Obesity and Spine Surgery: A Qualitative Review About Outcomes and Complications. Is It Time for New Perspectives on Future Researches?

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Abstract

Study Design: Literature review.

Objectives: An increasing number of obese patients requires operative care for degenerative spinal disorders. The aim of this review is to analyze the available evidence regarding the role of obesity on outcomes after spine surgery. Peri-operative complications and clinical results are evaluated for both cervical and lumbar surgery. Furthermore, the contribution of MIS techniques for lumbar surgery to play a role in reducing risks has been analyzed.

Methods: Only articles published in English in the last 10 years were reviewed. Inclusion criteria of the references were based on the scope of this review, according to PRISMA guidelines. Moreover, only papers analyzing obesity-related complications in spine surgery have been selected and thoroughly reviewed. Each article was classified according to its rating of evidence using the Sacket Grading System.

Results: A total number of 1636 articles were found, but only 130 of them were considered to be relevant after thorough evaluation and according to PRISMA checklist. The majority of the included papers were classified according to the Sacket Grading System as Level 2 (Retrospective Studies).

Conclusion: Evidence suggest that obese patients could benefit from spine surgery and outcomes be satisfactory. A higher rate of peri-operative complications is reported among obese patients, especially in posterior approaches. The use of MIS techniques plays a key role in order to reduce surgical risks. Further studies should evaluate the role of multidisciplinary counseling between spine surgeons, nutritionists and bariatric surgeons, in order to plan proper weight loss before elective spine surgery.

Keywords

obesity, spine, spine surgery, weight loss, minimally-invasive techniques, bariatric surgery, bariatrics

Abbreviations

WHO, World Health Organization; BMI, Body Mass Index; QoL, Quality of Life; MIS, Minimally Invasive Surgery; LBP, Low Back Pain; LDD, Lumbar Degenerative Disease; OR, Odds Ratio; NDI, Neck Disability Index; mJOA, modified Japanese Orthopedic Association; SF-36, Short Form-36; SF-36 MC; Mental Component and SF-36 PC, Physical Component; SF-12, Short Form-12;

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Introduction

Obesity is defined by the WHO as a BMI equal or higher than 30 Kg/m². However, obese patients are often subdivided in: 1) Class I obese (BMI: 30-34.9 Kg/m²), 2) Class II obese (BMI: 35-39.9 Kg/m²) and 3) Class III obese (also defined as morbidly obese) (BMI ≥ 40 Kg/m²).1

The strict association between obesity and numerous diseases such as Type 2 diabetes, hypertension, cardiovascular diseases and several types of cancer has been extensively outlined, reporting also a higher mortality rate among these patients.1 In 2009, a landmark collaborative analysis of 57 prospective studies, including about 900,000 adults, reported significant reduction of life-expectancy for patients exceeding the BMI range of normal weight, being BMI itself a strong predictor of overall mortality both above and below the apparent optimum of about 22.5-25 Kg/m². In particular, the authors reported a reduction of median survival of 2-4 years in the 30-35 Kg/m² group and of 8-10 years in the 40-45 Kg/m².2

Obesity represents 1 of the most relevant concerns of the modern health systems: approximately 13% of the world’s adult population resulted to be obese in the 2014 and, consistent with the more recent estimations, 1.9 billion of adult patients resulted obese in the 2016.3-5 In addition to BMI-related increase in mortality, obesity also represents a significant factor influencing the quality of life. Low back pain (LBP), indeed, represents 1 of the main complaints of obese patients.4 In 2009, a landmark collaborative analysis of 57 prospective studies, including about 900,000 adults, reported a higher mortality rate among these patients.1

Thus, several studies enrolling obese patients have been performed, with the aim to evaluate the feasibility of MIS techniques.43-47 Due to the aging of the population and to the rising prevalence of obesity, an increasing number of obese patients, suffering from LDD, is asking to be evaluated for spine surgery, in order to reduce the impact of pain on their life.6,11,15,16 This phenomenon has led spine surgeons to tackle a challenging problem, namely the effort to balance the patients’ legitimate need for pain relief with the reported increased risk of post-operative complications that is closely related to obesity. Furthermore, surgeons have to face against surgical risk for complications of this patients’ population, due to the high incidence of comorbidities (e.g. diabetes, hypertension, sleep apnea).17 Notably, indeed, higher risk for wound infections, dural tears, anemia, deep vein thrombosis and pulmonary embolism is usually reported for obese patients undergoing spinal fusion.3,18-20 However, despite several studies—investigating complications rate in gynecological, orthopedic, cardiovascular and general surgeries21-23—carved out the increased peri-operative risk of obese patients undergoing surgery, there is a not negligible amount of literature that did not report significantly higher risk.24,25 Likewise, this specific relationship between post-operative complications in spine surgery for obese patients was not so clear and numerous studies are still investigating this aspect.18,26-28 In a retrospective cohort study analyzing 332 patients undergoing lumbar and/or thoracic spine fusion, Patel et al firstly reported that patients with higher BMI were more likely to experience post-operative complications; the chance of significant complications (event that lengthened hospital stay or delayed recovery) resulted to be 14% with a BMI of 25, 20% with a BMI of 30 and 36% with a BMI of 35. Additionally, although several studies now revealed a higher complication rate, inferior clinical outcomes among obese population have not been consistently demonstrated being the topic still controversial.29-40 Puvanesarajah et al investigated the role of obesity on 90-day complication rates and 30-day readmission rates following 1- to 2-level, primary, lumbar spinal fusion surgery for degenerative pathology in an elderly population. Obese patients resulted to have significantly higher odds of suffering from any 1 major medical complication (odds ratio [OR] 1.79). Moreover, also wound infection and dehiscence rates were increased in obese patients (ORs 3.71 and 3.8 respectively). Additionally, obesity resulted able to significantly increase length of stay and hospital costs ($8000 greater than controls).51,52 On the other hand, during the last years, the surgical evolution has led to even more Minimally Invasive Surgery (MIS) techniques, reporting less blood loss, reduced post-operative pain, shorter length of stay and encouraging long term outcomes when compared with classical open techniques.41-47
among this high-risky population, and to investigate whether the reported good clinical outcomes and lower complication rate could widen the surgical indication for obese patients.\(^4,7,18,28,48-54\)

The aim of this review is to globally analyze the available evidence regarding the role of obesity on outcomes after spine surgery: after brief metabolic considerations, their impact on peri-operative complications and clinical results is evaluated investigating separately both cervical and lumbar surgery. Furthermore, the contribution of MIS techniques for lumbar surgery to play a role in reducing risks has been analyzed. Finally, starting points for future researches on this topic according to the Literature will be outlined.

### Methods

Selection criteria and references for this review were identified by searching PubMed database using the following research strings: ”obesity related complications AND degenerative spine fusion surgery”; ”obesity AND spine fusion”; ”degenerative spine surgery AND obese patients”; ”degenerative spine surgery AND obesity related complications”; ”obesity related complications AND degenerative spine fusion surgery”; ”spine fusion AND obesity related complications”; ”spine surgery OR obese patients”; ”spine fusion OR obesity morbidity”; ”obesity related complications OR spine fusion surgery”; ”obesity related complications AND minimally invasive spine surgery”; ”obesity related complications AND indirect decompression”; ”obesity related complications AND anterior lumbar inter body fusion”; ”obesity related complications AND transpsoas access for lumbar fusion; ”obesity related complications AND minimally invasive Transforaminal Interbody Fusion.”

Only articles published in English in the last 10 years until January 31, 2021 were reviewed. Inclusion criteria of the references were based on the scope of this review, according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis) guidelines.\(^55\)

Therefore, only articles analyzing spine fusion for degenerative disease in obese patients have been considered, while narrative review articles and case report have been excluded, as for papers regarding the influence of obesity in spine fusion for adolescent idiopathic scoliosis.

Moreover, according with the first aim of this review, only paper analyzing obesity-related complications in spine surgery have been selected and thoroughly reviewed. Hence, each article was classified according to its rating of evidence using the Sacket Grading System\(^56\) (Table 1).

### Results

Two authors (GDP, FC) independently evaluated the English literature and a total number of 1636 articles were found, but only 130 of them were considered to be relevant after thorough evaluation and according to PRISMA checklist (Figure 1).

Specifically, 729 papers were duplicated, while 732 articles were found to have irrelevant title. Moreover, 45 articles were excluded after reading since they did not meet the inclusion criteria. According to the Literature will be outlined.

### Table 1. Review of the Literature With Evidence Levels Classification (According to Sacket Grading System).

| Study number | Reference | Type of study | Evidence rate |
|--------------|-----------|---------------|---------------|
| 1            | Mulvaney G et al, 2021\(^{57}\) | Retrospective study | 2             |
| 2            | Paranjape CS et al, 2021\(^{32}\) | Retrospective study | 2             |
| 3            | Chan AK et al, 2020\(^{2}\) | Retrospective study | 2             |
| 4            | Divi SN et al, 2020\(^{59}\) | Retrospective study | 2             |
| 5            | Duan PG et al, 2020\(^{60}\) | Retrospective study | 2             |
| 6            | Fatima N et al, 2020\(^{61}\) | Retrospective study | 2             |
| 7            | He X et al, 2020\(^{62}\) | Retrospective cohort study | 3             |
| 8            | Jain D et al, 2020\(^{63}\) | Retrospective study | 2             |
| 9            | Jenkins NW et al, 2020\(^{64}\) | Retrospective study | 2             |
| 10           | Khan JM et al, 2020\(^{65}\) | Retrospective cohort study | 3             |
| 11           | Kasevman GA et al, 2020\(^{66}\) | Retrospective study | 2             |
| 12           | Othman YA et al, 2020\(^{67}\) | Meta-analysis | 1             |
| 13           | Malik AT et al, 2020\(^{68}\) | Retrospective cohort study | 3             |
| 14           | Passias PG et al, 2020\(^{70}\) | Retrospective study | 2             |
| 15           | Qi M et al, 2020\(^{69}\) | Retrospective study | 2             |
| 16           | Safae MM et al, 2020\(^{71}\) | Retrospective study | 2             |
| 17           | Sircoli A et al, 2020\(^{72}\) | Retrospective study | 2             |
| 18           | Sridharan M et al, 2020\(^{73}\) | Retrospective study | 2             |
| 19           | Xi Z et al, 2020\(^{74}\) | Retrospective cohort study | 3             |
| 20           | Basques et al, 2019\(^{75}\) | Retrospective cohort study | 3             |
| 21           | Buyuk AF et al, 2019\(^{76}\) | Retrospective cohort study | 3             |
| 22           | Cheng CW et al, 2019\(^{77}\) | Retrospective cohort study | 3             |
| 23           | Goh GS et al, 2019\(^{78}\) | Retrospective study | 2             |
| 24           | Goyal A et al, 2019\(^{79}\) | Meta-analysis | 1             |
| 25           | Elsamadicy et al, 2019\(^{80}\) | Retrospective study | 2             |
| 26           | Kashkoush A et al, 2019\(^{81}\) | Retrospective study | 2             |
| 27           | Kruiger et al, 2019\(^{82}\) | Retrospective study | 2             |
| 28           | Linhares D et al, 2019\(^{83}\) | Retrospective study | 2             |
| 29           | Malik AT et al, 2019\(^{84}\) | Retrospective study | 2             |
| 30           | Mombell KW et al, 2019\(^{85}\) | Retrospective study | 2             |
| 31           | Villavicencio et al, 2019\(^{86}\) | Retrospective study | 2             |
| 32           | Yoo JS et al, 2019\(^{87}\) | Retrospective study | 2             |
| 33           | Zhang G.A. et al, 2019\(^{88}\) | Meta-analysis | 1             |
| 34           | Zhang Y. et al, 2019\(^{89}\) | Retrospective study | 2             |
| 35           | Abbasi H et al, 2019\(^{90}\) | Retrospective cohort study | 3             |
| 36           | Akins et al, 2018\(^{91}\) | Retrospective cohort study | 3             |
| 37           | Bono OJ et al, 2018\(^{92}\) | Retrospective study | 2             |
| 38           | Byval’tsev VA et al, 2018\(^{93}\) | Retrospective cohort study | 3             |
| 39           | Chung AS et al, 2018\(^{94}\) | Retrospective cohort study | 3             |
| 40           | Jain et al, 2018\(^{95}\) | Retrospective cohort study | 3             |
| 41           | Lovecchio F et al, 2018\(^{96}\) | Retrospective study | 2             |
| 42           | Madsbu MA et al, 2018\(^{97}\) | Retrospective study | 2             |
| 43           | Nahhas CR et al, 2018\(^{98}\) | Retrospective study | 2             |

(continued)
criteria: 13 of them were constituted by narrative review or case report, 26 dealt with adolescent idiopathic scoliosis while 6 papers evaluated the effect of obesity on mineral bone

Table 1. (continued)

| Study number | Reference | Type of study | Evidence rate |
|--------------|-----------|---------------|---------------|
| 44           | Narain AS et al, 2018 | Retrospective study | 2             |
| 45           | Passias PG et al, 2018 | Retrospective study | 2             |
| 46           | Ranson WA et al, 2018 | Retrospective cohort study | 3             |
| 47           | Senker et al, 2018 | Prospective study | 1             |
| 48           | Tan JH et al, 2018 | Meta-analysis | 1             |
| 49           | Vinas-Rios JM et al, 2018 | Retrospective study | 2             |
| 50           | Wang T et al, 2018 | Meta-analysis | 1             |
| 51           | Xie Q et al, 2018 | Meta-analysis | 1             |
| 52           | Flippin M et al, 2017 | Retrospective study | 2             |
| 53           | Grover PJ et al, 2017 | Retrospective study | 2             |
| 54           | Joseph et al, 2017 | Retrospective cohort study | 3             |
| 55           | Onyekwelu et al, 2017 | Retrospective study | 2             |
| 56           | Phan, Rogers et al, 2017 | Retrospective study | 1             |
| 57           | Phan, Kothari et al, 2017 | Retrospective study | 2             |
| 58           | Puvanesarajah et al, 2017 | Retrospective study | 2             |
| 59           | Wang H et al, 2017 | Retrospective study | 2             |
| 60           | Wilson JR et al, 2017 | Prospective study | 1             |
| 61           | Adogwa et al, 2016 | Retrospective cohort study | 2             |
| 62           | Burgstaller JM et al, 2016 | Retrospective study | 1             |
| 63           | Chotai et al, 2016 | Retrospective study | 1             |
| 64           | Elsamadicy AA et al, 2016 | Retrospective study | 2             |
| 65           | Higgins DM et al, 2016 | Retrospective study | 2             |
| 66           | Huang S et al, 2016 | Retrospective study | 2             |
| 67           | Lucas et al, 2016 | Retrospective study | 2             |
| 68           | Manson NA et al, 2016 | Retrospective study | 2             |
| 69           | McAnany et al, 2016 | Retrospective study | 2             |
| 70           | Owens et al, 2016 | Retrospective study | 2             |
| 71           | Sielatycki et al, 2016 | Retrospective study | 2             |
| 72           | Sielatycki JA et al, 2016 | Retrospective study | 2             |
| 73           | Sing et al, 2016 | Retrospective cohort study | 3             |
| 74           | Sorimachi Y et al, 2016 | Prospective study | 1             |
| 75           | Stienen et al, 2016 | Prospective study | 1             |
| 76           | Wang H et al, 2016 | Retrospective study | 2             |
| 77           | Wang YP et al, 2016 | Retrospective study | 2             |
| 78           | Adogwa et al, 2015 | Retrospective study | 2             |
| 79           | Burks et al, 2015 | Retrospective study | 2             |
| 80           | Cao J et al, 2015 | Meta-analysis | 1             |
| 81           | De la Garza Ramos et al, 2015 | Retrospective study | 2             |
| 82           | Giannadakis C et al, 2015 | Retrospective study | 1             |
| 83           | Goldin AN et al, 2015 | Retrospective study | 2             |
| 84           | Kukreja et al, 2015 | Retrospective study | 2             |
| 85           | Lingutla et al, 2015 | Meta-analysis | 1             |
| 86           | Nota SP et al, 2015 | Retrospective study | 2             |
| 87           | Ou et al, 2015 | Retrospective study | 2             |
| 88           | Planchard RF et al, 2015 | Retrospective study | 2             |
| 89           | Yagi et al, 2015 | Retrospective study | 2             |
| 90           | Auffinger B et al, 2014 | Retrospective study | 2             |
| 91           | Buerba et al, 2014 | Retrospective cohort study | 3             |
| 92           | Buerba RA et al, 2014 | Retrospective cohort study | 3             |
| 93           | Fu et al, 2014 | Retrospective cohort study | 3             |
| 94           | Jiang J et al, 2014 | Meta-analysis | 1             |
| 95           | Marquez-Lara A et al, 2014 | Retrospective study | 2             |
| 96           | Mclendon et al, 2014 | Retrospective study | 2             |
| 97           | McGuire KJ et al, 2014 | Retrospective study | 1             |
| 98           | Pereira BJ et al, 2014 | Retrospective study | 2             |
| 99           | Quah C et al, 2014 | Retrospective study | 2             |
| 100          | Seicean A et al, 2014 | Retrospective cohort study | 3             |
| 101          | Srinivasan et al, 2014 | Retrospective study | 2             |
| 102          | Terman et al, 2014 | Retrospective cohort study | 3             |
| 103          | Wang J et al, 2014 | Retrospective study | 2             |
| 104          | Lau, Khan et al, 2013 | Retrospective study | 2             |
| 105          | Lau, Ziewacz et al, 2013 | Retrospective study | 2             |
| 106          | Rihn JA et al, 2013 | Retrospective study | 2             |
| 107          | Rosenfeld HE et al, 2013 | Retrospective study | 1             |
| 108          | Gaudelli C et al, 2012 | Retrospective cohort study | 3             |
| 109          | Kalamithi et al, 2012 | Retrospective study | 2             |
| 110          | Mehta Al et al, 2012 | Retrospective study | 2             |
| 111          | Mogganam et al, 2012 | Retrospective study | 2             |
| 112          | Rihn JA et al, 2012 | Retrospective study | 2             |
| 113          | Senker et al, 2012 | Retrospective study | 2             |
| 114          | Anderson PA et al, 2012 | Retrospective study | 2             |
| 115          | Rodgers et al, 2012 | Retrospective study | 2             |
| 116          | Singh et al, 2012 | Retrospective study | 2             |
| 117          | Yadla et al, 2012 | Retrospective study | 3             |
| 118          | Walid MS et al, 2012 | Retrospective study | 2             |
| 119          | Peng et al, 2009 | Retrospective study | 1             |
| 120          | Shamji MF et al, 2009 | Retrospective study | 2             |
| 121          | Vaidya R et al, 2009 | Retrospective study | 2             |
| 122          | Djurasovic et al, 2008 | Retrospective cohort study | 3             |
| 123          | Park et al, 2016 | Retrospective study | 2             |
| 124          | Rosen et al, 2008 | Retrospective study | 2             |
| 125          | Patel et al, 2007 | Retrospective study | 2             |
| 126          | Sonne-Holm et al, 2007 | Retrospective study | 2             |
| 127          | Gepstein et al, 2004 | Retrospective study | 2             |
| 128          | Epstein, 2003 | Case series | 4             |
| 129          | Telfeian AE et al, 2002 | Retrospective study | 2             |
| 130          | Andreshak TG et al, 1997 | Retrospective study | 1             |
metabolism (Figure 1). The majority of the included papers were classified according to the Sacket Grading System as Level 2 (Retrospective Studies).

**Discussion**

*Obesity-Metabolic Considerations*

Albeit not influencing long-term surgical outcomes, obesity is generally considered to exert an adverse effect on major surgeries. In particular, obesity could prolong operative time and may represent a risk factor for short-term complications. The strict correlation between obesity—especially the visceral one—and insulin resistance could increase the risks for complications. Specifically, increase in the secretion of some adipokines such as resistin, TNF- and IL-6, was found to have a negative effect on insulin sensitivity. Moreover, the arterial hypertension and atherogenic dyslipidemia—often associated with obesity—contribute to create a prothrombotic and pro-inflammatory general state. Furthermore, a close relationship between the content of skeletal muscle and systemic insulin resistance was demonstrated, since the metabolic lipo-toxicity of diacylglycerol and ceramides, able to create a direct pro-oxidative and inflammatory activity. Lastly, recent evidence shows that ectopic lipids deposition can also compromise the turnover of muscle proteins promoting systemic and muscular oxidative stress. Blood glucose concentrations could also play substantial roles with its opposing effects on immunological/cellular mechanisms. The augmented risk for infections of diabetic patients is well known, together with the consequences of acute, short term hyperglycemia on innate immunity and the ability of the host to combat infections. Although there is still no global consensus and sufficient evidence to support a rigid glycemic control in the peri-operative management beyond common routinely measures, the implications of acute hyperglycemia on neutrophil activity, cytokine patterns and microvascular reactivity are well described.

*Obesity and Cervical Spine Surgery*

Most studies analyzing the association between obesity and outcomes in spine surgery have focused on thoracic and lumbar diseases, while few reports evaluated outcomes and complications following cervical surgery (Table 2).

In a multi-centric Japanese study, Wilson et al conducted a quantitative analysis of 1-year clinical outcomes (Neck Disability Index (NDI), modified Japanese Orthopedic Association (mJOA) score, and Short Form-36 (SF-36) scores) in a cohort
of 757 patients. NDI scores resulted to be 5.7 points higher for obese patients compared with individuals of normal weight and, albeit strong trends toward reduced SF-36 mental component scores and physical component scores resulted among obese patients, no associations were found between BMI and 1-year mJOA.106

In 2016, comparing 80 obese with 219 non-obese patients, Sielatycki et al observed that despite obesity was associated with worst clinical myelopathy (mJOA score: 10.7 vs 12.2) and higher general physical and mental health impairment (SF-12 mental physical component scale: 28.7 vs 31.8; SF-12 mental component scale score: 38.9 vs 42.3) at the baseline evaluation, all patient-referred outcomes resulted to be significantly improved at 12-months after surgery, and, additionally, the multivariate analysis showed that the pre-operative BMI did not turned out to be a predictor of less improvement in post-operative disability (NDI), neck pain (NRS), general mental and physical health (SF-12 MCS and PCS), and mJOA scale scores.113

Narain et al retrospectively reviewed 277 obese patients who underwent primary 1-to-2-level anterior cervical disectomy and fusion (ACDF) for degenerative spinal pathology, evaluating clinical outcomes, complications, narcotics consumption and hospital costs after patients’ stratification in the different obesity classes. The authors did not report out significant differences in terms of outcomes (fusion rate and clinical improvement) and also operative time, intraoperative blood loss, length of hospital stay, postoperative narcotics consumption, complication rates, reoperation rates and total direct costs across BMI stratifications.95 Same results about outcomes were outlined by Auffinger et al in a prospective study.128

Although many studies did not find global differences in terms of clinical outcomes both in the immediate post-operative period and at long-term follow up comparing obese and non-obese patients—s1—suggesting that cervical spine fusion procedures resulted to be effective for all patients across the entire BMI spectrum—very few studies have critically investigated the rate of complications.74,108

Recently, Zhang et al handled with this aspect, reporting interesting results in a meta-analysis including 7 studies resulting in a total number of 90 740 patients. The results showed that higher BMIs were significatively associated with longer hospital stay (weight mean difference (WMD): 1.61 days), longer surgical time (WMD: 4.55), higher mortality rate (risk ratio (RR) = 3.01) and higher postoperative rates of cardiac complications (RR = 1.30), deep venous thromboembolism (RR = 2.29) and wound complications (RR = 1.69). Conversely, no significant differences were reported between high and normal BMI groups in terms of NDI, SF-36 MC and PC score, overall complications, pulmonary and septic complications.18

Hence, albeit several limitations could be remarked in this study, such as the fact that no randomized control trials have been conducted and the lack of subgroups analysis, due to the poor data availability, high BMI appeared to be associated with longer surgical time, hospital stay and higher post-operative complication rates.18,95 Buerba et al did not find significative associations analyzing the impact of obesity on 30-day complications following cervical fusions in 2072 patients, while a significative longer operative time was reported among Class III comparing to non-obese patients (138.75 vs 132.21 for anterior cervical spine fusion; 200.24 vs 177.35 for posterior cervical spine fusion). Nonetheless, their study lacked of long-term outcomes assessment.130 Fatima et al reported more complications in obese vs nonobese patients after posterior cervical fusion in terms of infections and hardware failure.61 Same results in terms of higher rates of post-surgical complications were reported by other studies. Evidences are stronger for posterior approaches 72,76 while for anterior surgery results are controversial.69,79,136

According to the available evidence, then, the topic is still debatable. Surgery seems to be equally of help in obese patients with valuable outcomes if compared to nonobese patients, while a not negligible amount of studies—especially about posterior surgery—describes an higher rate of complications. Therefore, patients with high BMI should be advised concerning the risk of postoperative complications related to cervical spine surgery and, besides, whereby allowed by neurological impairment, a weight loss program with the aim to reduce the pre-operative BMI could be considered.
Table 3. Literature Regarding Lumbar Spine Surgery in Obese Patients.

| Study number | Reference | Type of study | Study number | Reference | Type of study |
|--------------|-----------|---------------|--------------|-----------|---------------|
| 1            | Mulvaney G et al, 2021 | Retrospective study | 72          | Sielatycki et al, 2016 | Retrospective study |
| 2            | Paranjape CS et al, 2021  | Retrospective study | 73          | Sielatycki JA et al, 2014 | Retrospective study |
| 3            | Chan AK et al, 2020     | Retrospective study | 75          | Sorimachi Y et al, 2016 | Prospective study |
| 4            | Dhan S et al, 2020      | Retrospective study | 76          | Stien et al, 2016       | Retrospective study |
| 5            | Duan PG et al, 2020     | Retrospective study | 77          | Wang H et al, 2016      | Retrospective study |
| 6            | He X et al, 2020        | Retrospective study | 78          | Wang YP et al, 2016     | Retrospective study |
| 7            | Jia D et al, 2020       | Retrospective study | 79          | Adogwa et al, 2015      | Retrospective study |
| 8            | Khan JM et al, 2020     | Retrospective study | 80          | Burks et al, 2015       | Retrospective study |
| 9            | Safaei MM et al, 2020   | Retrospective study | 81          | Cao J et al, 2015       | Meta-analysis |
| 10           | Siccoli A et al, 2020   | Retrospective study | 82          | De la Garza Ramos et al, 2015 | Retrospective study |
| 11           | Xi Z et al, 2020        | Retrospective study | 83          | Giannadakis C et al, 2015 | Retrospective study |
| 24           | Goyal A et al, 2019     | Meta-analysis     | 86          | Lingulata et al, 2015   | Meta-analysis |
| 25           | Esmadgicy et al, 2019   | Retrospective study | 87          | Nota SP et al, 2015     | Retrospective study |
| 28           | Linhares D et al, 2019  | Prospective study | 88          | Ou et al, 2015          | Retrospective study |
| 30           | Mombell KW et al, 2019  | Retrospective study | 89          | Planchard RF et al, 2015 | Retrospective study |
| 34           | Zhang Y. et al, 2019    | Retrospective study | 90          | Yagi et al, 2015        | Retrospective study |
| 36           | Akins et al, 2018       | Retrospective study | 92          | Buerra et al, 2014      | Retrospective study |
| 37           | Bono OJ et al, 2018     | Retrospective study | 96          | Marquez-Lara A et al, 2014 | Retrospective study |
| 39           | Chung AS et al, 2018    | Retrospective study | 98          | McGuire K et al, 2014   | Retrospective study |
| 40           | Jain et al, 2018        | Retrospective study | 100         | Quah C et al, 2014      | Retrospective study |
| 41           | Lovecchio F et al, 2018 | Retrospective study | 107         | Rihn JA et al, 2013     | Retrospective study |
| 42           | Madsbu MA et al, 2018   | Retrospective study | 108         | Rosenfeld HE et al, 2013 | Case series |
| 43           | Nahhas CR et al, 2018   | Retrospective study | 109         | Gaudelli C et al, 2012  | Retrospective study |
| 46           | Ranson WA et al, 2018   | Retrospective study | 110         | Kalanithi et al, 2012   | Retrospective study |
| 47           | Senker et al, 2018      | Retrospective study | 111         | Mehta AI et al, 2012    | Retrospective study |
| 49           | Vinas-Rios JM et al, 2018 | Retrospective study | 112         | Mogannam et al, 2012    | Retrospective study |
| 50           | Flippin M et al, 2017   | Retrospective study | 113         | Rihn JA et al, 2012     | Retrospective study |
| 51           | Grover PJ et al, 2017   | Retrospective study | 114         | Senker et al, 2011      | Retrospective study |
| 52           | Joseph et al, 2017      | Retrospective study | 115         | Anderson PA et al, 2010 | Meta-analysis |
| 55           | Onyekwelu et al, 2017   | Retrospective study | 117         | Singh et al, 2010       | Retrospective study |
| 56           | Pan, Rogers et al, 2017 | Retrospective study | 118         | Yadla et al, 2010       | Retrospective study |
| 58           | Puvanesarajah et al, 2017 | Retrospective study | 120         | Peng et al, 2009        | Retrospective study |
| 59           | Wang H et al, 2017      | Retrospective study | 121         | Samji MF et al, 2009    | Retrospective study |
| 62           | Burgstaller JM et al, 2016 | Retrospective study | 122         | Vaidya R et al, 2009    | Retrospective study |
| 65           | Lucas et al, 2016       | Retrospective study | 123         | Dijuraskovic et al, 2008 | Retrospective study |
| 68           | Manson NA et al, 2016   | Retrospective study | 124         | Sonne-Holm S et al, 2007 | Retrospective study |
| 71           | Owens et al, 2016       | Retrospective study | 125         | Gepstein R et al, 2004  | Retrospective study |
| 1            | Mulvaney G et al, 2021  | Retrospective study | 126         | Epstein, 2003           | Case series |

Obesity and Lumbar Spine Surgery

In the 1987, Hanigan et al reported 1 of the first experience of lumbar surgery for obese patients. The authors conducted a prospective study, enrolling 110 patients suffering from intractable sciatica, with a total number of 17 obese patients and 6-month follow up, and They concluded that obesity did not result to be a prognostic factor when patients were considered eligible for surgery according to their protocol (clinical condition and similar conservative management).165

Subsequently, reports from Spine Patient Outcomes Research Trial (SPORT)—one of the largest studies of operative and non-operative are of patients with lumbar degenerative diseases—started to define outcomes and complications after spine surgery in obese patients. One of the analysis derived from the SPORT Trial, analyzing the effects of surgical and non-surgical treatment in 2 subgroups—nonobese vs obese patients—reported significant treatment effects in the surgical arm, both for obese and nonobese patients. However, while obesity did not result to affect surgical outcomes in lumbar stenosis, it was found to be associated with higher risks for infection, re-operation rate and lower improvement in SF-36 physical score, when surgery was performed for degenerative spondylolisthesis142; less improvement in Oswestry Disability Index (ODI) scale and SF-36 physical score was similarly reported for inter-vertebral disk herniation from the Trial.138
loss (weighted mean difference (WD) 28.89) for obese patients (OR 1.43), longer operative times (OR 14.55) and higher blood thromboembolism (OR 3.15), mortality (OR 2.6), revision rate increased risk for surgical site infections (OR 2.33), venous patients (highly obese) compared to class I obese patients.

Table 4. Literature Regarding MIS Technique in Obese Patients Undergoing Spine Surgery.

| Study number | Reference                          | Type of study            |
|--------------|------------------------------------|--------------------------|
| 9            | Jenkins NW et al, 202064           | Retrospective study      |
| 12           | Othman YA et al, 202067            | Retrospective study      |
| 21           | Buyuk AF et al, 201952             | Retrospective cohort study |
| 23           | Goh GS et al, 201977               | Retrospective study      |
| 27           | Kruiger et al, 20199               | Retrospective study      |
| 32           | Yoo JS et al, 201984               | Retrospective study      |
| 35           | Abbasi H et al, 201886             | Retrospective cohort study |
| 38           | Byval'tsev VA et al, 201889        | Retrospective cohort study |
| 45           | Passias PG et al, 201886           | Retrospective study      |
| 48           | Tan JH et al, 201850               | Meta-analysis            |
| 50           | Wang T et al, 201889               | Meta-analysis            |
| 51           | Xie Q et al, 2018100              | Meta-analysis            |
| 61           | Adogwa et al, 201623               | Retrospective study      |
| 69           | McNany et al, 201627              | Retrospective study      |
| 84           | Goldin AN et al, 2015124           | Retrospective study      |
| 85           | Kukreja et al, 201551              | Retrospective study      |
| 103          | Terman et al, 201428               | Retrospective study      |
| 104          | Wang J et al, 201437               | Prospective study        |
| 105          | Lau, Khan et al, 201327           | Retrospective study      |
| 106          | Lau, Ziewacz et al, 201352        | Retrospective study      |
| 116          | Rodgers et al, 2010143            | Retrospective study      |
| 125          | Patel et al, 200719               | Retrospective study      |

Table 5. Literature Regarding Future Perspective to Achieve the Best Management of Obese Patients Who Underwent Spine Surgery.

| Study number | Reference                          | Type of study            |
|--------------|------------------------------------|--------------------------|
| 2            | Paranjape CS et al, 202158         | Retrospective study      |
| 17           | Siccoli A et al, 202071            | Retrospective study      |
| 29           | Malik AT et al, 201981             | Retrospective study      |
| 40           | Jain et al, 201811                | Retrospective cohort study |
| 45           | Passias PG et al, 201886           | Retrospective study      |
| 115          | Anderson PA et al, 201071          | Meta-analysis            |

Additionally, McGuire et al reported a sub-group analysis from the SPORT trial highlighting higher rate of wound infections and longer operative time for class II and III obese patients (highly obese) compared to class I obese patients. Moreover, although highly obese patients reported worst outcomes compared with class I obesenes, especially when surgery was performed for disc herniation, surgical treatment resulted able to provide better outcomes when compared with non-surgical treatment.132

In a recent meta-analysis, Jiang et al reported significative increased risk for surgical site infections (OR 2.33), venous thromboembolism (OR 3.15), mortality (OR 2.6), revision rate (OR 1.43), longer operative times (OR 14.55) and higher blood loss (weighted mean difference (WD) 28.89) for obese patients. Nonetheless, the lack of stratification on the basis of the type of surgery performed (fusion/non-fusion; open/ MIS) and the involved level, could represent a limit of these aforementioned studies.

Thus, despite several studies described good outcomes following spine fusion in obese patients, the majority of spine surgeons seems to show a tendency toward favor for non-fusion procedures—a priori considered “less invasive”—since the historically reported higher rate of complications.3,98,103,104,121,134

Recently, Onyekwelu et al conducted an interesting retrospective study aiming to establish differences in clinical outcomes and complication rates between obese and nonobese patients (1181 vs 1266) following decompression alone compared with decompression plus fusion for lumbar spinal stenosis. Specifically, considering 12-month ODI or leg pain improvement evaluation, no differences were found in the decompression plus spine fusion group between obese and non-obese patients. Then, improvement in back pain resulted to be less consistent among the obese group when spine fusion was not performed. Conversely, blood loss and operative times resulted higher in obese patients, despite fusion or non-fusion procedures, if compared to non-obese patients and, also, obese patients who underwent spine fusion needed a longer hospital stay than non-obese patients (4.1 vs 3.3 days).5 Kalanithi et al conducted a retrospective cross-sectional study of all spinal fusions performed in California from 2003 to 2007 analyzing whether morbid obesity alters rates of complications and charges in patients undergoing spinal fusion, resulting in 1455 were morbidly obese. Higher morbidity rate among the morbidly obese was reported as were average hospital costs ($108,604 vs. $84,861, P < .0001). Morbid obesity was the most significant predictor of complications in posterior lumbar fusion. However, no subgroup analysis was reported in order to evaluated the role of MIS techniques among the posterior lumbar fusion group and this could actually represent a bias.17

Hence, major trends support valuable clinical outcomes in obese patients, both at short and long-term follow up, surgically treated for LDD59 and better results were observed with spine fusion. While outcomes are reported to be satisfactory and often comparable among obese and nonobese patients treated with surgery when needed, peri-operative complications rate seems to be higher in most of the analyzed papers with few exceptions (Table 3).

The role of MIS techniques for lumbar spine surgery. In summary, the introduction of MIS techniques represents a great stride in the operative care of obese patients. By reducing surgical related complications and, specifically, the overall higher complications rate that burden on these patients, MIS techniques could represent a feasible solution against the tendency toward favor non-fusion of the spine—even when needed—due to the fear of complications (Table 4).124 Most of the aforementioned studies reported higher complication rates among obese patients who underwent surgery, especially for spinal
fuson.120,149 Similarly, many studies highlighted the benefits, in terms of relief from pain and QoL improvement, obtained with surgery.115,117,127,144,145,150 Therefore, in recent years, several authors focused their research on the need for less invasive procedures capable to guarantee similar outcomes to those reported with the “classic” open surgery.7,27,28,43,45,49,50

MIS Trans-Foraminal Interbody Fusion (TLIF) have been described for the first time by Foley et al in 2003 and showed encouraging results, namely reduced operative times, length of stay, blood loss and wound problems, due to the minimal muscles retraction and to the smaller incision, when compared with open techniques.64,173 Interesting studies analyzing the peak muscles pressure due to the retractors and/or evaluating post-operative muscles edema with MRI or post-operative values of muscles pressure due to the retractors and/or evaluating post-operative values of muscles disruption enzymes, indeed, showed significative less retraction and less muscles damage with MIS techniques when compared with open techniques.49,174,175

Lau et al reported in 2013 a retrospective analysis that compared MIS-TLIF with open TLIF in 127 obese patients—stratified for obesity classes—reporting significative less blood loss and shorter hospital stay and, above all, reduced total and intra-operative complication rate (respectively 11.5% vs 28.6% and 3.8% vs 16.3%) in the MIS-TLIF cohort. Besides, when stratified by obesity class, this effect on total complication rate was more evident and statistically significant in patients with Class III obesity (7.1% vs 42.9%).27

In a prospective study, Senker et al assessed the perioperative and postoperative complications of MIS techniques in a large population of 187 patients. The authors evaluated perioperative and postoperative complication rates in obese and normal-weight patients and no infection or severe wound healing disorder were reported. Moreover, no significant differences in terms of cerebrospinal fluid leakage, blood loss or length of hospital stay and major complications (i.e. venous thrombo-embolism, strokes, cardiac infarction) was found, while more clinically insignificant hematomas and urinary infections were encountered in the obese groups than in the normal-weight patients.49

Terman et al retrospectively compared the clinical benefit of open and MIS-TLIF in 74 obese patients with a mean follow up of 30 months, measuring post-operative improvement in visual analog scale (VAS), ODI, blood loss and length of stay. No differences were found between MIS-TLIF and open cohorts when mean VAS score improvement (2.4 vs 2.8) and mean ODI improvement (15 vs 13) were compared, even after stratification according to obesity classes. However, complications and blood loss were significatively greater for the open group than for the MIS-TLIF group (overall complication rate: 52% vs 17%; durotomy rate: 14% vs 4%).28

McAnany et al reported interesting results analyzing the interaction between obesity status and the change in SF-12 results, concluding that patients undergoing MIS TLIF sustain meaningful and significant gains in SF-12 (mental and physical components) that is not affected by obesity (no interactions between SF-12 changes and obesity status (p .33).7 Reasons to promote the use of MIS TLIF vs open-TLIF are also related to other complications rate that could affect the perioperative outcomes of obese patients, as reported by 2 meta-analysis: less blood loss, shorter hospital stay and less risk of dural tears.50,67,75,84,89,99,100,137

Indirect decompression of the spinal canal, then without the need for arrectomy and laminectomy could be considered as a powerful weapon in obese patients because of the reduced need for muscle dissection, surgical trauma and, subsequently, blood loss.83,86

In these terms, the Lateral Transpsoas Access for Lumbar Fusion (LLIF) has gained popularity for the treatment of spinal stenosis or instability in obese patients during the last 2 decades. Spinal interbody cages for LLIF, with their large footprint, are able to span both lateral cortical rims while preserving the anterior longitudinal ligament, restoring then a proper disc height while achieving stability in addition to posterior percutaneous fixation from upper lumbar segments to the L4-L5 level.176 In this way, this technique is able to perform indirect decompression enlarging the neuroforamen and the spinal canal, reducing the bulging/prolapse of the disk and stretching the yellow ligament. Rodgers et al (2010) retrospectively compared obese and non-obese patients who underwent LLIF procedures, focusing on early complications rate—a defined as any adverse event observed within 3 months after surgery—and, unlike traditional open lumbar fusion procedures, no greater risk of complication in the obese patients was found.143

Nevertheless, although commonly accepted as a proper strategy in obese patients, no studies have compared since now open posterior vs lateral approaches in these patients. The anterior retroperitoneal access for fusion (ALIF) represented another effective way to gain indirect decompression with a minimally invasive approach for L5-S1 level.177 Phan et al aimed to compare complication risks, functional outcomes, and subsidence rates in a group of 137 patients who underwent ALIF, categorizing them into 3 groups according to their BMI: normal-weight, overweight, and obese. There was no difference in operative duration, blood loss, or hospital stay and no difference was found in terms of total complications. Despite fusion rates resulted to be lower for obese patients, obesity should not be considered a contraindication for anterior approaches.103

Another mini-open technique potentially able to reduce surgical impact on the patient is represented by the use of Cortical Bone trajectory screws for posterior fusion. This approach requires less posterior exposure because of the more medial entry point of screws, then preserving from dissection a larger amount of Multifidus muscle and respecting its innervation.35,47,178 No studies, however, have been conducted to verify benefits of this technique in obese patients if compared to standard open approaches. Together with percutaneous fixation, posterior focal decompression with tubular retractors and/or the use of the endoscope could constitute other effective strategies to reduce complications in obese patients.119,179
Future Perspectives

Future researches should probably concentrate their effort to evaluate the effects of a proper weight loss before spine surgery instead of verifying the risk of complications of surgery in obese patients (Table 5). Jain et al published a retrospective evaluation of the use of bariatric surgery before elective posterior lumbar surgery.91 Given the limits of a retrospective evaluation, they showed how bariatric surgery was able to mitigate the risk of post-operative complications, with lower rates of respiratory failure (odds ratio [OR] 0.59, P = .019), urinary tract infection (OR 0.64, P = .031), acute renal failure (OR 0.39, P = .007), overall medical complications (OR 0.59, P < .001), and infection (OR 0.65, P = .025). This effort could be justified also because, from the opposite point of view, obese patients who benefit from spine surgery seem to show a valid trend of weight loss after surgery. In a cohort analysis of 7303 patients obese and extremely obese patients were more likely to lose a clinically significant amount of weight 1 year after surgery (BMI 3039: OR1.42, 95% CI 1.22 1.65; BMI 40: OR1.73, 95% CI 1.212.47) compared with nonobese patients.87 Recently, Malik et al reported interesting results assessing the impact of prior bariatric surgery on 90-day outcomes following ACDF. Patients were divided into 2 groups- obese ACDF patients who underwent bariatric surgery within 2 years before an ACDF and obese patients with no history of a bariatric surgery within the last 2 years. Multivariate regression analyzes revealed that undergoing BS before an elective ACDF was associated with a significantly reduced risk of pulmonary, renal and cardiac complications, sepsis and 90-day readmissions.68 Other papers supported these results 58,91,180 although some results questioned the real measured effect of a proper weight loss.71,96 These results, together with the presented literature, suggest that a multidisciplinary strategy could play a key role in obese patients. The use of a proper diet plan before elective surgery, in order to reduce the fat mass while preserving/reinforcing the lean mass, while reserving bariatric surgery for severely obese patients, could be a powerful strategy to reduce surgical related complications, to increase the chances of functional recovery from spinal diseases and to encourage further and valid post-operative weight loss.

Conclusions

In cervical and lumbar spine surgery Evidence suggest that obese patients could benefit from spine surgery and outcomes be satisfactory. Given this, the majority of the analyzed studies reported higher rates of peri-operative complications among obese patients, especially in posterior approaches. The use of MIS techniques plays a key role in order to reduce surgical risks. According to preliminary evidence, further studies should evaluate and encourage the role of multidisciplinary counseling between spine surgeons, nutritionists and, in selected cases, bariatric surgeons, in order to plan proper weight loss before elective spine surgery.

Authors’ Note

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