

Comparison of Outcome between Obese and Non-Obese Patients after Primary Lumbar Discectomy

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ABSTRACT

BACKGROUND AND AIM: Increasing numbers of patients undergoing spinal surgery are overweight or obese. It is unknown if the degree of obesity influences surgical outcomes in patients undergoing primary lumbar discectomy. The purpose of this study was to evaluate the effect of different body mass indices on the surgical experience, perioperative data and clinical outcomes in patients undergoing primary elective lumbar discectomy.

METHODS: A single-center review of prospective database of patients treated by a single surgeon over an 8-year period was

performed. From this we identified 92 consecutive patients who underwent primary lumbar discectomy. Visual Analogue Scores (VAS) for leg and back pain and Oswestry Disability Index (ODI) were recorded preoperatively and postoperatively, as were complications, recurrence of disc and subsequent revision surgery. From medical records we also recorded various demographics including height (cm), weight (kg), body mass index (BMI), comorbidities, smoking status, operative time, time to ambulate, length of hospital stay. Patients were stratified into the standard BMI categories: normal ($< 25 \text{ kg/m}^2$), overweight ($25 - 29.9 \text{ kg/m}^2$) or obese ($\geq 30 \text{ kg/m}^2$).

RESULTS: The overall study group consisted of 36 normal patients, 33 overweight and 23 obese patients. Indications for surgery were a uni-lateral disc prolapse in 74 (80%) patients and a central disc prolapse in 18 (20%), and patients underwent a discectomy, decompression or a combination. The three patient groups were comparable in terms of age, sex, and diagnosis. All three patient groups demonstrated significant improvements in leg pain, back pain, and ODI scores ($p < 0.001$) at 2-months and 6-months following surgery compared to baseline. There was no significant difference in the mean improvements observed in obese or overweight patients compared to patients of normal weight with respect to leg pain ($p = 0.69$), back pain ($p = 0.14$), and ODI ($p = 0.3$). Operative time was significantly longer for the obese group. Time to ambulate and length of hospital stay were comparable. The incidence of wound infections was also comparable while the incidence of a dural tear was higher in the non-obese group. There was no difference in the revision rate between the groups.

CONCLUSION: Obese patients undergoing lumbar discectomy achieve similar benefits to non-obese patients.

Key words: Discectomy; Obesity; Outcome

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INTRODUCTION

The prevalence of overweight and obese individuals in the Western World has reached epidemic proportions^[1-5]. Recent survey conducted in 2009 and 2010 by Centers for Disease Control statistics report that 69.2% of adults older than 20 years are now overweight and 35.9% are obese^[6]. Obesity has long been linked to a multitude of health problems, and has been shown to be an independent risk factor for lumbar spine related disorders^[7-11]. Consequently, the number of overweight and obese patients requiring spinal surgery is on the rise.

Much has changed the face of modern spine surgery especially over the last two decades. There may still exist some degree of subconscious bias among spinal surgeons against operating on obese patients. Surgeons often perceive spinal surgery in obese patients to be associated with increased operative times, perioperative complications and inferior clinical outcomes.

Some authors have evaluated the effect of obesity on the complication rates and clinical results of spine surgery^[12-16]. Existing studies have focused mainly on lumbar fusion and a mixed group of surgical procedures (discectomies, laminectomies, and fusions). None has specifically looked at the direct relationship between obesity and primary lumbar discectomy. Lumbar discectomy is the most common procedure performed by spinal surgeons.

The purpose of the current study was to determine if different body mass indices has an impact on the surgical experience, perioperative data and clinical outcomes in patients undergoing primary elective open lumbar discectomy.

MATERIALS AND METHODS

We analysed a prospectively maintained single spine surgeon's database at our institution containing patient demographics, procedure details, and pre-and postoperative outcome scores.

We searched this database for patients undergoing elective primary lumbar open discectomy for herniated nucleus pulposus (HNP) between October 2001 and September 2009. Exclusion criteria included age younger than 18 years and those patients undergoing emergent lumbar discectomy for traumatic herniation or cauda equina syndrome (CES). Current review of this database identified 92 consecutive patients undergoing primary lumbar discectomy with a minimum of 6-months follow-up and complete functional outcomes data, and this group comprised the subjects for the current study. All patients were operated by our senior author (MLN). Institutional review board approved the review of the prospective database for this study.

In addition, medical notes, anaesthetic charts, operative notes, and clinic letters were reviewed. Patient demographics included gender, age, height (cm), weight (kg), body mass index (BMI), smoking habitus, associated comorbidities, and American Society of Anesthesiologists (ASA) scores. Comorbidities that were considered included: hypertension, diabetes mellitus, heart disease, and pulmonary disease. Operative variables included type of procedure, operative time, estimated blood loss (EBL), length of time to ambulate, and length of stay (LOS). Complication variables that were assessed included dural tears, wound infection, recurrence of disc, and re-operations. Any technical difficulties in relation to intubation and positioning were also collated. Our spine database collects visual Analogue Scores (VAS) for leg and back pain and Oswestry Disability Index (ODI) outcome measures in a standard written format during scheduled clinic visits preoperatively and postoperatively at 2 months and 6 months.

Body mass index (BMI) was calculated for each individual patients as the weight in kilograms divided by height in meters squared. Patients were then grouped according to National Institutes of Health criteria^[17]. These criteria define a BMI of less than 25 kg/m² as normal weight, 25.0 to 29.9 kg/m² as being overweight, and greater than 30.0 kg/m² as obese. To assess the effect of different body mass indices on the outcome of lumbar discectomy, we stratified patients into normal (< 25 kg/m²), overweight (25-29.9 kg/m²) or obese (\geq 30 kg/m²) groups. Demographics, operative variables, complication rates, and patient outcomes were compared between these 3 groups.

Statistical Analysis

Normality of data was evaluated with Shapiro-Wilk test. Normally distributed continuous data relating to the three groups (normal, overweight and obese) was compared using analysis of variance (ANOVA). Tukey's post hoc test was performed to determine which differences were significant. Non-normal data was analysed with Kruskal Wallis test. Categorical data was compared using Chi-squared test. *P*-values of less than 0.025 were deemed to be clinically significant. Statistical tests were performed with PASW 18 statistical software package (PASW © Chicago IBM).

RESULTS

There were 92 patients with a mean age was 44.3 years (range, 20-72 yrs). Of these, 47 (51%) were women. For the whole group the mean BMI was 26.4 kg/m², the mean height was 171.2 cm, and the mean weight was 77.8 kg/m².

When categorised by BMI, 39% of patients were normal-weight or underweight (BMI, < 25), 36% were overweight (BMI, 25-29.9), and 25% were obese (BMI, > 30). Co-morbidities were noted in 48% of obese patients, 24% of overweight and 17% of normal-weight patients. All patients with diabetes were overweight or obese. Table 1 shows the clinical characteristics of the study population. Groups were similar with respect to age, gender, diagnosis, and surgical level. Smoking habitus was noted in 67% of normal weight patients and 52% of obese patients as compared to 24% in overweight patients. All patients with diabetes were overweight or obese reflecting the higher ASA.

Table 2 compares the perioperative parameters of all three BMI classifications. A positive impact of increased BMI on the operating time was observed. There was a statistically significant difference between the operating time for the obese and those of normal weight ($p < 0.025$). While the operative time for the overweight cohort was greater for than that for those of normal weight and less than the obese cohort, this difference did not reach statistical significance. A similar pattern was observed with regard to estimated blood loss. Obese patients suffered a greater degree of blood loss compared to the overweight who in turn endured greater loss than the normal-weight cohort. However, a statistical significant difference only existed in the estimated blood loss between the obese and normal weight cohort ($p < 0.01$). The length of time to ambulation and length of hospital stay was not influenced by the BMI ($p = 0.32$ and $p = 0.69$ respectively). There were 3 cases of prolonged intubation in the obese group. No positioning-related issues were noted in the study groups.

All three patients groups demonstrated significant improvements in leg pain, back pain, and ODI scores ($p < 0.001$) at 2-months and 6-months following surgery compared to baseline Table 3. There was no significant difference in the mean improvements between the three groups at six months with respect to leg pain ($p = 0.69$), back pain (p

= 0.14), and ODI ($p = 0.3$).

Table 4 discusses the Surgical complications, which occurred in 14 patients with an overall complication rate of 15%. Intraoperative complications included six dural tears (6.5%), the symptoms from which resolved without the need for additional operative interventions. However, no case of inadvertent durotomy occurred in the obese group. There were eight cases of superficial wound infection with two cases requiring washout in addition to antibiotic therapy. Three of them were stitch abscess and we coded them under infection category as these were treated by General Practitioner as “presumptive” wound infection without a positive culture. One case of paralytic ileus occurred in an overweight patient for 2 days post-operatively. One obese patient had lung collapse post-operatively requiring prolonged high dependency support. No cases of post operative symptomatic deep vein thrombosis were seen. Eight late recurrent disc herniations occurred (8.6%) necessitating additional operative interventions. The incidence of infection, dural tear or reoperation was not influenced by BMI ($p = 0.76$, $p = 0.24$ and $p = 0.92$ respectively). The same was observed with regard to the overall complication rate ($p = 0.14$).

DISCUSSION

The primary finding of this report is that degree of body habitus measured by BMI does not appear to significantly affect self-reported outcome after open primary lumbar discectomy. Although there was a trend for obese patients to have a slightly lower general health and

higher back-specific outcome scores before surgery and after surgery, the degree of improvement with surgery was similar to non-obese controls.

Recent studies in other areas of orthopaedic surgery have examined whether the presence of obesity adversely affects patient outcomes after surgery. Foran *et al*^[18] reported inferior knee society scores at 8-year follow-up in obese patients undergoing total knee arthroplasty, when compared with a matched group of non-obese patients. Amin *et al*^[19] reported that morbidly obese patients demonstrated inferior Knee Society scores, more complications, and worse implant survival. Namba *et al*^[20] found a 6-fold higher infection rate for obese patients undergoing total knee arthroplasty, and a 4-fold higher infection rate for total hip arthroplasty. However, several other studies have shown equivalent outcomes for obese patients undergoing hip and knee arthroplasty^[21-25].

In the area of spinal surgery, there has been a paucity of studies examining the influence of obesity on clinical outcomes. Glassman *et al*^[26] categorised 497 open lumbar fusion patients as normal weight, overweight, and obese using BMI. Their analysis did not demonstrate a difference between the groups in the pre-and postoperative change in SF-36 and ODI. Andreshak *et al*^[13] reported, in a mixed group of surgeries (discectomies, laminectomies, and fusion), equivalent clinical results in obese and non-obese patients. They concluded that proper surgical indications are the predominant factor affecting surgical results and the patient weight should not influence surgical decision-making. Gepstein *et al*^[14] recently reported their results in elderly obese patients undergoing decompressive procedures for

Table 1 Clinical Characteristics of the Study Population.

Demographic	All	BMI < 24.9	BMI 25-29.9	BMI > 30	P Value
Number of Patients	92	36 (39%)	33 (36%)	23 (25%)	
Mean Age (years)	44.3	42.5	45.5	45.4	0.52
Gender					0.39
Women	47 (51%)	22 (61%)	15 (45%)	10 (43%)	
Men	45 (49%)	14 (39%)	15 (55%)	13 (57%)	
BMI	26.4	21.8	27	32.9	
ASA	1.5	1.3	1.48	1.82	
1	48	25	18	5	
2	42	11	14	17	
3	2	0	1	1	
Smoking Status					
Yes	44 (48%)	24 (67%)	8 (24%)	12 (52%)	
No	48 (52%)	12 (33%)	25 (76%)	11 (48%)	
Diagnosis					0.127
Uni - HNP	74 (80%)	32 (89%)	23 (70%)	19 (83%)	
Central HNP	18 (20%)	4 (11%)	10 (30%)	4 (17%)	
Surgical Level					
Single Level	83 (90%)	35 (97%)	28 (85%)	20 (87%)	
L4-5	30	13	10	7	
L5-S1	53	22	18	13	
Multilevel	9 (10%)	1(3%)	5 (15%)	3 (13%)	
L2-3	1		1		
L3-5	1			1	
L4-S1	7	1	4	2	

Table 2 Comparison of peri-operative parameters.

Examined Parameter	All (n = 92)	BMI < 25 (n = 36)	BMI 25-29.9 (n = 33)	BMI > 30 (n = 23)
Operating Time (min)	92.7 (51-190)	85.7 (52-135)	94.3 (57-190)	101.3 (51-158) ($p < 0.025$)
Estimated Blood Loss (mL)	293 (100-1000)	248 (150-500)	300 (100-1000)	353 (200-500) ($p < 0.01$)
Length of time to ambulate (hrs)	1.2 (1-5)	1.1 (1-3)	1.2 (1-5)	1.23 (1-2) ($p < 0.32$)
Length of hospitalization (d)	2.8 (2-10)	2.7 (2-5)	3 (2-10)	2.7 (2-5) ($p < 0.69$)

Table 3 Baseline and post-operative outcome measures.

Outcome	Normal	Overweight	Obese	P Value
Number of patients	36(39%)	33(36%)	23(25%)	
VAS (Leg Pain)				
Baseline	70	74.6	75.4	
2 month	26.4	24	31.7	< 0.001
6 month	24.1	22.5	27.1	< 0.001
VAS (Back Pain)				
Baseline	52.2	44.3	49.9	
2 month	18.8	20.1	31.5	< 0.001
6 month	17.7	21	31.7	< 0.001
ODI				
Baseline	52.6	50.1	54.1	
2 month	23.5	22.6	30.4	< 0.001
6 month	20.8	17.9	29.2	< 0.001

Table 4 Surgical Complications.

Adverse Event	ALL	BMI < 25	BMI 25-29.9	BMI > 30	P Value
Number of patients	92	36(39%)	33(36%)	23(25%)	
SSI	8	4	2	2	0.76
Dural Tear	6	4	2	0	0.24
Reoperation	10	4	4	2	0.92
Indication					
Infection	2	1	1	0	
Recurrent Disc	8	3	3	2	

lumbar stenosis, and found similar degrees of improvement and subjective satisfaction rates in their obese and non-obese patients.

Djurasovic *et al*^[27] similarly reported that obese patients undergoing lumbar fusion achieve similar benefits to non-obese patients. The addition of patient-directed quality of life measure SF-36 in their study confirms the equivalence of outcomes from a patient perspective as well.

Our findings are consistent with the limited previous data on the relationship between body habitus and spine surgery.

Several studies have demonstrated increased complication rates in overweight or obese patients in the setting of elective spinal fusion^[12,28,29]. The present study in contrast found no impact of increasing body habitus on the peri-operative complications in a cohort of patients undergoing primary lumbar discectomy.

In the published literature, rates of surgical site infection (SSI) after spinal surgery reported from individual institutions have ranged from 0% to 15%, depending on the indication for the operation, the site, the approach, and the use of instrumentation^[30-35]. In this present series it was 8.6%. The incidence of SSI in our cohort without instrumentation is rather high since we used generous criteria to include the presumptive wound infection cases treated in the community by general practitioner. Nevertheless we did not find any difference in terms of wound complications among various body habitus groups.

The incidence for unindented postdiscectomy dural tears also varies from as low as 1% to 7.1%^[36-38] and as high as 16.7% for spinal surgery in the obese^[16]. In our study it was 6.5%. We noted no case of inadvertent dural tear in obese patients. We registered no significant difference in the occurrence of dural tears in our 3 BMI groups.

We observed symptomatic re-herniation needing revision discectomy in 8.6% of our patients and this correlates with published data^[39-41]. We also found no significant difference in the occurrence of disc recurrence in our 3 BMI groups.

Although this study found no significant difference of peri-operative complications, recurrence, reoperation rate or functional outcomes of surgery between non-obese, overweight and the obese group, we do not suggest that obesity should be ignored. This current study showed a positive impact of the degree of obesity on blood loss and operative time. It should be recognised that the obese patient is more difficult to position for surgery and surgery is relatively more difficult, although this by itself should not be a contraindication for this procedure in obese patients. Our analysis also showed that obese patients had similar faster rehabilitation potential and length of hospital stay as non-obese patients. There have not been many studies comparing outcomes of minimally invasive discectomies, however Mae *et al* reports in selected obese patients endoscopic lumbar discectomy can be a safe effective as it can reduce perioperative morbidity and allow early rehabilitation and return to work^[42].

In summary, this study found equivalent degrees of improvement with respect to back and leg pain, and low back specific quality of life measures in obese patients undergoing lumbar discectomy. Our findings also suggest that increasing BMI has no impact on hospital stay, peri-operative complications, disc reherniation, and functional outcome after primary lumbar discectomy. Obese population should not be denied surgery based on their BMI values alone and patient selection continues to be the most important factor in terms of operative success.

REFERENCES

1. Flegal KM, Carroll MD, Kuczmarski RJ, Johnson CL. Overweight and obesity in the United States: prevalence and trends, 1960-

1994. *Int J Obes Relat Metab Disord.* 1998; **22**: 39-47. [PMID: 9481598]

2. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999-2000. *JAMA.* 2002; **288**: 1723-1727. [PMID: 12365955]
3. Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002. *JAMA.* 2004; **291**: 2847-2850. [PMID: 15199035]; [DOI: 10.1001/jama.291.23.2847]
4. No authors listed. Obesity: preventing and managing the global epidemic, technical report series 894. Part 1: the problem of overweight and obesity: defining the problem. *World Health Organisation* 2000: 6-15. [PMID: 11234459]
5. Ogden CL, Yanovski SZ, Carroll MD, Flegal KM. The epidemiology of obesity. *Gastroenterology.* 2007; **132**: 2087-2102. [PMID: 1749850]; [DOI: 10.1053/j.gastro.2007.03.052]
6. Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of Obesity and Trends in the Distribution of Body Mass Index Among US Adults, 1999-2010. *JAMA.* 2012 Jan 20. [Epub ahead of print] [PMID: 2225336]; [DOI: 10.1001/jama.2012.39]
7. Deyo RA, Bass JE. Lifestyle and low-back pain. The influence of smoking and obesity. *Spine* 1989; **14**: 501-506. [PMID: 2524888]
8. Hangai M, Kaneoka K, Kuno S, Hinotsu S, Sakane M, Mamizuka N, Sakai S, Ochiai N. Factors associated with lumbar intervertebral disc degeneration in the elderly. *Spine J.* 2008; **8(5)**: 732-740. [PMID: 18037353]; [DOI: 10.1016/j.spinee.2007.07.392]
9. Luke M, Solovieva S, Lamminen A, Luoma K, Leino-Arjas P, Luukkonen R, Riihimäki H. Disc degeneration of the lumbar spine in relation to overweight. *Int J Obes (London)* 2005; **29**: 903-908. [PMID: 15917859]; [DOI: 10.1038/sj.ijo.0802974]
10. Symmons DP, van Hemert AM, Vandenbroucke JP, Valkenburg HA. A longitudinal study of back pain and radiological changes in the lumbar spines of middle aged women. II: radiographic findings. *Ann Rheum Dis* 1991; **50**: 162-166. [PMID: 1826598]; [PMCID: PMC1004366]
11. Parkkola R, Rytokoski U, Kormano M. Magnetic resonance imaging of the discs and trunk muscles in patients with chronic low back pain and healthy control subjects. *Spine* 1993; **18**: 830-836. [PMID: 8316880]
12. Patel N, Bagan B, Vadera S, Maltenfort MG, Deutsch H, Vaccaro AR, Harrop J, Sharan A, Ratliff JK. Obesity and spine surgery: relation to perioperative complications. *J Neurosurg* 2007; **6**: 291-297. [PMID: 17436915]; [DOI: 10.3171/spi.2007.6.4.1]
13. Andreshak T, An HS, Hall J, Stein B. Lumbar spine surgery in the obese patient. *J Spinal Disord* 1997; **10**: 376-9. [PMID: 9355052]
14. Gepstein R, Shabat S, Arinzon ZH, Berner Y, Catz A, Folman Y. Does obesity affect the results of lumbar decompressive spinal surgery in the elderly? *Clin Orthop Relat Res* 2004; **426**: 138-144 [PMID: 15346065]
15. Hanigan W, Elwood PW, Henderson JP, Lister JR. Surgical results in obese patients with sciatica. *Neurosurgery* 1987; **20**: 896-899. [PMID: 3614568]
16. Telfeian AE, Reiter GT, Durham SR, Marcotte P. Spine surgery in morbidly obese patients. *J Neurosurg* 2002; **97(1 Suppl)**: 20-24. [PMID: 12120647]
17. National Institutes of Health: Clinical guidelines on the identification, evaluation and treatment of overweight and obesity in adults-the evidence report. *Obes Res* 1998; **6**: 51S-209S. [PMID: 9813653]
18. Foran JR, Mont MA, Etienne G, Jones LC, Hungerford DS. The outcome of total knee arthroplasty in obese patients. *J Bone Joint Surg Am* 2004; **86**: 1609-1615. [PMID: 15292406]
19. Amin AK, Clayton RA, Patton JT, Gaston M, Cook RE, Brenkel IJ. Total knee replacement in morbidly obese patients: results of a prospective, matched study. *J Bone Joint Surg Br* 2006; **88**: 1321-1326. [PMID: 17012421]; [DOI:

- 10.1302/0301-620X.88B10.17697]
20. Namba RS, Paxton L, Fithian DC, Stone ML. Obesity and perioperative morbidity in total hip and total knee arthroplasty patients. *J Arthroplasty* 2005; **20**: 46-50. [PMID: 16214002]; [DOI: 10.1016/j.arth.2005.04.023]
 21. Amin AK, Patton JT, Cook RF, Brenkel IJ. Does obesity influence the clinical outcome at five years following total knee replacement for osteoarthritis? *J Bone Joint Surg Br* 2006; **88**: 335-340. [PMID: 16498007]; [DOI: 10.1302/0301-620X.88B3.16488]
 22. Hamoui N, Kantor S, Vince K, Crookes PF. Long-term outcome of total knee replacement: does obesity matter? *Obes Surg* 2006; **16**: 35-38. [PMID: 16417755]; [DOI: 10.1381/096089206775222140]
 23. Jackson MP, Sexton SA, Yeung E, Walter WL, Walter WK, Zicat BA. The effect of obesity on the mid-term survival and clinical outcome of cementless total hip replacement. *J Bone Joint Surg Br* 2009; **91-B**: 1296-300. [PMID: 19794162]; [DOI: 10.1302/0301-620X.91B10.22544]
 24. Ibrahim T, Hobson S, Beiri A, Esler N. No influence of body mass index on early outcome following total hip arthroplasty. *Int Orthop* 2005; **29**: 866-869. [PMID: 16184403]; [PMCID: PMC2231583]; [DOI: 10.1007/s00264-005-0012-8]
 25. Andrew JG, Palan J, Kurup HV, Gibson P, Murray DW, Beard DJ. Obesity in total hip replacement. *J Bone Joint Surg Br* 2008; **90-B**: 424-9. [PMID: 18378913]; [DOI: 10.1302/0301-620X.90B4.20522]
 26. Glassman S, Gornet MF, Branch C, Polly D Jr, Peloza J, Schwender JD, Carreon L. MOS short form 36 and Oswestry Disability Index outcomes in lumbar fusion: A multicenter experience. *Spine J* 2006; **6**: 21-26. [PMID: 16413443]; [DOI: 10.1016/j.spinee.2005.09.004]
 27. Djurasovic M, Bratcher KR, Glassman SD, Dimar JR, Carreon LY. The effect of obesity on clinical outcomes after lumbar fusion. *Spine J* 2008; **33(16)**: 1789-1792. [PMID: 18628712]; [DOI: 10.1097/BRS.0b013e31817b8f6f]
 28. Vaidya R, Carp J, Bartol S, Ouellette N, Lee S, Sethi A. Lumbar spine fusion in obese and morbidly obese patients. *Spine (Phila Pa 1996)* 2009; **34(5)**: 495-500. [PMID: 19212274]; [DOI: 10.1097/BRS.0b013e318198c5f2]
 29. Yadla S, Malone J, Campbell PG, Maltenfort MG, Harrop JS, Sharan AD, Vaccaro AR, Ratliff JK. Obesity and spine surgery: reassessment based on a prospective evaluation of perioperative complications in elective degenerative thoracolumbar procedures. *Spine J* 2010; **10(7)**: 581-587. [PMID: 20409758]; [DOI: 10.1016/j.spinee.2010.03.001]
 30. Olsen MA, Mayfield J, Laurysen C, Polish LB, Jones M, Vest J, Fraser VJ. Risk factors for surgical site infection in spinal surgery. *J Neurosurg Spine*. 2003; **98**: 149-155 [PMID: 12650399]
 31. Abbey DM, Turner DM, Warson JS, Wirt TC, Scalley RD. Treatment of postoperative wound infections following spinal fusion with instrumentation. *J Spinal Disord*. 1995; **8**: 278-83. [PMID: 8547767]
 32. Picada R, Winter RB, Lonstein JE, Denis F, Pinto MR, Smith MD, Perra JH. Postoperative deep wound infection in adults after posterior lumbosacral spine fusion with instrumentation. *J spinal Disord*. 2000; **13**: 42-5. [PMID: 10710149]
 33. Tenney JH, Vlahov D, Salzman M, Ducker TB. Wide variation in risk of wound infection following clean neurosurgery. Implications for perioperative antibiotic prophylaxis. *J Neurosurgery*. 1985; **62**: 243-7. [PMID: 3968563]; [DOI: 10.3171/jns.1985.62.2.0243]
 34. Weinstein MA, McCabe JP, Cammisa FP. Postoperative spinal wound infection: a review of 2391 consecutive index procedures. *J Spinal Disord*. 2000; **13**: 422-426. [PMID: 11052352]
 35. Olsen MA, Nepple JF, Riew D, Lenke LG, Birdwell KH, Mayfield J, Fraser VJ. Risk factors for surgical site infection following orthopaedic spinal operations. *J Bone Joint Surg Am* 2008; **90**: 62-9. [PMID: 18171958]; [DOI: 10.2106/JBJS.F.01515]
 36. Stolke D, Sollmann W, Seifert V. Intra- and postoperative complications in lumbar disc surgery. *Spine*. 1989; **14**: 56-59. [PMID: 2913669]
 37. Wang JC, Bohlman HH, Riew KD. Dural tears secondary to operations on the lumbar spine: management and results after a two-year minimum follow-up of eighty-eight patients. *JBJS*. 1998; **80**: 1728-1732. [PMID: 9875930]
 38. Tafazal S, Sell PJ. Incidental durotomy in lumbar spine surgery: incidence and management. *Eur Spine J*. 2005; **14(3)**: 287-290. [PMID: 15821921. PMCID: PMC3476743]; [DOI: 10.1007/s00586-004-0821-2]
 39. Keskimaki L, Seitsalo S, Osterman H, Rissanen P. Reoperations after lumbar disc surgery. *Spine* 2000; **25**: 1500-1508. [PMID: 10851098.
 40. Weir BK, Jacobs GA. Reoperation rate following lumbar discectomy: an analysis of 662 lumbar discectomies. *Spine* 1980; **5**: 366-370. [PMID: 7455766]
 41. Morgan-Hough CVJ, Jones PW, Eisenstein SM. Primary and revision lumbar discectomy: A 16-year review from one centre. *J Bone and Joint Surg Br* 2003; **85(6)**: 871-874. [PMID: 12931809]
 42. Bae JS, Lee SH. Transforaminal full-endoscopic lumbar discectomy in obese patients. *Int J Spine Surg*. 2016 May 4; **10**: 18. [PMID: 27441176]; [PMCID: PMC4943208]; [DOI: 10.14444/3018]

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