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Changes in the glycosylated hemoglobin levels and body mass index after decompression surgery in patients with lumbar spinal stenosis in a tertiary care center, Saudi Arabia

Sami I. Aleissa, MD.[1,2,3], Mohammed A. Alabdulsalam, MBBS.[2,3], Taif M. Alqahtani, MBBS.[2,3], Abdullah M. Alshehri, MBBS.[4], Abdulaziz A. Alabdulsalam[2,3], Faisal M. Konbaz, MD.[1,2,3], Fahad H. Alhelal, MD.[1,2,3], Majed S. Abalkhail, MD.[1,2,3]

[1]Department of Surgery, Division of Orthopedics, Ministry of National Guard-Health Affairs, [2]College of Medicine, King Saud bin Abdulaziz University for Health Sciences, [3]King Abdullah International Medical Research Center, Riyadh, [4]Department of Orthopaedic Surgery, King Fahd Hospital of the University, Imam Abdul Rahman Bin Faisal University, AlKhobar, Saudi Arabia.

***Corresponding author:**
Mohammed A. Alabdulsalam, College of Medicine, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia.

mo.alabdulslam@gmail.com

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ABSTRACT

Objectives: Lumbar spinal decompression surgery is a well-studied intervention in its benefit in pain control. It can also improve physical activity that indirectly facilitates glycemic control in diabetic patients and weight loss in obese patients. This study aimed to assess the changes of glycosylated hemoglobin (HbA1c) and body mass index (BMI) in patients with lumbar spinal stenosis (LSS) post-intervention at 6- and 12-month follow-ups.

Methods: This was a retrospective cohort study of patients with LSS who had lumbar decompression, with or without instrumentation at King Abdulaziz Medical City, from 2016 and 2020. Patients over 18 years, treated surgically for LSS, were included with a minimum of a 1-year follow-up. Patients with Type 1 diabetes mellitus, with comorbidities, that limited physical activity, or without follow-up records were excluded from the study.

Results: In total, 140 patients were included in the study. They had three underlying diseases: LSS (n = 87, 62.1%), spondylolisthesis (n = 37, 26.4%), and degenerative disc disease (n = 16, 11.4%). Results showed that obese patients were associated with the lower BMI at 6- and 12- month follow-ups compared to the non-obese. In addition, there was a statistical difference in HbA1c change at follow-ups between controlled (HbA1c <7) and uncontrolled diabetes groups (HbA1c ≥7).

Conclusion: Lumbar spinal decompression can help in the reduction of BMI of obese patients with LSS. However, there is a need for extensive investigation of the reasons for the contradicting results of an increase in the HbA1c level at 12-month follow-up in the current study.

Keywords: Diabetes mellitus, Intervertebral disc degeneration, Laminectomy, Lumbar vertebrae, Spinal stenosis, Spondylolisthesis

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INTRODUCTION

Lumbar spinal stenosis (LSS) is a narrowing of the spinal canal, lateral recess, or foramina in which the bony anteroposterior or transverse diameters of the spinal canal is decreased, or the oval shape of the canal is distorted in the cross-sectional view resulting in the compression of the lumbosacral nerve roots.[1-3] The causes of LSS are classified as congenital-developmental and acquired.[2,3] The most frequent acquired cause is a degenerative disease, such as spondylosis and spondylolisthesis.[3] Anatomically, LSS is classified into central, lateral recess, foraminal, extraforaminal stenosis, or combined. All are close enough to the nerve roots that narrowing or reducing the diameter causes compression.[4]

LSS affects around 200,000 adults in the United States, and it is a common indication for spinal surgery in the elderly.[5] The most frequently used modality for diagnosis is magnetic resonance imaging (MRI), but myelography, computed tomography (CT), and CT myelography may also be used.[6,7] Initial conservative management includes physiotherapy sessions and pain control.[6] If conservative management fails to control the pain, and the pain starts to affect daily activities negatively, surgical intervention is indicated. Surgical management varies depending on the underlying condition. It can be decompressive surgery or stabilization in addition to decompressive surgery for pathologies such as scoliosis and spondylolisthesis.[6] Lumbar spinal decompression surgery is effective in relieving pain. It can also improve physical activity, which could indirectly affect glycemic control and weight loss in diabetic and obese patients.[8-10]

Diabetes mellitus (DM) and obesity represent major healthcare challenges, with an increasing prevalence over time.[11,12] Literature highlights that both diabetic and obese patients have a higher risk of developing LSS.[13-15] Although many studies reported the impact of diabetes and obesity on surgical intervention outcomes, limited studies explored the effect of lumbar spinal surgeries on glycemic control and body mass index (BMI) reduction. Kim *et al.* reported that surgical intervention in DM-2 patients with LSS improved glycemic control, and reduced BMI.[16] Another study in 2014 demonstrated a reduction in the glycosylated hemoglobin A1C levels (HbA1c) in diabetic patients after surgical decompression with or without fusion, and this reduction was indirectly related to increased physical activity after surgery.[17] No local study has investigated the effect of surgical intervention on glycemic control and BMI.

We presumed that managing LSS with a surgical intervention can improve glycemic control in diabetic patients and reduce BMI in our local population. Therefore, in this study, we primarily aimed to assess the changes in the HbA1c and BMI after lumbar decompression. In addition, we assessed the association between postoperative complications and the length of hospital stay (LOS), and the association between smoking and postoperative complications and the LOS.

MATERIALS AND METHODS

This was a retrospective cohort study of patients with LSS, who had lumbar decompression surgery, with or without instrumentation at King Abdulaziz Medical City (KAMC), Riyadh, from 2016 and 2020. Both genders who were more than 18 years of age, treated surgically for LSS at KAMC, with or without instrumentation, with a minimum of 1-year follow-up post-intervention, were included in this study. We excluded Type 1 DM patients, depending on insulin for the management of diabetes, patients with comorbidities that limited their physical activity, or patients without follow-up records.

The data were obtained from the patient files using the Best Care System used by the Ministry of National Guard-Health Affairs. The medical records were reviewed, and all eligible patients were involved in this study. The data were entered in a prepared datasheet in Microsoft Excel. The variables included demographic factors including age, gender, weight, height, BMI, diabetes, hypertension, dyslipidemia, and smoking. The surgery-related variables were prior surgical interventions, type of the previous intervention, pain visual analog scale (VAS) score, preoperative BMI, and preoperative HbA1c. In addition, the type of surgical technique, decompression levels, LOS, postoperative infectious complications, wound complications, cardiovascular complications, thromboembolism, and renal complications were collected, as well as the BMI and HbA1c at 6- and 12-months follow-up.

All the data were analyzed using the John's Macintosh Project version 15 pro. The continuous variables were compared using parametric or non-parametric methods depending on the normality of the data. Descriptive analysis, such as frequency and percentage, was used to describe the categorical variables, including age (<50 and ≥50 years old), and gender. The mean and standard deviation were used to describe continuous variables, including age, HbA1c, and LOS. The BMI was used to determine the category of the weight of patients. The weight categories used were underweight (BMI < 18.5), normal (BMI = 18.5–24.9), overweight (BMI = 25–29.9), and obese (BMI = 30 and above). The DM was considered controlled if HbA1c was lower than seven and uncontrolled if equal or higher than seven. Pearson correlation test was used to analyze the correlation between the changes in the HbA1c and the changes in the BMI, where Fischer's exact test was used to analyze the categorical variables. $P < 0.05$ was

Table 1: Demographic information of the sample (*n*=140).

Age in years (mean±SD)	**63.61±9.03**
Age groups (%) (years)	
<50	9 (6.43%)
≥50	131 (93.57%)
Gender (%)	
Male	48 (34.3)
Female	92 (65.7)
BMI groups (%)	
<30 BMI	39 (27.9)
≥30 BMI	101 (72.1)
HbA1c groups (%)	
Controlled*	35 (25)
Uncontrolled**	26 (18.6)
Diabetes (%)	
Yes	88 (62.9)
No	52 (37.1)
Hypertension (%)	
Yes	88 (62.9)
No	52 (37.1)
Dyslipidemia (%)	
Yes	75 (53.6)
No	65 (46.4)
Smoker (%)	
Yes	9 (6.4)
No	131 (93.6)

*Controlled: <7 HbA1c. **Uncontrolled: ≥7 HbA1c

Table 2: Post-operative complications (*n*=140).

Post-operative infectious complications	*n* (%)
Wound infection	2 (1.43)
Urinary tract infection	3 (2.14)
Septicemia	1 (0.71)
Post-operative wound complications	
Wound dehiscence	1 (0.71)
Hematoma	2 (1.43)
Wound necrosis	1 (0.71)
Post-operative CVS complications	
Tachycardia	1 (0.71)
Post-operative thromboembolism	
Deep venous thrombosis	2 (1.43)
Pulmonary embolism	1 (0.71)
Post-operative renal complications	
Acute kidney injury	2 (1.43)

considered statistically significant.

RESULTS

In total, 140 patients were included in the study [Table 1]. They had three underlying diseases: LSS (*n* = 87, 62.1%), spondylolisthesis (*n* = 37, 26.4%), and degenerative disc disease (*n* = 16, 11.4%). Of the 140, 37 (26.4%) had previous lumbar spinal decompression. Preoperatively, the back pain VAS score varied from 0 to 10. The majority (47.1%, *n* = 66) had a score of 5 or less, and 74 (52.9%) more than 5.

The surgical technique was either decompression with instrumentation (*n* = 136, 97.1%) or decompression (*n* = 4, 2.9%). The instrumentation level was one level in four patients (2.9%) and two or more levels in 81 (97.1%). There were no intraoperative complications except a dural tear in one patient. The LOS from the day of admission to the day of discharge had a mean of 15.45 ± 15.3 days.

The majority (89.3%, *n* = 124) of the patients had no complications. Only a small proportion (11.4%, *n* = 16) had one or more complications [Table 2]. The mean LOS for the no complications group was 13.41 ± 10.1 days compared to 31.25 ± 32.23 for the ≥ 1 complications group, which was statistically significantly different ($P < 0.05$). We assessed a possible correlation between smoking and LOS and postoperative complications. Both smoking and post-operative complications, as well as LOS and smoking, were not statistically significantly different ($P > 0.05$).

The BMI was calculated preoperatively, at the 6-month and the 12-month follow-ups, with means of 33.53 ± 5.85, 32.62 ± 5.7, and 33.52 ± 6.28 kg/m^2, respectively. The postoperative change in the BMI was statistically significant at the 6-month follow-up ($P < 0.05$), but not significant at the 12-month follow-up. The sample was divided into two groups: Group A (*n* = 39, BMI <30) and Group B (*n* = 101, BMI ≥30 kg/m^2) to assess whether there was any difference in the BMI change at the two follow-ups between the two groups. Analysis showed that Group B had statistically significant BMI reduction at both 6-month and 12-month follow-up periods compared to Group A, which had higher BMI values at follow-up periods [Table 3]. The mean LOS for Groups A and B were 13.64 ± 8.42 and 16.15 ± 17.23 days, respectively, and the difference was not statistically significant ($P > 0.05$). At the 6-month follow-up, Group A had significantly different HbA1c values compared to Group B ($P < 0.05$), but it was not significantly different at the 12-month follow-up.

The HbA1c was measured at the same period. Of 140, only 61 (43.6%) of the patients had recorded pre-operative HbA1c values. In contrast to what was assumed, the post-operative HbA1c increased compared to pre-operative values. The pre-operative HbA1c mean was 7.15 ± 1.82, which increased to 7.21 ± 2.07 at the 6-month follow-up and 7.22 ± 1.94 at the 12-month follow-up. We also divided the patients based on the preoperative HgA1c values into two groups: Controlled (*n* = 35, HbA1c <7) and uncontrolled blood sugar (*n* = 26, HbA1c ≥7). Statistical findings after grouping showed a statistically significant difference between the two groups. The controlled group had lower HbA1c, while the uncontrolled group had higher

Table 3: Comparison of post-operative change in BMI mean at follow-up periods between Group A versus Group B.

Sample size	*n*=140	*n*=107	*n*=98
	Preoperative BMI	6-month follow-up BMI	12-month follow-up BMI
BMI group			
Group A (*n*=39, BMI<30)	26.19±2.17	26.30±2.78	26.62±2.94
Group B (*n*=101, BMI≥30)	35.93±4.60	35.08±4.52	35.88±5.29
P-value of difference in change at follow-ups		<0.0001	<0.0001

Table 4: Comparison of post-operative change in HgA1c at follow-up periods between controlled versus uncontrolled diabetes group.

Sample size	*n*=61	*n*=34	*n*=35
	Pre-operative HbA1c	6-month follow-up HbA1c	12-month follow-up HbA1c
HgA_{1C} Group			
Controlled group (*n*=35, HbA1c<7)	6.05±0.49	5.85±0.50	6.16±1.70
Uncontrolled group (*n*=26, HgA_{1C}≥7)	8.62±1.92	8.75±2.22	8.99±1.40
P-value of difference in change at follow-ups		<0.0001	<0.0001

HbA1c at 6-month follow-up. However, both groups had higher HbA1c values at 12-month follow-up, as shown in [Table 4]. The controlled group's mean LOS was 17.20 ± 22 and 17.15 ± 13.26 for the uncontrolled group, which was not statistically different. Statistically, there was no significant difference between the two HbA1c groups and the LOS or postoperative complications.

DISCUSSION

The present study did not find an improvement in the HbA1c levels post-intervention. There was a slight increase in the mean HbA1c levels at the 6-month and 12-month follow-up. The pre-operative mean HbA1c score was 7.15%, which increased to 7.21% at the 6-month follow-up and 7.22% at the 12-month follow-up. When we assessed the difference between controlled diabetes and uncontrolled group, there was a decrease in the HbA1c value at 6-month follow-up in the controlled group, while it increased in the uncontrolled group. According to the literature, regular physical activity is crucial for diabetic patients to maintain HbA1c values in the recommended range. Patients with LSS, on the other hand, are unable to perform sufficient physical activity, which might cause the HbA1c levels to fluctuate on the higher side.[18,19]

It is generally accepted that LSS decompression facilitates HbA1c reduction. A study was done to evaluate the variation in glycemic homeostasis in diabetic and LSS patients after decompression surgery. They reported a significant decrease in the HbA1c levels at the first and second assessments after the surgery.[17] A 2-year follow-up study was conducted to assess the changes in the HbA1c and BMI after a successful LSS surgery. The results highlighted a significant decrease in the HbA1c level from 7.08% to 6.58% at the first follow-up of 6-month, which remained consistent (6.59%) at 1st- and 2nd-year follow-ups.[16]

It was noticed that glycemic control indirectly improves after decompression surgery in diabetic LSS patients. The baseline HbA1c value (7.20%) significantly reduced (6.63%, $P = 0.001$) at first assessment and second assessment (6.77%, $P = 0.011$).[20] The improvement in the HbA1c level was significantly correlated with the Oswestry Disability Index score. An increased mobility status and a possible change in hormone levels, such as cortisol, may reduce the HbA1c levels.[20] A meta-analysis reported a limitation, which was a lack of glycemic data over the period for diabetic patients who underwent LSS surgery, and a lack of evidence of the effect of spinal surgery on the HbA1c level.[21] The results reported in the literature indicate that the HbA1c values tend to decrease postoperatively after LSS surgery, which is contradictory to the current study.

In the current study, the pre-operative mean BMI was 33.53 kg/m^2, and there was a significant reduction (32.62, $P < 0.05$) at the 6-month follow-up, but non-significant (33.52, $P > 0.05$) at the 12-month follow-up. In terms of the two groups: Group A (BMI <30 kg/m^2) and Group B (BMI ≥30 kg/m^2), there was a significant reduction in the mean BMI of Group A at the 6-month follow-up. The baseline mean BMI for Group B was 35.93 ± 4.60 kg/m^2 and it significantly reduced to 35.08 ± 4.52 kg/m^2 after 6 months, which is consistent with the literature. According to Kim *et al.*, there was no statistically significant difference in the mean BMI pre-intervention and post-intervention at the 2-year follow-up after LSS decompression. However, when the patients were divided into two groups (normal weight [BMI <25] and overweight [BMI >25]), there was a significant BMI reduction in the overweight group at the 2 years follow-up.[16] According to a study from the Swedish spine registry, the mean BMI (SD) at baseline was 32.8 kg/m^2 (2.5), and the average BMI reduction during follow-up was 0.6 kg/m^2 (95% CI, 0.4–0.8), the mean weight (SD) at baseline was 94.6 kg (11.9), and the average weight loss was 1.9 kg (95% CI, 1.5–2.3) 1 year after the surgery and 2.0 kg (95% CI, 1.5–2.4) 2 years after the surgery. Only 45 individuals had clinically significant weight reduction, which is relevant since weight loss is normal, obese, and morbidly obese patients is assessed differently.[22] The current study found a significant BMI reduction at the 6-month follow-up, which was non-significant at 12-month. A possible explanation is that patient compliance with the rehabilitation and physiotherapy exercises in the early postoperative period facilitates BMI reduction. However, they return to their baseline lifestyle for the long-term period, which limits further reduction.

A 10-year retrospective analysis of spinal surgeries for the degenerative disease was done to assess weight loss postoperatively. The study included 65,667 procedures, of which 19,665 were lumbar spinal fusion surgeries. The analysis was done separately for the generalized spine degenerative surgeries, surgeries for obese cases, and LSS surgeries. The results highlighted that the mean pre-operative weight for all the spinal surgeries was 91.8 kg and the mean pre-operative BMI 29.2 kg/m^2. The follow-up was conducted at a mean of 1.9 years after the surgery and the mean postoperative weight was 92.5 kg, mean BMI was 29.4 kg/m^2, and mean weight increase was 0.7 kg. The change in the mean weight ($P < 0.001$) and mean BMI ($P > 0.001$) was significant. The findings of spinal surgery in 26772 obese patients (BMI >30 kg/m^2) highlighted that the mean postoperative weight loss was 2.2 kg, and 46.9% of the patients lost 2.3 kg, 35.3% gained 2.3 kg, and 17.8% retained their weight within 2.3 kg of their pre-operative weight. It was identified that the pre-operative weight and BMI predicted the postoperative weight and BMI. The findings of the spinal surgeries revealed that the mean weight and mean BMI before surgery were 92.5 kg and 29 kg/m^2. After a mean of 1.9 years, the follow-up results showed that mean weight and mean BMI after surgery were 93.9 kg and 30 kg. The literature review indicated a variation in weight and BMI after LSS surgery, as some studies report no overall decrease in BMI, but some reported a change in BMI for the obese groups after follow-up at certain intervals.[23]

The current study found that 89.3% of the patients had no postoperative complications. However, 10.7% had one or more complications. The postoperative complications were divided into five categories: Post-operative infections, wound complications, CVS complications, thromboembolism, and renal complications. The most prevalent complications were postoperative infections (wound infection, urinary tract infection [UTI], and septicemia), with UTI the most prevalent ($n = 3$, 2.14%). The present study described that the average LOS was 15.45 ± 15.3 days. The average LOS for the patients with no complications was 13.41 ± 10.1 days compared to 31.25 ± 32.23 days for the group with more complications. Shih *et al.* evaluated the complications of LSS surgeries. There was only one wound complication (3.8%), and urinary retention was reported in 23.1%, of which 18.1% were male patients. They also reported that the LOS for open lumbar spine surgery was 2.92 days.[24] The American College of Surgeons' National Surgical Quality Improvement Program (ACS-NSQIP) conducted a study, which collected its data for 2 years from the ACS-NSQIP database to analyze the patient characteristics related to an increased LOS and readmission. The findings highlighted that the average LOS was 2.1 days and readmission due to post-operative complications 3.6%. Surgical site infection was the leading cause (25%) of the readmissions, followed by pain (9.6%), urinary tract infection (7.6%), wound seroma (5.8%), and thromboembolism (5.8%).[25] A study was done to assess the trends of complications and costs related to LSS surgery. The results indicated that the average LOS was 1.91 days, with wound complications 0.2% postoperatively. Overall, the major complications were 1.7% and 4% for elderly patients. The readmission rate at 28 days was 2.0% and the 30-day mortality 0.4%.[23]

The current study found no significant association between smoking and postoperative complications and no statistically significant difference between the LOS and the smoking and non-smoking groups. A study about the patient characteristic associated with LOS after LSS surgery described that 16% of the sample were smokers. The average LOS of the smokers was 1.8 ± 2.0 days. Smoking history was associated with a slightly decreased LOS with the bivariate analysis ($P = 0.012$).[25] A research study to identify smoking-related poor-quality outcomes in hospitalized patients due to spinal disease indicated that 10% were smokers. The findings suggested that the smokers had overall poor-quality outcomes when compared to the non-smokers. Smokers had 4.87 days mean LOS compared to 3.77 days for the non-smokers. The mean ICU admission rate of the smokers was 18% compared to 12% for the non-smokers. The mean complication rate was also higher (6.97%) compared to the non-smokers (5.24%). Similarly, the mean readmission at 7 days, 14 days, and 30 days was higher in the smoker group compared to non-smokers.[26] Smoking should be considered when planning LSS surgery and patient counseling is equally important to achieve better quality outcomes.

Limitations

This study has limitations, including the unavailability of information for the baseline HbA1c levels. The follow-up duration may be increased to 2–5 years. The study duration and a multicenter approach would facilitate the generalization of the findings. Obesity-related factors and BMI should also be considered.

CONCLUSION

Lumbar spinal decompression surgery can facilitate BMI reduction in obese patients. There is a strong need to intensively investigate the underpinning reasons for the contradicting results of an increase in the HbA1c level in the current study, as well as the variation in the BMI scores in non-obese.

RECOMMENDATIONS

A future recommendation may be to divide the HbA1c into three groups, namely, normal, prediabetic, and diabetic, as described by the CDC. Similarly, the BMI can be categorized into three groups, normal, obese, and morbidly obese. BMI and obesity should be analyzed together. There is a need for a multidisciplinary approach, which includes a dietitian, a physiotherapist, and an endocrinologist to optimize patient care and a supervised treatment plan for an extended period. Both will have an impact on BMI reduction and HbA1c control. There is also a need to control post-operative complications, especially hospital-acquired infections, which will improve the postoperative outcomes and reduce the LOS.

AUTHORS' CONTRIBUTION

FMK and SIA conceived and designed the study. MAA and TMA did the literature search. MAA, TMA, AMA, and AAA collected the data and wrote the initial draft. MAA, TMA, AMA, AAA, FHA, and MSA prepared the data collection sheet, analyzed the data, and wrote the final draft of the article. FMK and SIA reviewed and edited the manuscript. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

ETHICAL APPROVAL

The study was reviewed and approved on June 15, 2021, by the Institutional Review Board of King Abdullah International Medical Research Center, Riyadh, Saudi Arabia, under the protocol number NRC21R/192/05.

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DECLARATION OF PATIENT CONSENT

The authors certify that they have obtained all appropriate patients consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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