Health-related quality of life following decompression compared to decompression and fusion for degenerative lumbar spondylolisthesis: a Canadian multicentre study

Y. Raja Rampersaud, MD[*†]
Charles Fisher, MD, MHSc[‡]
Albert Yee, MD, MSc[§]
Marcel F. Dvorak, MD[‡]
Joel Finkelstein, MD, MSc[§]
Eugene Wai, MD, MSc[¶**]
Edward Abraham, MD[††]
Stephen J. Lewis, MD, MSc[*†]
David Alexander, MD[‡‡]
William Oxner, MD[‡‡]

From the *Division of Orthopaedic Surgery, Department of Surgery, University of Toronto, Toronto, Ont., †Spinal Program, Krembil Neuroscience Center, Toronto Western Hospital University Health Network, University of Toronto, Toronto, Ont., ‡Combined Neurosurgical and Orthopaedic Spine Program (CNOSP), Department of Orthopaedics, University of British Columbia, Vancouver Coastal Health Research Institute, Vancouver General Hospital, Vancouver, BC, §Sunnybrook Health Sciences Centre, Toronto, Ont., ¶Division of Orthopaedic Surgery, Department of Surgery, University of Ottawa, The Ottawa Hospital, Ottawa, Ont., **Clinical Epidemiology Program, Ottawa Hospital Research Institute, Ottawa, Ont., ††Atlantic Health Science Corporation, St. John, NB, and ‡‡Dalhousie University, QEII Health Sciences Centre, Halifax, NS

Accepted for publication
Jan. 27, 2014

Correspondence to:
Y.R. Rampersaud
Division of Orthopaedic Surgery and Neurosurgery
Toronto Western Hospital
399 Bathurst St. East Wing, 1-441
Toronto ON M5T 2S8
raja.rampersaud@uhn.on.ca

DOI: 10.1503/cjs.032213

Background: Decompression alone (D) is a well-accepted treatment for patients with lumbar spinal stenosis (LSS) causing neurogenic claudication; however, D is controversial in patients with LSS who have degenerative spondylolisthesis (DLS). Our goal was to compare the outcome of anatomy-preserving D with decompression and fusion (DF) for patients with grade I DLS. We compared patients with DLS who had elective primary 1–2 level spinal D at 1 centre with a cohort who had 1–2 level spinal DF at 5 other centres.

Methods: Patients followed for at least 2 years were included. Primary analysis included comparison of change in SF-36 physical component summary (PCS) scores and the proportion of patients achieving minimal clinically important difference (MCID) and substantial clinical benefit (SCB).

Results: There was no significant difference in baseline SF-36 scores between the groups. The average change in PCS score was 10.4 versus 11.4 (p = 0.61) for the D and DF groups, respectively. Sixty-seven percent of the D group and 71% of the DF group attained MCID, while 64% of both D and DF groups attained SCB. There was no significant difference between D and DF for change in PCS score (p = 0.74) or likelihood of reaching MCID (p = 0.81) or SCB (p = 0.85) after adjusting for other variables.

Conclusion: In select patients with DLS, the outcome of D is comparable to DF at a minimum of 2 years.

Contexte : La décompression seule est un traitement bien accepté pour la sténose lombaire (SL) causant une claudication neurogène. Son utilisation ne fait cependant pas l'unanimité chez les patients atteints de SL qui souffrent d'un spondylolisthésis dégénératif (SLD). Notre objectif était de comparer l'issue d'une décompression avec préservation anatomique à celle d'une décompression-arthrodèse (DA) chez des patients atteints de SLD de grade 1. Nous avons comparé les patients atteints de SLD ayant subi une décompression élective primaire de niveau 1–2 dans un centre à une cohorte ayant subi une DA de niveau 1–2 effectuée dans 5 autres centres.

Méthodes : Nous avons inclus les patients qui ont été suivis pendant au moins 2 ans. L'analyse primaire comportait une comparaison des changements aux scores sommaires pour la composante physique (CP) du questionnaire SF-36 et la proportion de patients ayant obtenu une différence minimale cliniquement importante (DMCI) et en ayant tiré un bienfait clinique substantiel (BCS).

Résultats : Il n'y avait pas de différence significative entre les scores SF-36 des 2 groupes au départ. Le changement moyen du score pour la CP a été de 10,4 c. 11,4 (p = 0,61) dans les groupes soumis à la décompression et à la DA, respectivement. Soixante-sept pour cent des patients du groupe soumis à la décompression et 71 % du groupe soumis à la DA ont obtenu une DMCI, tandis que 64 % des 2 groupes ont obtenu un BCS. On n'a noté aucune différence significative entre les groupes soumis à la décompression et à la DA pour ce qui est du changement du score pour la CP (p = 0,74) ou de la probabilité d'obtenir une DMCI (p = 0,81) ou un BCS (p = 0,85) après ajustement pour tenir compte d'autres variables.

Conclusion : Chez certains patients souffrant de SLD, l'issue de la décompression est comparable à celle de la DA après une période minimale de 2 ans.

Degenerative lumbar spondylolisthesis (DLS) is a common spinal disorder that can lead to substantial back and/or leg pain. It is also a very common reason for spinal surgery in individuals older than 65 years.[1] The estimated incidence of DLS is 12.7% with an overall prevalence of 6% that increases between the fifth and eighth decades of life.[2–4] For symptomatic patients, the recent Spine Patient Outcomes Research Trial (SPORT) — DLS study has demonstrated that surgical management is superior to conservative care at 2 and 4 years post-intervention.[5,6]

From a surgical perspective, since the controlled study by Herkowitz and Kurz[7] demonstrated a high failure rate following decompression (conventional midline laminectomy) alone (D), decompression and fusion (DF) has become the surgical treatment of choice for patients with DLS. A recent systematic review by Martin and colleagues[8] concluded that "decompression and spinal fusion may lead to better clinical outcome compared to decompression alone." The contemporary management of DLS is reflected in the SPORT — DLS study in which 95% of patients underwent fusion, the majority of which (74%) were instrumented fusions.[5]

Degenerative spondylolisthesis, however, represents a spectrum of pathology from very stable collapsed discs to maintained disc height with significant translation on loading dynamic imaging studies. Clinical symptoms also vary, with the patient experiencing either classical bilateral neurogenic claudication symptoms and/or unilateral/bilateral lumbar radiculopathy/sciatica. Physicians and surgeons experienced in the treatment of patients with this condition recognize this broad clinical presentation, which is a consideration given recent randomized controlled trials (RCTs) evaluating "similar patients" from an experimental and control perspective. By carefully delineating these potential subgroups the question arises as to whether all cases of DLS require fusion and, if so, whether instrumentation may or may not be required as an adjunct to fusion. The importance of this question is further amplified when one considers the additional morbidity associated with instrumented spinal fusion in elderly patients and the scarcity of health care resources for this growing segment of the population.[9–13]

The development of less destructive midline anatomy-sparing decompressive techniques have created renewed interest in D rather than DF for certain patients with "stable" DLS.[14] The literature to date has demonstrated good efficacy of the less invasive decompressive techniques in treating simple lumbar spinal stenosis (LSS),[15–25] but to our knowledge no comparative study in a pure cohort of patients with DLS has been conducted. The purpose of the present study was to assess the outcomes of anatomy-preserving D in a select subgroup of patients with DLS compared with those of a multicentre cohort of patients with DLS who underwent DF.

Methods

We conducted a Canadian multicentre ambispective (retrospective review of prospectively collected data) cohort study. We sought to determine whether the 2-year postoperative improvement in health-related quality of life (HRQoL) outcomes for D was equivalent to that of DF for the management of focal (1–2 level) stenosis and associated DLS with similar clinical presentation. The study was approved by each institution's research ethics board.

Patient population

Inclusion and exclusion criteria were applied to prospective surgical databases collecting HRQoL outcome measures from 6 academic spine centres across Canada. We included patients with DLS who had 1- or 2-level surgery for whom baseline and 2-year primary outcome data were available. All patients had failed at least 6 months of nonoperative care. Exclusion criteria were other causes of spinal stenosis (e.g., congenital, post-traumatic, degenerative scoliosis), multilevel surgery (> 2 levels), previous surgeries (at the symptomatic or adjacent level; a prior discectomy was allowed) or multilevel coronal and/or sagittal plane deformity.

Surgical technique

Indication for surgery and type of surgery was as per the individual surgeons' practices.

Decompression alone was performed at 1 centre only (Toronto Western Hospital [TWH]). This technique was chosen for patients with neurogenic claudication/mechanical radiculopathy (i.e., leg-dominant symptoms that were relieved by postural change and/or rest), no (or tolerable) mechanical back pain, facet anatomy favourable to facet-sparing (i.e., undercutting) decompression, up to a 25% (grade I) spondylolisthesis, and no obvious dynamic instability on imaging. Radiographic dynamic instability was defined as an increase in spondylolisthesis by 4–5 mm or more demonstrated on supine to standing or flexion-extension imaging.[14] Preoperative disc height was not considered in the decision for D. It entailed a midline-sparing, bilateral decompression from a unilateral approach using a tubular retractor system (METRx Medtronic) that has been previously described by Kelleher and colleagues.[14]

At the time of surgery (2000–2006) all 8 surgeons from the 5 other academic centres performed DF for all patients with symptomatic DLS. This group represents the broader structural presentations of DLS, including the more "stable" patients amenable to D as well as those with more complex structural pathology (e.g., grade II or greater listhesis and/or more complex coronal or sagittal plane spinal alignment) for which DF may be indicated. The primary indications for surgery were leg-dominant pain and, to a much lesser extent, back and leg pain. Fusion for back-dominant pain

was rarely performed by any of the surgeons. All fusions were instrumented using pedicle screws with posterolateral and/or interbody fusion.

Data collection

Data included the patient characteristics of age and sex. The preoperative and postoperative (2 yr minimum) Medical Outcomes Study Short-Form General Health Survey (SF-36) was administered. Data were obtained from site-specific prospective surgical registries collecting patient-reported HRQoL (SF-36) data. Varying definitions of what constituted an adverse event and different methods for reporting all or selected events precluded comparison of adverse events.

Outcome measures

The SF-36 physical component summary (PCS) score was the primary outcome measure. Primary analysis included comparison of the degree of change between pre- and postoperative PCS scores and the proportion of patients from each cohort reaching minimal clinically important difference (MCID) and substantial clinical benefit (SCB) for PCS, as defined for degenerative spinal surgery.[26] Our secondary analysis compared the 2-year postoperative change in scores on the 8 SF-36 subscales and the mental component summary (MCS) score.

Statistical analysis

We performed univariate analysis using an unpaired Student *t* test for continuous variables and a Pearson χ^2 test for categorical variables. Multivariate analysis was performed to control for any significant baseline difference between cohorts.

A priori power analysis

Using historical standard deviations for PCS in this population, with α (type I error rate) set 0.05 and power at 80%, we determined that 50 patients per group would be required to detect an MCID for PCS between groups.

RESULTS

A total of 179 patients underwent surgery for the diagnosis of spinal stenosis with DLS. Decompression alone was performed in 46 patients (57% single-level), whereas DF was performed in 133 patients (64% single-level). The baseline demographic and clinical characteristics of the groups are presented in Table 1. The D group was on average 5 years older (p = 0.003) and had 15% fewer women (p = 0.044) than the DF group. The mean time from surgery was equivalent between the groups (p = 0.69). The D group had slightly more 2-level procedures than the DF group (43% vs. 36%, respectively). Baseline SF-36 values are presented in Table 2. There was no significant difference in baseline SF-36 scores between the groups; however, 3 SF-36 components nearly reached significance: MCS, general health (GH) and mental health (MH; all p = 0.06). With the exception of GH, there was significant improvement pre- to postoperatively in all SF-36 subscales and summary scores for both the D and DF groups (Table 3).

Comparison between the subgroups of D and DF patients from the only centre performing D (TWH) are shown in Table 4. There was no significant difference between the D and DF groups' baseline and 2 year SF-36 scores (data presented for only the PCS, physical functioning [PF] and bodily pain [BP] scores; no difference was noted for any other subscales). The results of patients who underwent DF at TWH were also compared with those of patients who underwent DF at the other centres. There was no significant difference between the D and DF groups' baseline and 2 year SF-36 scores (data presented for only the PCS, PF and BP scores; no difference was noted for any other subscales).

Primary outcome

With regard to the numeric mean change in overall physical HRQoL (PCS) there was no significant difference in the mean change in PCS for D and DF (10.4 v. 11.4, p = 0.61). Similarly, the number of patients reaching MCID

Table 1. Demographic and clinical characteristics of the study sample

Characteristic	Group; mean ± SD or no. (%)		*p* value*
	Decompression alone, *n* = 46	Decompression and fusion, *n* = 133	
Age, yr	67.80 ± 8.66	62.47 ± 10.83	0.003
Sex, female	27 (59)	98 (74)	0.044
% with 1-level surgery	26 (57)	85 (64)	0.35
Time from surgery	29.95 ± 14.34	29.17 ± 10.36	0.69
Baseline PCS score	28.90 ± 7.90	30.00 ± 7.00	0.39
Baseline MCS score	42.90 ± 12.70	46.80 ± 11.80	0.06

MCS = mental component summary; PCS = physical component summary; SD = standard deviation.
*Two sample Student *t* test (mean) or Pearson χ^2 test (percentage).

(4.9 point change in PCS) was 68% for D and 73% for DF (p = 0.58). The number of patients reaching SCB (6.2 point change in PCS) was 64% for D and 66% for DF (p = 0.81). The results of multivariate analysis are shown in Tables 5–7. The multivariate analysis demonstrated that baseline age (p = 0.039) and PCS (p < 0.003) were independent predictors of change in PCS and likelihood of reaching MCID and SCB for PCS. Older patients and those with higher baseline PCS scores (i.e., better physical HRQoL) had less change in PCS and were less likely to reach MCID and SCB for PCS. There was no significant difference in change in PCS or likelihood of reaching MCID or SCB for PCS between the D and DF groups when adjusted for other variables (all p > 0.74).

Secondary outcome

The mean change in SF-36 subscale and component summary scale scores are presented in Table 3. Overall, there was no significant difference between the D and DF groups in the pre- to postoperative change in any of the subscales or the MCS (all p > 0.19).

Discussion

The results of our study demonstrate that in a select subgroup of patients with DLS (i.e., those with leg-dominant symptoms and what is typically termed a "stable DLS") D can achieve the same significant improvement in HRQoL as DF.

The generally accepted clinical belief that DF is superior to D for the surgical management of DLS was recently supported by a systematic review by Martin and colleagues.[8] Historically superior outcomes of DF versus D are demonstrated in patient-reported outcomes,[7,8,27–30] postoperative increase in listhesis (instability)[7,27,30,31] and reoperation rates.[8,28,32] However, in contrast to the present study, a distinct "stable cohort" of patients with DLS was

Table 2. Baseline and postoperative SF-36 subcomponent scores

	Group; mean ± SD						
	Decompression alone, n = 46			Decompression and fusion, n = 133			Overall
SF-36 component	Baseline	Postoperative	p value*	Baseline	Postoperative	p value*	p value*
Physical component summary	28.89 ± 7.95	39.02 ± 11.69	< 0.001	29.97 ± 7.00	41.39 ± 10.59	< 0.001	0.39
Mental component summary	42.91 ± 12.69	50.23 ± 10.62	0.004	46.78 ± 11.83	50.94 ± 10.66	0.003	0.06
Physical functioning	24.82 ± 20.64	52.16 ± 30.66	< 0.001	30.43 ± 22.09	60.81 ± 27.26	< 0.001	0.13
Role-physical	13.72 ± 20.35	46.60 ± 35.51	< 0.001	16.71 ± 25.65	54.01 ± 36.26	< 0.001	0.48
Bodily pain	26.15 ± 22.15	57.29 ± 25.16	< 0.001	27.52 ± 14.57	56.38 ± 23.88	< 0.001	0.62
General health	59.87 ± 22.87	61.00 ± 22.99	0.81	66.39 ± 19.55	68.50 ± 19.18	0.37	0.06
Vitality	37.69 ± 19.01	51.69 ± 22.09	0.002	38.36 ± 20.28	56.43 ± 21.14	< 0.001	0.84
Social functioning	44.57 ± 26.57	76.67 ± 23.47	< 0.001	47.92 ± 26.58	75.28 ± 26.58	< 0.001	0.46
Role-emotional	46.37 ± 39.97	70.46 ± 35.73	0.003	56.57 ± 40.98	74.00 ± 34.57	< 0.001	0.15
Mental health	61.13 ± 20.28	73.12 ± 18.07	0.004	68.21 ± 18.29	76.55 ± 34.57	< 0.001	0.06

SD = standard deviation.
*Two-sample Student t test comparing pre- and postoperative values.

Table 3. Two-year change in health-related quality of life, SF-36 components

	Group; mean ± SD Δ quality of life		
SF-36 component	Decompression alone, n = 46	Decompression and fusion, n = 133	p value*
Physical component summary	10.43 ± 10.77	11.36 ± 10.21	0.61
Mental component summary	7.36 ± 14.01	4.26 ± 13.35	0.19
Physical functioning	27.34 ± 31.16	30.37 ± 27.06	0.53
Role-physical	32.88 ± 36.41	37.71 ± 38.62	0.46
Bodily pain	32.78 ± 23.57	28.53 ± 27.04	0.35
General health	1.06 ± 22.53	2.01 ± 21.70	0.80
Vitality	14.28 ± 25.34	17.88 ± 25.35	0.41
Social functioning	32.50 ± 32.57	27.18 ± 34.28	0.36
Role-emotional	23.06 ± 48.43	17.99 ± 45.28	0.53
Mental health	12.67 ± 20.06	8.35 ± 19.23	0.20

SD = standard deviation.
*Two-sample Student t test.

not identified and a midline anatomy-sparing minimally invasive approach was not used.[7,8,27,28,33] A traditional laminectomy does not preserve any of the midline structures and also may not be facet-preserving. Consequently, a traditional laminectomy has a higher likelihood of increased postoperative instability, clinical failure and revision rate over time, particularly in the DLS patient population.[7,34] However, several small series in which facet-preserving techniques were used also suggest that DF was still superior for this patient population.[28,30,32,35]

The findings of the present study are contrary to those in most of the literature and to surgeon belief.

Although limited in number, there are a few published studies that contradict the studies favouring fusion and that support the findings of the present study. Matsudaira and colleagues[31] demonstrated no difference in outcome between midline-sparing (bilateral laminotomy), facet-preserving decompression (n = 18) and decompression and instrumented posterolateral fusion (n = 19) 2 years after surgery in patients with grade 1 DLS.[31] In the recently published SPORT — DLS study, 19 patients underwent D and 344 patients underwent DF.[36] As reported by Tosteson and colleagues,[36] the quality-adjusted life years (QALY) gained by the 19 patients who had D was the same as that in the DF cohort 2 years post-surgery.[36] Unfortunately, no details regarding selection criteria for those undergoing D are provided in these studies.

It is our belief that, from a structural and clinical perspective, all patients with asymptomatic DLS are not equal. Symptomatic patients typically present with 3 clinical scenarios (back-dominant pain, leg-dominant pain and equal back and leg pain) and a stable or unstable (i.e., mobile) low-grade (I-II) listhesis. Regardless of outcome, it would appear that the 2 main selection criteria used in this study are consistent with those of other contemporary studies where D was applied in the DLS population: leg-dominant symptoms and stable (< 3–5mm of movement) grade 1 spondylolisthesis.[14,31,32,37] Essentially, these patients present with unilateral or bilateral neurogenic claudication symptoms, much like patients with LSS.[38] Two studies using these selection

Table 4. SF-36 component scores: decompression alone versus decompression and fusion in Toronto Western Hospital patients, and decompression and fusion in Toronto Western Hospital patients versus all sites

	TWH groups; mean ± SD*			Group; mean ± SD*		
Factor	Decompression alone, n = 46	Decompression and fusion, n = 25	p value†	TWH decompression and fusion, n = 25	All sites depression and fusion, n = 108	p value†
Baseline PCS	28.9 ± 8.0	31.2 ± 7.6	0.25	31.2 ± 7.6	29.7 ± 6.9	0.39
2 year PCS	39.0 ± 11.7	42.8 ± 9.7	0.16	42.8 ± 9.7	41.1 ± 10.8	0.45
Change in PCS	10.4 ± 10.8	12.1 ± 9.4	0.51	12.1 ± 9.4	11.2 ± 10.4	0.69
PCS MCID,‡ %	65	76		76	70	
PCS SCB,§ %	61	72		72	63	
Baseline PF	24.8 ± 20.6	31.1 ± 23.7	0.27	31.1 ± 23.7	30.3 ± 21.8	0.87
2-year PF	52.2 ± 30.7	62.2 ± 25.0	0.14	62.2 ± 25.0	60.5 ± 27.9	0.77
Change in PF	27.3 ± 31.2	31.1 ± 24.7	0.58	31.1 ± 24.7	30.2 ± 27.7	0.88
Baseline BP	26.2 ± 19.5	30.3 ± 18.4	0.38	30.3 ± 18.4	26.9 ± 13.6	0.39
2-year BP	57.3 ± 25.2	59.2 ± 20.7	0.73	59.2 ± 20.7	55.7 ± 24.6	0.46
Change in BP	32.8 ± 23.6	29.0 ± 25.4	0.54	29.0 ± 25.4	28.4 ± 27.5	0.93

BP = bodily pain; MCID = minimal clinically important difference; PCS = physical component summary; PF = physical functioning; SCB = substantial clinical benefit; SD = standard deviation; TWH = Toronto Western Hospital.
*Unless otherwise indicated.
†Two-sample Student t test.
‡MCID for PCS = 4.9.
§SCB for PCS = 6.2.

Table 5. Multiple linear regression results for change in physical component summary score, n = 175

Variable	Coefficient (95% CI)	p value
Age, yr	–0.20 (–0.34 to –0.05)	0.009
Sex, female	–1.21 (–4.66 to 2.24)	0.49
Baseline PCS	–0.47 (–0.70 to –0.25)	< 0.001
Baseline MCS	0.06 (–0.07 to 0.19)	0.35
Decompression and fusion	0.60 (–2.97 to 4.17)	0.74

CI = confidence interval; MCS = mental component summary; PCS = physical component summary; SD = standard deviation.

Table 6. Logistic regression results for MCID on physical component summary score,* n = 125

Variable	Odds ratio (95% CI)	p value
Age, yr	0.96 (0.93–1.00)	0.039
Sex, female	0.80 (0.36–1.82)	0.60
Baseline PCS score	0.91 (0.87–0.96)	0.001
Baseline MCS score	1.02 (0.99–1.05)	0.13
Decompression and fusion	1.11 (0.48–2.55)	0.81

CI = confidence interval; MCID = minimal clinically important difference; MCS = mental component summary; PCS = physical component summary; SD = standard deviation.
*MCID for PCS = 4.9.

criteria have directly assessed the outcome of D alone for DLS compared with LSS patients without DLS. Sasai and colleagues[37] demonstrated that the outcomes of midline facet-preserving D in select patients with DLS (n = 23) was similar to those of patients with LSS (n = 25) without spondylolisthesis at a minimum of 2 years (mean follow-up was 4 yr). Most recently, Kelleher and colleagues[14] demonstrated comparable outcomes at 2 years with D in the same subpopulation of DLS patients as those in our study compared to patients with LSS without spondylolisthesis.

By applying the aforementioned selection criteria (see methods), D for this defined subset of patients with DLS has several obvious advantages. From the perspective of elderly patients, reduced surgical morbidity and recovery time with similar clinical outcomes are clearly desirable.[6,39,40] From a health care system perspective, the reduced duration of surgery, length of hospital stay and cost of D versus DF translate to cost savings or increased service delivery (i.e., more patients treated) for the same cost. However, before wide adoption of D for a subpopulation of patients with DLS can be considered, the generalizability and sustainability of the alternative technique must be demonstrated. Although a keyhole technique was used in our study (i.e., the preferred access of the specific surgeon using this approach), others have demonstrated similar findings with more conventional access and a bilateral technique.[31,37] The postoperative increase in radiographic listhesis demonstrated in the studies of Kelleher and colleagues,[14] Matsudaira and colleagues[31] and Sasai and colleagues[37] (1.7% to 8.4%) is concerning regarding long-term sustainability. However, these studies all noted that an increase in listhesis did not correlate with an inferior clinical outcome or higher reoperation rate 2–4 years postoperatively. Furthermore, the revision rates in these studies (4% at 48 month follow-up[14,37]) are comparable to that reported in the literature for contemporary DF in this population.[5,6] Regardless, the clinical and economic impact of any potential difference in the long-term revision rate of these cohorts requires further investigation. Although not part of the present study, the TWH patients reported in Table 4 are part of an ongoing observational study with follow-up ranging from 5 to 13 years. In this group, the longer term revision rate for those who underwent D was 11% (n = 5 [3 with same site and 2 adjacent segment procedures]; 3 of these patients required a subsequent DF and 2 had repeat D; mean time to revision was 61.2 months) and 36% for those with DF (n = 9 [2 with same site and 7 with adjacent segment procedures]; all had a repeat DF; mean time to revision was 62.1 months). It must be emphasized that the primary DF group at this centre would represent the more unstable and complex anatomic presentations of DLS. Given the possibility of therapeutic equipoise, the question of D versus DF for a defined subpopulation of patients with DLS lends itself ideally to an RCT. However, as demonstrated by the ongoing controversy of instrumented versus noninstrumented fusion for DLS, an RCT demonstrating minimal difference without long-term follow up is unlikely to change the established practice of fusion for most — if not all — patients with DLS who require surgical intervention.[9,35,41–44]

Table 7. Logistic regression results for SCB on physical component summary score,* n = 114

Variable	Odds ratio (95% CI)	p value
Age, yr	0.96 (0.92–0.99)	0.010
Sex, female	1.07 (0.50–2.28)	0.87
Baseline PCS score	0.93 (0.88–0.97)	0.002
Baseline MCS score	1.01 (0.98–1.04)	0.41
Decompression and fusion	0.93 (0.42–2.05)	0.85

CI = confidence interval; MCS = mental component summary; PCS = physical component summary; SCB = substantial clinical benefit; SD = standard deviation.
*SCB for PCS = 6.2.

Table 8. Comparison of degenerative spondylolisthesis patients in SPORT trial sample versus present sample: change in SF-36 physical functioning and bodily pain scores

	Group; Δ score	
SF-36 component	SPORT, n = 324	Present, n = 179
Physical functioning	26.6	29.7
Bodily pain	29.9	30.1

SPORT = Spine Patient Outcomes Research Trial.

Limitations

The major strength of our study is that it assesses an alternative surgical management strategy (D) in a highly selected subpopulation of DLS patients compared with a generalizable multicentre cohort of DLS patients with similar clinical presentation in whom this selection criteria was not applied and who all received DF. To our knowledge, this study also represents the largest comparative study of its kind and presents clearly defined selection criteria and surgical principle for D in the DLS population. The methodological limitations of this study are related to the retrospective nature of our data abstraction from prospective databases. The potential confounding effects of patient and surgeon selection biases, differential complication rates and differences in surgical technique (mix of posterolateral or interbody instrumented fusion) for the DF cohort cannot be accounted for, but may reinforce the generalizability of our control group. In addition, all the other participating surgeons in this study performed DF for DLS patients. Patients who received DF at the centre performing selective D demonstrated similar results compared with the rest of the DF cohort as well as compared with the D cohort, suggesting a similar treatment effect can be achieved for the selected subgroup from within the same centre. The experimental group (D) was a highly selected subpopulation of patients with DLS and was thus not generalizable to the current literature. In addition, these patients underwent a specific minimally invasive decompression technique that

has not been assessed for generalizability, thus introducing the possibility of a technique-based surgeon and procedural bias. Furthermore, the baseline demographic characteristics were not equal between cohorts. The D group was on average 5 years older, included fewer women and had more 2-level procedures than the DF group. Furthermore, the D group had a trend toward lower baseline MCS, GH and MH scores (Table 2, $p = 0.06$). However, these differences would more likely bias against the D group.[45–47] As noted in the results, multivariate analysis controlling for age, sex and baseline PCS and MCS scores did not alter the outcome between those with D and DF. However, we did not control for other potential counfounders, such as medical comorbidities, smoking status, fusion techniques (i.e., posterolateral v. interbody fusion) or percent of spondylolisthesis. Although we cannot comment on all possible confounders, the older age and less intensive procedure performed in the D cohort would suggest they were probably more likely to have other medical comorbidities, which would again cause bias toward a lower SF-36 outcome in that group.[46] Finally, it is possible that a superior result could have been obtained for the DF cohort if all patients underwent more contemporary interbody fusion using less invasive techniques. To date, however, studies comparing minimally invasive surgery to open fusion for spondylolisthesis at 2 years or greater have demonstrated equivalence in clinical outcome.[48–50] Furthermore, if we compare our overall DLS cohort to the as-treated surgical cohort from the SPORT — DLS study, the mean age, sex, preoperative and 2-year postoperative PF and BP scores between our studies are very similar (Table 8). Consequently, with the aforementioned limitations considered, it seems that our cohorts and overall outcomes are consistent with those of a contemporary surgical DLS population.[5,6]

Conclusion

The present study demonstrates that for a specific subpopulation of patients with DLS (i.e., those with leg-dominant symptoms and a radiographically stable grade I spondylolisthesis), undergoing an anatomic midline-sparing microdecompression alone can achieve the same improvement in HRQoL as that of DF for the overall DLS population at 2 years postoperatively. The routine implementation of D for this defined subpopulation of patients with DLS could result in fewer surgical complications, improved reactivation and potentially less health care utilization in a growing segment of society. Therefore, further multicentre prospective evaluation and longer term follow up is probably warranted.

Acknowledgements: This study was supported by a grant from the Canadian Spine Society through unrestricted research funds from Depuy, Medtronic, Stryker, and Synthes. Additional Funding was also received from the Minimal Access Ambulatory Surgical Spine Research and Education Fund, Toronto General and Western Hospital Foundation.

Competing interests: Y.R. Rampersaud is a paid consultant of Medtronic. C. Fisher is a paid consultant of Medtronic and Nuvasive and has received grants from Medtronic, AO Spine and the Orthopaedic Research and Education Foundation. M. Dvorak and E. Abraham are paid consultants of and have received speaker fees and travel assistance from Medtronic. W. Oxner has received honoraria and speaker fees from Medtronic. No other competing interests declared.

Contributors: All authors designed the study and acquired the data. Y.R. Rampersaud and C. Fisher analyzed the data. Y.R. Rampersaud wrote the article, which all authors reviewed and approved for publication.

References

1. Deyo RA, Gray DT, Kreuter W, et al. United States trends in lumbar fusion surgery for degenerative conditions. *Spine* 2005;30:1441-7.
2. Aono K, Kobayashi T, Jimbo S, et al. Radiographic analysis of newly developed degenerative spondylolisthesis in a mean twelve-year prospective study. *Spine* 2010;35:887-91.
3. Kalichman L, Kim DH, Li L, et al. Spondylolysis and spondylolisthesis: prevalence and association with low back pain in the adult community-based population. *Spine* 2009;34:199-205.
4. Jacobsen S, Sonne-Holm S, Rovsing H, et al. Degenerative lumbar spondylolisthesis: an epidemiological perspective: the Copenhagen Osteoarthritis Study. *Spine* 2007;32:120-5.
5. Weinstein JN, Lurie JD, Tosteson TD, et al. Surgical compared with nonoperative treatment for lumbar degenerative spondylolisthesis. Four-year results in the Spine Patient Outcomes Research Trial (SPORT) randomized and observational cohorts. *J Bone Joint Surg Am* 2009;91:1295-304.
6. Weinstein JN, Lurie JD, Tosteson TD, et al. Surgical versus nonsurgical treatment for lumbar degenerative spondylolisthesis. *N Engl J Med* 2007;356:2257-70.
7. Herkowitz HN, Kurz LT. Degenerative lumbar spondylolisthesis with spinal stenosis. A prospective study comparing decompression with decompression and intertransverse process arthrodesis. *J Bone Joint Surg Am* 1991;73:802-8.
8. Martin CR, Gruszczynski AT, Braunsfurth HA, et al. The surgical management of degenerative lumbar spondylolisthesis: a systematic review. *Spine* 2007;32:1791-8.
9. Buckwalter JA, Heckman JD, Petrie DP. AOA. An AOA critical issue: aging of the North American population: new challenges for orthopaedics. *J Bone Joint Surg Am* 2003;85-A:748-58.
10. Agency for Healthcare Research and Quality. Healthcare Cost and Utilization Project. 2013. Available: http://hcup-us.ahrq.gov/ (accessed 2013 Aug. 27).
11. Lafortune G, Balestat G. *Trends in severe disability among elderly people*. Paris (FR): Organisation for Economic Co-operation and Development; 2007. Available: www.oecd-ilibrary.org/content/workingpaper/217072070078 (accessed 2013 Aug. 27).
12. Deyo RA, Mirza SK, Martin BI, et al. Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults. *JAMA* 2010;303:1259-65.
13. Institute of Medicine of the National Academies. Initial national priorities for comparative effectiveness research [report]. 2009 June 30. Available: www.iom.edu/Reports/2009/ComparativeEffectivenessResearchPriorities.aspx. (accessed 2013 Aug. 27).
14. Kelleher MO, Timlin M, Persaud O, et al. Success and failure of minimally invasive decompression for focal lumbar spinal stenosis in patients with and without deformity. Spine 2010;35:E981-7.
15. Khoo LT, Fessler RG. Microendoscopic decompressive laminotomy for the treatment of lumbar stenosis. *Neurosurgery* 2002;51(Suppl):S146-54.
16. Podichetty VK, Spears J, Isaacs RE, et al. Complications associated with minimally invasive decompression for lumbar spinal stenosis. *J Spinal Disord Tech* 2006;19:161-6.
17. Palmer S, Turner R, Palmer R. Bilateral decompression of lumbar spinal stenosis involving a unilateral approach with microscope and tubular retractor system. *J Neurosurg* 2002;97(Suppl):213-7.

18. Palmer S, Turner R, Palmer R. Bilateral decompressive surgery in lumbar spinal stenosis associated with spondylolisthesis: unilateral approach and use of a microscope and tubular retractor system. *Neurosurg Focus* 2002;13:E4.
19. Guiot BH, Khoo LT, Fessler RG. A minimally invasive technique for decompression of the lumbar spine. *Spine* 2002;27:432-8.
20. Cavusoglu H, Kaya RA, Türkmenoglu ON, et al. Midterm outcome after unilateral approach for bilateral decompression of lumbar spinal stenosis: 5-year prospective study. *Eur Spine J* 2007;16: 2133-42.
21. Thomé C, Zevgaridis D, Leheta O, et al. Outcome after less-invasive decompression of lumbar spinal stenosis: a randomized comparison of unilateral laminotomy, bilateral laminotomy, and laminectomy. *J Neurosurg Spine* 2005;3:129-41.
22. Mackay DC, Wheelwright EF. Unilateral fenestration in the treatment of lumbar spinal stenosis. *Br J Neurosurg* 1998;12:556-8.
23. Weiner BK, Walker M, Brower RS, et al. Microdecompression for lumbar spinal canal stenosis. *Spine* 1999;24:2268-72.
24. McCulloch JA. Microdecompression and uninstrumented single-level fusion for spinal canal stenosis with degenerative spondylolisthesis. *Spine* 1998;23:2243-52.
25. Ikuta K, Tono O, Oga M. Clinical outcome of microendoscopic posterior decompression for spinal stenosis associated with degenerative spondylolisthesis — minimum 2-year outcome of 37 patients. *Minim Invasive Neurosurg* 2008;51:267-71.
26. Glassman SD, Copay AG, Berven SH, et al. Defining substantial clinical benefit following lumbar spine arthrodesis. *J Bone Joint Surg Am* 2008;90:1839-47.
27. Feffer HL, Wiesel SW, Cuckler JM, et al. Degenerative spondylolisthesis. To fuse or not to fuse. *Spine* 1985;10:287-9.
28. Lombardi JS, Wiltse LL, Reynolds J, et al. Treatment of degenerative spondylolisthesis. *Spine* 1985;10:821-7.
29. Satomi K, Hirabayashi K, Toyama Y, et al. A clinical study of degenerative spondylolisthesis. Radiographic analysis and choice of treatment. *Spine* 1992;17:1329-36.
30. Bridwell KH, Sedgewick TA, O'Brien MF, et al. The role of fusion and instrumentation in the treatment of degenerative spondylolisthesis with spinal stenosis. *J Spinal Disord* 1993;6:461-72.
31. Matsudaira K, Yamazaki T, Seichi A, et al. Spinal stenosis in grade I degenerative lumbar spondylolisthesis: a comparative study of outcomes following laminoplasty and laminectomy with instrumented spinal fusion. *J Orthop Sci* 2005;10:270-6.
32. Ghogawala Z, Benzel EC, Amin-Hanjani S, et al. Prospective outcomes evaluation after decompression with or without instrumented fusion for lumbar stenosis and degenerative Grade I spondylolisthesis. *J Neurosurg Spine* 2004;1:267-72.
33. Mardjetko SM, Connolly PJ, Shott S. Degenerative lumbar spondylolisthesis. A meta-analysis of literature 1970-1993. *Spine* 1994; 19(Suppl):2256S-65S.
34. Martin BI, Mirza SK, Comstock BA, et al. Reoperation rates following lumbar spine surgery and the influence of spinal fusion procedures. *Spine* 2007;32:382-7.
35. Yone K, Sakou T, Kawauchi Y, et al. Indication of fusion for lumbar spinal stenosis in elderly patients and its significance. *Spine* 1996;21:242-8.
36. Tosteson ANA, Tosteson TD, Lurie JD, et al. Comparative effectiveness evidence from the spine patient outcomes research trial: surgical versus nonoperative care for spinal stenosis, degenerative spondylolisthesis, and intervertebral disc herniation. *Spine* 2011; 36:2061-8.
37. Sasai K, Umeda M, Maruyama T, et al. Microsurgical bilateral decompression via a unilateral approach for lumbar spinal canal stenosis including degenerative spondylolisthesis. *J Neurosurg Spine* 2008;9:554-9.
38. Suri P, Rainville J, Kalichman L, et al. Does this older adult with lower extremity pain have the clinical syndrome of lumbar spinal stenosis? *JAMA* 2010;304:2628-36.
39. Weinstein JN, Tosteson TD, Lurie JD, et al. Surgical versus nonsurgical therapy for lumbar spinal stenosis. *N Engl J Med* 2008;358:794-810.
40. Wang MY, Green BA, Shah S, et al. Complications associated with lumbar stenosis surgery in patients older than 75 years of age. *Neurosurg Focus* 2003;14:e7.
41. Tsutsumimoto T, Shimogata M, Yoshimura Y, et al. Union versus nonunion after posterolateral lumbar fusion: a comparison of long-term surgical outcomes in patients with degenerative lumbar spondylolisthesis. *Eur Spine J* 2008;17:1107-12.
42. Kornblum MB, Fischgrund JS, Herkowitz HN, et al. Degenerative lumbar spondylolisthesis with spinal stenosis: a prospective long-term study comparing fusion and pseudarthrosis. *Spine* 2004;29: 726-34.
43. Kimura I, Shingu H, Murata M, et al. Lumbar posterolateral fusion alone or with transpedicular instrumentation in L4–L5 degenerative spondylolisthesis. *J Spinal Disord* 2001;14:301-10.
44. Fischgrund JS, Mackay M, Herkowitz HN, et al. 1997 Volvo award winner in clinical studies. Degenerative lumbar spondylolisthesis with spinal stenosis: a prospective, randomized study comparing decompressive laminectomy and arthrodesis with and without spinal instrumentation. *Spine* 1997;22:2807-12.
45. Hopman WM, Towheed T, Anastassiades T, et al. Canadian normative data for the SF-36 health survey. Canadian Multicentre Osteoporosis Study Research Group. *CMAJ* 2000;163:265-71.
46. Slover J, Abdu WA, Hanscom B, et al. The impact of comorbidities on the change in Short-Form 36 and Oswestry scores following lumbar spine surgery. *Spine* 2006;31:1974-80.
47. Aalto TJ, Malmivaara A, Kovacs F, et al. Preoperative predictors for postoperative clinical outcome in lumbar spinal stenosis: systematic review. *Spine* 2006;31:E648-63.
48. Dhall SS, Wang MY, Mummaneni PV. Clinical and radiographic comparison of mini-open transforaminal lumbar interbody fusion with open transforaminal lumbar interbody fusion in 42 patients with long-term follow-up. *J Neurosurg Spine* 2008;9:560-5.
49. Tsutsumimoto T, Shimogata M, Ohta H, et al. Mini-open versus conventional open posterior lumbar interbody fusion for the treatment of lumbar degenerative spondylolisthesis: comparison of paraspinal muscle damage and slip reduction. *Spine* 2009;34: 1923-8.
50. Peng CWB, Yue WM, Poh SY, et al. Clinical and radiological outcomes of minimally invasive versus open transforaminal lumbar interbody fusion. *Spine* 2009;34:1385-9.