Gender differences in the surgical management of lumbar degenerative disease: a scoping review

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OBJECTIVE Despite efforts toward achieving gender equality in clinical trial enrollment, females are often underrepresented, and gender-specific data analysis is often unavailable. Identifying and reducing gender bias in medical decision-making and outcome reporting may facilitate equitable healthcare delivery. Gender disparity in the utilization of surgical therapy has been exemplified in the orthopedic literature through studies of total joint arthroplasty. A paucity of literature is available to guide the management of lumbar degenerative disease, which stratifies on the basis of demographic factors. The objective of this study was to systematically map and synthesize the adult surgical literature regarding gender differences in pre- and postoperative patient-reported clinical assessment scores for patients with lumbar degenerative disease (disc degeneration, disc herniation, spondylolisthesis, and spinal canal stenosis).

METHODS A systematic scoping review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines. MEDLINE, Embase, and the Cochrane Registry of Controlled Trials were searched from inception to September 2018. Study characteristics including patient demographics, diagnoses, procedures, and pre- and postoperative clinical assessment scores (pain, disability, and health-related quality of life [HRQoL]) were collected.

RESULTS Thirty articles were identified, accounting for 32,951 patients. Six studies accounted for 84% of patients; 5 of the 6 studies were published by European groups. The most common lumbar degenerative conditions were disc herniation (59.0%), disc degeneration (20.3%), and spinal canal stenosis (15.9%). The majority of studies reported worse preoperative pain (93.3%), disability (81.3%), and HRQoL (75%) among females. The remainder reported equivalent preoperative scores between males and females. The majority of studies (63.3%) did not report preoperative duration of symptoms, and this represents a limitation of the data. Eighty percent of studies found that females had worse absolute postoperative scores in at least one outcome category (pain, disability, or HRQoL). The remainder reported equivalent absolute postoperative scores between males and females. Seventy-three percent of studies reported either an equivalent or greater interval change for females.

CONCLUSIONS Female patients undergoing surgery for lumbar degenerative disease (disc degeneration, disc herniation, spondylolisthesis, and spinal canal stenosis) have worse absolute preoperative pain, disability, and HRQoL. Following surgery, females have worse absolute pain, disability, and HRQoL, but demonstrate an equal or greater interval change compared to males. Further studies should examine gender differences in preoperative workup and clinical course.

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KEYWORDS gender; disparity; differences; sex; spine; lumbar; degenerative; stenosis; spondylolisthesis; disc degeneration; patient-reported outcome

ABBREVIATIONS DSL = degenerative spondylolisthesis; EQ-5D = EuroQol-5D; HRQoL = health-related quality of life; LDH = lumbar disc herniation; MCID = minimal clinically important difference; MSC = modified Stauffer-Coventry; NRS = numeric rating scale; OA = osteoarthritis; ODI = Oswestry Disability Index; OFI = Objective Functional Impairment; PRISMA-ScR = Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews; QST = quantitative sensory testing; RCT = randomized controlled trial; RDQ = Roland-Morris Disability Questionnaire; SF-12 = Short-Form 12; SF-36 = Short-Form 36; SIP-PD = Sickness-Impact-Profile Physical Dimension; SPORT = Spine Outcomes Research Trial; TJA = total joint arthroplasty; TUG = Timed-Up-and-Go; VAS = visual analog scale.

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PATIENT preference is an integral component of shared medical decision-making.²⁸ Preference-based care provides patients with the autonomy to understand and appreciate relevant information, weigh treatment options, and make informed decisions.²⁴ Despite the apparent utility of this model, many studies consistently document racial, ethnic, and gender disparities in the use of health services (we refer to gender as the socially acquired aspect of being male or female).³⁵ White males are frequently reported to receive better access to medical and surgical interventions compared to females and minorities.^{3,9,13,18,25,31,46} Despite efforts toward gender equality in clinical trial enrollment, females are often underrepresented and gender-specific data analysis is often unavailable.^{1,38}

Gender disparity in the utilization of surgical therapy has been exemplified in the orthopedic literature by studies of total joint arthroplasty (TJA).³⁸ It has been reported that female patients are offered surgery later in the course of their disease, and have worse preoperative pain, disability, and radiographic findings.³⁸ While empirical research demonstrates sex differences in clinical and experimental pain responses,¹⁵ clinical studies of TJA have demonstrated that following surgery, females experience similar improvement in pain and disability compared to males.^{11,36,42}

Identifying and reducing gender bias in medical decision-making and outcome reporting may facilitate equitable healthcare delivery. A paucity of literature is available to guide the surgical management of lumbar degenerative disease that stratifies on the basis of demographic factors.^{17,22,64} Given these challenges, our objective was to map and synthesize the adult surgical literature regarding gender differences in pre- and postoperative patient-reported clinical assessment scores for patients diagnosed with lumbar degenerative disease (disc degeneration, disc herniation, spondylolisthesis, and spinal canal stenosis).

Methods

Study Design

A scoping review was systematically conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines.⁵⁵ This study design was utilized to map and synthesize the degenerative lumbar spine literature dichotomizing patient-reported clinical assessment scores by gender.

Research Question

Do adult female patients with a diagnosis of lumbar degenerative disease (disc degeneration, disc herniation, spondylolisthesis, and spinal canal stenosis) have worse absolute pre- and postoperative patient-reported clinical assessment scores (pain, disability, and health-related quality of life [HRQoL]) compared to males?

Search and Inclusion/Exclusion Criteria

A comprehensive electronic search of the literature was conducted with the assistance of a medical research librarian. MEDLINE, Embase, and the Cochrane Central Register of Controlled Trials were searched from incep-

tion until September 2018. Search terms included subject headings (MeSH terms) specific to the respective databases (Supplemental Digital Content A). Free-text words relevant to gender, sex, and spinal surgery (discectomy, laminectomy, and/or instrumented fusion) for lumbar degenerative diseases (disc degeneration, disc herniation, spinal canal stenosis, and spondylolisthesis) were included. Abstracts were screened using predefined inclusion and exclusion criteria (Table 1). Eligible abstracts were imported into Covidence Review Manager. Duplicate articles were excluded automatically. A single reviewer (M.A.M.) reviewed exclusions to ensure accuracy of the duplicate removal algorithm. Two reviewers (M.A.M., J.H.H.) independently screened titles and abstracts using the criteria for inclusion. Full texts for citations passing the screening were then further assessed (M.A.M., C.J.T.) for eligibility. In cases of disagreement, consensus was reached via open discussion.

Data Collection

A standardized data extraction form was reviewed and refined by all authors prior to use (Supplemental Digital Content B). Study characteristics collected included article citation, database (if applicable), country of publication, study design, sample size, number and percentage of male and female patients in the cohort, diagnoses treated, corresponding surgical procedure, and study objectives (Table 2). Other variables included timing of assessments, assessment scoring measures, pre- and postoperative assessment scores, interval change in scores, and study conclusions (Table 3). Reference lists of all included full-text articles were manually searched (M.A.M.). Institution and database of published studies were used to avoid inclusion of duplicate patient data. When multiple papers were published utilizing the same cohort of patients, the largest sample with the greatest duration of follow-up was selected. Pre- and postoperative patient-reported clinical assessment results were categorized according to pain, disability, and HRQoL. Scoring measures for back and leg pain included the visual analog scale (VAS) and numeric rating scale (NRS); for disability, the Oswestry Disability Index (ODI), Roland-Morris Disability Questionnaire (RDQ), Sickness-Impact-Profile Physical Dimension (SIP-PD), and modified Stauffer-Coventry (MSC) score; and for HRQoL, the Short-Form 12 (SF-12), Short-Form 36 (SF-36), and EuroQol-5D (EQ-5D). Other scoring tools less commonly used are listed in Table 3. A comparative analysis was not performed due to the heterogeneous nature of the collected data.

Evidence Appraisal

Included studies were critically appraised by two reviewers (M.A.M., C.J.T.) using the “Oxford Levels of Evidence 2” grading system.²⁷ Disagreements were resolved through open, full-text review.

Results

Literature Search and Selection

Our initial database search yielded 1523 articles. After duplicates (n = 268) were removed, titles and abstracts

TABLE 1. Inclusion and exclusion study criteria

Inclusion Criteria	Exclusion Criteria
<ul style="list-style-type: none"> • Original research on human subjects • Mean cohort age ≥ 18 yrs • Diagnosed w/ lumbar degenerative disease; examples include degenerative disc disease, disc herniation, spinal canal stenosis, & degenerative spondylolisthesis • Direct comparison of M & F pts • Use of at least 1 pt-reported clinical assessment scoring tool: HRQoL (SF-36 or EQ-5D), pain or anxiety (VAS, NRS, BRS), disability (ODI, RDQ, SIP-PD, MSC score), global functional status (Beaujon scoring system), satisfaction (Likert scale), or other (COMI, Barthel Index) • Contain a majority of pts w/ at least 1 of the following assessment dates: preop or postop (for those w/ only preop data, pts must have been scheduled for or awaiting spinal surgery) • Prospective or retrospective cohort design 	<ul style="list-style-type: none"> • Cervical, thoracic, or sacral disease • Disease related to trauma, infection, &/or neoplasm • Case series & case reports • Publication language other than English • Studies not reporting statistical testing w/ significance values reported as either p values or effect sizes w/ 95% CIs

BRS = Borg Rating Scale; COMI = Core Outcomes Measure Index; pt = patient.

($n = 1255$) underwent screening and 1219 articles were excluded. Full text was obtained for 36 studies to assess eligibility. Thirteen articles were excluded via full-text assessment. Twenty-three articles were included.^{6,12,14,19,20,23,26,29,32,34,37,39,41,47,48,50,52–54,56–58,63} The reference list of each included article was manually searched. An additional 7 articles were identified,^{2,7,21,40,48,59,60} resulting in 30 articles for data collection. The PRISMA flow diagram summarizes the selection process (Fig. 1).

Study and Cohort Characteristics

Descriptive characteristics are presented in Table 2. The included studies contained a combined total of 32,951 patients. The total numbers of male and female patients were 16,651 (50.5%) and 16,300 (49.5%), respectively. On average, patients were operated on at the age of 51.2 years for males and 48.8 years for females. The majority of included studies reported no gender differences in BMI at the time of preoperative assessment. No study examined the association between gender and BMI in relation to clinical assessment scores. Furthermore, no study examined gender differences in sarcopenia or composite frailty measures. Data included in this review are mainly from European cohorts (70%), followed by North American (16.7%) and other continents (13.3%). Prospective cohorts represent 30% of the data, whereas retrospective analysis of either prospectively (60%) or retrospectively (3.3%) collected data forms the rest. Two articles provide data from randomized cohorts, contributing 890 patients (2.7% of the total).^{39,40} Six studies account for 27,754 patients (84.2%); 5 were published by European groups.^{41,48,52–54,56}

Diagnoses and Procedures

All patients were diagnosed with lumbar degenerative disease. Specific diagnoses (e.g., disc degeneration, disc herniation, spondylolisthesis, and spinal canal stenosis) were available for 32,567 patients (98.8%). A single study included patients with multiple degenerative conditions

without reporting the number of patients per diagnosis.¹⁴ Disc herniation (59.0%), disc degeneration (20.3%), spinal canal stenosis (15.9%), and spondylolisthesis (4.7%) accounted for the majority of diagnoses. The majority of studies contained a cohort of patients with the same diagnosis: disc herniation (26.7%), spinal canal stenosis (26.7%), disc degeneration (13.3%), and spondylolisthesis (6.7%). Seven studies (23.3%) did not restrict inclusion criteria to a single diagnosis; all 7 presented clinical assessment scores dichotomized by gender but did not stratify by diagnosis.^{19,20,34,41,48,54,59} No study examined gender differences in the severity of radiographic findings.

A discectomy was performed in all cases of disc herniation and none conducted concomitant laminectomy with fusion. Of the 15 studies reporting postoperative scores for patients with spinal canal stenosis, 12 (80.0%) reported laminectomy only. Laminectomy with instrumented fusion was mostly performed for spondylolisthesis or disc degeneration (92.9%).

Main Study Objectives and Patient-Reported Clinical Assessment Scales

Examining gender differences in clinical assessment scoring was the primary objective in 17 studies (56.7%). Scoring measures used in pre- and postoperative patient-reported clinical assessment are listed in Table 3. The VAS score for back or leg pain was used by 94.7% of the studies reporting on pain. The ODI was used by 72.0% of the studies assessing disability. The EQ-5D (52.9%) and SF-36 (41.2%) were the most common measures of HRQoL. Gender differences were evaluated over a follow-up period averaging 27 months across included studies.

Preoperative Pain, Disability, and HRQoL

Of the studies reporting preoperative clinical assessment data (Table 3), all 18 (100%) reported significant differences between male and female patients in at least one of the following categories: back or leg pain, disability,

TABLE 2. General characteristics of studies, patients, diagnoses, treatments, and objectives

Authors & Year	Database (country of publication)	Study Type	No. of Pts	% Sex, Mean Age $\pm$ SD	Diagnoses	Corresponding Procedure	Study Objectives
Pearson et al., 2013	Multicenter, SPORT (USA)	RCT (n = 304), PSP (n = 303)	607	31% M/69% F, mean age NR	DSL	Laminectomy $\pm$ single-level fusion w/ or w/o instrumentation; conservative (physical therapy, counseling, NSAIDS, education, home exercise)	To determine variables that were significant, independent, Tx-effect modifiers for degenerative spondylo-listhesis
Tropiano et al., 2005	Single-center registry (France)	RS	55	55% M/45% F, mean age NR	DDD	Single or multilevel TDR $\pm$ 1- to 3-level arthrodesis, either retroperitoneal (82%) or transperitoneal (18%)	To present the clinical & radiographic results assessed w/ long-term FU of a Prodisc lumbar TDR & to determine the pt factors affecting clinical outcome
Dederer et al., 2006	Single-center registry (Sweden)	PSP	43	63% M, 42.2 $\pm$ 11.5; 37% F, 42.4 $\pm$ 10.4	LDH	Discectomy	Primary: to investigate back muscle fatigue/endurance in pts w/ disc herniation undergoing surgery & establish the degree of association btwn perceived fatigue & objectively measured fatigue; secondary: to investigate relation btwn muscle fatigue & endurance vs activity, participation, self-efficacy, overall health
Shabat et al., 2005	Single-center registry (Israel)	RS	367	52% M, 71.0 $\pm$ 4.8; 48% F, 72.0 $\pm$ 5.9	LSS	Laminectomy $\pm$ discectomy	To assess the differences caused by gender on the satisfaction of elderly pts following lumbar spinal surgery
Bouras et al., 2010	Single-center registry (Greece)	RS	182	42% M/58% F, 71.3 (no SD)	LSS	Laminectomy	To evaluate possible demographic, comorbidity, prognosticators for pain reduction & functional improvement in elderly pts undergoing laminectomy for lumbar spinal stenosis
Korovessis et al., 2010	Single-center registry (Greece)	RS	50	32% M/68% F, 64 $\pm$ 5	DDD	2-, 3-, or 4-level laminectomy & post transpedicular instrumentation, & posterolateral fusion	To investigate the possible effects of radiographic & other related parameters on LBP in pts undergoing decompression & posterolateral instrumented fusion for degenerative lumbar spine disease
Mariconda et al., 2000	Single-center registry (Italy)	RS	37	38% M/62% F, 61 (no SD)	LSS	Laminectomy $\pm$ discectomy (n = 20), conservative (n = 17)	To evaluate the influence of decreased dural sac cross-sectional area & baseline clinical parameters on the outcome of pts treated surgically or conservatively for spinal canal stenosis
Ungureanu et al., 2018	Single-center registry (Romania)	RS	61	49% M, 50.9 $\pm$ 14.5; 51% F, 48.7 $\pm$ 12.7	DSL (n = 31), LSS (n = 30)	PLIF	Primary: determine the influence of gender on HRQoL, disability, & the correlation btwn the 2 in pts undergoing spinal fusion; secondary: determine if the surgical procedure influenced the risk of depression differently in M & F pts
Gautschi et al., 2016 ²⁰	2-center registry (Switzerland)	PSP	214	58% M, 57.3 $\pm$ 15.4; 42% F, 61.3 $\pm$ 14.9	A: LDH (n = 108), B: LSS (n = 76), C: DDD (n = 30)	A: discectomy, B: laminectomy, C: PLIF, TLIF, or XLIF	To investigate pre- & postop gender differences in subjective & objective assessment measures in pts w/ DDD

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TABLE 2. General characteristics of studies, patients, diagnoses, treatments, and objectives

Authors & Year	Database (country of publication)	Study Type	No. of Pts	% Sex, Mean Age $\pm$ SD	Diagnoses	Corresponding Procedure	Study Objectives
Tschugg et al., 2017	Single-center registry (Austria)	PSP	53	60% M, 45.5 $\pm$ 11; 40% F, 43.2 $\pm$ 2	LDH	Sequestrectomy	To investigate gender differences in pain patterns after lumbar sequestrectomy using quantitative sensory testing
Airaksinen et al., 1997	Single-center registry (Finland)	RS	438	58% M, 52 $\pm$ 10; 42% F, 54 $\pm$ 9	LSS	Laminectomy	To investigate the overall outcome of surgery for spinal canal stenosis & to investigate the preop factors affecting outcome
Strömqvist et al., 2016 ⁵²	Swespine, national multicenter registry (Sweden)	RS	1250	53% M, 70.6 $\pm$ 5.0; 47% F, 71.3 $\pm$ 5.2	LDH	Discectomy	To evaluate outcomes after surgery for disc herniation in elderly pts & determine if females have inferior preop status & improve to the same extent as males postop
Pochon et al., 2016	Single-center registry/link to the Spine Tango Registry Eurospine (Switzerland)	RS	1518	53% M, 60.4 $\pm$ 16.4; 47% F, 62.6 $\pm$ 16.0	A: LDH (n = 667), B: LSS (n = 540), C: DSL (n = 311)	A: discectomy, B: laminectomy, C: laminectomy $\pm$ fusion	To examine the influence of gender on baseline status & 12-mo postop outcomes in a large series of pts undergoing surgery for degenerative spinal disorders
Gautschi et al., 2016 ¹⁹	2-center registry (Switzerland)	RS	305	58% M, 57.1 $\pm$ 15.7; 42% F, 60.5 $\pm$ 15.5	A: LDH (n = 165), B: LSS (n = 97), C: DDD (n = 43)	A: discectomy, B: laminectomy, C: PLIF, TLIF, XLIF	To elucidate gender differences in subjective & objective measures of pain, functional impairment, & HRQoL in pts w/ DDD
Triebel et al., 2017	Swespine national multicenter registry (Sweden)	RS	4780	47% M, 46 $\pm$ 10; 53% F, 46 $\pm$ 11	DDD	Interbody fusion, pst instrumented fusion, TDR, pst noninstrumented fusion	To investigate whether gender affects clinical outcome after lumbar fusion
Katz et al., 1994	Multicenter (USA)	RS	154	36% M, 69.5 $\pm$ 8.3; 64% F, 68.9 $\pm$ 8.5	LSS	Laminectomy	To determine whether female pts have worse functional/disability status compared to male pts
Taylor et al., 2005	Multicenter (USA; "Spine Network Outcomes Database")	RS	5690	52% M, 50.1 (no SD); 48% F, 54.4 (no SD)	A: LDH (n = 2456), B: LSS (n = 1686), C: DSL (n = 156), D: DDD (n = 1392)	No postop data	To investigate if the pt gender influences workup & Tx of degenerative spinal pathologies
Elsamadicy et al., 2017	Single-center registry (USA)	RS	384	52% M, 58.7 $\pm$ 12.7; 48% F, 56.6 $\pm$ 13.9	A: DSL, B: LSS, C: LDH (breakdown not reported)	A: fusion only, B: laminectomy, C: laminectomy $\pm$ fusion	To determine the impact of gender on pt-reported outcomes & satisfaction after elective spine surgery
Siccoli et al., 2018	Single-center registry (Netherlands)	PSP	3279	53% M, 47.7 $\pm$ 13.3; 47% F, 48.5 $\pm$ 13.5	A: LDH (n = 2342), B: LSS (n = 599), C: DSL (n = 140), D: DDD (n = 163), E: synovial cyst (n = 35)	A: microdiscectomy, B: laminectomy, C: MIS-fusion (TLIF, PLIF, ALIF)	To evaluate the effect of gender on pt-reported outcomes after lumbar spine surgery for degenerative pathologies
Herno et al., 1996	Single-center registry (Finland)	RS	439	58% M, 52.1 $\pm$ 10.5; 42% F, 54.1 $\pm$ 8.9	LSS	Laminectomy	To compare working capacities after lumbar spine surgery & pre- & postop factors associated w/ return to work

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TABLE 2. General characteristics of studies, patients, diagnoses, treatments, and objectives

Authors & Year	Database (country of publication)	Study Type	No. of Pts	% Sex, Mean Age $\pm$ SD	Diagnoses	Corresponding Procedure	Study Objectives
Yamashita et al., 2006	Single-center registry (Japan)	PSP	70	44% M, 66.5 (range 53–78); 56% F, 65.4 (range 50–81)	LSS	Laminectomy only, laminectomy $\pm$ fusion	To investigate whether long-term outcomes following surgical Tx of spinal canal stenosis differ as a function of age & gender
Häkkinen et al., 2007	Single-center registry (Finland)	PSP	98	61% M, 45 $\pm$ 12; 39% F, 43 $\pm$ 14	LDH	Discectomy	To investigate change in ODI pre- & postop in M & F pts
Strömqvist et al., 2008	Single-center study/"Swedish Spine Registry" (Sweden)	PSP	301	55% M, 42 (no SD); 45% F, 42 (no SD)	LDH	Discectomy	To evaluate preop & postop gender differences in pts undergoing discectomy for disc herniation
Lee et al., 2016	Single-center registry (Korea)	PSP	157	49% M/51% F, mean age overall 59.5 $\pm$ 13.8	A: LSS (n = 96), B: LDH (n = 61)	A: laminectomy, B: discectomy	To determine how many pts have preop anxiety about spinal surgery, to evaluate the level of anxiety & identify associated pt factors, to describe the characteristics of the anxiety experienced during the periop period
Strömqvist et al., 2016 ⁵³	Single-center registry (Sweden)	RS	11,237	55% M, 45 $\pm$ 13; 45% F, 44 $\pm$ 13	LDH	Discectomy	To evaluate whether there exist gender differences in outcome following discectomy & whether the gender-specific referral pattern influences the outcome
Gepstein et al., 2006	Single-center registry (Israel)	RS	367	49% M/51% F, mean age overall 71.4 $\pm$ 5.4	LSS	Laminectomy	To investigate expectations & satisfaction rates in elderly pts operated on for spinal canal stenosis & the factors that might impact them
Chan et al., 2018	Multicenter/"Quality Outcomes Database" (USA)	RS	281	43% M/57% F, mean age overall 63.4 $\pm$ 10.6	DSL	Laminectomy $\pm$ fusion	To identify factors that predict which pts will be most satisfied after surgery for DSL
Vucetic et al., 1999	Single-center registry (Sweden)	PSP	160	53% M/47% F, mean age overall 43 $\pm$ 10	LDH	Discectomy	To identify factors that predict which pts will be most satisfied after discectomy for disc herniation
Peul et al., 2008	Multicenter (Netherlands)	RCT	283	66% M/34% F, mean age overall 43 $\pm$ 9.8	LDH	Discectomy, conservative	To quantify the relationship btwn gender & recovery or satisfaction for pts w/ disc herniation
Staatjes et al., 2018	Single-center registry (Netherlands)	RS	91	41% M/59% F, mean age overall 43 $\pm$ 10.4	DDD	Lumbar interbody fusion (PLIF & ALIF)	To investigate the value of prognostic tests & sociodemographic factors in predicting outcomes following lumbar fusion surgery for DDD

ALIF = anterior lumbar interbody fusion; DDD = degenerative disc disease; FU = follow-up; LBP = low-back pain; LSS = lumbar spinal stenosis; MIS = minimally invasive surgery; NR = not reported; NSAID = nonsteroidal anti-inflammatory drug; PLIF = posterolateral interbody fusion; PSP = prospective; pst = posterior; RS = retrospective; TDR = total disc replacement; TLIF = transforaminal lumbar interbody fusion; Tx = treatment; XLIF = extreme lateral interbody fusion.

TABLE 3. Pre- and postoperative clinical assessment scores and study conclusions

Authors & Year	Timing of Assessments	Pt-Reported Clinical Assessment Measures	Preop Scores	Postop Scores	Conclusions
Pearson et al., 2013	Preop, postop (6 wks, 3 mos, 6 mos, 12 mos, 2 yrs, 3 yrs, 4 yrs)	SF-36, ODI, leg & back pain bothersomeness scale	NA	F: greater Tx effect of surgery ($p = 0.01$) on ODI score compared to M; M: had significantly improved disability (ODI) compared to F when treated nonoperatively ($p = 0.029$)	All pt subgroups improved more w/ surgery than w/ nonoperative Tx for DSL; F gender ($p = 0.01$), opioid use, not taking antidepressants, dissatisfaction w/ symptoms, & anticipating a high likelihood of being pain free w/ surgery were independently associated w/ a greater TE for surgery (greater improvement in ODI)
Tropiano et al., 2005	Preop, postop (mean 104 mos)	NRS: back & leg pain; disability (MSC score); satisfaction scales	F: greater preop disability ($p = 0.005$); M & F: no difference in preop back pain, lower-limb pain, MSC score	M & F: overall significant improvements postop in back pain, leg pain, disability, & MSC scores, w/ no gender difference	F: worse disability preop; M & F: no gender difference in postop outcomes; heterogeneous cohort: >50% pts multiple prior spine surgeries, 2 different surgical approaches, 1- to 3-level surgeries $\pm$ fusion
Dederig et al., 2006	Preop, postop (4 wks)	ODI, RDQ, SF-36, self-efficacy scale, BRS, So-ensen's test of muscle fatigue	No significant difference btwn F & M regarding age, BMI, pain duration, time for sick leave, & physical therapy; M: greater physical fitness as measured by straight-leg raise ($p = 0.005$) & time on endurance test ($p = 0.001$)	F: worse postop leg pain ($p < 0.01$); F: worse postop disability ($p < 0.01$); M & F: significantly reduced Borg rating of leg pain at the end of an endurance test (M, $p < 0.001$; F, $p = 0.008$), as well as improved RDQ ($p < 0.001$), ODI ($p = 0.001$), & self-efficacy ($p < 0.001$) scores; M: significantly reduced leg pain at start of endurance test ($p = 0.005$); F: significantly reduced back pain at start of endurance test ($p = 0.034$); M: all SF-36 subscales improved, except "role physical" & "general health"; F: SF-36, only "physical functioning" & "mental health" improved significantly	F: worse physical fitness status preop w/ no difference in pain duration compared to M; back muscle fatigue improved w/ surgery for M w/ LDH; F: significantly shorter endurance times than M before & after surgery; F: worse postop disability; F: worse postop leg pain
Shabat et al., 2005	Preop, postop (minimum 12 mos, mean 64 mos)	Barthel Index, walking distance, VAS	F: significantly greater BMI ($p = 0.016$), more likely to have associated depression ($p = 0.017$), significantly greater no. of pts having LBP ($p = 0.004$) & lower-extremity pain ($p = 0.027$); M: significantly greater no. of M having any motor weakness ($p = 0.035$); M: having greater positive belief in operative success ($p = 0.0077$); F: greater mean VAS ($p = 0.04$) & analgesic drug used ($p = 0.01$); M & F: no difference in Barthel Index	M & F: both cohorts demonstrated an overall significant improvement in the Barthel Index; F: lower Barthel Index compared to M ($p = 0.02$; worse disability); F: fewer F able to walk an unlimited distance ($p = 0.03$); F: worse pain VAS ($p = 0.034$) & analgesic drug used ($p = 0.005$); F: greater % not having pain relieved by surgery ($p = 0.037$); F: greater % having pain aggravated by surgery ($p = 0.033$); F: greater % somewhat or very dissatisfied w/ surgery ($p = 0.0003$)	M & F: no difference in preop disability; M & F: both showed improvement in ADLs & reduction in pain perception postop; F: worse postop pain & disability; F: greater % "somewhat" or "very" dissatisfied pts postop compared to M; subjectively graded surgical outcome worse in those who were pessimistic about surgical success ($p < 0.0001$) & no. of pts skeptical about surgical success that eventually had poor satisfaction was higher for F (57%) than M (39%; $p = 0.043$)
Bouras et al., 2010	Preop, postop (mean 60.8 mos)	ODI, VAS leg or back, pt satisfaction questionnaire	NA	F: significantly worse ODI compared to M ($p = 0.019$); M & F: similar VAS ($p = 0.405$) & satisfaction ($p = 0.538$) scores	F: worse postop disability (ODI) compared to M; M & F: no difference in postop pain (VAS) & satisfaction

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TABLE 3. Pre- and postoperative clinical assessment scores and study conclusions

Authors & Year	Timing of Assessments	Pt-Reported Clinical Assessment Measures		Preop Scores		Postop Scores		Conclusions
		Preop	postop	Preop	postop	Preop	postop	
Korovessis et al., 2010	(12 mos)	SF-36 BP		NA		M: significantly greater improvement in LBP compared to F (p = 0.024)		M: significantly greater postop improvement in LBP compared to F
Mariconda et al., 2000	Preop, postop (12 & 24 mos)	Beaujon score (pain, disability, HRQoL), leg pain, LBP		NA (no p values presented)		F: worse global functional status (Beaujon scoring system, p < 0.05); F: worse LBP (p < 0.05)		F: worse postop global functional status; F: worse postop LBP
Ungureanu et al., 2018	Preop, postop (12 mos)	SF-36, depression assessed using SF-36 MCS, ODI		No difference in HRQoL; M: more disability than F in 7/10 ODI domains; M & F: similar duration of pain (no p value reported)		M & F: HRQoLs improved significantly for both, no difference in postop HRQoL; M & F: ODI improved significantly in both, but amount of improvement higher in M (p < 0.05); F: significantly higher disability on walking (p < 0.02), sitting disability (p < 0.05), impaired social life (p < 0.02); significant improvement in the risk of depression for M (no p value reported)		M: higher preop disability but improved more than F in all domains of disability at postop evaluation; M & F: no difference in preop or postop HRQoL, w/ similar degree of improvement
Gautschi et al., 2016 ²⁰	Preop, postop (3 days, 6 wks, 6 mos, 12 mos)	VAS, EQ-5D, RMDI, ODI, SF-12 (PCS/MCS), TUG, OFI (derived using age- & gender-adjusted TUG)		F: Significantly higher VAS back (p = 0.005) & leg pain (p = 0.033) intensity; worse ODI (p = 0.032), RMDI (p = 0.077), & SF-12 PCS (p = 0.016) scores compared to M; M & F: no difference in EQ-5D, SF-12 MCS, TUG, OFI; M: more frequently operated on for LDH than F (p = 0.011)		M (3-day postop): significantly greater improvement in all PROs as compared to F; VAS back pain (p = 0.003), RMDI (p = 0.015), ODI (p = 0.017), EQ-5D (p = 0.002), SF-12 PCS (p = 0.008), except for VAS leg pain (p = 0.432) & SF-12 MCS (p = 0.163); M & F (6 wks postop): similar degree of improvement in all PROs & OFI; M & F (6 & 12 mos postop): similar degree of improvement & no differences in pain, disability, or HRQoL		F: significantly worse preop pain, disability, & HRQoL compared to M; M & F: all differences in pain, disability, & HRQoL resolved in the postop period (similar degree of improvement btwn M & F)
Tschuggel et al., 2017	Preop, postop (1 wk, 6 mos, 12 mos)	VAS, BDI, PDQ, ODI, COMI, EQ-5D thermometer, QST		F: greater VAS (p < 0.05); M & F: no difference in BDI, ODI, COMI; F: lower heat pain threshold (p < 0.05) & pressure pain threshold (p < 0.05)		F: lower pressure pain thresholds at 1 wk, 6 mos, & 12 mos postop (p < 0.005); M: lower vibration detection threshold at 1 wk postop (p < 0.05); F: lower mechanical detection threshold at 12 mos postop (p < 0.05); M: lower mechanical pain sensitivity at 12 mos postop (p < 0.05); M & F: no difference in postop pain scores; M & F: no difference in postop disability scores		F: lower preop heat & pressure pain thresholds & worse preop pain (VAS); M & F: no difference in preop disability; M & F: no difference in postop pain; M & F: no difference in postop disability; F: lower postop pressure pain & mechanical detection thresholds; M: lower vibration detection threshold & mechanical pain sensitivity postop
Airaksinen et al., 1997	Postop (4.3 ± 2.5 yrs)	ODI		NA		M & F: no difference in no. of pts achieving "excellent to good" surgical outcome; F: worse postop disability compared to M (p < 0.05)		M & F: no difference in no. of pts achieving "excellent to good" surgical outcome; F: worse postop disability compared to M (p < 0.05)

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TABLE 3. Pre- and postoperative clinical assessment scores and study conclusions

Authors & Year	Timing of Assessments	Pt-Reported Clinical Assessment Measures		Preop Scores		Postop Scores		Conclusions
		Preop, postop (12 mos)	SF-36, VAS, EQ-5D, ODI, satisfaction (5-point Likert), self-estimated walking distance	M & F: both severe disability/HRQoL; F: more severe back & leg pain (VAS, both $p < 0.001$); F: longer duration of back/leg pain (both $p < 0.01$); F: consumed more analgesics ($p < 0.001$); inferior self-estimated walking ability ($p = 0.04$); inferior HRQoL (SF-36 PCS, $p = 0.002$); greater disability on ODI ($p = 0.011$))	M & F: similar degree of statistically significant improvement in nearly all PROMs (except SF-36 BP & MCS); F: report worse (VAS) back ($p \leq 0.001$)/leg pain ($p = 0.003$); F: reported higher consumption of analgesics ($p < 0.001$) & inferior self-estimated walking distance ($p = 0.043$); M & F: equally satisfied w/ surgical outcome; F: worse HRQoL SF-36 all domains (all $p < 0.03$)/disability on ODI ($p < 0.001$), EQ-5D ($p < 0.05$))	F: worse preop back & leg pain, disability, & HRQoL; F: worse absolute postop back & leg pain, disability, & HRQoL; F: similar degree of postop improvement in back & leg pain, disability, & HRQoL; M & F: equally as satisfied w/ surgical outcome; F: preop higher consumption of analgesia; F: postop higher consumption of analgesia		
Strömqvist et al., 2016 ⁵²	Preop, postop (12 mos)	SF-36, VAS, EQ-5D, ODI, satisfaction (5-point Likert), self-estimated walking distance	M & F: both severe disability/HRQoL; F: more severe back & leg pain (VAS, both $p < 0.001$); F: longer duration of back/leg pain (both $p < 0.01$); F: consumed more analgesics ($p < 0.001$); inferior self-estimated walking ability ($p = 0.04$); inferior HRQoL (SF-36 PCS, $p = 0.002$); greater disability on ODI ($p = 0.011$))	M & F: similar degree of statistically significant improvement in nearly all PROMs (except SF-36 BP & MCS); F: report worse (VAS) back ($p \leq 0.001$)/leg pain ($p = 0.003$); F: reported higher consumption of analgesics ($p < 0.001$) & inferior self-estimated walking distance ($p = 0.043$); M & F: equally satisfied w/ surgical outcome; F: worse HRQoL SF-36 all domains (all $p < 0.03$)/disability on ODI ($p < 0.001$), EQ-5D ($p < 0.05$))	F: worse preop back & leg pain, disability, & HRQoL; F: worse absolute postop back & leg pain, disability, & HRQoL; F: similar degree of postop improvement in back & leg pain, disability, & HRQoL; M & F: equally as satisfied w/ surgical outcome; F: preop higher consumption of analgesia; F: postop higher consumption of analgesia			
Pochon et al., 2016	Preop, postop (12 mos)	COMI	F: worse back ($p < 0.01$) & leg ($p < 0.01$) pain; F: worse HRQoL ($p < 0.002$); M & F: no difference in disability; F: worse overall COMI score; M & F: >90% of both groups reported goal of surgery as "pain relief"	F: worse absolute COMI scores ($p < 0.007$); F: more severe intensity of absolute "worst back or leg pain" ($p < 0.009$), except LDH group ($M = F$); F: worse absolute disability ($p < 0.025$), except LDH group ($M = F$); F: worse absolute HRQoL ($p < 0.017$), except LDH ($M = F$); M & F: no difference in % meeting MCIC (2-point reduction), 71% M & 72% F; M & F: no difference in satisfaction w/ care; M & F: similar degree of improvement in COMI, "worst back or leg pain intensity," disability, & HRQoL	M & F: no difference in preop disability; F: worse preop leg/back pain, HRQoL, & overall COMI score; F: similar preop duration of back/leg pain; F: worse absolute postop COMI, "worst back or leg pain," disability, & HRQoL scores, except LDH group ($M = F$); M & F: similar degree of improvement in COMI, "worst back or leg pain," disability, & HRQoL scores; equal amount of pts achieving the MCIC (>70% both groups) after controlling for confounders; M & F: equally satisfied w/ outcome			
Gautschi et al., 2016 ¹⁹	Preop	TUG, OFI (derived using age- & gender-adjusted TUG), VAS, ODI, RDQ, EQ-5D, SF-12	F: worse back ($p = 0.001$), leg pain ($p = 0.002$); F: worse disability ($p = 0.005$); F: slower mean TUG ($p < 0.0001$); F: worse HRQoL on EQ-5D ($p = 0.011$), SF-12 PCS ($p = 0.001$); M & F: no difference in SF-12 MCS or RMDI; M & F: no difference in OFI	NA	F: worse preop pain, disability, & HRQoL; F: pts had a slower TUG; correction via age- & gender-adjusted cutoffs derived from the normal population revealed similar OFI compared to M			
Triebel et al., 2017	Preop, postop (12 mos, 24 mos)	VAS, ODI, VAS back, EQ-5D	F: worse leg pain ($p < 0.001$), back pain ($p = 0.002$); F: lower HRQoL ($p < 0.001$); F: greater disability ($p = 0.001$); F: greater % not working ($p < 0.001$); F: greater analgesic use ($p < 0.001$)	F: greater degree of improvement in leg/back pain, HRQoL, & disability (all $p < 0.01$); F: slower improvement regarding leg/back pain & disability (all $p < 0.01$); F: when adjusting for baseline factors, F had higher odds of achieving MCID for leg pain (OR 1.39, $p < 0.01$), back pain (OR 1.20, $p = 0.02$), & ODI (OR 1.24, $p = 0.01$); M & F: no difference in absolute pain, disability, or HRQoL (no p values presented)	F: worse preop leg/back pain, disability, & HRQoL; M & F: similar absolute postop leg/back pain, disability, & HRQoL (no p values); F: greater postop degree of improvement in leg/back pain, disability, & HRQoL; F: greater odds of achieving MCID for leg/back pain & disability			

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TABLE 3. Pre- and postoperative clinical assessment scores and study conclusions

Authors & Year	Timing of Assessments	Pt-Reported Clinical Assessment Measures		Preop Scores	Postop Scores	Conclusions
		Preop	Postop (6 mos)			
Katz et al., 1994	Preop, postop (6 mos)	SIP-PD		F: worse disability ($p < 0.01$); M & F: no significant difference in neuro-muscular impairment score; F & M: no difference in use of walking support	M & F: similar absolute disability; F: substantially greater improvement from baseline in disability (by effect size)	F: worse preop disability; M & F: no difference in absolute postop disability; F: greater postop improvement in disability
Taylor et al., 2005	Preop	SF-36		M: more likely to have surgery recommended ($p < 0.031$); F: more likely to have imaging/investigations ordered ($p < 0.005$); F: non-white F 52% less likely to have surgery recommended at first visit vs white M ($p < 0.005$); F: white F 18% more likely than white M to have nonsurgical Tx recommended ($p < 0.005$); F: worse HRQoL ($p < 0.001$)	NA	F: worse preop HRQoL; M: more likely to have surgery offered compared to F, regardless of ethnic group
Elsamadicy et al., 2017	Preop, postop (3 mos, 12 mos)	ODI, VAS back, VAS leg, EQ-5D, EQ-VAS, satisfaction		F: worse ODI ($p < 0.0001$), VAS back pain ($p < 0.0004$), EQ-5D ($p < 0.0001$); M & F: similar VAS leg pain & EQ-VAS	F (3 mos): worse disability ($p = 0.0016$), leg pain ($p = 0.016$), back pain ($p < 0.0001$), HRQoL ($p = 0.014$); F (12 mos): worse ODI ($p = 0.0006$), VAS leg pain ($p = 0.008$), VAS back pain ($p = 0.005$), & EQ-5D ($p = 0.008$); M & F: similar degree of improvement in pain, disability, & HRQoL at 3 & 12 mos, except for 12 mos VAS leg pain ($p = 0.04$, $M > F$); M: greater % of pts w/ "surgery met my expectations" ($p = 0.02$); F: greater % of pts reporting "did improve, but would not undergo surgery for same results" ($p = 0.03$)	F: worse preop pain, HRQoL, & disability; F: worse absolute postop pain, disability, & HRQoL; M & F: similar degree of postop improvement in pain, disability, & HRQoL; M: greater % felt surgery met their expectations
Siccoli et al., 2018	Preop, postop (6 wks, 12 mos, 24 mos)	NRS, ODI, EQ-5D, EQ-VAS		F: worse disability on ODI ($p < 0.001$); F: worse NRS back ($p = 0.006$) & leg ($p = 0.016$) pain; M & F: similar HRQoL; M & F: all other baseline demographic data comparable	F: worse disability at 6 wks, 12 mos, & 24 mos postop (all $p < 0.001$); F: worse HRQoL on EQ-5D at 6 wks ($p = 0.027$), 12 mos ($p = 0.016$), no 24-mo data; F: worse NRS leg pain at 12 & 24 mos (both $p < 0.001$); F: worse NRS back pain at 6 wks, 12 mos, 24 mos (all $p < 0.01$); M & F: mean change from baseline to 6 wks, 12 mos, & 24 mos for ODI, NRS leg & back pain, EQ-5D index, & EQ-5D VAS all similar btwn M & F; M & F: no difference in % of pts achieving "clinical success" as defined by 12-mo improvement $>30\%$ from baseline in ODI	F: worse preop pain, disability, & HRQoL; F (short- & long-term FU): worse absolute pain, HRQoL, & disability scores; M & F: similar degrees of improvement from baseline in pain, disability, & HRQoL
Herno et al., 1996	Postop (mean 4.3 yrs)	ODI		NA	F: worse absolute disability ($p = 0.046$)	F: worse absolute postop disability

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TABLE 3. Pre- and postoperative clinical assessment scores and study conclusions

Authors & Year	Timing of Assessments	Pt-Reported Clinical Assessment Measures	Preop Scores	Postop Scores	Conclusions
Yamashita et al., 2006	Preop, postop (6, 12, 24, 36, 48, & 60 mos)	VAS back & leg, VAS leg-numbness, VAS difficulty walking	F: worse preop leg pain ($p = 0.029$); M & F: no difference in back pain, leg numbness, & difficulty walking	F: worse absolute back pain (3 mos, $p = 0.0038$; 12 mos, $p = 0.0007$; 48 mos, $p = 0.015$), leg pain (3 mos, $p = 0.005$; 12 mos, $p = 0.014$), & difficulty in walking (12 mos, $p = 0.045$); M & F: similar proportion of pts achieving "better," "same," & "worse" change in back pain, leg pain, leg numbness, & difficulty walking	F: worse preop leg pain; M & F: no difference in preop back pain, disability, leg numbness; F: worse absolute postop back pain, leg pain, disability
Häkkinen et al., 2007	Preop, postop (6 wks, 12 mos)	VAS back, VAS leg, ODI	F: higher back pain ($p = 0.003$); M & F: similar leg pain ($p = 0.23$); F: worse disability ($p = 0.03$) & walking ($p = 0.033$), sex life ($p = 0.007$), social life ($p = 0.034$), & traveling ($p = 0.015$)	M & F: no difference in absolute leg/back pain, or disability; F: greater degree of improvement in ODI ($p < 0.001$); M: changes in disability were greatest in pain, social life, & traveling; F: changes in disability were greatest in subcategories of self-estimated walking, social life, & traveling	F: worse preop back pain & disability; M & F: similar preop leg pain; M & F: no difference in absolute postop leg/back pain or disability; F: greater degree of postop improvement in disability
Strömqvist et al., 2008	Preop, postop (12 mos)	VAS back, ODI, SF-36 MCS/PCS, EQ-VAS, EQ-5D	F: worse back pain ($p = 0.001$), more likely to report pain higher than 60/100 compared to M ($p = 0.05$); M & F: no difference in leg pain; F: worse disability ($p = 0.07$), w/ none reporting absence/minimal disability (i.e., score of 0–20); F: worse HRQoL on SF-36 ($p < 0.05$); M & F: no difference in EQ-5D	F: consumed more analgesics ($p = 0.002$); F: less % pts w/ back pain score < 10 ($p = 0.0003$); F: worse VAS back pain ($p = 0.04$); F: no difference in leg pain ($p = 0.07$); F: less % pts w/ leg pain < 10 ($p = 0.01$); F: less reduction in ODI ($p = 0.04$); F: less % pts w/ ODI score < 20 (none/minimal disability, $p = 0.008$); F: worse SF-36 PF ($p = 0.02$), BP ($p = 0.004$) & VT ($p = 0.001$) scores; M & F: similar MSC score, PSS, EQ-5D & EQ-VAS; M & F: no difference in degree of improvement in VAS back & leg pain; M & F: no difference in overall satisfaction w/ outcome of surgery	F: worse preop back pain, disability, & HRQoL (SF-36, but not EQ-5D, M = F); M & F: no difference in preop leg pain; F: worse absolute postop back pain, disability, & HRQoL (SF-36, but not EQ-5D, M = F); M & F: similar absolute postop leg pain, but greater % of M pts w/ leg pain score < 10 ; F: lower postop % of pts scoring "no or insignificant disability"; M & F: back pain, leg pain, & HRQoL improved to similar extent; F: higher analgesia consumption; M & F: similar overall postop satisfaction
Lee et al., 2016	Preop	VAS anxiety	F: higher level of preop anxiety ($p = 0.009$)	NA	F: worse preop anxiety
Strömqvist et al., 2016 ⁵³	Preop, postop (12 mos)	EQ-index, EQ-VAS, SF-36, ODI	F: Higher consumption of analgesic ($p < 0.001$); F: inferior walking distance ($p < 0.001$); F: worse VAS back pain ($p < 0.001$); F: worse VAS leg pain ($p < 0.001$); F: inferior HRQoL on SF-36 all domains (all $p < 0.001$) & EQ-VAS ($p < 0.001$) & EQ-index ($p < 0.001$) & EQ-VAS ($p < 0.001$) & EQ-VAS ($p < 0.001$) & EQ-VAS ($p < 0.001$); F: worse disability on ODI ($p < 0.001$); F: worse disability on ODI ($p < 0.001$)	F: higher consumption of analgesia ($p < 0.001$); F: inferior walking distance ($p < 0.001$); F: worse back pain ($p < 0.001$); F: worse leg pain ($p < 0.001$); F: inferior HRQoL on SF-36 all domains (all $p < 0.001$) & EQ-VAS ($p < 0.001$) & EQ-index ($p < 0.001$) & EQ-VAS ($p < 0.001$) & EQ-VAS ($p < 0.001$) & EQ-VAS ($p < 0.001$); M & F: similar degree of improvement in postop leg/back pain, disability, & HRQoL; M & F: no difference in satisfaction w/ outcome	F: inferior preop pain, HRQoL, & disability; F: worse absolute postop pain, HRQoL, & disability; M & F: similar postop degree of improvement in leg/back pain, disability, & HRQoL; M & F: no difference in satisfaction w/ outcome of surgery; F: higher consumption of analgesia

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TABLE 3. Pre- and postoperative clinical assessment scores and study conclusions

Authors & Year	Timing of Assessments	Pt-Reported Clinical Assessment Measures	Preop Scores	Postop Scores	Conclusions
Gepstein et al., 2006	Preop, postop (41.62 mos)	VAS, Barthel Index, satisfaction questionnaire	F: lower preop expectations than M ($p < 0.001$)	F: less satisfied w/ outcome ($p < 0.001$)	F: lower expectations for surgical success, but less satisfied w/ outcome postop
Chan et al., 2018	Preop, postop (3 mos, 12 mos)	NASS satisfaction questionnaire	NA	F: greater satisfaction w/ surgical outcome ($p = 0.02$)	F: greater satisfaction w/ surgical outcome
Vucetic et al., 1999	Postop 24 mos	NRS	NA	F: worse leg pain at 2 yrs ($p < 0.05$)	F: less postop relief of leg pain & less likely to return to work
Peul et al., 2008	Preop, postop (2, 4, 8, 12, 26, & 38 wks)	RDQ, VAS leg, VAS back, global perceived recovery scale, satisfaction	F: worse disability ($p = 0.009$); F: worse VAS leg ($p < 0.001$); F: worse VAS back ($p = 0.042$)	F: worse disability ($p = 0.001$); F: worse VAS leg pain ($p < 0.001$); F: worse VAS back pain ($p = 0.006$); F: slower rate of recovery & less satisfied w/ surgical outcome ($p < 0.05$)	F: Worse postop disability, leg pain, back pain; F: less satisfied w/ surgical outcome
Staartjes et al., 2018	Preop, postop (12 mos)	VAS leg, VAS back, ODI	NA	F: better VAS back pain improvement ($p = 0.021$); M & F: nonsignificant difference in ODI improvement; M: the only predictor of worsening back pain	F: better surgical outcome (improvement in back pain)

ADL = activities of daily living; BDI = Beck Depression Inventory; BP = bodily pain; EQ-VAS = EuroQol VAS; MCIC = minimal clinically important change; MCS = Mental Component Summary; NASS = North American Spine Society; PCS = Physical Component Summary; PDQ = PainDETECT questionnaire; PF = physical function; PRO = patient-reported outcome; PROM = PRO measure; PSS = physical score; RMDI = Roland-Morris Disability Index; TE = treatment effect; VT = vitality scale.

FIG. 1. Flowchart outlining the systematic scoping review process. *Additional articles identified and included by manually searching the reference list of the included full-text articles. Figure is available in color online only.

or HRQoL. Of the 15 studies reporting preoperative back or leg pain, mean pain intensity was significantly worse for females in 14 studies (93.3%). A single study (6.7%) reported no gender difference in pain but found worse preoperative disability among females.⁵⁷ No studies reported worse preoperative pain among males. Of the 16 studies reporting data on preoperative disability, 13 (81.3%) found worse scores among females, whereas a single study (6.3%) found worse scores among males,⁵⁹ and 2 (12.5%) found equivalent scores.^{41,58} Preoperative HRQoL data were reported in 12 studies. Females had worse scores compared to males in 9 studies (75.0%), compared to equivalent scores in 3 studies (25.0%).^{48,58,59} No studies found worse preoperative HRQoL among males.

Preoperative Anxiety

Preoperative anxiety was the focus of a single retrospective study including 150 patients.³⁴ Anxiety was more prevalent among female patients.

Postoperative Pain, Disability, and HRQoL

Statistically significant gender differences in postop-

erative patient-reported clinical assessment scores were identified for pain, disability, and HRQoL (Table 3). Twenty-five (83%) of 30 studies reported at least one of the following categories: pain, disability, or HRQoL. Ten (40%) reported only absolute scores, 5 (20%) reported interval change or treatment effect, and 10 (40%) reported both absolute scores and interval change. Most studies reported at least 12 months of follow-up data.

Of the 20 studies reporting absolute scores, 16 (80%) found that females had worse scores in at least one outcome category. No study found males to have worse postoperative pain, disability, or HRQoL. Sixteen studies reported absolute pain scores. Females reported worse pain in 11 studies (68.8%). Five (31.3%) did not identify a difference between genders. Nineteen studies reported absolute postoperative disability scores. In 15 studies (78.9%) females reported worse postoperative disability. Four (21.1%) did not identify a difference between genders. Eight studies reported absolute postoperative HRQoL scores; females reported worse postoperative HRQoL in 6 studies (75.0%),^{14,41,48,50,52,53} whereas 2 studies (25.0%) found no gender differences.^{20,59} Global functional status was assessed using the Beaujon scoring system in a single

study.³⁷ The authors found worse scores for females at the 24-month follow-up.

Fifteen studies reported either interval change or treatment effect following surgery. Six studies (40%) reported a similar interval change between genders for pain, disability, and HRQoL.^{14,20,41,48,52,53} Five studies (33.3%) reported that females^{23,29,39,49,56} and 4 (26.7%) found that males^{32,50,59,60} reported greater improvement, respectively. Of the 10 studies reporting postoperative interval change in pain, 7 (70.0%) found no gender difference,^{14,20,41,48,50,52,53} and 1 (10.0%) found that males⁶⁰ and 2 (20.0%) found that females^{49,56} reported a greater degree of improvement, respectively. Of the 13 studies reporting postoperative interval change in disability, 7 (53.8%) found no gender difference,^{14,20,41,48,49,52,53} and 2 (15.4%) found that males^{50,59} and 4 (30.8%) found that females^{23,29,39,56} reported a greater degree of improvement, respectively. Ten studies reported an interval change in HRQoL: 8 (80%) found no gender difference in interval change,^{14,20,41,48,50,52,53,59} whereas males reported greater improvement in a single study,³² and females in another.⁵⁶

As aforementioned, 6 of 30 studies accounted for 27,754 patients (84.2%). Four of the 6 studies, accounting for 17,284 patients, reported postoperative assessment scores.^{41,48,52,53} All 4 reported that female patients had worse absolute scores but similar interval change in pre- and postoperative pain, disability, and HRQoL. One study reported worse preoperative scores but did not report absolute postoperative scores; these investigators reported a greater degree of postoperative improvement for females in pain, disability, and HRQoL.⁵⁶ One study reported worse preoperative HRQoL among females but did not report postoperative data.⁵⁴

Preoperative Duration of Symptoms and Clinical Assessment Scores

The majority of studies (63.3%) did not report preoperative duration of symptoms. Duration was reported in 7 studies (23.3%);^{12,23,37,40,41,47,52} 5 (16.7%) reported no difference between genders,^{12,23,40,41,47} and 4 (13.3%) reported data without statistical significance.^{26,53,58,59} All 5 studies reporting an equivalent preoperative duration of symptoms between genders reported inferior absolute clinical assessment scores among females,^{12,23,40,41,47} 4 reported females had worse absolute postoperative clinical assessment scores,^{12,40,41,47} and 2 reported females had a greater degree of postoperative improvement.^{23,41}

Postoperative Satisfaction With Surgical Outcome

Postoperative patient satisfaction data were available for 10 studies (33.3%). Five (50.0%) found no gender difference in satisfaction with surgical outcome.^{6,41,50,52,53} Four studies (40.0%) found that females are less satisfied,^{14,21,40,47} while a single study (10.0%) found that males are less satisfied with surgical outcome.⁷ Three of the studies reporting equal satisfaction between males and females were published by the same research group.^{50,52,53} In all of the studies in which females reported less satisfaction with the surgical outcome, they also reported worse absolute pain score compared to males. In the single study reporting less satisfaction among males, no pain, disability, or HRQoL data were available.⁷

Pre- and Postoperative Analgesia Usage

Four of 30 studies reported preoperative analgesia usage.^{47,52,53,56} A single study accounted for 11,237 patients.⁵³ All 4 studies reported that female patients had greater preoperative analgesic use. Four studies reported postoperative analgesia usage; all found higher usage among females.^{47,50,52,53} Three of those studies reported equal postoperative satisfaction between genders.^{50,52,53}

Objective Scoring Measures

A single study examined “pain thresholds” using quantitative sensory testing (QST).⁵⁸ The authors reported prospective data on pre- and postoperative pain thresholds for heat and pressure among patients treated for disc herniation. Females had lower heat pain and pressure pain thresholds. Postoperatively, females had lower pressure pain and mechanical detection thresholds, whereas males reported a lower vibration detection threshold and mechanical pain sensitivity. Notably, there were no gender differences in postoperative patient-reported clinical assessment scores. Two studies from the same group utilized Timed-Up-and-Go (TUG) testing. The first reported no gender differences in preoperative TUG or Objective Functional Impairment (OFI) scores (derived using age- and gender-adjusted cutoff values for TUG scores).²⁰ A similar interval change in postoperative scores was noted for males and females. The other study reported only preoperative data, with slower mean TUG among females and no difference in OFI.¹⁹

Evidence Appraisal

The majority of studies constitute level 4 evidence.^{6,7,12,14,19,26,29,32,37,47–49,56–59,63} The remainder constitute level 1b,⁴⁰ 2b,^{2,20,21,23,34,39,41,50,52,53,60} and 3b⁵⁴ evidence.

Discussion

This study summarizes the adult surgical literature regarding gender differences in patients with lumbar degenerative disease (disc degeneration, disc herniation, spondylolisthesis, and spinal canal stenosis). The data suggest that despite equal or greater postoperative improvement, females undergo surgery with inferior clinical status (pain, disability, HRQoL), leading to inferior postoperative clinical status. All studies reporting preoperative scores identified gender differences. Most studies reported worse preoperative pain (93.3%), disability (81.3%), and HRQoL (75%) among females. The remainder reported equivalent results between males and females. Eighty percent of studies found that females had worse absolute postoperative scores in at least one category of pain, disability, or HRQoL, whereas 73.3% reported either an equivalent or greater degree of improvement between genders. No study found males to have worse absolute postoperative pain, disability, or HRQoL scores. A subgroup analysis of studies including only patients with disc herniation or spinal canal stenosis was performed (Supplemental Digital Content C). Trends in pre- and postoperative clinical assessment scores were similar to those identified for aggregate data from all studies. The majority of studies constitute level 4 evidence.

Patient Selection and Management Guidelines

White males are reported to receive better access to interventions compared to females and minorities; examples include admission to an intensive care unit, access to lipid-lowering medication following myocardial infarction, cardiac catheterization, renal dialysis, transplantation, and TJA.^{3,9,13,18,25,31,46} Perception of the risk and benefits of therapeutic interventions systematically varies across racial and gender groups, often reflecting the outcomes of care provided to those groups.²⁸ Provider-level factors may also influence patient expectations, which patients access surgery, and satisfaction with clinical outcome.^{38,50,51} Physicians often utilize evidence-based guidelines outlining the management of chronic conditions, which typically do not stratify by gender.¹ This is likely related to a paucity of literature on gender differences in pre- and postoperative clinical assessment scores. Future research may facilitate guideline development with attention toward gender stratification. This has been exemplified by studies of carotid endarterectomy for the treatment of carotid stenosis.⁴⁴

Objective and Subjective Outcome Measurement

The use of patient-reported clinical assessment scores in the context of patient-centered care is intuitive. Geography and culture may influence patient-reported assessment scores, as evidenced by varying conclusions regarding the management of lumbar degenerative conditions in randomized controlled trials (RCTs) from Europe and North America.^{17,22} Furthermore, patient-reported clinical assessment tools typically lack age and gender specificity; age- and gender-adjusted cutoff values are not readily available, as they are for objective TUG testing.^{19,38} We identified two studies that reported age- and gender-adjusted cutoff values for TUG testing.^{19,20} One reported no gender difference in preoperative TUG scores adjusted for age- and gender-based cutoff values.²⁰ No gender differences were observed for postoperative scores. The other reported only preoperative data, with slower mean TUG among females, but no difference in adjusted values.¹⁹ Time constraints during clinics may be prohibitive with respect to such testing.

Biological, environmental, and socioeconomic factors may influence gender role expectations of pain thresholds; both males and females report that females are more sensitive to, and less enduring of, pain.⁴³ QST of patients undergoing lumbar surgery has revealed lower preoperative thresholds for both heat- and pressure-related pain among females.⁵⁸ Postoperatively, females had lower pressure pain and mechanical detection thresholds, whereas males reported lower vibration detection threshold and mechanical pain sensitivity. Notably, there were no differences in patient-reported assessment scores.

Gender Disparity in Joint Arthroplasty for the Treatment of Osteoarthritis

Gender, racial, and geographic variability in the utilization of surgical therapy has been exemplified by studies of TJA for the treatment of osteoarthritis (OA).³⁸ Hawker et al. demonstrated that females have a higher prevalence of OA compared to males, with worse pain and disability.²⁵ No gender differences were observed in willingness

to undergo hip and knee TJA; however, surgeons were less willing to offer TJA to females. In practice, the observed underuse of TJA in appropriate candidates is three times greater among females.⁶² Opinion surveys have found that 93% of surveyed orthopedic surgeons reported gender did not affect their decision to offer TJA.^{10,62} Borkhoff et al. conducted a blinded assessment of family physicians and orthopedic surgeons, examining standardized patients with OA of the knee, differing only by gender.⁵ Forty-two percent of physicians recommended TJA to the male but not the female patient. Eight percent of physicians recommended TJA to the female but not the male. Orthopedic surgeons were 22 times more likely, and family physicians 2 times more likely, to offer TJA to a male patient. The data suggest females are offered surgery with inferior clinical status but demonstrate equal or greater postoperative improvement compared to males. Further research should attempt to determine if this observation reflects a bias against offering surgery to female patients.

Gender Differences in the Workup and Management of Lumbar Degenerative Disease

It has been suggested that female patients present or are referred for assessment later in the course of their disease, leading to inferior clinical status at the time of surgery.^{41,48,56} The data herein support the claim regarding inferior clinical status among female patients at the time of surgery. Few studies have examined the impact of gender bias on workup and decision-making for the management of degenerative spinal conditions.⁵⁴ It is unclear to what extent referral, patient selection, and patient preference contribute. Five of 7 studies examining preoperative duration of symptoms reported no difference between genders.^{12,23,40,41,47} All 5 studies reported that females had inferior clinical assessment scores. These findings suggest that duration of symptoms alone does not explain gender differences in clinical assessment scores.

A retrospective analysis of 5690 patients, attending an initial preoperative surgical assessment for degenerative lumbar disease, stratified the findings by gender.⁵⁴ Although females were more likely than males to have imaging tests ordered, males were more likely to be offered surgery. The number of patients referred for assessment or offered surgery at a later follow-up visit is not reported.

Kim et al. used a preference-based shared decision-making model to evaluate patient willingness to choose surgery or conservative management; male gender was associated with patient preference for surgery.³⁰ Bono et al. found that preoperative back pain intensity was positively associated with patient acceptance of lumbar fusion complication risk, whereas gender was not.⁴ It has been reported that physicians believe female patients are more likely to experience adverse outcomes following TJA.⁶¹ However, a systematic review found that males were at increased odds of death, but not complications, following spine surgery.⁴⁵ To our knowledge, no comparable study to that of Borkhoff et al.⁵ has prospectively examined surgeon willingness to offer spine surgery to standardized patients who only differ in gender. Prospective studies accounting for patient referral may facilitate identification of biases in patient selection for surgery. Gender of the surgeon may play

a role. In this paper, only a single study reported surgeon gender, and indicated that all were male.⁵⁰

Gender Disparity in Lumbar Spine Surgery for Degenerative Conditions

Pearson et al. reviewed Spine Outcomes Research Trial (SPORT) data for 607 patients by combining RCT and observational cohort study data for degenerative spondylolisthesis (DSL) via an as-treated analysis.³⁹ Female gender was associated with greater treatment effect. Strömqvist et al. published data for 15,631 patients from the Swedish National Register for Spine Surgery, reporting that females scheduled for discectomy reported inferior walking ability, consumed more analgesics, and reported worse pain, disability, and HRQoL.⁵¹ A prospective cohort study of 4780 patients receiving fusion for lumbar degenerative disease found that females had inferior preoperative pain, disability, and HRQoL, but greater postoperative improvement than males.⁵⁶ Several studies report comparable findings; females report inferior clinical status, but similar postoperative improvement following treatment of lumbar disc herniation (LDH), spondylolisthesis, and spinal canal stenosis.^{23,33,41,52,53} Four studies found that males reported greater clinical improvement following surgery; males were more satisfied that surgery met their expectations, and females were more likely to report they would not undergo surgery for the same results.^{32,50,59,60}

Sarcopenia, Frailty, and Severity of Radiographic Disease

Sarcopenia has been investigated as a surrogate marker of frailty in patients undergoing spine surgery.⁶⁵ Zakaria et al. found that the psoas area predicted postoperative complications in males but not females.⁶⁵ Their results are not generalizable given the heterogeneous cohort that included deformity, revisions, and anterior procedures. A separate ambispective study of patients undergoing scheduled surgery for degenerative spine disease found that gender and BMI were associated with psoas size but not frailty.⁸ Psoas size did not predict the occurrence of adverse events, length of stay, or mortality. A study of 53,145 patients undergoing lumbar surgery for degenerative conditions found that only 4% are frail.¹⁶ Frailty was twice as common in patients greater than 65 years of age, although the mean age of their cohort was 56.1 years. They included patients with cervical and thoracic disease and these patients had higher rates of frailty compared to those with lumbar disease.

Frailty likely does not explain the gender differences identified in this review. First, the average age of patients in this study was approximately 50 years and there is a low prevalence of frailty in patients undergoing degenerative spine surgery, even among those over the age of 65 years.¹⁶ Second, sarcopenia does not correlate with frailty or postoperative outcomes.⁸

Limitations

Our review has several limitations. First, innumerable studies have examined the surgical treatment of lumbar degenerative disease without dichotomizing by gender. As such, a true systematic review was not feasible. Second, we did not search “gray literature.” The majority of eligible studies were retrospective analyses of prospectively

collected cohort data. The largest eligible study reported data from a nonconsecutive prospective database.⁵³ Only two RCTs were included, contributing 2.7% of the total patients. Many included studies had a small sample size and may be underpowered to detect meaningful clinical response to surgery. Most studies did not compare postoperative results to minimal clinically important difference (MCID) values. A small number of studies account for the majority of patients and were mostly published by European groups; cultural differences in patient-reported clinical assessment scores may vary geographically. The clinical assessment tools used to determine the severity of disease and response to treatment are, for the most part, subjective patient-reported measures. While validated, the relative contribution and importance of biology, pathology, and psychosocial considerations are not able to be determined. We did not set an inclusion limit on study publication year. While older studies preceding the development of novel surgical techniques may report inferior results, the majority of patients received routine discectomy or laminectomy. None of the included studies predate 1994. Lastly, we utilized a binary assessment of gender. To our knowledge, a nonbinary assessment has not been published in the spine surgery outcome literature.

Conclusions

Female patients undergoing surgery for lumbar degenerative disease (disc degeneration, disc herniation, spondylolisthesis, spinal canal stenosis) report worse preoperative pain, disability, and HRQoL. Following surgery, females report worse absolute pain, disability, and HRQoL, but demonstrate an equal or greater interval change compared to males.

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Disclosures

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Author Contributions

Conception and design: Pickett, MacLean. Acquisition of data: MacLean, Touchette, Han. Analysis and interpretation of data: MacLean, Touchette, Han. Drafting the article: MacLean, Touchette, Han, Christie. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Pickett. Statistical analysis: MacLean, Touchette. Administrative/technical/material support: Pickett, Christie. Study supervision: Pickett, Christie.

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