Incidence and outcome of kyphotic deformity following laminectomy for cervical spondylotic myelopathy

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Object. The authors undertook a study to explore the predisposing risk factors, frequency of occurrence, and clinical implications of kyphosis following laminectomy for cervical spondylotic myelopathy (CSM).

Methods. Preoperative radiological studies were available in 46 patients with CSM who had undergone laminectomy. Records were reviewed to obtain demographic data and operative reports. Preoperative radiographs were assessed to determine spinal alignment. In a follow-up interview the authors established clinical outcome and patient satisfaction. Postoperative cervical alignment and mobility was also determined by assessing lateral neutral, flexion, and extension x-ray films.

Preoperatively, the cervical spine was shown to be kyphotic in four (9%) of 46, straight in 20 (43%) of 46, and lordotic in 22 (48%) of 46 patients. Nine (21%) of 42 patients with either straight or lordotic alignment demonstrated in the preoperative period developed kyphosis after surgery. Kyphosis developed in six (30%) of 20 patients in whom straight spinal alignment was demonstrated preoperatively and in only three (14%) of 22 patients in whom lordosis was found preoperatively. Clinically, 13 (29%) of 45 patients improved and 19 (42%) of 45 remained unchanged after an average 4-year follow-up period; 36 (80%) patients believed that their surgery was successful (one patient, who was mentally retarded, could not respond to the follow-up questionnaire). Spinal alignment was not predictive of outcome; cervical mobility as demonstrated on flexion and extension, however, correlated with improved functional performance (p = 0.005).

Conclusions. Kyphosis may develop in up to 21% of patients who have undergone laminectomy for CSM. Progression of the deformity appears to be more than twice as likely if preoperative radiological studies demonstrate a straight spine. In this study, clinical outcome did not correlate with either pre- or postoperative sagittal alignment.

Key Words • cervical spine • deformity • kyphosis • laminectomy • myelopathy

POSTLAMINECTOMY kyphosis of the cervical spine has been suggested as a cause of worsening myelopathy, functionally debilitating postural deformity, and intractable pain. The risk of deformity seems dependent on the patient’s age, the nature of underlying spinal lesion, and the extent of bone removal necessary to effect the spinal decompression. Cervical traction and corpectomy with or without internal fixation have been offered as an effective means of treating symptomatic deformity. Laminoplasty, laminectomy with lateral mass fusions, and cervical corpectomy have been used to treat both OPLL and CSM, the assumption having been that clinically significant deformity occurs commonly after cervical laminectomy alone. In several papers the authors have documented the potential occurrence of kyphosis after laminectomy in patients with OPLL. The incidence and clinical significance of deformity after laminectomy for CSM, however, is debatable. In their surgical series, Scofield, Fager, and others have noted that spinal stability and alignment were preserved in patients who underwent laminectomy with facetectomy. Whitecloud and Butler have attributed this observation to the “inherent stability” imparted by the “degenerative changes in the anterior spinal column.” By contrast, others have noted that deformity after laminectomy for CSM is a frequent and potentially deleterious complication. In this retrospective analysis we identify the frequency and clinical implications of postlaminectomy deformity in patients with CSM to help clarify these conflicting observations.
Clinical Material and Methods

Study Design

This study was designed as a retrospective analysis of the incidence of sagittal-plane deformity and its correlation with functional outcome in patients with cervical spondylotic myelopathy treated with laminectomy.

Patient Population

We included patients treated for CSM in whom total cervical laminectomy had been performed; patients were identified by a review of the surgical registry of the Derriford Hospital (Plymouth, United Kingdom). We excluded those treated with hemilaminectomy, laminectomy with fusion, or laminoplasty. Patient charts were reviewed to obtain demographic data, operative reports, and postoperative status. There were 24 men (52%) and 22 women (48%); their average age was 63 years.

Operative Technique

Laminectomy was performed through a midline dorsal incision. Rongeur and bone punches were used to remove the laminae and spinous processes of the relevant segments. Less than one fourth of the medial aspect of each facet was removed except in cases in which foraminotomy was required for associated cervical radiculopathy.

Clinical Evaluation

Patient age, sex, history of smoking, duration and pattern of symptoms, and medical history were obtained by reviewing their charts. Follow-up evaluation consisted of an interview with the primary author (G.J.K.). A standardized questionnaire was completed by 45 of the participants and evaluated to determine their overall level of satisfaction with surgery-related outcome as well as to determine the extent of functional recovery. A grading scale modified from the Nurick outcome scale score was used to obtain an overall understanding of functional recovery (Table 1). Satisfaction was determined by the patient’s response to four questions (Table 2).

Radiographic Evaluation

Radiographic studies were obtained in all patients whenever possible. Unfortunately, radiographic files are destroyed if they remain inactive for 2 years, and this policy significantly reduced the number of patients in the study group. Radiographs were assessed for sagittal alignment by the method outlined by Katsumi and colleagues. Three categories were used to classify spinal alignment: lordotic, straight, and kyphotic (Fig. 1). Fewer than 4° of either kyphotic or lordotic angulation was defined as straight alignment. Included in the kyphotic category were all patients with swan-neck deformity.

Postoperative lateral cervical (neutral, flexion, and extension) radiographs were obtained at the time of the follow-up interview; they were assessed for the presence of subluxation and sagittal alignment. Cervical mobility was assessed by subtracting the degree of kyphosis in full flexion from lordosis in extension. Sagittal alignment in these postures was obtained by measuring the Cobb angle from the base of the axis to the superior endplate of C-7.

Statistical Analysis

The chi-square test and Student’s t-test were used to compare proportions and continuous variables, respectively. The null hypothesis was rejected when p < 0.05.

Results

Patient Population

One hundred thirty patients were treated with laminectomy for CSM at the Derriford Hospital between 1991 and 1996. Preoperative radiological studies were available in 57, and 46 of these patients agreed to participate in an interview and undergo lateral neutral, flexion, and extension radiography at an average follow-up time of 48 months. One of the 46 patients was mentally retarded and could not complete the follow-up questionnaire. The average age of the group was 63 years at the time of interview; 24 men (52%) and 22 women (48%); their average age was 63 years.

TABLE 1

Functional outcome in 45 patients after laminectomy for CSM

<table>
<thead>
<tr>
<th>Preop Condition</th>
<th>Postop Condition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Perfectly Fit</td>
</tr>
<tr>
<td>perfectly fit</td>
<td>2</td>
</tr>
<tr>
<td>mildly disabled but working</td>
<td>3</td>
</tr>
<tr>
<td>not able to work</td>
<td>5</td>
</tr>
<tr>
<td>completely disabled</td>
<td>3</td>
</tr>
<tr>
<td>total</td>
<td>3 (7)</td>
</tr>
</tbody>
</table>

TABLE 2

Subjective assessment of outcome reported by 45 patients

<table>
<thead>
<tr>
<th>Question</th>
<th>Positive Response (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think that surgery was successful or a failure?</td>
<td>36 (80)</td>
</tr>
<tr>
<td>Are you better or worse off now than before your surgery?</td>
<td>28 (62)</td>
</tr>
<tr>
<td>Knowing what you know now, would you choose to have surgery again?</td>
<td>36 (80)</td>
</tr>
<tr>
<td>Did surgery help your problems?</td>
<td>31 (69)</td>
</tr>
</tbody>
</table>
may have complicated functional improvement. Forty-four (96%) presented with difficulty walking as a symptom of myelopathy. The average duration of symptoms prior to treatment was 21.2 months.

Operative Technique

A C-2 laminectomy was performed in five (11%) of the patients, and foraminotomy was performed on an additional five (11%). The majority of patients underwent a four-level decompressive procedure (19 [41%] of 46).

Radiographic Outcome

Preoperatively, curvature was kyphotic in four (9%), straight in 20 (43%), and lordotic in 22 (48%) patients. Nine patients (21%) with either straight or lordotic alignment demonstrated on preoperative radiography developed kyphosis as a new finding (Table 3). The extent of kyphosis was measured in three fourths (75%) of the patients with preoperative deformity; an exaggeration of preexisting kyphosis was documented in two (67%) of three patients. Factors such as sex, age, history of smoking, C-2 laminectomy, foraminotomy, and the number of spinal levels treated were not associated with progression of deformity. Kyphosis, however, developed in six (30%) of 20 patients in whom straight spinal alignment was demonstrated preoperatively and in only three (14%) of 22 patients in whom lordosis was found. This difference was not statistically significant (p = 0.197).

Functional Outcome and Patient Satisfaction

Clinical follow-up assessment revealed that 13 (29%) of 45 patients able to complete the questionnaire noted improvement and 19 (42%) noted no change in their functional abilities (Table 1). An additional 13 patients (29%) reported worsening in their level of function; none of these patients was treated with additional surgery as a result of this decline in function. Age, sex, duration of symptoms, history of smoking, and the number of levels surgically treated were not significantly associated with functional outcome.

Patient satisfaction was measured by responses to four questions at the time of the follow-up interview (Table 2). Thirty-six (80%) of the 45 patients capable of responding to the questionnaire thought that surgery was successful and that they would agree to it again if it were required. Only 28 (62%) of these patients considered their condition to be better at the time of follow up compared with their preoperative status.

Correlation of Functional Outcome With Radiographic Findings

Outcome was dichotomized to good (either perfectly fit or mildly disabled but working) and poor (disabled and not working or severely disabled) (Table 4). Increased postoperative cervical mobility correlated with a good outcome. In those patients with a good outcome there was an average movement on flexion–extension of 42° where-
TABLE 3
Sagittal alignment after laminectomy demonstrated in 46 patients

<table>
<thead>
<tr>
<th>Preop Alignment</th>
<th>Kyphosis</th>
<th>Straight</th>
<th>Lordosis</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>kyphosis</td>
<td>4 (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>straight</td>
<td>6 (9)</td>
<td>5 (7)</td>
<td>20 (43)</td>
<td></td>
</tr>
<tr>
<td>lordosis</td>
<td>3 (7)</td>
<td>12 (27)</td>
<td>22 (49)</td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>13 (28)</td>
<td>16 (35)</td>
<td>17 (37)</td>
<td>46</td>
</tr>
</tbody>
</table>

as in those with poor outcome it was 30° (p = 0.005). Five (42%) of 12 patients with kyphotic deformity, five (31%) of 16 with straight alignment, and eight (47%) of 17 with lordotic deformity reported a good functional outcome at follow up. These differences were not of statistical significance (p = 0.648). Measures of patient satisfaction also did not correlate with radiographic parameters.

Discussion

In numerous reports the authors have described cases in which postlaminectomy deformity resulted in clinically significant complications. The majority of these reports, however, were either surgical series in which the authors described methods of correcting the deformity once it occurred, or reports on present complications associated with postlaminectomy kyphosis in children with spinal cord tumors. Studies in which the investigators describe the incidence and clinical implications of deformity in patients undergoing laminectomy for the treatment of degenerative disease of the cervical spine in an unselected series are rare. Problems imposed by cervical kyphosis have been particularly noted in patients with OPLL; Hirabayashi and Satomi as well as other investigators have responded to these observations by advocating the use of laminoplasty. In their analysis of the impact of laminectomy on degenerative cervical spine disease, Mikawa, et al., found that only patients with OPLL developed postlaminectomy deformity.

In the present study, 21% of those treated for CSM developed postlaminectomy deformity within the 4-year follow-up period. In previous reports addressing the issue of sagittal alignment after laminectomy the authors have noted similar rates ranging from 6 to 30%. These findings refute the concept that the spondyloitic process acts as a buffer in preventing the progression of deformity after laminectomy. Analysis of both demographic and anatomical factors did not provide insight into predicting which individuals were at risk for developing kyphosis. Despite numerous biomechanical and clinical reports in which it was predicted that the lateral extent of the decompression may significantly predispose patients to the progression of kyphosis, in patients with CSM and radiculopathy who were treated with laminectomy and extensive foraminotomy a higher rate of postoperative kyphosis was not demonstrated. The absence of a demonstrable link between kyphosis and the lateral extent of facetectomy may be attributed to the limited statistical power imposed by the small sample size. Alternatively, destruction of the facet joint complex may not play as significant a role in the preservation of alignment in the spondyloitic spine. The rate of postlaminectomy deformity in our group of patients is consistent with that reported by both Hamanishi and Tanaka and Herkowitz. In both of these series, laminectomy was combined with facetectomy to treat cervical spondylosis; the incidence of kyphosis in these series ranged from 6 to 25%.

Loss of the normal lordotic curvature of the cervical spine is one of many factors that has been associated with poor functional outcome after laminectomy. Batzdorf and Batzdorf have hypothesized that a lordotic curve permits the migration of the spinal cord away from anteriorly place osteophytes, thereby allowing for indirect neural decompression. In this study, 30% of patients with straight cervical alignment developed a kyphotic deformity whereas only 14% of patients with a lordotic deformity progressed to this end. Despite the apparent predilection for the progression of kyphosis, sagittal alignment did not have an impact on outcome, suggesting that the undertaking of procedures designed to prevent deformity may be unnecessary.

Outcome was assessed using a modification of the Nurick grading scale, which allowed for the evaluation of overall functional improvement rather than ambulatory mobility in isolation. Symptomatic improvement was reported by only 29% of patients whereas 42% noted no change in functional status (Table 1). These disappointing results reflect a bias in patient selection. Because quiescent archives of radiographic studies were kept for only 2 years, only patients with problems requiring radiological investigations could be included in the study. Consequently, functional improvement of a significant proportion of patients in this survey would be hindered by the restrictive effects of other orthopedic or medical conditions. Despite the poor functional outcomes reported in this series, a significant proportion seemed to be satisfied with the results of their operation, with 80% reporting that

TABLE 4
Postoperative sagittal alignment and outcome in 45 patients

<table>
<thead>
<tr>
<th>Postop Alignment</th>
<th>Perfectly Fit</th>
<th>Mildly Disabled but Working</th>
<th>Not Able to Work</th>
<th>Completely Disabled</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>kyphosis</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>12 (27)</td>
<td></td>
</tr>
<tr>
<td>straight</td>
<td>2</td>
<td>3</td>
<td>9</td>
<td>16 (36)</td>
<td></td>
</tr>
<tr>
<td>lordosis</td>
<td>1</td>
<td>7</td>
<td>9</td>
<td>17 (38)</td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>3 (7)</td>
<td>15 (33)</td>
<td>23 (51)</td>
<td>4 (9)</td>
<td>45</td>
</tr>
</tbody>
</table>
they felt that treatment was successful (Table 2).

Because follow-up magnetic resonance imaging studies were not obtained routinely in this series, a comprehensive analysis of the potential causes of persistent disability cannot be undertaken. Given these limitations, however, a comparison of outcomes between groups of patients within the study is valid with the understanding that sample size may subject conclusions to type II error. With this in mind, higher degrees of mobility in flexion-extension were found to correlate with improved functional outcome (p = 0.005). These conclusions contradict the findings of previous investigations. Adams and Logue have suggested that both static compression and trauma imposed by movement of the spinal cord over spondylotic bars may result in myelopathy. The contradictory findings in the current study may be a result of variability in the measurement of cervical excursion on flexion and extension radiographs or patient effort during the acquisition of these x-ray films. However, this observation may indicate real differences between groups, thus reflecting the importance of spinal mobility for functional outcome.

Conclusions

The progression of deformity occurs commonly after laminectomy for CSM. The development of kyphosis, furthermore, appears to be more than twice as likely if preoperative radiography demonstrates a loss of cervical lordosis. Interestingly, outcome did not correlate with sagittal-plane alignment but was ameliorated in patients with preserved cervical mobility. These findings confirm the hypothesis that kyphotic deformity is associated with the surgical disruption of the posterior elements. The presence of postoperative kyphosis did not, however, predict a poor functional outcome. The use of laminoplasty and laminectomy with facet joint fusion, although theoretically effective in arresting progression of the deformity, may have no impact on the relief of myelopathy.

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