Predicting Postoperative C5 Palsy Using Preoperative Spinal Cord Rotation

A. Jessey Chugh, BS; Jeremy J. Gebhart, MD; Jason D. Eubanks, MD

Abstract

The development of C5 nerve palsy after cervical decompression surgery has been well documented. The goal of this study was to determine whether preoperative spinal cord rotation could be used as a predictor of C5 palsy in patients who underwent posterior cervical decompression at C4-C6. The authors reviewed the records of 72 patients who had posterior decompression and 77 patients who had anterior decompression. With the patients undergoing anterior decompression used as a control group, magnetic resonance imaging scans were analyzed for area of the spinal cord, anterior-posterior diameter, and cord rotation relative to the vertebral body. The rate of C5 palsy was 7.3%. Average degrees of rotation were 3.83°±2.47° and 3.45°±2.23° in the anterior and posterior groups, respectively. A statistically significant association was detected between degree of rotation and C5 palsy. Point-biserial correlations were 0.58 (P<.001) and 0.60 (P<.001) in the anterior and posterior groups, respectively. With a diagnostic cutoff of 6°, the sensitivity and specificity of identifying patients with C5 palsy in the posterior group were 0.67 (95% confidence interval, 0.24-0.94) and 0.95 (95% confidence interval, 0.86-0.98), respectively. The results suggested that preoperative spinal cord rotation may be a valid predictor of C5 nerve palsy after posterior cervical decompression. With mild rotation defined as less than 6°, moderate rotation as 6° to 10°, and severe rotation as greater than 10°, the prevalence of C5 palsy in the posterior group was 2 of 65 for mild rotation, 3 of 6 for moderate rotation, and 1 of 1 for severe rotation. [Orthopedics. 2015; 38(9):e830-e835.]
Cervical decompression, whether anterior or posterior, is a common form of treatment for patients with radiculopathy or myelopathy as a result of spinal stenosis.\(^1\)\(^3\) These procedures have been associated with C5 nerve palsy in the perioperative period, resulting in muscle weakness, numbness, and even paralysis.\(^1\)\(^2\)\(^4\)\(^6\) The prevalence of C5 nerve palsy, generally between 4\% and 8\%, was documented in several studies. Two large retrospective studies of 750 and 857 patients found prevalence rates for C5 nerve palsy of 6.7\% and 5.7\%, respectively.\(^7\)\(^8\) A similar study reviewed the literature on C5 palsy from 1986 to 2002 and found an average prevalence of 4.6\%.\(^5\)

Numerous etiologies for postoperative C5 palsy have been proposed. These mechanisms include nerve root injury, preexisting asymptomatic damage of the anterior horn cells at C3-C4 and C4-C5, changes in the cervical curvature index as a result of tethering of the nerve root, use of internal fixation, posterior drift of the cord, and thermal damage from a high-speed burr.\(^2\)\(^4\)\(^5\)\(^9\) Although intraoperative traction has also been proposed as a likely cause, some studies refuted this finding.\(^10\) In addition, this variable can be difficult to measure retrospectively. Few studies have examined reliable preoperative risk factors, but 1 study identified superior articular process hypertrophy as a possible factor.\(^11\) However, assessment of this variable is impractical, especially in a retrospective analysis, where this information may be missing for many patients.

This study focused on a known predictor of C5 palsy, preoperative spinal cord rotation. Previous work found a significant association between the preoperative degree of cervical spinal cord rotation and C5 palsy in patients who underwent anterior cervical decompression or corpectomy at C4-C6 (\(P<.001\)) and identified a prevalence rate of 6.8\% for C5 palsy.\(^12\) Another study identified cervical spinal cord rotation as a marker for nerve damage, predisposing patients to C5 palsy.\(^13\) The current study examined patients who underwent posterior cervical decompression surgery and compared them with a similar group of patients who underwent anterior cervical decompression and fusion. The authors hypothesized that preoperative cord rotation affects postoperative C5 palsy rates in patients undergoing posterior cervical procedures.

**Materials and Methods**

This study was a retrospective review of previously collected data from the practices of 2 academic spine surgeons. The study was approved by the institutional review board at University Hospitals Case Medical Center. Patient data from these 2 practices were extracted from the medical records from 2009 to 2012 and from 2005 to 2010, respectively. The authors reviewed the records of 293 patients from the 2 databases who underwent anterior and posterior cervical decompression procedures. After surgery, these patients were evaluated at follow-up visits for an average duration of 30 months. The study included all patients who underwent posterior cervical surgery (with or without fusion) from 2005 to 2012 in the practices of 2 surgeons. Exclusion criteria were as follow: preexisting C5 palsy before surgery and missing demographic, radiologic, or pertinent medical information. When these criteria were applied, the final study population was 149. Of this group, 72 patients had posterior surgery and 77 had anterior surgery. These sample sizes exceeded the minimum needed to reach a power of 80\% in both the control and experimental groups, as calculated with 1-tailed Student’s \(t\) test at a significance level of \(P<.05\).

Data were divided into 3 categories: preoperative, intraoperative, and postoperative. Preoperative variables included demographic characteristics, body mass index, smoking status, diabetes status, history of cervical surgery, duration of neurologic symptoms, diagnosis at the time of surgery, and magnetic resonance imaging (MRI) measurements of the cross-section of the spinal cord, anteroposterior diameter of the spinal canal, and rotation of the spinal cord relative to the vertebral body. Intraoperative variables included operating room time, blood loss, and somatosensory evoked potential signals. Postoperative data included the status of C5 palsy (absent or present), time course for recovery of C5 palsy, and postoperative assessment at the time of discharge and 3 weeks postoperatively. In this study, C5 palsy was defined as a manual muscle testing score of 3 or less on a scale of 0 to 5. Postoperative C5 palsy was correlated with all preoperative variables.

The MRI measurements were taken from the most recent preoperative cervical MRI scans, which were obtained 1 week to 5 months before surgery. Unique patient codes were used to blind observers to patients’ C5 palsy status and other variables. Measurements were taken 3 times, and an average value was recorded. To control for intraobserver and interobserver bias and ensure reproducibility, the intraclass correlation coefficient was calculated. Analysis was done with 20 randomly selected patients. The intraclass correlation coefficient values for intraobserver and interobserver analysis were 0.99 and 0.79, respectively, showing a strong agreement within these measurements.

Measurements were obtained according to a strict protocol. For cross-sectional area (Figure 1), only the area within the spinal canal was measured, and the area extending into the intervertebral foramen was not considered. For anteroposterior diameter (Figure 2), the widest part of the canal was considered. For relative rotation (Figure 3), the angle of the vertebral bodies was assessed via the position of the vertebral arteries and compared with the angle of the spinal canal. Figures 1-3 show sample...
and presence of C5 palsy. This form of analysis compares a dichotomous variable (presence or absence of C5 palsy) with a continuous variable (cord rotation). As in a study by Eskander et al\(^2\) that assessed cervical spinal rotation, this study used a classification system to separate cord rotation into 3 categories, mild, moderate, and severe. The authors defined a continuous range to provide the best diagnostic efficiency. Mild rotation was defined as less than 6°, moderate rotation was defined as 6° to 10°, and severe rotation was defined as greater than 10°.

**RESULTS**

Mean patient age in both groups was 55.39±13.48 years (range, 29-88 years). Average body mass index was 28.85±4.41 kg/m\(^2\). Mean duration of symptoms before surgery was 1 month to several years. In the posterior group, 15 patients had a preoperative diagnosis of isolated cervical radiculopathy and 35 patients had isolated cervical myelopathy. The rest of the patients had cervical myeloradiculopathy, and 3 of these patients had central cord syndrome as well. In the anterior group, 12 patients had diabetes, and in the posterior group, 14 patients had diabetes. In the anterior and posterior groups, 22 and 29 patients, respectively, were current smokers. The overall prevalence of C5 palsy was 7.3%.

In the posterior group, 6 of 72 patients had C5 palsy, and in the anterior group, 5 of 77 patients were affected. Because this was a retrospective study, the only way to assess the status of C5 palsy and the time course for recovery was through review of the postoperative notes at discharge and follow-up visits. Therefore, it was difficult to determine an exact time of diagnosis.

Mean values for MRI measurements for both groups are shown in Table 1. As summarized in Table 2, a 6° cutoff was not as sensitive in predicting C5 palsy in the posterior group as in the anterior group because a larger number of false-negative findings occurred in the posterior group. Additionally, at a cutoff of 10°, sensitivity was low in both groups, which indicates that a large number of false-negative findings would be missed within the 6° to 10° range. Regardless, the 6° cutoff provided the highest diagnostic efficiency values out of several others tested, and the authors included this classification in the analysis. According to this classification, in the anterior group, no patients with C5 palsy had mild rotation, 5 had moderate rotation, and 1 had severe rotation. In the posterior group, 2 patients with C5 palsy had mild rotation, 4 had moderate rotation, and 1 had severe rotation. The authors used point-biserial correlation to determine the level of correlation. Table 3 shows the relationship with degree of rotation in patients with and without the diagnosis. Additionally, cord rotation values for each patient are plotted in Figure 4 (anterior group) and Figure 5 (posterior group). Labeled bars indicate the patients who were diagnosed with postoperative C5 palsy.

A significant association was noted between the severity of cord rotation and...
C5 palsy in both the anterior and posterior groups. Initially, the correlation seemed to be stronger in the posterior group vs the anterior group, with a point-biserial coefficient of +0.6 for the posterior group (P<.001) vs +0.58 for the anterior group (P<.001). However, this difference was not statistically significant (P>.05). Similar point-biserial correlations were calculated for the other preoperative and intraoperative variables. No significant association was found with any of them, and point-biserial values were between -0.07 and +0.08, with P>.05 for all. Logistic regression analysis was conducted to ensure that cord rotation was an independent predictor of C5 palsy. Odds ratios were 2.90 (P<.05) and 3.42 (P<.05) for the anterior and posterior groups, respectively. None of the other variables showed significance (P>.05), confirming the likelihood that cord rotation could independently predict the outcome in question.

**Discussion**

Although cervical spine surgery can provide excellent relief of radicular and myelopathic symptoms, complications can occur. Among these, C5 palsy can occur in 4% to 8% of cases.\(^4\)\(^,\)\(^7\)\(^,\)\(^8\) Given the prevalence of this complication, discussion of possible risk factors included preoperative variables, such as cord rotation. Previous work suggested that cord rotation may predispose patients to postoperative C5 nerve palsy.\(^1\(^3\)\) Another study linked this rotation more specifically to anterior cervical procedures.\(^1\(^2\)\) The current study evaluated cord rotation in patients with posterior cervical surgery. As predicted, patients who underwent posterior cervical decompression surgery showed a significant association between preoperative spinal cord rotation and postoperative C5 palsy. The authors confirmed this association in patients who underwent anterior decompression surgery. However, correlation in this group was not as strong as that described by Eskander et al.\(^1\(^2\)\) Their study included only patients who underwent anterior surgery and showed point-biserial correlation of +0.94 (P<.001). In contrast, the current study showed values of +0.60 and +0.58 (P<.001) for posterior and anterior patients, respectively. According to Pett,\(^1\(^4\)\) the strength of association of point-biserial correlation can be interpreted as follows: 0.00 to 0.24, weak; 0.25 to 0.48, moderate; 0.49 to 0.80, strong; and greater than 0.81, very strong. According to this system, the current study values would be considered strong.

This study confirmed earlier reports that showed that preoperative rotation of the spinal cord may predispose patients to postoperative C5 palsy. According to the diagnostic efficiencies assigned in this study, a cutoff of 6° identified all patients with C5 palsy in the anterior group but not in the posterior group. A cutoff of 10° identified all patients with C5 palsy in both groups, but was associated with a larger number of false-negative findings. These findings raise 3 important points: (1) the larger number of patients with C5 palsy with mild rotation (<6°) in the posterior

<table>
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<tr>
<th>Table 1</th>
<th>Magnetic Resonance Imaging Measurements</th>
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<tbody>
<tr>
<td>Measurement</td>
<td>Anterior</td>
</tr>
<tr>
<td>Cross-sectional area, cm(^2)</td>
<td>1.48±0.29</td>
</tr>
<tr>
<td>Anterior-posterior diameter, mm</td>
<td>9.56±1.66</td>
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<tr>
<td>Cord rotation</td>
<td>3.83°±2.47°</td>
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<tr>
<td>Cord rotation without C5 palsy</td>
<td>3.45°±1.92°</td>
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<tr>
<td>Cord rotation with C5 palsy</td>
<td>9.26°±3.23°</td>
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<th>Table 2</th>
<th>Diagnostic Efficiency</th>
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<tbody>
<tr>
<td>Cord Rotation</td>
<td>Sensitivity</td>
</tr>
<tr>
<td>Anterior</td>
<td></td>
</tr>
<tr>
<td>≥6°</td>
<td>1.00 (0.47-1.00)(^a)</td>
</tr>
<tr>
<td>≥10°</td>
<td>0.20 (0.01-0.70)</td>
</tr>
<tr>
<td>Posterior</td>
<td></td>
</tr>
<tr>
<td>≥6°</td>
<td>0.67 (0.24-0.94)</td>
</tr>
<tr>
<td>≥10°</td>
<td>0.17 (0.01-0.64)</td>
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\(^a\)Ninety-five percent confidence intervals are in parentheses.
group vs. the anterior group may be the result of mechanistic differences between the anterior and posterior surgical approaches; (2) the relatively high specificities overall show that a patient with C5 palsy is more likely to have moderate (range, 6°-10°) or severe (>10°) rotation vs mild rotation; and (3) severe rotation may be a stronger predictor of C5 nerve palsy than moderate rotation.

To further study the posterior group, the authors determined the number of patients with C5 palsy who underwent laminoplasty vs laminectomy and fusion surgery. Because of differences in the extent of bony decompression and rigidity of the postoperative cervical spine in these patients, rates of postoperative C5 palsy may differ. Possible etiologies include compression of the C5 root on the hinge side in laminoplasty and posterior spinal cord drift and C5 root traction in a widely decompressed, rigid laminectomy and fusion construct. In the current study, only 1 of the 6 patients who had postoperative C5 palsy had undergone laminoplasty. This finding may suggest a greater role of posterior cord drift and traction of the C5 root in postoperative C5 palsy.

Limitations

Although the current findings agreed with those of previous studies, the study had several limitations. First, because the study was retrospective, the authors could only analyze the data that were available. Because the most recent MRI images for each patient before surgery varied over the span of a few months, it was difficult to control for possible changes that occurred near the date of surgery. Second, because the diagnosis of C5 palsy was assessed at several different time points and by different examiners, it was difficult to assess the true onset of C5 palsy and to standardize the differing expertise levels of physicians (ie, resident physicians assessing neurologic function at discharge vs attending spine surgeons assessing the same function at postoperative follow-up). Lastly, a number of variables may have confounded the results, including multiple surgeons with varying techniques. However, the authors controlled for a broad depth of variables, and the lack of association with any of those risk factors and outcomes is promising.
CONCLUSION

The current study suggested that cord rotation is associated with postoperative C5 palsy in posterior cervical decompression procedures. Future studies should focus on collecting prospective data to analyze cord rotation preoperatively to better inform patients who might be at risk for this neurologic complication.

REFERENCES