The Effect of Diabetes Mellitus on the Neurological Function of Patients with Cervical Spondylotic Myelopathy

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Objective: To evaluate the clinical value of diabetes mellitus for diagnosis and postoperative prognosis in patients with cervical spondylotic myelopathy undergoing anterior decompression and fusion.

Methods: A total of 84 Patients (50 males and 34 females) who underwent anterior decompression and fusion were reviewed in this single-center retrospective study. The patients were divided into two groups (44 patients in the diabetes mellitus group and 40 in the non-diabetic group). Clinical manifestations were evaluated, including characteristics baseline, clinical tests, MRI information, clinical scores, and complications. The predictive effect of diabetes mellitus on clinical scores were assessed via the receiver operating characteristic curve. The correlation between the severity of diabetes mellitus and neurological function recovery was estimated using the Pearson correlation coefficient.

Results: Patients with diabetes mellitus exhibited a higher ratio of hyperintensity of the spinal cord (P < 0.05) and worse preoperative clinical scores and neurological recovery (all P < 0.05). Receiver operating characteristic curve results indicated that diabetes mellitus could serve as a good indicator for preoperative evaluation of the Japanese Orthopedic Association (JOA) score (area under curve [AUC] = 0.639), visual analogue score (AUC = 0.642), and Nurick score (AUC = 0.740). In addition, analysis of JOA in isolation suggested that diabetes mellitus correlated closely with the sensory function in the upper and lower limbs (both P < 0.01). The Receiver operating characteristic curve also demonstrated that diabetes mellitus as a clinical test had a reasonable specificity for sensory function in the upper (AUC = 0.654) and lower limbs (AUC = 0.671). Both the level of HbA1c and the duration of diabetes mellitus were negatively correlated with the recovery rate of the JOA score. There was no significant difference between the perioperative complications between the two groups (P > 0.05).

Conclusion: This present study revealed that the neurological impairment caused by diabetes mellitus in patients undergoing anterior decompression and fusion does not only affect postoperative functional recovery but also interferes with the preoperative clinical manifestations, especially the sensory function in the upper and lower limbs.

Key words: Cervical spondylotic myelopathy; Clinical outcomes; Diabetes mellitus; Diabetic peripheral neuropathy; Neurological recovery
**Introduction**

Cervical spondylotic myelopathy (CSM) has ranked as one of the most common cervical degenerative diseases among adults over 55 years old.\(^1\)\(^2\) Patients with CSM frequently exhibit severe manifestations due to its nature of insidious onset, and functional impairment in these patients can significantly reduce independence and quality of life. Thus, immediate surgical decompression has been the preferred option to decompress the spinal cord to prevent further spinal cord damage. It has been reported that many factors correlate closely with postoperative outcomes, including duration of symptoms, age, preoperative neurological status, and signal changes within the spinal cord.\(^3\)\(^4\) Anterior decompression and fusion (ADF) is an effective surgical method in treating CSM; it can bring about good outcomes and high fusion rates.

Diabetes mellitus (DM) is one of the most age-related chronic systemic diseases. The high global prevalence of diabetes among adults aged 20–79 has imposed numerous economic burdens on society.\(^7\) The possibility of DM should be considered in the differential diagnosis of many neurologic conditions, because peripheral nerves, autonomic nerves, cranial nerves, spinal cord and brain are all frequently involved in DM. DM has recently aroused wide public attention in DM groups. The results were primarily to compare differences in neurological function recovery.

**Methods and Materials**

This study is a single-center retrospective study. The subjects were selected from CSM patients who underwent ADF in our institution from May 2017 to February 2019, and the grouping method was whether they had DM or not. The two groups were mainly divided into the DM and non-DM groups. The results were primarily to compare differences in neurological function recovery.

**Ethical Considerations**

The independent ethics committee (IEC) of Shanghai Changzheng Hospital approved the study protocol (Approval No.2017SL030). The IEC agreed that this study would not raise patients’ risk or cause any extra harm to patients. The IEC further agreed that the investigation is in accordance with the Declaration of Helsinki and that the study will be conducted without ethics problems.

**Inclusion and Exclusion Criteria**

Patients were enrolled if they satisfied the following criteria: (i) with CSM and underwent ADF; (ii) without obvious response to conservative more than 3 months; (iii) had complete medical records including patients’ baseline characteristics, physical examination, clinical evaluations, and imaging information; and (iv) had MRI suggesting evident compression of neural elements.

The exclusion criteria were as follows: (i) with a previous history of spine surgery due to trauma, infection, or tumor; (ii) clinical symptoms resulting from thoracic or lumbar degenerative disease; (iii) clinical symptoms inconsistent with radiological results; (iv) combined with neurological diseases such as Parkinson and Alzheimer dementia; and (v) with congenital or degenerative spine deformity.

**Evaluation of the Severity of DM**

The amount of HbA1c produced is closely related to the level of blood glucose, and HbA1c is much more stable than blood glucose, so the measurement of HbA1c can reflect the average level of blood glucose in a period of 8–12 weeks before this blood draw and is an excellent indicator to reflect the quality of blood glucose control over a long period. We recorded the time of diagnosis of DM and the last preoperative measurement of HbA1c (usually on the final morning before the operation day) to assess the DM group’s severity.

**Preoperative Clinical Manifestations**

The clinical tests for myelopathy were carried out within 2 h after admission and performed blindly and independently by two spine surgeons. In addition, the two examiners were blinded to mutual results, the patients’ imaging information, and the patients’ initial diagnosis. The final diagnosis was determined by the consensus of the two clinicians. All patients underwent preoperative radiological examination of the cervical spine.

**Evaluation of the Clinical Outcomes and Perioperative Complications**

Visual analogue scale (VAS) score was used to evaluate patients’ pain index. Neurological function was assessed by the Japanese Orthopedic Association (JOA) score, Nurick score, before surgery and at the follow-up. The recovery rate of JOA was calculated as follows: The recovery rate of JOA = (final JOA score – preoperative JOA score/17 – preoperative JOA score) × 100%. In addition, the preoperative...
and follow-up JOA score was further evaluated intergroup in isolation. Perioperative complications were recorded.

**Statistical Analysis**

Data were analyzed using SPSS (Version 20.0; IBM Corp., Armonk, NY, USA). The data were expressed as the mean ± standard deviation. Independent-sample t-test was used to compare the difference in demographic profile and clinical outcomes (JOA, VAS, and Nurick score) between the two groups. The chi-square test or Fisher’s exact test was used in the comparisons of the gender, vertebral surgery segment, preoperative symptoms sign (neck pain, radiating pain of upper extremities, myelopathy symptoms, hyperintensity of the spinal cord, and clinical test items), and perioperative complications between the two groups. The sensitivity and specificity of DM predicting clinical scores were evaluated via the receiver operating characteristic (ROC) curve. The correlation between the recovery rate of neurological function and HbA1C/Duration time of DM was estimated using the Pearson correlation coefficient (r). Values less than 0.05 ($P < 0.05$) were considered statistically significant.

**Results**

**Characteristic Baseline**

Table 1 showed the demographic characteristics of patients. There were 44 patients (28 males and 16 females) in the DM group and 40 (22 males and 18 females) in the non-DM group. The mean age of patients was 56.81 ± 11.01 years in the DM group and 55.93 ± 10.86 years in the non-DM group. The mean follow-up period was 12.39 ± 4.18 months in the DM group and 12.15 ± 6.65 months in the non-DM group. No difference was observed between the two groups regarding gender, age, and follow-up period.

**Clinical Evaluation**

Regarding the patient’s preoperative symptoms, patients in the DM group showed a relatively high incidence of radiation pain and numbness in the upper extremity (both $P < 0.05$). Patients in the DM group also exhibited a higher ratio of hyperintensity in the spinal cord, knee-jerk reflex, and ankle clonus preoperatively ($P < 0.05$). With regards to outcomes of preoperative clinical scores, patients in the DM group showed higher Nurick ($P < 0.05$) and VAS scores ($P < 0.001$) and lower JOA score ($P < 0.05$) than patients in the non-DM group (Table 2).

Table 3 showed perioperative information and postoperative clinical scores at the final follow-up. Although postoperative clinical scores of patients in both groups improved to some extent, JOA ($P < 0.01$), Nurick ($P < 0.05$), and VAS ($P < 0.001$) of patients in the DM group were worse than those in the non-DM group. The recovery rate of the JOA score in the DM group was also lower than in the non-DM group ($P < 0.05$).

**The JOA Score in Isolation**

To investigate the specific effect of DM on patients’ preoperative dysfunction, we further analyzed JOA items in isolation (Table 4). The results showed that the preoperative sensory function score of the upper and lower extremities was significantly worse in patients with DM than in non-DM patients (both $P < 0.01$). The postoperative sensory function score of the upper ($P < 0.001$) and lower ($P < 0.05$) extremities in the DM group was lower than that in the non-DM group. At the same time, the postoperative trunk sensory function of patients in the DM group was also worse than that of the non-DM group ($P < 0.05$) (Table 4).

**Comparison of Clinical Characteristics Based on the Recovery Rate**

We further divided the patients into two groups according to the recovery rate of JOA score (group less than 75% and group more than 75%). As shown in Table 5, a large proportion of patients with a recovery rate of less than 75% have DM ($P < 0.05$). Furthermore, for preoperative JOA and Nurick scores, patients with a recovery rate of more than 75% had significantly better clinical scores (all $P < 0.05$). Moreover, although there was only a significant difference in sensory function in the lower extremity, all the isolated items of the JOA score were worse in the patients with a recovery

**TABLE 1** General characteristics

| Gender, no. | DM(+) | DM(-) | Statistic | P value |
|-------------|-------|-------|-----------|---------|
| Male        | 28    | 22    | $X^2 = 0.641$ | 0.421 |
| Female      | 16    | 18    |           |         |
| Age, Years  | 55.95 ± 9.22 | 57.63 ± 8.80 | $t = -0.849$ | 0.399 |
| Duration of symptoms, Months | 16.89 ± 5.21 | 18.00 ± 4.79 | $t = -1.02$ | 0.313 |
| Period of follow-up, Months   | 12.39 ± 4.18 | 12.15 ± 6.65 | $t = 0.197$ | 0.919 |
| Surgical segment | 2     | 11    | $X^2 = 0.038$ | 0.981 |
|             | 3     | 19    |           |         |
|             | 4     | 14    |           |         |

Note: + indicated positive DM, − indicated negative DM.
rate of less than 75%. The above results indicated that poor clinical recovery might relate closely to worse preoperative clinical manifestations.

The ROC Curve for Clinical Scores
The ROC curve suggested DM as a good indicator for preoperative clinical scores (Fig. 1). The sensitivity of DM relative to preoperative VAS score was 65.00%, and specificity was 75.00%. The area under curve (AUC) of DM predicting preoperative VAS score was 0.740 ($P = 0.0002$; 95% confidence interval [CI], 0.634–0.846).

For the JOA score, DM was found to have a sensitivity of 68.18%, specificity of 52.50%, and the AUC was 0.639 ($P = 0.029$; 95% CI, 0.520–0.757). In addition, for Nurick score, the sensitivity was 95.45% and the specificity was 25%, with the AUC of 0.642 ($P = 0.025$; 95% CI, 0.523–0.762).

For the preoperative JOA score in isolation, the ROC curve indicated that DM had a sensitivity of 56.82%, specificity of 70% for the sensory function of the upper extremity, and a specificity of 75% for the sensory function of the lower extremity.

### TABLE 2 Preoperative clinical evaluation

| Pain symptoms | DM(+) | DM(-) | Statistic | P value |
|---------------|-------|-------|-----------|---------|
| Neck pain, no (%) | 8(18.2%) | 10(25%) | $X^2 = 0.58$ | 0.447 |
| Radiating pain, no (%) | 26(59.1%) | 13(32.5%) | $X^2 = 5.956$ | 0.015 |
| myelopathy symptoms | | | | |
| Numbness, no (%) | 29(66.0%) | 15(37.5%) | $X^2 = 6.779$ | 0.009 |
| Weakness, no (%) | 35(79.5%) | 27(67.5%) | $X^2 = 1.573$ | 0.210 |
| High signal in spinal cord | 27(61.3%) | 15(37.5%) | $X^2 = 7.473$ | 0.029 |
| Knee-jerk reflex (hyperfunction) | 9(20.5%) | 24(60%) | | <0.001 |
| Ankle clonus (hyperfunction) | 11(25%) | 24(60%) | | 0.001 |
| Hoffman sign positive | 13(29.5%) | 19(47.5%) | $X^2 = 2.864$ | 0.091 |
| Babinski sign positive | 1(2.2%) | 2(5%) | $X^2 = 0.447$ | 0.603 |
| Preoperative clinical scores | | | | |
| JOA | 11.090 ± 2.49 | 12.28 ± 2.43 | $t = 2.205$ | 0.030 |
| Nurick | 2.84 ± 0.86 | 2.33 ± 1.02 | $t = 2.509$ | 0.014 |
| VAS | 4.48 ± 2.01 | 3.03 ± 1.12 | $t = 4.041$ | 0 |

Note: + indicated positive DM, - indicated negative DM.; Abbreviations: JOA, Japanese orthopedic association; VAS, visual analogue scale/score

### TABLE 3 Perioperative period and postoperative conditions

| Recovery rate grouping | DM(+) | DM(-) | Statistic | P value |
|------------------------|-------|-------|-----------|---------|
| <50% | 2 | 2 | | |
| <75% | 34 | 20 | | |
| >75% | 8 | 18 | | |
| Isolated post-JOA upper extremity | | | | |
| Motor function | 3.59 ± 0.58 | 3.43 ± 0.59 | $t = 1.289$ | 0.201 |
| Sensory function | 1.27 ± 0.45 | 1.73 ± 0.51 | $t = 4.311$ | 0 |
| Lower extremity | | | | |
| Motor function | 3.66 ± 0.53 | 3.65 ± 0.53 | $t = 0.079$ | 0.938 |
| Sensory function | 1.61 ± 0.49 | 1.88 ± 0.46 | $t = -2.498$ | 0.014 |
| Sensory function in trunk | 1.84 ± 0.37 | 2.03 ± 0.36 | $t = -2.319$ | 0.023 |
| Bladder function | 2.89 ± 0.32 | 2.88 ± 0.33 | $t = 0.199$ | 0.874 |
| Complications | | | | |
| Wound infection, no. (%) | 2(4.5%) | 1(2.5%) | $X^2 = 0.252$ | 1.000 |
| Dysphagia, no. (%) | 1(2.3%) | 1(2.5%) | $X^2 = 0.005$ | 1.000 |
| Hoarseness, no. (%) | 4(9.1%) | 4(10%) | $X^2 = 0.020$ | 1.000 |
| CS-Palsy, no. (%) | 6(11.4%) | 3(7.5%) | $X^2 = 0.359$ | 0.715 |
| Length of stay (days) | 11.5 ± 3.6 | 9.7 ± 2.7 | $t = 2.466$ | 0.016 |
| Operation time (min) | 155.61 ± 21.66 | 163.83 ± 28.055 | $t = -1.491$ | 0.135 |
| Blood loss(mL) | 107.45 ± 19.03 | 112.50 ± 23.89 | $t = -1.099$ | 0.275 |

Note: + indicated positive DM, - indicated negative DM.; Abbreviations: JOA, Japanese orthopedic association; VAS, visual analogue scale/score
TABLE 4 Preoperative isolated JOA score

| Isolated Pre-JOA | DM(+) | DM(-) | Statistic | P value |
|-----------------|-------|-------|-----------|---------|
| Upper extremity |       |       |           |         |
| Motor function  | 2.66 ± 0.61 | 2.65 ± 0.74 | t = 0.062 | 0.951   |
| Sensory function| 0.55 ± 0.70  | 0.98 ± 0.77  | t = 2.688 | 0.009   |
| Lower extremity |       |       |           |         |
| Motor function  | 2.82 ± 0.97  | 2.80 ± 0.91  | t = 0.088 | 0.930   |
| Sensory function| 0.84 ± 0.71  | 1.33 ± 0.80  | t = 2.937 | 0.004   |
| Sensory function in trunk | 1.59 ± 0.66 | 1.70 ± 0.65 | t = 0.763 | 0.447   |
| Bladder function| 2.64 ± 0.72  | 2.83 ± 0.50  | t = 1.383 | 0.170   |

Note: + indicated positive DM, - indicated negative DM.; Abbreviations: JOA, Japanese orthopedic association.

TABLE 5 Clinical characteristics of patients based on the recovery rate of JOA score

|               | RR < 75% | RR > 75% | Statistic | P value |
|---------------|----------|----------|-----------|---------|
| Duration of symptoms, Months | 10.6 ± 5.4 | 11.6 ± 6.6 | X² = 2.036 | 0.154   |
| High signal in spinal cord | 30 | 12 | X² = 7.051 | 0.008   |
| Preoperative clinical scores | | | | |
| Pre-JOA | 11.4 ± 2.62 | 13.0 ± 2.36 | t = -2.797 | 0.011   |
| Pre-Nurick | 2.75 ± 0.95 | 2.21 ± 0.93 | t = -2.394 | 0.020   |
| Pre-VAS | 3.46 ± 1.42 | 3.93 ± 1.93 | t = -1.951 | 0.269   |
| Isolated pre-JOA | | | | |
| Upper extremity |       |       |           |         |
| Motor function  | 2.60 ± 0.67  | 2.79 ± 0.66  | t = -1.200 | 0.237   |
| Sensory function| 0.72 ± 0.76  | 0.83 ± 0.76  | t = -0.634 | 0.527   |
| Lower extremity |       |       |           |         |
| Motor function  | 2.73 ± 0.97  | 3.00 ± 0.83  | t = -1.180 | 0.241   |
| Sensory function| 0.88 ± 0.76  | 1.54 ± 0.66  | t = -3.956 | 0       |
| Sensory function in trunk | 1.70 ± 0.74 | 1.83 ± 0.82 | t = -0.693 | 0.472   |
| Bladder function| 2.65 ± 0.67  | 2.92 ± 0.28  | t = -1.782 | 0.078   |

Note: + indicated positive DM, - indicated negative DM.; Abbreviations: JOA, Japanese orthopedic association; VAS, visual analogue scale.

Fig. 1 ROC curve of diabetes mellitus for preoperative clinical scores. (A), ROC curve of DM for preoperative JOA score showed DM is related to preoperative neurological impairment. (B), ROC curve of DM for preoperative VAS showed DM is related to preoperative pain symptoms. (C), ROC curve of DM for preoperative Nurick score showed DM is related to preoperative neurological impairment.
and the AUC was 0.654 ($P = 0.015$; 95% CI, 0.536–0.771). For sensory function of lower extremity, the sensitivity was 52.50%, and specificity was 81.82%, with the AUC of 0.671 ($P = 0.007$; 95% CI, 0.553–0.788) (Fig. 2).

The ROC curve of the recovery rate of JOA suggested the sensitivity of DM relative to the recovery rate of JOA score was 45.00%, the specificity was 81.82%, and the AUC was 0.612 ($P = 0.078$; 95% CI, 0.487–0.737) (Fig. 3).

**Perioperative Complications**
Among the indicators related to perioperative complications, the DM group’s hospitalization duration was longer than that of the non-DM group ($P < 0.05$). There was no significant difference in other indicators.

**The Correlation between the Severity of DM and RR of JOA Score**
Fig. 4 showed that the severity of DM, such as HbA1c level and duration time of DM, is negatively correlated with neurological function recovery. The recovery rate of the JOA score significantly decreased when the HbA1c level and duration time of DM increased.

**Discussion**
In recent years, the incidence of DM in the general population has been increasing. By 2030, the number of DM patients is projected to grow to 439 million. Similarly, CSM is one of the most common spinal diseases and has seen a two-to seven-fold increase in the number of operations compared to the last decades. DM may dampen or promote some neurological symptoms of CSM and may adversely affect surgical outcomes. Kawaguchi et al. reported that DM patients undergoing cervical spine surgery might have worse neurological recovery in the lower extremities, and
Dokai et al.\(^9\) said that the DM group showed poorer recovery of sensory and motor function in the lower extremities postoperatively and a negative correlation between preoperative HbA1c levels and recovery of patients with DM. Kim et al.\(^{14}\) also showed that compared to those without DM, the postoperative recovery rate of JOA of DM patients has no significant improvement. The results above indicated that the low recovery rate of neurological function was caused by diabetic polyneuropathy. The previous study has shown that diabetic polyneuropathy involves not only the peripheral nerve but also the spinal cord.\(^{15}\) This kind of damage may cause a particular impact on the patient’s signs and symptoms, obscuring the surgeon’s judgment of the patient’s preoperative condition. Therefore, we conducted this study for a better preoperative diagnosis and surgical prognosis of DM patients.

In this study, we can clearly find that DM has a serious impact on the preoperative neurological function of patients, including the incidence of neurological symptoms and clinical scores, mainly reflected in the occurrence of sensory dysfunction and pain symptom. Through the comparison of HbA1c indicators, we also confirmed that the severity of DM affects the recovery of postoperative neurological function. Our findings may provide some new insights for the treatment of CSM in the future, that is, preoperative neurological dysfunction and surgical neurological recovery after ADF may be closely related to DM.

**The Effects on Preoperative Neurological Function**

Our current study showed that the DM group had a significantly higher ratio of upper extremities pain than the non-DM group. The cause may also be diabetic polyneuropathy, one of the main symptoms reported to be the pain in the extremities.\(^{16}\) Meanwhile, the preoperative VAS score of the DM group was considerably higher than that of the non-DM group. Furthermore, the postoperative VAS score showed that the DM group had more residual pain symptoms. In contrast, the nerve root pain in CSM patients without DM was usually relieved after the surgical release of nerve root compression. No other researchers have proposed relevant views on postoperative pain control in DM patients after cervical spine surgery, and further studies are necessary to confirm our results. Based on the researchers’ conclusions about the effect of glycemic control on the symptoms of DM, it reminds the surgeon to strictly control the DM patient’s blood sugar during the perioperative period, otherwise, the patient’s pain symptoms cannot be adequately relieved.\(^9,17,18\)

To determine the effect of DM on preoperative neurological function in CSM patients, we assessed the JOA score of the patients. And we further analyzed the isolated JOA score to obtain the effects of DM on specific preoperative neurological function in CSM patients. The results show that the main affected items are the sensory function of the upper and lower extremities. In the study by Machino et al.,\(^8\) preoperative lower extremity sensory function scores in the DM group were lower than that in the non-DM group, and the postoperative recovery rate of upper extremity sensory function of patients in the DM group was significantly lower. Kawaguchi et al.\(^{19}\) have also reported that the recovery rate of lower extremity sensory function was poor in the DM group after CSM surgery. Compared with their results, although our research mainly discussed the influence of preoperative symptoms and signs, the interference of DM on the neurological function, especially the sensory function of CSM patients, is worthy of our attention.

**Surgical Prognosis of DM Patients Undergoing ADF**

Even though the JOA score is considered the most comprehensive traditional measure of the degree of spinal cord injury quantified,\(^{20}\) the scoring system is based solely on the subjective assessment of the patients and may affect the accuracy of the results. Thus, the JOA score alone is insufficient to quantify the results effectively. Therefore, to better reduce the error in assessing the effect of spinal cord function, we simultaneously calculated the Nurick score of both groups. The preoperative Nurick score of the DM group was higher than that of the non-DM group. In a follow-up of 113 patients over 2 years, Kusin et al.\(^{21}\) found a significant
difference in postoperative Nurick score but no significant difference in preoperative score. The limitation of Kusin et al.’s study was that they only evaluated patients’ Nurick scores. However, we also performed statistical analyses of preoperative clinical manifestations to confirm the neurological function effects of spinal cord injury caused by DM. The results stem from the injury effect of DM itself on the spinal cord and peripheral nerves. Previous studies have examined the spinal cord and peripheral nerve of patients with long-term DM and found that spinal cord changes, atrophy of the medullary, peripheral nerve degeneration, and the accompanying neurogenic muscular atrophy and other manifestations. In addition, studies have shown that sensory/motor evoked potentials in DM patients with polyneuropathy extend in the spinal cord structure. Nakanishi et al. found that the peripheral conduction time of patients with CSM and DM was significantly longer, suggesting that DM may damage the peripheral nerves of such patients. These results directly indicate that diabetes can cause a variety of spinal cord and nerve damage. Due to diabetic polyneuropathy, the symptoms produced have many similarities with CSM. In addition to the more severe symptoms in the DM group, the decreased hyperreflexia may give us some diagnostic inspiration. Second, a vital differentiation point is that the symptoms of diabetic polyneuropathy mostly appear in the lower extremities first and affect the upper extremities later, while CSM symptoms are often the first to appear in the hands. The severity of DM is also correlated with postoperative neurological recovery to a certain extent. We detected the linear correlation between HbA1c level and duration time of DM in the DM group. The better the HbA1c level was controlled, the higher the postoperative neurological recovery rate was.

There have been many studies on surgical prognosis, most of which suggest that the recovery rate of neurological function after cervical surgery in the diabetic group is inferior. Our results are similar to that. In particular, the results that need to be paid attention to are reflected in the difference in sample size between the two groups after we divided them into the excellent recovery rate group (>75%) and the non-excellent recovery rate group (<75%) according to the recovery rate of JOA score (the proportion of DM patients in the group less than 75% was significantly higher). In addition, the preoperative score of the excellent recovery rate group was at a better level, and there was a significant difference in the preoperative sensory score of the lower extremity between the two groups in the isolated JOA score. These results suggested that the patients whose postoperative efficacy could not reach the expectation were mostly DM patients. Their overall status was relatively poor, especially in the sensory function of the lower extremity. This proves the negative effect of DM on the spinal cord and nerve from another perspective. Patients with DM have poor preoperative neurological function and a low recovery rate of postoperative neurological function. For patients undergoing cervical surgery with DM, the solution of spinal cord compression through surgery may not be able to improve neurological function effectively, and the symptoms are severely affected by blood sugar. In Tanishima et al.’s study, after 61 patients were treated with cervical surgery, the recovery rate of JOA in the group with good glycemic control was significantly higher than that in the poor control group at the one-year follow-up. In the past, many researchers have proposed a correlation between DM and surgical wound infections. However, there was no significant difference between the peroperative indicators between the DM and the non-DM groups in our current study, which does not mean that our results are problematic. The low incidence of perioperative period complications in our surgical patients was mainly due to the guidance of the specialist. Before the surgery, we carried out strict glycemic control for patients with DM and preventive antibiotics and albumin. The glycemic level of patients is critical, which affects the overall status of DM patients preoperatively and the recovery of neurological function of patients postoperatively, and has a direct impact on the occurrence of wound infection and other complications in the perioperative period.

Limitations
There are also some limitations to this study. First, this study is a retrospective study, and errors may occur in the inclusion of patients or recording of patient data, which may affect the experimental results. Second, compared with other relevant research, the sample size of this study is relatively small, which increases the systematic error of the experimental results. In addition, although we have concluded that DM patients have significantly poor postoperative neurological function recovery, the results are indirect. We will control the general baseline conditions of patients before surgery to get direct evidence for differences in postoperative neurological recovery in future research. Furthermore, this study observed the manifestations caused by neurological damage in patients with diabetes, and our main reference criterion was neurological functional symptoms. However, we lacked neuroelectrophysiological studies on diabetic polyneuropathy; we will carry out a prospective study immediately, including the neuro-electrophysiological study and the peripheral blood vessels study.

Conclusion
This present study revealed that the neurological impairment caused by DM in patients undergoing cervical spine surgery does not only affect postoperative functional recovery but also interferes with the preoperative clinical manifestations, especially the sensory function in the upper and lower limbs.

Author Contributions
Jialin Jiang designed this study. Jialin Jiang and Kaiqiang Sun finished the paper draft. Feng Lin, Mincheng Lu, and Le Huan conducted the methodology. Ximing Xu, Jingchuan Sun, and Jialin Jiang did the analysis. Jiangang Shi and Yongfei Guo did the supervision. All authors contributed to manuscript preparation. All authors read and approved the final manuscript.
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References

1. Toledano M, Bartleson JD. Cervical spondylotic myelopathy. Neurol Clin. 2013;31:287–305.
2. Baron EM, Young WF. Cervical spondylotic myelopathy: a brief review of its pathophysiology, clinical course, and diagnosis. Neurosurgery. 2007;60:535–41.
3. Yamazaki T, Yanaka K, Sato H, Uemura K, Tsukada A, Nose T. Cervical spondylotic myelopathy: surgical results and factors affecting outcome with special reference to age differences. Neurosurgery. 2003;52:122–6.
4. Zhang JT, Wang LF, Wang S, Li J, Shen Y. Risk factors for poor outcome of surgery for cervical spondylotic myelopathy. Spinal Cord. 2016;54:1127–31.
5. Takasawa E, Sorimachi Y, Iizuka Y, et al. Risk factors for rapidly progressive neurological deterioration in cervical Spondylotic myelopathy. Spine (Phila Pa 1976). 2019;44(12):E723–30.
6. Kohno K, Kikutani N, Oka Y, Matsu S, Ohue S, Sakaki S. Evaluation of prognostic factors following expansive laminoplasty for cervical spinal stenotic myelopathy. Surg Neurol. 1997;48:237–45.
7. Shaw J, Sircue R, Zimet P. Global estimates of the prevalence of diabetes for 2010 and 2030. Diabetes Res Clin Pract. 2010;87:4–14.
8. Machino M, Imagama S, Ando K, et al. Impact of diabetes on the outcomes of cervical expansive laminoplasty in patients with diabetes mellitus. Spine (Phila Pa 1976). 2000;25:551–5.
9. Machino M, Yokawa Y, Ito K, et al. Impact of diabetes on the outcomes of cervical laminoplasty: a prospective cohort study of more than 500 patients with cervical spondylotic myelopathy. Spine (Phila Pa 1976). 2014;39:220–7.
10. Kusin DJ, Ahe UM, Ahe NU. The influence of diabetes on surgical outcomes in cervical myelopathy. Spine (Phila Pa 1976). 2016;41:1436–40.
11. Reske-Nielsen E, Lundbaek K. Pathological changes in the central and peripheral nervous system of young long-term diabetics. II. The spinal cord and peripheral nerves. Diabetologia. 1968;4:34–43.
12. Selvarajah D, Wilkinson ID, Emery CJ, et al. Early involvement of the spinal cord in diabetic peripheral neuropathy. Diabetes Care. 2006;29:2684–9.
13. Suzuki C, Oyakawa T, Tanosaki M, Suda T, Baba M, Matsunaga M. Peripheral and central conduction abnormalities in diabetes mellitus. Neurology. 2000;54:1932–7.
14. Nakanishi K, Tanaka N, Kamei N, et al. Electrophysiological assessments of the motor pathway in diabetic patients with compressive cervical myelopathy. J Neurosurg Spine. 2015;23:707–14.
15. Brown MJ, Asbury AK. Diabetic neuropathy. Ann Neurol. 1984;15:2–12.
16. Ojo OA, Owolabi BS, Oseni AW, Kanu OO, Bankole OB. Surgical site infection in posterior spine surgery. Niger J Clin Pract. 2016;19:821–6.
17. Richards JE, Kaufmann RM, Zuckerman SL, Obremesky WT, May AK. Relationship of hyperglycemia and surgical-site infection in orthopaedic surgery. J Bone Joint Surg Am. 2012;94:1181–6.