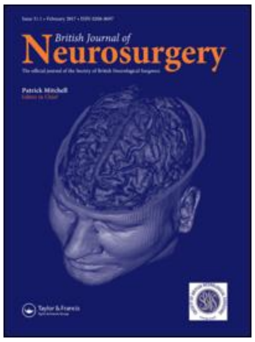

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British Journal of Neurosurgery

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ibjn20

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To cite this article: Julian Ghobrial, Pravesh Gadjradj, Biswadjiet Harhangi, Ruben Dammers & Carmen Vleggeert-Lankamp (2021): Outcome of non-instrumented lumbar spinal surgery in obese patients: a systematic review, British Journal of Neurosurgery, DOI: 10.1080/02688697.2021.1885615

To link to this article: https://doi.org/10.1080/02688697.2021.1885615

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Published online: 23 Feb 2021.

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BRITISH JOURNAL OF NEUROSURGERY
https://doi.org/10.1080/02688697.2021.1885615

REVIEW ARTICLE

OPEN ACCESS

Outcome of non-instrumented lumbar spinal surgery in obese patients: a systematic review

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ABSTRACT

Introduction: Lumbar spinal decompression procedures are well known in their techniques and outcomes. However, outcomes of lumbar spinal surgery in patients with obesity are relatively unknown. The aim of this review is to assess the effect of obesity on post-operative outcomes of lumbar non-instrumented decompressive spinal surgery.

Methods and materials: A literature search through PubMed, Embase, Web of Science and Cochrane was performed. Articles were included if they reported outcomes of obese patients after non-instrumented lumbar decompression surgery, if these outcomes were described using patient-reported outcome measures and if there was at least two months of follow-up. Risk of bias was assessed using an adjusted version of the Cowley score.

Results: From the 222 unique articles, 14 articles, comprising 13,653 patients, met the inclusion criteria. Eight out of 14 studies had a low risk of bias, while the remaining six had an intermediate risk of bias. Thirteen studies evaluated leg and back pain, and the vast majority demonstrated less decrease in pain in the obese group. Six studies evaluated disability and all but one showed less improvement in obese patients. Five studies evaluated functionality and wellbeing and all but one showed less satisfactory outcome in obese patients.

Conclusions: Literature does not reveal a difference in clinical outcome nor in complications in patients undergoing non-instrumented lumbar surgery with a BMI lower than 30 or equal to or higher than 30. This may be used by physicians to inform patients prior to lumbar decompression surgery.

ARTICLE HISTORY
Received 3 June 2019
Revised 16 March 2020
Accepted 1 February 2021

KEYWORDS
Neurosurgical procedures; obesity; BMI; functional outcomes; complications

Introduction

Surgery for lumbar spinal stenosis (LSS) (with or without degenerative lumbar spondylolisthesis (DLS)), and lumbar disc herniation (LDH) is frequently performed. Spinal stenosis can give rise to neurogenic claudication complaints and this can be an indication for surgery.[1] LDH accompanied by lumbar radiculopathy is typically characterized as sciatica and may be an indication for surgery.[2] Outcome of this type of surgery is well described.[3–7] In surgery for LSS, on average two-third of patients has a satisfactory outcome after surgery and in lumbar disc surgery, on average 90% of patients is satisfied after surgery.[8] However, it is not specifically known whether these outcome data also apply to obese patients.

Obesity is a global health problem, associated with a high rate of morbidity and an increased mortality.[9,10] Obesity is defined as having a body mass index (BMI) equal to or higher than 30 and morbid obesity is defined as having a BMI higher than 40 (2015). Patients suffering from obesity are at an increased risk of developing lumbar conditions, such as spinal stenosis, disc degeneration and low back pain.[11–13]

In obese patients, the clinical presentation of complaints is comparable to the complaints in non-obese patients. Although surgical intervention has the same objective, namely decompression of the nervous tissue, it can be different in its access. The thick layer of fat covering the long back muscles enlarges the distance from the skin to the structures of interest for surgery and necessitates the surgeon to use a spreading device with longer blades. Hence, the overview of the region of interest is somewhat less than in non-obese patients. Moreover, all tissue is covered in fat, which also contributes to a poor overview of the surgical area. On top of that, in postoperative mobilization, the mass of the patient makes mobilization more difficult with an increased load on the long back muscles.[14] This may have a negative influence on the postoperative leg and back pain and mobilization.

The aim of this review will be to compare the outcome of non-instrumented decompressive spinal surgery in obese and non-obese patients, and to evaluate whether obesity has a negative effect on post-operative outcome.

Materials and methods

Data search and study selection

In order to obtain all relevant literature, searches were performed in PubMed, Embase, Web of Science and Cochrane (search string in Appendix 1) from September 2004 to May 2018. PRISMA guidelines were followed and the articles were independently reviewed for relevance by two reviewers (JG and PG). Disagreement was resolved through mutual discussion and/or a third-party opinion (CVL).

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The relevance of articles was based on the following inclusion criteria: the article was written in Dutch or English and published in a peer-reviewed journal, the article described the outcome of surgery in obese patients undergoing a lumbar spinal surgical intervention for LSS or LDH, the article described one or more of the following outcomes: Oswestry Disability Index (ODI), Roland-Morris Disability Questionnaire (RMDQ), Visual Analogue Scale (VAS) or Numeric Rating Scale (NRS) for back pain and/or leg pain, SF-36, EQ-5D, complications, morbidity and mortality. Follow-up of patients had to be at least two months. Articles in which patients underwent lumbar fusion were excluded, unless the results of the fusion group could be separated from study results on decompression of spinal stenosis or decompression of a compressed nerve root. Review articles were also excluded.

Risk of bias assessment

Quality of studies was judged by performing a risk of bias assessment using the Cowley[15] scoring system adjusted for low-complex lumbar surgery in obese patients (Table 1).

The items reviewed in the assessment were: definition of patient group, for which a maximum of three points could be attributed, selection bias, with a maximum of one point, outcome bias, for which three points could be attributed, and attribution bias, with a maximum of two points. Studies could be awarded a maximum of 9 points. Studies were then divided into a low (8–9 points), intermediate (5–7 points) or high (4 or less points) risk of bias group.

Data-extraction and analysis

The following data were extracted from each article: total number of operated patients, indication for intervention, type of intervention, BMI class, length of follow-up, blood loss, operation time, days of hospitalisation, complication rate (dural tear, nerve injury, wound infection) re-operation rate, and clinical outcomes (leg pain, back pain, ODI, RMDQ, EQ-5D, SF-36 and patient satisfaction). For reasons of comparability, we divided the study population in patients with a BMI lower than 30 ('non-obese') and patients with a BMI equal to or higher than 30 and indicated the latter group as 'obese patients'. For the ODI, EQ-5D, SF-36, leg pain and back pain we used a numerical outcome. Per BMI category post-operative scores of 0–100 were noted. If only the preoperative outcome was given and the difference in outcome pre- and post-operatively was stated, the postoperative value was calculated and incorporated in the analysis. If multiple EQ-5D or SF-36 outcomes were stated, we calculated the mean outcome. Leg and back pain outcomes that were not presented as a value from 0 to 100 were recalculated to a percentage for comparability. Since EQ-5D and SF-36 are both measures for general health status, both parameters were analysed together in a single category representing patient health status.

For patient satisfaction evaluation scores, we dichotomised the outcome into 'satisfied' and 'not satisfied', even if more classes were used by the authors. For example, for Gepstein *et al.*'s study,[23] we considered the classes 'excellent' and 'good' to be 'satisfied' and classes 'fair' and 'bad' to be unsatisfied. Due to an expected high heterogeneity, different interventions assessed threating different degenerative lumbar diseases and different study designs, a meta-analysis was not performed.[30]

Clinical relevance of differences

Besides the statistical evaluations and the adjoining conclusions made by the authors, we evaluated the relevance of the observed differences between the group of obese and non-obese patients. To that end, we evaluated whether the postoperative outcome met the criteria for minimal clinical important difference (MCID). In general, the MCID was deemed to be 20%.[31] For the ODI we used an MCID of 15%.[32] To calculate the difference, we use the 'anchor-method'[33] in which the improvement in outcome in the non-obese patients is the anchor-value.

Results

Search results and selection results

One hundred and ninety-three articles were retrieved from PubMed, 222 from Embase, 115 from Web of Science and 12 from Cochrane. After undoubling 222 articles were left. The selection process eventually yielded 21 articles. Seven of these articles were assessed by the third reviewer after disagreement and were excluded. Fourteen articles fitted the in- and exclusion criteria (Figure 1). The articles included a total of 13,653 patients. Seven studies[16–19,25,26,28] were prospective cohort studies and seven studies[20–24,27,29] were cohort studies that were analysed in retrospect. Of the prospective cohort studies, four studies[17,19,26,28] acquired their data from (national) registries and one study[18] from the SPORT-trial.

Demographics

Patients had a mean age of 52.6 years with a mean range of 11.1 years (Table 1). On average 46.4% of all patients was female. Mean follow-up was approximately 24 months. All studies had a follow-up of more than 12 months, except for the study by Wang *et al.*[29] who performed a follow-up from 3 to 23 months with a mean follow-up of 11.8 months. A minority had a follow up of more than 60 months.[19,23,28] If a study did not primarily divide its patients into an obese group with a BMI equal to or higher than 30 and a non-obese group with a BMI lower than 30, we would make this division ourselves for reasons of comparability. All patients with a BMI lower than 30 were taken together and their correlating data were averaged. The same was done for all patients with a BMI equal to or higher than 30. The groups were respectively referred to as the 'non-obese' and the 'obese patients'.

Risk of bias

The majority of studies had low risk of bias (Table 2). The studies by McGuire *et al.*[18] Giannadakis *et al.*[17] Wang *et al.*[29] Brennan *et al.*[26] and Madsbu *et al.*[28] scored the maximum score of nine points, and the studies by Knutsson *et al.*[19] and Gepstein *et al.*[23] scored eight out of nine points. The studies by Burgstaller *et al.*[16] Onyekwelu *et al.*[25] and Bae and Lee[27] scored seven points on the risk of bias scale, which indicates a medium level of bias in comparison to the highest scoring studies. Selection and attrition bias could not be completely excluded from Burgstaller *et al.*'s[16] study. In Bae and Lee's study, selection bias could not be completely excluded and outcome was not described completely. In Onyekwelu *et al.*'s[25] study, the age range and the number of men and women were not given. Furthermore, attrition bias could not be completely excluded in this study. Tomasino *et al.*'s[20] study

Table 1. Characteristics of included studies.

Study (year of publication)	*N* total (13,653)	% Obese	Mean age in years (range)	Women in %	Operative technique	BMI classes	Follow up in months
Burgstaller *et al.*[16]	166	26.5	74 (12)	48.2	Laminectomy/ laminotomy	Three BMI classes, non-obese <25, overweight 25–30, obese ≥30	12
Giannadakis *et al.*[17]	1473	24	66.1 (10.7)	49.2	Laminectomy/ laminotomy	Four BMI classes, normal <25, overweight 25–29.9, obese 30–34.9, high obese ≥35	12
McGuire *et al.*[18]	413	41	63.5 (10.9)	42	Laminectomy	Three BMI classes, non-obese <30, obese 30–35, high obese ≥35	48
McGuire *Degenerative Spondylolisthesis* (2014)	389	28.5	64.7 (9.6)	72.3	Laminectomy	Three BMI classes, non-obese <30, obese 30–35, high obese ≥35	48
McGuire *Intervertebral Disc Herniation* (2014)	787	28	41.3 (11.0)	48	Discectomy	Three BMI classes, non-obese <30, obese 30–35, high obese ≥35	48
Knutsson *et al.*[19]	2633	23	68.7 (8.3)	42.3	Discectomy/laminectomy	Three BMI classes, non-obese <25, overweight 25–30, obese ≥30	24
Tomasino *et al.*[20]	115	31	51.5 (13.5)	47.8	Tubular microdiscectomy/ laminectomy	Two BMI classes, non-obese <30 and obese ≥30	15.9
Cole and Jackson[21]	32	100	38	46.9	Minimally invasive discectomy	One BMI class, obese ≥30	15.3
Fakouri *et al.*[22]	68	50	38 (22–58)	35.3	Microdiscectomy	Two BMI classes, non-obese <30 and obese ≥30	20–60
Gepstein *et al.*[23]	298	22	71.4 (5.36)	51.3	Laminectomy/discectomy	Four BMI classes, normal <25, overweight 25–29.9, obese 30–34.9, high obese ≥35	64
Bohl *et al.*[24]	226	40	40.5 (11.6)	28.6	Laminectomy	Four BMI classes, normal <25, overweight 25–29.9, obese 30–39.9, high obese ≥40	24
Onyekwelu *et al.*[25]	1791	47	64.4	–	Laminectomy	Two BMI classes, non-obese <30 and obese ≥30	12
Brennan *et al.*[26]	120	34.5	42.7 (19–70)	46.7	Microdiscectomy	Two BMI classes, non-obese <30 and obese ≥30	12
Bae and Lee[27]	143	44	38.0 (17–75)	45.8	Transforaminal endoscopic discectomy	Two BMI classes, non-obese 18.95–22.9, obese ≥30	24
Madsbu *et al.*[28]	4,932	18.5	44 (12.8)	40.4	Microdiscectomy	Two BMI classes, non-obese <30 and obese ≥30	12
Wang *et al.*[29]	67	100	34 (24–43)	50.7	Transforaminal endoscopic discectomy	One BMI class, obese ≥28	3–23

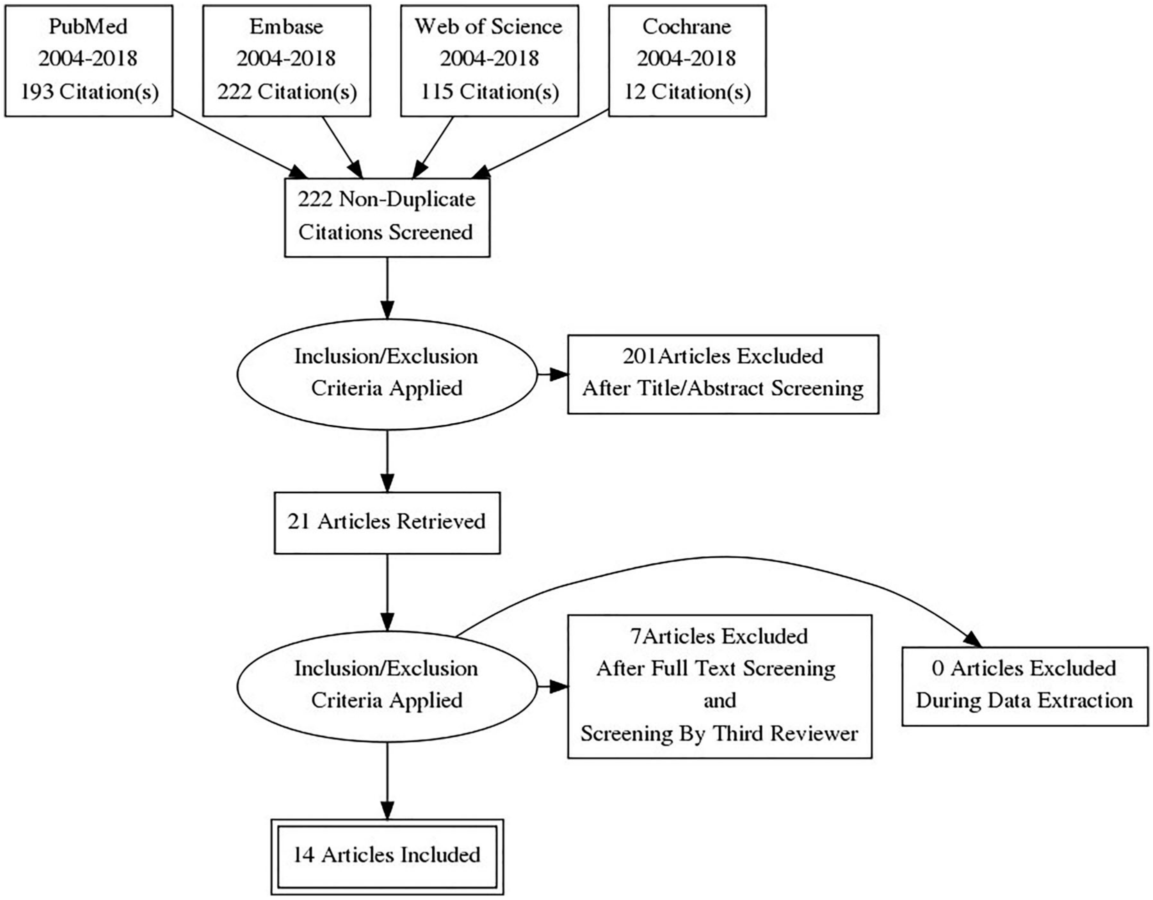

Figure 1. Flowchart of the selection process of the articles.

Table 2. Risk of bias assessment scores.

	Definition of patient group	Absence of selection bias	Description and validity of outcomes	Absence of attrition bias	Total points	Final score on RoB scale
Burgstaller	***	–	***	*	*******	Intermediate
Giannadakis	***	*	***	**	*********	Low
McGuire	***	*	***	**	*********	Low
Knutsson	***	*	***	*	********	Low
Tomasino	***	*	**	–	******	Intermediate
Col	***	*	**	–	******	Intermediate
Fakouri	***	–	**	*	******	Intermediate
Gepstein	***	*	***	*	********	Low
Bohl	***	*	**	–	******	Intermediate
Onyekwelu	**	*	***	*	********	Low
Ya Peng Wang	***	*	***	**	*********	Low
Madsbu MA	***	*	***	**	*********	Low
Brennan PM	***	*	***	**	*********	Low
Jun Saek Bae	***	–	**	**	*******	Intermediate

The items reviewed in the assessment were: definition of patient group, for which a maximum of three points could be attributed, selection bias, with a maximum of one point, outcome bias, for which three points could be attributed, and attribution bias, with a maximum of two points. Studies could be awarded a maximum of nine points in total. Studies were then divided into a low (8–9 points), intermediate (5–7 points) or high (4 points or less) risk of bias group.

scored six points on the risk of bias scale. It contained a degree of attrition bias and lacked in clarity and validity in description of outcomes. Cole and Jackson,[21] Fakouri *et al.*[22] and Bohl *et al.*[24] performed studies which scored six points on the risk of bias scale, indicating a relatively high risk of bias in comparison to the other studies. The studies of Cole and Jackson[21] and Bohl *et al.*[24] contained a degree of attrition bias and lacked in a completely clear and valid description of outcomes and study population. In addition to these points, selection bias could not be completely excluded from Fakhouri *et al.*'s[22] study.

Outcomes

Leg pain

Leg pain was evaluated in 13,427 patients in 13 (out of 14) different studies (Table 3). In most articles,[17,19,20,22,23,25–29] pain was scored using the VAS or Numeric Rating Scale (NRS). VAS is represented on a 0–100 mm scale (0 mm indicates 'no pain' and 100 mm indicates the 'worst pain imaginable') and NRS is reported on a 1–10 scale (1 indicates 'no pain' and 10 indicates the 'worst pain imaginable'). One article[18] scored leg pain using the Sciatica Bothersomeness Index (SBI). This index scores

Table 3. Leg pain.

Article (number of patients)	Measurement method	Risk of bias	Baseline (0–100%)		Post-operative pain (0–100%)		MCID reached		Significance indicated by authors
			BMI <30	BMI ≥30	BMI <30	BMI ≥30	BMI <30	BMI ≥30	
Burgstaller[a] (166)	NRS	Intermediate	53	56	20	30	Yes	Yes	NM
Giannadakis (1473)	NRS	Low	66	66	32	40	Yes	Yes	$p = .001$
McGuire *Spinal Stenosis* (413)	SBI	Low	60	60	26	32	Yes	Yes	$p = .18$
McGuire *Degenerative Spondylolisthesis* (389)	SBI	Low	60	63	49	39	No	Yes	$p = .12$
McGuire *Intervertebral Disc Herniation* (787)	SBI	Low	64	67	14	68	Yes	No	$p < .001$
Knutsson (2633)	VAS	Low	60	61	31.5	40	Yes	Yes	$p < .001$
Tomasino *Discectomy* (87)	VAS	Intermediate	78	83	23	15	Yes	Yes	NM
Tomasino *Laminectomy* (28)	VAS	Intermediate	68	81	24	22	Yes	Yes	NM
Cole (32)	Leg pain outcome score	Intermediate				23[b]	–	–	NM
Fakouri (68)	VAS	Intermediate	58	63	1[c]	3	Yes	Yes	$p = .025$
Gepstein[a] (298)	VAS	Low	81	89	32	39	Yes	Yes	$p = .03$
Onyekwelu (1791)	VAS	Intermediate	67.0	67.3	25.1	29.1	Yes	Yes	$p = .153$
Brennan (120)	VAS	Low	46.6	48.8	24.8	12.7	Yes	Yes	$p = .113$
Jon Sok Bae (143)	VAS	Low	79	76	10	14	Yes	Yes	$p < .0001$
Madsbu (4,932)	VAS	Low	68	70	19	27	Yes	Yes	$p = .264$
Ya Peng Wang[a] (67)	VAS	Low	71.2		22.7		Yes		$p < .05$

NM: not mentioned.

Leg pain was measured with several outcomes scales: the Visual Analogue Scale (VAS), the Numeric Rating Scale (NRS), the Sciatica Bothersomeness Index (SBI) and the leg pain outcome score. VAS is represented on a 0–100 mm scale (0 mm indicates 'no pain' and 100 mm indicates the 'worst pain imaginable') and NRS is reported on a 0–10 scale (0 indicates 'no pain' and 10 indicates the 'worst pain imaginable'). The SBI scores sciatica/leg pain from 0 to 24, with higher scores indicating more pain. The leg pain outcome score is scored from 1 to 4. A score of 1 indicates minimal to no leg pain, a score of 2 indicates moderate leg pain with preservation of daily activity, a score of 3 indicates moderate leg pain with loss of daily activity and a score of 4 indicates severe leg pain. The values measured on these scales are uniformly transformed to a 0–100 scale for reasons of comparability.

[a]Combined VAS/NRS for both leg and back pain.

[b]Leg pain score converted to a 0–100 scale with the following equation: $(25 \times 1.406)/1.5$.

[c]Fakouri provided a total amount of pain pre-operatively and post-operatively and in what ratio pain was distributed between legs and back. Based on this ratio and the total pain, the amount of leg pain could be derived and calculated.

sciatica/leg pain from 0 to 24, with higher scores indicating more pain. Cole and Jackson[21] used an outcome score, in which leg pain was scored from 1 to 4. A score of 1 indicates minimal to no leg pain, a score of 2 indicates moderate leg pain with preservation of daily activity, a score of 3 indicates moderate leg pain with loss of daily activity and a score of 4 indicates severe leg pain. For reasons of comparability, all scores were converted to scores on a scale from 0 to 100. We calculated the MCID for all studies.

From 11 studies,[16–20,22,23,25–29] comparing post-operative leg pain, outcome data for patient groups with a BMI lower and equal to or higher than 30 could be extracted. All studies demonstrated a decrease in leg pain after surgery both in obese and non-obese patients. In the majority of studies, the authors reported that there was no significant difference in leg pain in the obese and non-obese patients. In the majority of studies, we evaluated that the MCID in leg pain was reached for both the obese and non-obese patients. Six studies[16,18,19,22,23,27] reported that obese patients had significantly more leg pain than non-obese patients at follow up. However, in five of those studies, we deemed the difference between the groups not clinically relevant, since the MCID was reached in both groups (Table 3). Only in the group of patients with LDH (787 patients) described by McGuire *et al.*[18], no improvement in leg pain in the obese patients was observed and was therefore statistically significant and clinically relevant worse in comparison to non-obese patients. In one article,[29] describing 67 patients the authors indicated that there was a statistically significant difference between the groups, but since the exact data were lacking we could not evaluate clinical relevance.

Back pain

Back pain was evaluated in 13,427 patients in 13 (out of 14) different studies (Table 4). Likewise, back pain in most studies[17,19,20,22,23,25–29] was scored using the VAS or NRS. One study[18] used the Low Back Pain Bothersomeness Index (LBPBI) to evaluate back pain. This scale scores back pain from 0 to 6, with higher scores indicating more severe back pain. Again, Cole and Jackson[21] used a back pain outcome score, scoring back pain from 1 to 4, with a score of 1 indicating minimal to no back pain, a score of 2 indicating moderate back pain with preservation of daily activity, a score of 3 indicating moderate back pain with loss of daily activity and a score of 4 indicating severe back pain. For reasons of comparability, all scores were converted to scores on a scale from 0 to 100. We calculated the MCID for all studies.

Again, from 11 studies[16–20,22,23,25–29] comparing post-operative back pain, outcome data for patient groups with a BMI lower and equal to or higher than 30 could be extracted. In the majority of studies in which statistics were performed the authors reported that obese patient had more back pain at follow up. However, in only one of those studies[19] (evaluating 2633 patients) the MCID was not reached in the obese patients, while the difference was over 20% in the non-obese patients. The difference in VAS back pain in absolute values at follow-up was minimal however (32 vs. 39 on a 100 mm scale). In one article,[27] back pain was reported to be significantly less in obese patients at follow up, but the absolute difference was small and MCID was reached in both obese and non-obese patients. In one article, describing 67 patients,[29] the authors indicated that there was a statistically significant difference between the groups, but since

Table 4. Back pain.

Article (number of patients)	Measurement method	Risk of bias	Baseline (0–100%)		Post-operative pain (0–100%)		MCID reached		Significance indicated by the authors
			BMI <30	BMI ≥30	BMI <30	BMI ≥30	BMI <30	BMI ≥30	
Burgstaller[a] (166)	NRS	Intermediate	77	76	20	30	Yes	Yes	NM
Giannadakis (1473)	NRS	Low	66	66	35	41	Yes	Yes	$p = .002$
McGuire *Spinal Stenosis* (413)	LBPBI	Low	67	69	33	43	Yes	Yes	$p = .11$
McGuire *Degenerative Spondylolisthesis* (389)	LBPBI	Low	68	76	33	42	Yes	Yes	$p = .87$
McGuire *Intervertebral Disc Herniation* (787)	LBPBI	Low	63	68	30	37	Yes	Yes	$p = .035$
Knutsson (2633)	VAS	Low	52	57	32	39	Yes	No	$p < .001$
Tomasino *Discectomy* (87)	VAS	Intermediate	72	61	18	25	Yes	Yes	NM
Tomasino *Laminectomy* (28)	VAS	Intermediate	63	72	28	36	Yes	Yes	NM
Cole (32)	Back pain outcome score	Intermediate	–	–		26[b]	–	–	NM
Fakouri (68)	VAS	Intermediate	15	19	11	21	No	No	$p = .025$
Gepstein[a] (298)	VAS	Low	81	89	32	39	Yes	Yes	$p = .03$
Onyekwelu (1791)	VAS	Intermediate	61.7	63.9	28.3	33.6	Yes	Yes	$p = .041$
Brennan (120)	VAS	Low	40.9	40.1	14.4	15.9	Yes	Yes	$p = .799$
Jon Sok Bae (143)	VAS	Low	43	49	20	16	Yes	Yes	$p = .01$
Madsbu (4932)	VAS	Low	60	65	26	28	Yes	Yes	$p = .321$
Ya Peng Wang[a] (67)	VAS	Low	71.2		22.7		Yes		$p < .05$

NM: not mentioned.
Back pain was measured with several outcomes scales: the Visual Analogue Scale (VAS), the Numeric Rating Scale (NRS), the Low Back Pain Bothersomeness Index (LBPBI) and the back pain outcome score. VAS is represented on a 0–100 mm scale (0 mm indicates 'no pain' and 100 mm indicates the 'worst pain imaginable') and NRS is reported on a 0–10 scale (0 indicates 'no pain' and 10 indicates the 'worst pain imaginable'). The LBPBI scores back pain from 0 to 6, with higher scores indicating more pain. The back pain outcome score is scored from 1 to 4. A score of 1 indicates minimal to no back pain, a score of 2 indicates moderate back pain with preservation of daily activity, a score of 3 indicates moderate back pain with loss of daily activity and a score of 4 indicates severe back pain. The values measured on these scales are uniformly transformed to a 0–100 scale for reasons of comparability.
[a]Combined VAS/NRS for both leg and back pain.
[b]Back pain score converted to a 0–100 scale with the following equation: $(25 \times 1.531)/1.5$.

Table 5. Oswestry disability index.

Article (number of patients)	Risk of bias	Baseline (0–100)		Post-operative ΔODI (0–100)		MCID reached		Significance indicated by the authors
		BMI <30	BMI ≥30	BMI <30	BMI ≥30	BMI <30	BMI ≥30	
Giannadakis (1473)	Low	38.9	41.7	−17.50	−14.30	Yes	No	$p = .007$
McGuire *Spinal Stenosis* (413)	Low	41.3	44.4	−20.1	−17.5	Yes	Yes	$p = .46$
McGuire *Degenerative Spondylolisthesis* (389)	Low	39.7	45.1	−23.2	−21.7	Yes	Yes	$p = .75$
McGuire *Intervertebral Disc Herniation* (787)	Low	48.4	52.7	−40.1	−33.7	Yes	Yes	$p < .001$
Knutsson (2633)	Low	42.5	46	−16.5	−13	Yes	No	$p < .001$
Onyekwelu (1791)	Low	43.7	46.91	−22.92	−21.25	Yes	Yes	$p = .099$
Jun Sok Bae (143)	Low	60.3	61.1	−49.3	−53.3	Yes	Yes	$p < .0001$
Madsbu (4932)	Low	45.4	46.7	−31.4	−30.1	Yes	Yes	$p = .182$

Disability was scored using the Oswestry Disability Index (ODI). The ODI is scored from 0 to 100, with 0 indicating no disability and 100 indicating maximum disability.

the exact data were lacking we could not evaluate clinical relevance.

Oswestry Disability Index

The ODI was evaluated in 13,397 patients in six[17–19,25,27,28] (out of 14) different studies (Table 5). The ODI was scored from 0 to 100, with 0 indicating no disability and 100 indicating maximum disability. We calculated the MCID for all studies.

From all studies, comparing pre-operative and post-operative ODI in patients with a BMI lower and equal to or higher than 30, data could be extracted. All six studies showed a general post-operative decrease in ODI, of which three studies, namely Giannadakis *et al.*[17] McGuire *et al.*'s IDH subgroup[18] and Knutsson *et al.*[19] demonstrated a larger decrease in the non-obese patients and one study[27] showed a larger ODI decrease in the obese group. In all studies, the differences between obese and non-obese patients were very small and not clinically significant. In the studies by Giannadakis *et al.*[17] and Knutsson *et al.*[19] respectively analysing 1473 and 2633 patients, the MCID was not reached in the obese study population.

Short Form-36 and EQ-5D

SF-36 or EQ-5D were analysed in 9440 patients in five[16,17,19,26,28] (out of 14) studies (Table 6). SF-36/EQ-5D was scored from 0 to 100, with 0 indicating minimum wellbeing and 100 indicating maximum wellbeing. None of the studies clearly stated if the given data were postoperative results or differences. For our calculations, we assumed that the given numbers were post-operative scores. We calculated the MCID for all studies.

From all studies, comparing pre-operative and post-operative SF-36/EQ-5D in patients with a BMI lower and equal to or higher than 30, data could be extracted. All five studies showed a

Table 6. EQ-5D and SF-36.

Article (number of patients)	Measurement method	Risk of bias	Baseline (0–100)		Post-operative EQ-5D/ SF-36 (0–100)		MCID reached		Significance indicated by the authors
			BMI <30	BMI ≥30	BMI <30	BMI ≥30	BMI <30	BMI ≥30	
Burgstaller (166)	EQ-5D	Intermediate	70	65	90	80	Yes	No	NM
McGuire *Spinal Stenosis* (413)	SF-36	Low	39.3	35.5	62	49	Yes	No	$p = .17$
McGuire *Degenerative Spondylolisthesis* (389)	SF-36	Low	40.2	34.3	66	57	Yes	Yes	$p = .45$
McGuire *Intervertebral Disc Herniation* (787)	SF-36	Low	36.9	32.6	83	68	Yes	Yes	$p = .007$
Knutsson (2633)	EQ-5D	Low	38.5	34	63.5	56	Yes	Yes	$p < .001$
Brennan (120)	SF-36	Low	43.9	45.9	68.8	80.5	Yes	Yes	$p = .119$
Madsbu (4932)	EQ-5D	Low	28	27	77	74	Yes	Yes	$p = .367$

NM: not mentioned.
Health status and wellbeing was scored using the EQ-5D or the SF-36. SF-36/EQ-5D was scored from 0 to 100, with 0 indicating no wellbeing and 100 indicating maximum wellbeing.

Table 7. Patient satisfaction.

Article (number of patients)	Measurement method	Risk of bias	Percentage of satisfied patients		Significance indicated by the authors
			BMI <30	BMI ≥30	
McGuire *Spinal Stenosis* (413)		Low	66.5%	55%	$p = .58$
McGuire *Degenerative Spondylolisthesis* (389)		Low	63%	64%	$p = .94$
McGuire *Intervertebral Disc Herniation*(787)		Low	78%	72%	$p = .24$
Knutsson (2633)		Low	65.5%	57%	(OR = 1.37 with 95% CI of 1.36–2.19)[a]
Tomasino *Discectomy* (87)	MacNab	Intermediate	84%	92%	NM
Tomasino *Laminectomy* (28)	MacNab	Intermediate	75%	75%	NM
Cole (32)		Intermediate		97%	NM
Gepstein (298)		Low	71.5%	52%	NS
Brennan (120)		Low	94.3%	89.5%	$p = .607$
Ya Peng Wang (67)	MacNab	Intermediate		83.5%	NM

NM: not mentioned; NS: not significant.
Patients were either classified as 'Satisfied' or 'Not-satisfied'. The percentage of satisfied patients is provided from 0 to 100%.
[a]Higher odds ratio of dissatisfaction.

Table 8. Dural tears.

Article (number of patients)	Risk of bias	Dural tears (0–100%)		Significance indicated by the authors
		BMI < 30	BMI ≥30	
Giannadakis (1473)	Low	2.9	4.5	$p = .124$
McGuire *Spinal Stenosis* (413)	Low	9	9	$p = .97$
McGuire *Degenerative Spondylolisthesis* (389)	Low	14	5.5	$p = .017$
McGuire *Intervertebral Disc Herniation* (787)	Low	3	4	$p = .41$
Tomasino *Discectomy* (87)	Intermediate	7.9	4.2	NM
Tomasino *Laminectomy* (28)	Intermediate	12.5	8.3	NM
Cole (32)	Intermediate		9.4	NM
Fakouri (68)	Intermediate	3	6	NM
Madsbu (4932)	Low	1.5	1.5	$p = .976$

Number of unintentional durotomies during lumbar surgery.

postoperative improvement in SF-36/EQ-5D. All five studies showed a postoperative improvement in SF-36/EQ-5D. In the studies by Knutsson *et al.*[19] and McGuire *et al.*'s LDH[18] group, significantly higher values were demonstrated for non-obese patients, but MCID was reached for both patient groups. Differences in all groups at follow up were small and not clinically relevant.

Patient satisfaction

Patient satisfaction was analysed in 4556 patients in seven[18–21,23,26,29] (out of 14) studies (Table 7). Tomasino *et al.*[20] and Wang *et al.*[29] used the MacNab criteria for patient satisfaction score. However, no statistics were performed on the data. Only in the study of Knutsson *et al.* it was demonstrated that obese patients were less satisfied with the decompression.[19,23] Differences between the groups in the other articles were reported to be not significantly different. Gepstein *et al.* additionally investigated satisfaction in a group with a BMI over 35. It was shown that patients with a BMI higher than 35 were significantly more dissatisfied than patients with lower BMI's.[23]

Dural tears

Unintentional durotomies were analysed in 8209 patients in six[17,18,20–22,28] (out of 14) studies (Table 8). No significant

Table 9. Wound infections.

Article (number of patients)	Risk of bias	Wound infection (0–100%) BMI <30	BMI ≥30	Significance indicated by the authors
Giannadakis (1473)	Low	2.7	2.8	$p = .852$
McGuire *Spinal Stenosis* (413)	Low	2	2	$p = .55$
McGuire *Degenerative Spondylolisthesis* (389)	Low	1	5.5	$p = .023$
McGuire *Intervertebral Disc Herniation* (787)	Low	2	2	$p = .96$
Tomasino *Discectomy* (87)	Intermediate	1.6	0	NM
Tomasino *Laminectomy* (28)	Intermediate	0	0	NM
Cole (32)	Intermediate		0	NM
Fakouri (68)	Intermediate	0	6	NM
Gepstein (298)	Low	36	13.5	$p = .01$
Madsbu (4932)	Low	2.8	3.0	$p = .793$

Number of wound infections after lumbar surgery.

differences were reported between the groups. Only in the study of McGuire *et al.*[18] (degenerative spondylolisthesis subgroup) reported more dural tears in the non-obese group than in the obese group.

Wound infection

Wound infection was analysed in 8507 patients in seven[17,18,20–23,28] (out of 14) studies (Table 9). In two studies, significant differences between the two groups were demonstrated: The degenerative spondylolisthesis group of McGuire was reported to have more wound infections in the obese patients and Gepstein *et al.*[23] showed lower percentages of wound infection in obese patients.

Remainder of outcomes

Other outcomes of clinical post-operative parameters, such as blood loss and duration of hospitalisation were not found to have a significant association with obesity.

Discussion

Literature data reveal that obesity is not associated with worse post-operative outcomes in comparison to non-obese patients in non-instrumented lumbar surgery. Parameters considering functionality and pain in leg and back, patient satisfaction and complications all failed to demonstrate different outcomes for obese and non-obese patients. These were all retrospective studies, but since results were equivocal, we consider the conclusions to be sound. Several reviews have focussed on the current issue in instrumented surgery of the lumbar spine. Lingutla *et al.*[34] published a meta-analysis of studies comparing outcomes of lumbar spinal fusion for low back pain in non-obese and obese patients. In agreement with our results, Lingutla *et al.* showed that there was no difference in pain or functional outcomes between the two groups. However, it was demonstrated by them that obese patients had a statistically significant higher rate of intra-operative blood loss, complications and surgery duration.

Jiang *et al.*[35] reported on the difference in complication rates between obese and non-obese patients after spinal surgery. They found that obesity appeared to be associated with an increased risk of surgical site infection, venous thromboembolisms, increased blood loss and increased duration of surgery. Jackson and Devine[36] evaluated the effect of obesity on post-operative complications and functional outcomes after spinal surgery. They found that obese patients had a higher risk of developing surgical site infections and venous thromboembolism after surgery. In agreement with our results, they demonstrated that functional outcomes were not worse in obese patients compared to non-obese patients. In all three reviews on instrumented surgery, complication rates were concluded to be higher in obese patients.

Our study differs from the aforementioned studies in the fact that we considered merely non-instrumented low back surgical interventions. Nevertheless, conclusions on comparability of clinical outcome are the same. However, in the studies described in the current review complication rates were not significantly different. Presumably, this is due to the shorter operation times in non-instrumented interventions and subsequent lower complication rates in general.

In this review, patients with BMI >30 were compared with BMI <30, e.g. comparing patients with obesity versus patients without obesity. The 'grey-area' of patients with a BMI between 25 and 30: the 'overweight category' have not been explicitly studied in this review or previous reviews.[34,36] However, some smaller studies may suggest more adverse outcomes for even overweight patients.[14,37] For example, a retrospective case series of 332 elective thoracic and lumbar spine fusions showed that patient who were merely overweight (BMI of 25) had an estimated risk of 14% for an adverse event, which increased to 20% for patients with a BMI of 30.[14] This may suggest that even patients who have a BMI <25 may have better outcomes than patients who are classified as overweight. Nevertheless, our review showed no differences in complications or clinical outcomes between obese patients versus non obese patients so we would hypothesize that the same would apply to patients with a BMI between 25 and 30.

One of the limitations of the current review was the inability to separate conclusions for surgery for herniated discs and stenosis. Patient groups undergoing these two types of surgery are different, and this may be accompanied by different outcome values for obese and non-obese patients. Furthermore, all the studies were retrospective and none of the studies randomized between patients. Moreover, the pooling of different values for the analysis of outcome, including values for BMI, leg and back pain, wellbeing and patient satisfaction, could lead to heterogeneity of the presented results. Ideally, these values have to be analyzed individually in order to acquire optimal found results. Finally, the cut off between obese and non-obese at a BMI of 30 is artificial. A study comparing patients with a healthy BMI between 20 and 25 and a BMI above 35 should have been more indicative of the research question that was intended to be answered. The literature, however, is scarce on this specific comparison. Optimally, data concerning BMI ranges other than the ones used in this review, should also have been reviewed in order to give a more specific answer to the research question.

Conclusions

Literature does not reveal a difference in clinical outcome nor in complications in patients undergoing non-instrumented lumbar surgery with a BMI lower, equal to or higher than 30. This may be used by physicians to inform patients prior to lumbar decompression surgery.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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APPENDIX 1: Search strategies

Search engine	Search string
PubMed	(lumbar surg*[tw] OR lumbar spine surg*[tw] OR lumbar spine operat*[tw] OR "low back surgery"[tw] OR "Lumbar Vertebrae/surgery"[Mesh] OR (("Lumbar Vertebrae"[Mesh] OR Lumbar Vertebra*[tw] OR "Lumbar Spine"[tw]) AND ("surgery"[subheading] OR "Surgical Procedures, Operative"[Mesh] OR "surgery"[tw] OR operation*[tw] OR surgical*[tw] OR neurosurg*[tw])) OR (("Lumbar Vertebrae"[Mesh] OR Lumbar Vertebra*[tw] OR "Lumbar Spine"[tw] OR "lumbar"[tw]) AND ("Intervertebral Disc Displacement"[mesh] OR herniated disc*[tw] OR herniated disk*[tw] OR "Spinal stenosis"[mesh] OR spinal steno*[tw] OR spine steno*[tw]) AND ("surgery"[subheading] OR "Surgical Procedures, Operative"[Mesh] OR "surgery"[tw] OR operation*[tw] OR surgical*[tw] OR neurosurg*[tw]))) AND ("Body Mass Index"[majr] OR "Body Mass Index"[ti] OR "BMI"[ti] OR "Quetelet Index"[ti] OR "Quetelet's Index"[ti] OR "Quetelets Index"[ti] OR "Body Weight"[majr] OR "Body Weight"[ti] OR "obesity"[ti] OR "obese"[ti])
Embase	((exp "lumbar spine"/ AND (exp "spine surgery"/ OR spine disease/su)) OR lumbar surg*.mp OR lumbar spine surg*.mp OR lumbar spine operat*.mp OR "low back surgery".mp OR exp lumbar vertebra/su OR ((exp "Lumbar Vertebra"/ OR Lumbar Vertebra*.mp OR "Lumbar Spine".mp) AND ("su".fs OR exp "Surgery"/ OR "surgery".mp OR operation*.mp OR surgical*.mp OR neurosurg*.mp)) OR ((exp "Lumbar Vertebra"/ OR Lumbar Vertebra*.mp OR "Lumbar Spine".mp OR "lumbar".mp) AND (exp "intervertebral disk disease"/ OR herniated disc*.mp OR herniated disk*.mp OR "vertebral canal stenosis"/ OR spinal steno*.mp OR spine steno*.mp) AND ("su".fs OR exp "Surgery"/ OR "surgery".mp OR operation*.mp OR surgical*.mp OR neurosurg*.mp))) AND (*"Body Mass"/ OR "Body Mass Index".ti OR "BMI".ti OR "Quetelet Index".ti OR "Quetelet's Index".ti OR "Quetelets Index".ti OR exp *"Body Weight"/ OR "Body Weight".ti OR "obesity".ti OR "obese".ti)
Web of Science	TS=(("lumbar spine" AND ("spine surgery" OR spine diseasesu)) OR lumbar surg* OR lumbar spine surg* OR lumbar spine operat* OR "low back surgery" OR lumbar vertebrasu OR (("Lumbar Vertebra" OR Lumbar Vertebra* OR "Lumbar Spine") AND ("Surgery" OR "surgery" OR operation* OR surgical* OR neurosurg*)) OR (("Lumbar Vertebra" OR Lumbar Vertebra* OR "Lumbar Spine" OR "lumbar") AND ("intervertebral disk disease" OR herniated disc* OR herniated disk* OR "vertebral canal stenosis" OR spinal steno* OR spine steno*) AND ("Surgery" OR "surgery" OR operation* OR surgical* OR neurosurg*))) AND TI=("Body Mass" OR "Body Mass Index" OR "BMI" OR "Quetelet Index" OR "Quetelet's Index" OR "Quetelets Index" OR "Body Weight" OR "Body Weight" OR "obesity" OR "obese")
Cochrane	(("lumbar spine" AND ("spine surgery" OR spine diseasesu)) OR lumbar surg* OR lumbar spine surg* OR lumbar spine operat* OR "low back surgery" OR lumbar vertebrasu OR (("Lumbar Vertebra" OR Lumbar Vertebra* OR "Lumbar Spine") AND ("Surgery" OR "surgery" OR operation* OR surgical* OR neurosurg*)) OR (("Lumbar Vertebra" OR Lumbar Vertebra* OR "Lumbar Spine" OR "lumbar") AND ("intervertebral disk disease" OR herniated disc* OR herniated disk* OR "vertebral canal stenosis" OR spinal steno* OR spine steno*) AND ("Surgery" OR "surgery" OR operation* OR surgical* OR neurosurg*))):ti AND ("Body Mass" OR "Body Mass Index" OR "BMI" OR "Quetelet Index" OR "Quetelet's Index" OR "Quetelets Index" OR "Body Weight" OR "Body Weight" OR "obesity" OR "obese"):ti,ab,kw