spinal stenosis in the elderly exists in the literature. However, for series involving conventional open surgery, it appears that higher adverse events rates occur in the elderly. Deyo et al. [5] reported an 18% complication rate for patients older than 75 years undergoing lumbar spine surgery and found that age positively correlated with complication rate. Spinal stenosis, which was a primary diagnosis in 85% of patients studied, was associated with increased risk of complications and longer LOS. In a subsequent study evaluating 18,122 patients, an

almost three times greater risk of postoperative complications in patients who were 75 years or older was found compared to patients younger than 40 years [6]. Benz et al. [2] reported a major complication rate of 12% and mortality rate of 1.4% in elderly patients undergoing decompression with or without fusion. Oldridge et al. [14] looked at 34,418 Medicare beneficiaries undergoing lumbar spine procedures and showed an overall mortality rate of 0.5%; this increased significantly to more than 10% in patients older than 80 years undergoing spinal fusion. Fujita et al. [7] found a major complication rate of 33% in patients older than 60 years undergoing fusion for lumbar spinal stenosis, with an overall complication rate of more than 80%. Vitaz et al. [26] reported a lower major complication rate of 10% in 65 patients older than 75 years undergoing decompression only or decompression and fusion for lumbar spinal stenosis. Comparatively, no difference was found in our series. In a recent study, Karikari et al. [9] reported a 7.4% rate of major complications and 25% rate of minor complications in 66 patients older than 70 years undergoing minimally invasive lumbar interbody fusion. However, a younger control group was not assessed in this study.

This reported variability in adverse event rates after surgical management of lumbar spinal stenosis may be a result of clinical and diagnostic heterogeneity, surgical heterogeneity, grouping decompression only and decompression and fusion together, use of disparate outcome measures, lengths of followup, age ranges, and institution or surgeon variability [23]. Unfortunately, as with our study, no study to date has presented a similar homogeneous cohort that has undergone conventional open versus minimally invasive procedures. Thus, any direct benefit to the elderly from the minimally invasive procedures described herein compared to comparable open procedures in the same population are purely speculative based on the available historical data.

We demonstrated that the 1-year outcomes of minimally invasive decompression only or decompression and fusion in elderly patients with focal (one- to two-level) lumbar spinal stenosis with or without degenerative spondylolisthesis were comparable to those of younger patients with similar clinical presentation and exposure-related surgical morbidity. We believe that our results provide useful information that may enable improved shared decision making between surgeons and elderly patients who may have concerns regarding the safety of lumbar spinal surgery for neurogenic claudication due to lumbar spinal stenosis. For patients with focal spinal stenosis, age alone should not be used as a relative contraindication for elderly patients who are otherwise appropriate for spinal surgery.

Acknowledgments We thank Oma Persaud MSc, Idris Aleem MHS, and Saleema Nawab BA for their assistance with tables/figures and data acquisition and analysis.

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