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Surgical Site Infection After Posterior Cervical Decompression: The Role of Adiposity-Related Factors

Bilal Younes[1], Jeyhun Farzullayev[1], Leili Kawish[1], Dorothee Mielke[1,2], Veit Rohde[1], Tammam Abboud[1]

BACKGROUND: **Local subcutaneous fat thickness has been identified as a significant predictor of surgical site infection (SSI) risk in lumbar spine procedures. This study aims to further investigate this association by comparing the impact of body mass index (BMI) and localized fat thickness at the C5 level on SSI risk in patients undergoing posterior cervical decompression without fusion.**

METHODS: **A retrospective analysis of patients treated with posterior cervical decompression without fusion or stabilization for cervical spondylotic myelopathy. A combination of univariate and multivariate analyses was employed to identify significant predictors of SSIs.**

RESULTS: **From the 346 patients, 20 (5.8%) experienced SSIs. Those with SSIs generally had higher BMIs (median 29 ± 4.6 vs. 27 ± 5.2, *P* = 0.032), greater fat thickness at C5 level (median 27 mm vs. 23 mm, *P* = 0.012), higher ratio of fat to muscle thickness (median 0.98 vs. 0.75, *P* = 0.003), and more extensive surgeries (75% had multiple levels operated compared to 55% in the non-SSI cohort, *P* = 0.001). In multivariable analysis restricted to 1 surgical and 1 patient-related factor, BMI (odds ratio = 1.10, 95% confidence interval 1.01–1.23; *P* = 0.038) and the number of operated levels (odds ratio = 2.25, 95% confidence interval 1.35–3.74; *P* = 0.002) remained independent predictors of SSI, whereas fat thickness and fat-to-muscle ratio did not provide additional predictive value beyond BMI.**

CONCLUSIONS: **This study indicates that, localized fat thickness at the C5 level was not shown to be an independent predictive factor for SSI following posterior cervical decompression. Instead, it highlights BMI and the number of operated levels as significant and quantifiable risk factors. Prompt surgical debridement should be considered the first-line treatment for deep or organ space SSIs.**

INTRODUCTION

Surgical site infection (SSI) rates following spinal surgeries vary widely, with figures ranging from 1% to 7%. Notably, the incidence of SSI after posterior cervical spine surgery presents an even broader range, from 0.5% to 18.2%, as reported in various studies.[1-5] This rate is significantly higher than that observed in surgeries employing the anterior cervical approach. SSIs are associated with prolonged hospital stays, increased readmission rates, and can quadruple overall health care costs. Identifying and understanding the risk factors for SSI is essential for developing and improving preventive strategies aimed at reducing its incidence. Established risk factors include diabetes, prolonged operative time, obesity, smoking, excessive blood loss, and immunosuppression.

Previous research has demonstrated a clear association between higher body mass index (BMI) and an increased risk of SSI following abdominal and spinal surgeries. An elevated BMI often correlates with greater subcutaneous tissue thickness. However, BMI alone does not provide sufficient insight into the localized distribution of adipose tissue, which can be critical for surgical outcomes. This has led to increased interest in measuring

Key words
- Cervical spine
- Posterior cervical decompression
- Postoperative complications
- SSI

Abbreviations and Acronyms
ASA: American Society of Anesthesiologists
BMI: Body mass index
SSI: Surgical site infection

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subcutaneous tissue thickness at specific surgical sites. The rationale is that thicker subcutaneous layers may create larger potential spaces after wound closure, complicating surgical exposure and potentially increasing the risk of tissue necrosis, thereby elevating the likelihood of SSI. Indeed, some studies have identified a positive correlation between increased peri-incisional subcutaneous fat thickness and the heightened risk of SSI following both posterior cervical and lumbar spine fusion surgeries.[6,7] However, the literature provides no data on the correlation between subcutaneous fat thickness and the risk of SSI in cases of posterior cervical surgery without additional fusion.

Unlike previous studies focusing primarily on posterior cervical fusion or combined approaches, this study specifically investigates SSI risk in patients undergoing posterior cervical decompression without fusion. This distinction is clinically relevant, as this less invasive technique may have a different risk profile that has not been fully characterized in the literature.

METHODS

This retrospective, single-center case series analyzed a cohort of 346 patients who underwent posterior cervical decompression without fusion or stabilization for degenerative cervical myelopathy at University Hospital Göttingen between 2015 and 2022.

We collected and reviewed demographic, radiological, and clinical data pre- and post-surgery, focusing on identifying potential surgical site infection (SSI) risk factors. The variables studied included age, gender, a history of diabetes, smoking status, the American Society of Anesthesiologists (ASA) classification, prior surgeries on cervical spine, length of operation, the number of levels operated, and the number of days stayed postoperatively. We also analyzed the incidence of SSI, including the associated microorganisms. The height and weight of patients at the time of the index surgery were recorded to calculate their BMI. Patients with varying degrees of neurological impairment due to degenerative cervical myelopathy were included in the study. Cases involving fusion constructs from the occiput to C7 were excluded from the analysis. Tumor and trauma cases were not included. All participants had undergone preoperative magnetic resonance imaging of the cervical spine. Patient identification for inclusion was done using concurrent International Classification of Diseases, 10th Revision (ICD-10) codes specific to posterior cervical spine decompression.

Operative Technique

Unilateral cervical decompression was performed as described by Mielke and Rohde.[8] After a midline skin incision, the muscle fascia is incised, and the muscle is detached from the hemilamina(e). Depending on the number of involved segments, a laminotomy or hemilaminectomy is performed under the microscope. A 5-mm diamond drill is used to remove the base of the spinous process from the medial hemilaminectomy edge to the contralateral medial facet joint, thinning the inner contralateral hemilamina(e) without breaching the outer corticalis. The usually hypertrophic yellow ligament is removed with a Kerrison rongeur until the contralateral dorsal nerve root is exposed. We did not use any tubular or endoscopic approaches in any case within this cohort. The wound is closed routinely without suction drainage (Figure 1).

Surgical Site Infection (SSI)

SSIs were defined and categorized as every infections occurring within 30 days postsurgery, following the guidelines set by the Centers for Disease Control and Prevention. Infections were identified based on local wound abnormalities such as redness, localized pain, delayed wound healing, and purulent discharge, with or without systemic signs of infection (e.g., fever and elevated inflammatory markers).

Measurement of Fat Thickness

For measuring subcutaneous fat and muscle thickness, we defined fat thickness as the distance from the dorsal-most point of the C5 spinous processes to the back skin and maximum muscle thickness as the distance from the lamina to the dorsal-most point of the C5 spinous process. All measurements were taken from axial and sagittal reformats in magnetic resonance imaging scans and were standardized to ensure uniformity (Figure 2).

Data Management and Statistical Analysis

Data capture was systematic and was entered into an Excel database (Microsoft Corp.). For the statistical analysis, the data were exported to SPSS and analyzed using IBM SPSS Statistics version 27.0 (IBM Corp, Released 2016, IBM SPSS Statistics for Windows, version 27.0, Armonk, NY, USA).

Associations between patient characteristics (age, gender, diabetes status, smoking status, ASA classification, BMI, and radiological fat parameters) and the development of SSI were first explored using bivariate analysis. Continuous variables such as age and BMI were analyzed with the Student's t-test or Mann-Whitney U test, depending on data distribution. Categorical variables, including gender, diabetes status, and number of operated levels, were compared using the χ^2 test or Fisher's exact test as appropriate.

Variables with a $P < 0.10$ in univariate analysis were considered candidates for multivariable modeling. To comply with established recommendations regarding the ratio of outcome events to predictors and to avoid model overfitting, the multivariable analysis was restricted to 2 predictors—1 surgical and 1 patient-related factor.

A Firth bias-reduced logistic regression model was used to address potential small-sample bias and improve estimate stability. The possible contribution of local adiposity, represented by fat thickness at the C5 level, was further evaluated in a sensitivity analysis to explore whether localized fat distribution provided additional predictive information beyond general obesity.

Multicollinearity among adiposity-related measures (BMI, fat thickness at C5, and fat-to-muscle ratio) was examined using variance inflation factor values. Model discrimination and calibration were assessed using the area under the receiver operating characteristic curve, calibration slope, and Brier score, with optimism correction performed through 1000 bootstrap resamples. A $P < 0.05$ was considered statistically significant.

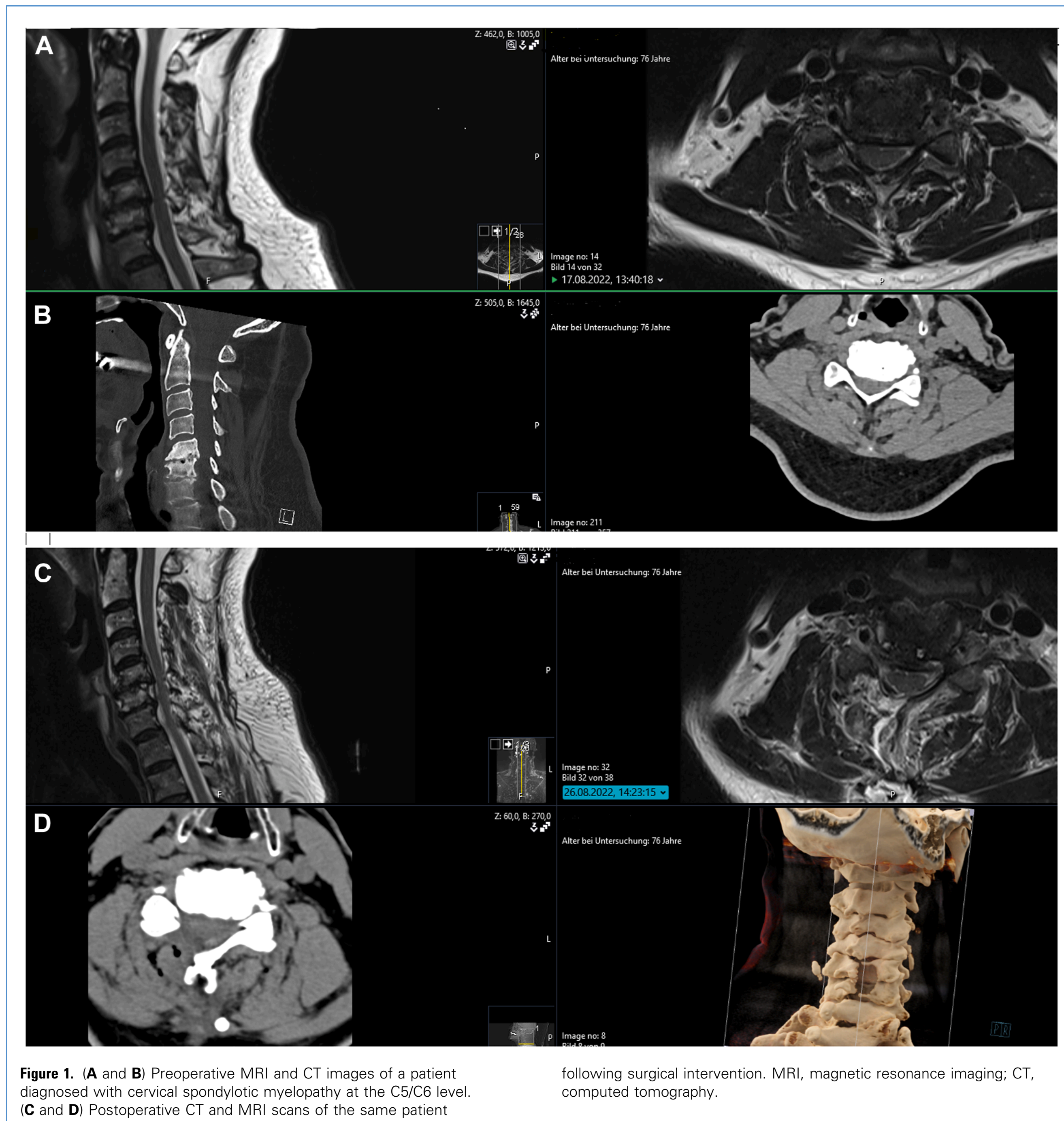

Figure 1. (**A** and **B**) Preoperative MRI and CT images of a patient diagnosed with cervical spondylotic myelopathy at the C5/C6 level. (**C** and **D**) Postoperative CT and MRI scans of the same patient following surgical intervention. MRI, magnetic resonance imaging; CT, computed tomography.

RESULTS

The cohort's mean age was 65 years. Values if descriptive with a gender distribution of 65% male (n = 225) and 35% female (n = 121). Diabetes was present in 16.8% (n = 58) of patients. The mean BMI was 27.8 ± 5.2 kg/m². Smoking was reported by 28.3% of the patients (n = 98). Details of ASA classification, length of surgery, and hospital stay are presented in **Table 1**. One hundred ninety-five patients (56%) received decompression of more than 1 level. Seven patients (2%) developed an epidural hematoma in the surgical access area, of which 6 underwent hematoma evacuation.

Among the 346 patients, 20 (5.8%) developed SSI. All SSIs manifested within four weeks postoperatively, and 16 already (80%) during hospital stay. Microbiologic cultures were obtained from all 20 patients diagnosed with SSIs (SSIs), with 12 individuals (60%)

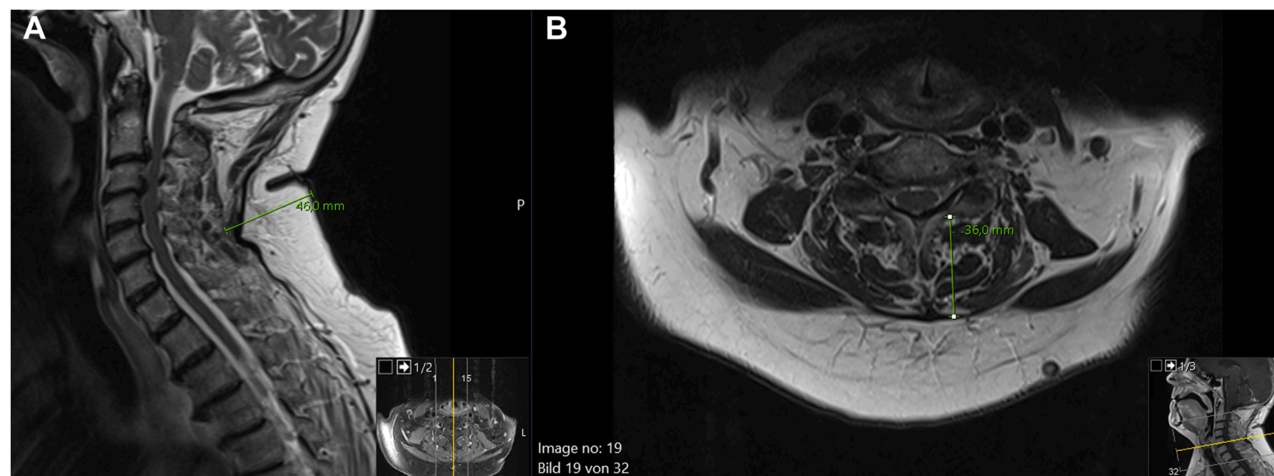

Figure 2. (**A**) Fat thickness, measured as the distance from the dorsal-most point of the C5 spinous process to the overlying skin. (**B**) Maximum muscle thickness, measured as the distance from the lamina to the dorsal-most point of the C5 spinous process.

exhibiting positive cultures. *Staphylococcus aureus* was identified in 8 cases (40%) of the positive cultures, and *Staphylococcus epidermidis* and Enterococcus spp. complex in 2 patients each.

Management of SSI

All patients with SSI received long-term antibiotic treatment in accordance with the results of antibiotic susceptibility testing. Conservative management of SSI failed in 17 of 20 patients (85%), who had to undergo wound debridement, while one of them (5%) had to be treated with additional vacuum-assisted closure therapy. In the remaining 3 patients (15%), conservative management was successful.

Analysis

Patients who developed SSI did not differ from those who did not regarding age, gender, rate of diabetes, smoking status, ASA, prior surgeries on the cervical spine, or length of operation. Occurrence of epidural hematoma and its surgical treatment did not correlate with SSI ($P = 0.995$).

Patients with SSIs generally had higher BMIs (median 29 ± 4.6 vs. 27 ± 5.2, $P = 0.032$, Figure 3), greater fat thickness (median 27 [18–38] mm vs. 23 [15–36] mm, Figure 4), and more extensive surgeries, with a higher median number of operated levels in the SSI group (2.4) compared to the non-SSI group (1.75), whereas 75% of the SSI patients underwent more than 1 level of surgery, compared to 55% in the non-SSI group ($P = 0.001$, Figure 5).The ratio of fat-to-muscle thickness was also higher in the SSI group (median 0.98 vs. 0.75, $P = 0.003$). Additionally, the occurrence of SSI resulted in a prolonged hospital stay (median 12 days vs. 7 days, $P \leq 0.001$). All results of univariate analysis are presented in Table 2.

Multivariable Analysis

The multivariable logistic regression model was limited to 2 predictors, representing 1 surgical and 1 patient-related factor, in accordance with the predefined analytic strategy. In the Firth bias-reduced logistic regression, BMI and the number of operated levels were independently associated with the occurrence of SSI. Each 1-kg/m^2 increase in BMI increased the odds of SSI by approximately 10% (odds ratio = 1.10; 95% confidence interval 1.01–1.23; $P = 0.038$), and multilevel surgery more than doubled the risk (odds ratio = 2.25; 95% confidence interval 1.35–3.74; $P = 0.002$).

When fat thickness at the C5 level was added to the model in a sensitivity analysis, it did not significantly improve model fit (likelihood-ratio $P = 0.18$) and its effect estimate was attenuated, indicating that localized adiposity did not provide additional predictive value beyond BMI. A similar finding was observed for the fat-to-muscle ratio, which also failed to demonstrate an independent association with SSI after accounting for BMI.

Multicollinearity testing among adiposity-related variables revealed strong intercorrelations between BMI and local fat measurements, indicating overlapping predictive information. Penalized (ridge and elastic-net) logistic regression and exact logistic regression yielded consistent results, confirming the stability of the findings across different analytical approaches.

Internal validation by 1000-sample bootstrap resampling demonstrated good model performance (optimism-corrected area under the receiver operating characteristic curve = 0.73, calibration slope = 0.96, Brier score = 0.055), indicating adequate discrimination and calibration of the final model.

DISCUSSION

Surgical site infections represent a prevalent complication associated with spine surgery, thereby amplifying patient morbidity and mortality rates. In this study, we presented a large series of patients who received posterior cervical decompression. A

Table 1. Patient Characteristics

Characteristic	Value
Total number of patients	346
Mean age (years)	65 ± 12
Gender	
Male	225 (65%)
Female	121 (35%)
Mean BMI	27.8 ± 5.2 kg/m^2
BMI categories	
<18.5	6
18.5—24.9	93
25.0—29.9	146
>30.0	81
Smoking	98 (28.3%)
Diabetes	58 (16.8%)
Mean muscle thickness at C5	34 ± 7.6 mm
Mean fat thickness at C5	25 ± 11 mm
Mean FT/MT	0.76
ASA classification	
Class I	52 (15%)
Class II	195 (56.4%)
Class III	99 (28.6%)
Class IV	0 (0%)
Prior cervical spine surgeries	20 (6.4%)
Number of operated levels	
1	151 (43.6%)
2	136 (39.3%)
3	46 (13.3%)
4	10 (2.9%)
5	3 (0.9%)
Mean length of surgery (minutes)	120 ± 57
Mean hospital stay (days)	8.3 ± 5.1
SSI	20 (5.8%)
Microbiological findings	
Staphylococcus aureus	8
Staphylococcus epidermidis	2
Enterococcus spp. complex	2

BMI, body mass index; ASA, American Society of Anesthesiologists; SSI, surgical site infection; FT/MT, fat-to-muscle ratio.

comprehensive analysis was conducted, investigating all factors that can be associated with SSI. Surgery-related risk factors included the number of operated levels and the duration of surgery. Patients' dependent risk factors included age, obesity, diabetes, smoking, and ASA classification.

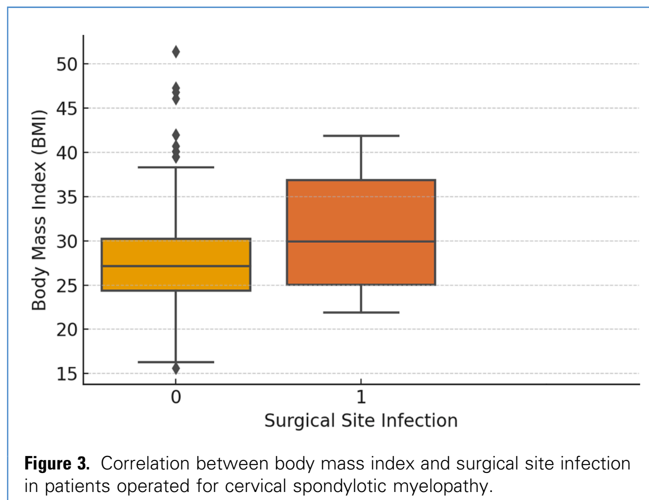

Figure 3. Correlation between body mass index and surgical site infection in patients operated for cervical spondylotic myelopathy.

Surgery-Related Risk Factors

We found that number of operated levels was an independent factor predicting postoperative SSI. Patients who were operated on more than 1 level had a 2-fold higher risk of developing SSI. Although the correlation between number of fused levels and SSI has been reported before,[9] our study is the first to highlight this risk during decompression surgery.

Duration of surgery, which is one of the known risk factors for SSI, was not found to be significant in the context of dorsal cervical compression. This can be attributed to the relatively short surgery duration compared with fusion surgery. Another known risk factor is blood loss.[10] Estimated blood loss over 1 L was reported to increase risk of SSI in spine surgery.[11] We did not address this aspect in our study, as blood loss during dorsal cervical decompression is unlikely to exceed the limit of 1 L. We also assessed the frequency of an operation-associated spinal

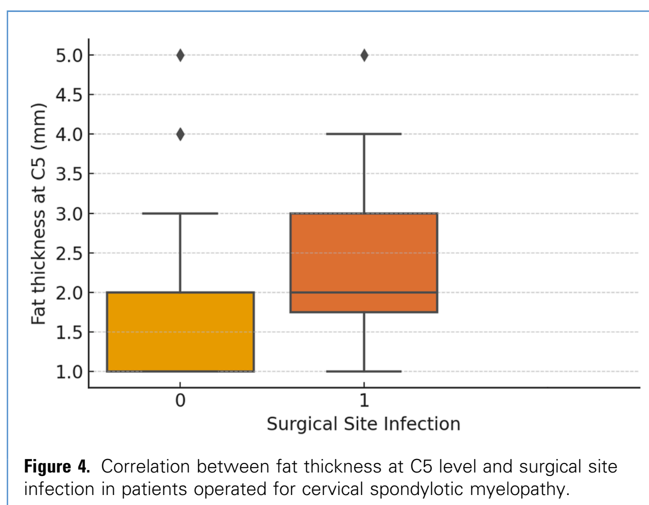

Figure 4. Correlation between fat thickness at C5 level and surgical site infection in patients operated for cervical spondylotic myelopathy.

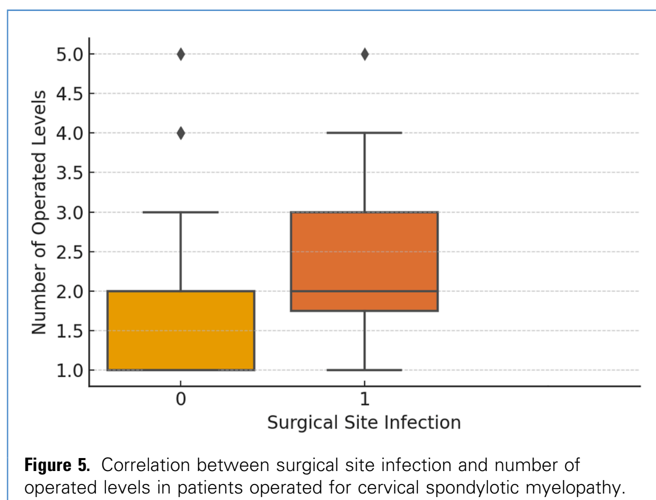

Figure 5. Correlation between surgical site infection and number of operated levels in patients operated for cervical spondylotic myelopathy.

epidural hematoma. Its occurrence rate was as low as 2% and did not correlate with SSI.

Patients' Dependent Risk Factors, BMI, or Fat-Index?

SSI in general might be associated with several patient characteristics, including age, smoking, diabetes, obesity, and previous surgeries. However, only a few of these factors were reported to be of significance in the context of dorsal cervical surgery. Obesity expressed by BMI or nuchal thickness was the most frequently reported factor to be associated with SSI among multiple studies addressing dorsal cervical spine surgery.[7,12-17] In posterior cervical fusion surgery, studies with large patient cohorts confirmed BMI as a clear risk factor for SSI.[12,16] However, current literature indicates that local fat distribution may have higher impact on SSI than general obesity in patients undergoing lumbar surgery,[18,19] and recent series suggested that increased surgical site subcutaneous fat thickness[13] and precisely increase fat-index[15,17] that are associated with higher risk of SSI following cervical spine surgery. Although both fat thickness and the fat-to-muscle ratio were significantly associated with SSI in univariate analysis, these associations lost significance in the multivariable model. This finding most likely reflects strong collinearity with BMI, which is inherently correlated with localized fat measurements. Evaluation of multicollinearity confirmed substantial overlap among adiposity-related variables, indicating that these measures capture similar aspects of patient body composition rather than independent risk factors.

Table 2. Univariate Analysis Including Factors Associated with SSI and FT/MT

	SSI Group (n = 20)	Non-SSI Group (n = 326)	*P* Value
Age (mean, years)	65 ± 8.3	64.9 ± 9.1	0.945
Gender (F:M)	8:12	121:225	0.627
BMI (mean, kg/m2)	29 ± 4.6	27 ± 5.2	0.032*
Diabetes mellitus	5:15	58:288	0.310
Smoking	4:16	98:248	0.685
ASA classification			0.168
Muscle thickness an C5 (median, range, mm)	33 [21—45]	34 [20—46]	0.557
Fat thickness at C5 (median, range, mm)	27 [18—38]	23 [15—36]	0.012*
FT/MT	0.98	0.75	0.003*
Length of surgery (median, range, minute)	131 [70—200]	120 [60—190]	0.415
Number of operated levels (median, range)	2.4 [1—4]	1.75 [1—4]	0.001*

BMI, body mass index; ASA, American Society of Anesthesiologists; SSI, surgical site infection; FT/MT, fat-to-muscle ratio.
*Significant value.

Our series is important as it addresses a specific surgical approach, namely, unilateral cervical decompression, while most studies included dorsal cervical fusion with or without laminectomy. We found an SSI rate of 5.8%, which lies within the range of reported SSI rates in the literature of 4—11%.[7,12,13,15] Our results indicate that the less invasive surgical approach does not reduce the risk of SSI in comparison to other dorsal cervical spine approaches and that BMI is the decisive factor among patient-related risk factors to be considered when counseling patients regarding postoperative SSI.

Medical versus Surgical Treatment of SSI

Medical treatment was applied in all patients suffering from SSI in this series. However, revision surgery was required in most cases (85%). Similarly high rate of repeated surgery for treatment of SSI was reported previously (3). This suggests that earlier surgical intervention to treat SSI, following dorsal cervical decompression is superior to medical treatment and encourages earlier surgical intervention to avoid longer hospital stays and in-hospital complications. However, larger studies will be needed to clarify the question of the optimal time of surgical intervention for the treatment of SSI.

CONCLUSION

This study concludes that the risk of SSI following posterior cervical decompression increases with both the number of operated levels and higher BMI. In contrast, localized fat parameters—including fat thickness at C5, and the fat-to-muscle ratio were not independently associated with SSI risk after adjusting for confounding variables. Prompt surgical debridement should be considered the first-line treatment for deep or organ space SSIs.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Bilal Younes: Writing — review & editing, Writing — original draft, Data curation. **Jeyhun Farzullayev:** Writing — original draft. **Leili Kawish:** Data curation. **Dorothee Mielke:** Supervision. **Veit Rohde:** Supervision, Project administration. **Tammam Abboud:** Writing — review & editing, Supervision, Project administration.

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