Vertical translocation. Part II. Outcomes after surgical treatment of rheumatoid cervical myelopathy

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This is a prospective observational study in 116 patients with rheumatoid arthritis and vertical translocation who underwent cervical spine surgery after developing symptomatic myelopathy. These patients, whose mean age was 62 years, had suffered from rheumatoid arthritis for almost 25 years. Surgery was performed via a combination of anterior (67 transoral decompressions) and posterior approaches. Surgical morbidity was recorded in 39% of patients, with a 30-day mortality rate of 10.3%, which was largely related to poor preoperative neurological grade. Neurological improvement of at least one Ranawat class was observed in 55 patients.

Univariate analysis revealed the following clinical variables to be associated with a good neurological outcome (Ranawat class): younger age and good preoperative muscle power. Significant radiological variables included the degree of vertical translocation as measured by the Redlund-Johnell method and the preoperative spinal cord area. The degree of transgression in the foramen magnum did not significantly affect neurological outcome. Neither the anterior nor the posterior atlantodens interval predicted neurological recovery. Multiple logistic regression models were constructed based on the preliminary evidence of the authors’ univariate analysis and these confirmed the importance of preoperative neurological function, spinal cord area, and the degree of vertical translocation in influencing the final neurological grade.

KEY WORDS • basilar impression • cervical vertebra • cranial settling • rheumatoid arthritis • vertical translocation

V ertical translocation occurs in approximately 5 to 34% of patients with rheumatoid arthritis. Our previous work on the results of surgery for the bed-bound, nonambulatory patient with rheumatoid arthritis and myelopathy has shown that vertical translocation exerts an adverse affect on both neurological and functional outcome. We describe our surgical approach to this disease and investigate the clinical and radiological factors that influenced outcome postsurgery.

Clinical Material and Methods

The patients in this study form part of a prospective consecutive series of 256 patients referred to the Department of Surgical Neurology over a 10-year period (1983–1993) for rheumatoid involvement of the cervical spine. Surgery was performed in 186 of these patients who had presented with symptoms or signs of myelopathy in conjunction with occipitocervical pain. Of this group of patients, radiological features of vertical translocation as defined by Redlund-Johnell and Pettersson were demonstrated in 116. It is these 116 patients with myelopathy and vertical translocation who form the basis of this report.

The data were collected prospectively by spine research fellows and entered into a relational database for storage and subsequent analysis. Postoperative outcome measures included the Ranawat neurological classification, the American Rheumatism Association (ARA) functional grading system developed by Steinbrocker, et al., the Stanford Health Activity Questionnaire (HAQ) disability index for rheumatoid arthritis, and the Myelopathy Disability Index (MDI) for cervical myelopathy. The MDI is a short questionnaire used to evaluate upper- and lower-limb function in patients with myelopathy. It was derived mathematically from the Stanford HAQ by principal components analysis. Its validity and reliability have been demonstrated, and it is also responsive to change. The patient’s response to 10 questions on function are graded on a four-point scale, and the final score is expressed as a percentage.

Other outcome measures used included morbidity (surgical complication rate) and mortality rates, which were divided into early (<30 days) and late (>30 days) postoperative mortality. The mean length of follow-up review was 45.3 months (range 0–126, median 43.5 months). Routine follow-up evaluations were scheduled at 6 weeks, 6 months, 1 year, and thereafter on an annual basis. Flexion–extension x-ray films were obtained during each clinic visit to look for disease progression or hardware failure.

The 1-year outcome was selected for purposes of statistical analysis (predictors of outcome). Long-term neurological function and survival postsurgery were also studied.
Patients had had rheumatoid arthritis for an average of 6.8 years (95% CI, 5.3–9.1 months). Severe neck pain was graded on a visual analog scale as 68 of 100 (95% CI, 62–73), and had been present for an average of 7.3 months (95% CI, 5.3–9.1 months).

Development of Surgical Management

The type of surgery was influenced by the reducibility of the deformity (fixed or mobile), the associated cervical subluxations present (horizontal, lateral, or rotatory atlantoaxial subluxation), and the presence of subaxial disease.23 The latter, in particular, dictated the extent of instrumentation required, with an attempt to include the lowest subaxial involvement in the construct. The surgery was also influenced by the available instrumentation and our own learning curve. During this period we helped develop the Hartshill–Ransford loop for occipitocervical fixation.33

Gross atlantoaxial instability was present in 45 (39%) of 116 cases, the remainder having a fixed nonreducible deformity (71 patients). Decompressive surgery was performed in these patients via either an anterior (transoral) or posterior approach depending on the site of maximum compression caused by subluxed bone structures or by rheumatoid pannus.7 Both the transoral decompressive and stabilizing surgery were evolving during this 10-year period, with differences occurring in technique and, more particularly, instrumentation. The range of constructs used in this period are summarized in Table 2.22,27,33 We currently use contoured loop systems for occipitocervical fusion (Ransford loop or Ti frame). Sixty-seven transoral procedures were required and were always accompanied by a stabilizing procedure. Transoral decompression was performed when there was significant anterior compression caused by an irreducible dens or, less commonly, by extensive pannus. The decision regarding what constituted significant anterior compression was subjective and not quantified. In the absence of anterior compression, posterior decompression and fixation were performed. In earlier procedures we supplemented our construct with bone grafts, but now consider this unnecessary in older patients with rheumatoid arthritis who place limited demands on the construct both in time and forces applied. This reduces the morbidity associated with harvesting grafts in these frail, debilitated patients and facilitates prompt postoperative mobilization. Thirty-three of 116 patients received a

<table>
<thead>
<tr>
<th>Complication/System Involved</th>
<th>No. of Patients</th>
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</thead>
<tbody>
<tr>
<td>respiratory (atelectasis, pneumonia, aspiration)</td>
<td>23</td>
</tr>
<tr>
<td>cardiovascular</td>
<td>12</td>
</tr>
<tr>
<td>transoral complication</td>
<td>5</td>
</tr>
<tr>
<td>posterior cervical wound infection</td>
<td>1</td>
</tr>
<tr>
<td>meningitis</td>
<td>3</td>
</tr>
<tr>
<td>gastrointestinal problem (peptic ulceration)</td>
<td>11</td>
</tr>
<tr>
<td>pressure sore/decubitus ulcer</td>
<td>5</td>
</tr>
<tr>
<td>total no. of patients</td>
<td>45</td>
</tr>
</tbody>
</table>

24.4 years (95% CI, 22.28–26.45 years), but had only reported myelopathic symptoms for an average of 5.5 months (95% CI, 3.8–7.3 months). Severe neck pain was graded on a visual analog scale as 68 of 100 (95% CI, 62–73), and had been present for an average of 7.3 months (95% CI, 5.3–9.1 months).

Table 1: Postoperative outcomes defined by different measurement scales*

<table>
<thead>
<tr>
<th>Ranawat neurological class</th>
<th>Characteristics</th>
<th>Preop</th>
<th>Postop</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>no neurological deficit (normal neurological condition)</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>II</td>
<td>subjective weakness w/ hyperreflexia &amp; dysesthesia</td>
<td>23</td>
<td>37</td>
</tr>
<tr>
<td>IIIA</td>
<td>objective weakness &amp; long-tract signs but ambulatory</td>
<td>51</td>
<td>26</td>
</tr>
<tr>
<td>IIIB</td>
<td>quadraparetic &amp; nonambulatory</td>
<td>42</td>
<td>37</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ARA functional grades</th>
<th>Characteristics</th>
<th>Preop</th>
<th>Postop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>complete ability to perform all usual duties w/o handicaps</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>adequate for normal activities despite handicap of discomfort or limited motion of one of the joints</td>
<td>31</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>limited to few or none of the duties of usual occupation or self-care</td>
<td>37</td>
<td>34</td>
</tr>
<tr>
<td>4</td>
<td>incapacitated, largely or wholly bed-ridden or confined to a wheelchair w/ little or no self-care</td>
<td>48</td>
<td>40</td>
</tr>
</tbody>
</table>

* Perioperative deaths were categorized as Ranawat Class IIIB.

Statistical Analysis

Univariate statistical analysis was performed for normally distributed continuous data by using the Student t-test and analysis of variance. The Mann–Whitney and Kruskal–Wallis tests were used for nonparametric analysis. The chi-square test and multiple logistic regression were also used, with significance being accepted at probability values of less than 0.05. All mean values are expressed with their corresponding 95% confidence intervals (CIs) unless otherwise stated. Survival analysis was performed using the Kaplan–Meier method and Cox’s proportional hazards model.

Results

One hundred sixteen patients with vertical translocation underwent surgery with the main indication for treatment being the presence of cervical myelopathy secondary to radiographically confirmed compression of the neuraxis. Preoperatively these patients were characterized according to neurological and functional severity as shown in Table 1. We treated 24 men and 92 women whose mean age was 62.3 years (95% CI, 60.6–63.9 years). The men were an average of 4 years younger than the women at the time of presentation (p = 0.05). These patients had had rheumatoid arthritis for an average of

Table 2: Type of surgical fixation used during the 10-year study period

<table>
<thead>
<tr>
<th>Posterior Cervical Fixation</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ransford loop</td>
<td>88</td>
</tr>
<tr>
<td>other loop system</td>
<td>11</td>
</tr>
<tr>
<td>occipitoatlantoaxial wiring</td>
<td>5</td>
</tr>
<tr>
<td>atlantoaxial fusion</td>
<td>5</td>
</tr>
<tr>
<td>Brooks- or Gallie-type fusion</td>
<td>5</td>
</tr>
<tr>
<td>Halifax clamp C-1C-2</td>
<td>4</td>
</tr>
<tr>
<td>Halifax clamp C1–3</td>
<td>3</td>
</tr>
</tbody>
</table>
Surgery for rheumatoid vertical translocation

![Cumulative Survival Curve](image)

**Fig. 1.** Graph showing Kaplan–Meier survival curve for those patients with vertical translocation who underwent surgery after the development of cervical myelopathy.

Bone graft, one of which was placed anteriorly and was subsequently resorbed. Earlier in the series, traction was used but we did not enjoy the success reported by others in the literature.26 One of the earlier patients sustained a subluxation at C2–3.

Reoperations were performed in nine patients, at a mean time interval of 15.9 months (range 4–40 months) from the original surgery. The patients whose fixation did not incorporate the occiput at the time of the original surgery (those with only very mild vertical translocation) were more likely to undergo a subsequent revision (three of 12) compared with those who underwent an occipitocervical fixation (six of 104). This difference was statistically significant ($\chi^2 = 5.56, p = 0.018$). There was also a trend for these patients to require revisional surgery sooner after the initial treatment: 7 compared with 20 months (95% CI for the difference between the two means, −7.44 to 33 months). The occipitocervical fixations failed because of the progression of subaxial disease below the immobilized segment; in one case this was also associated with sublaminar wire breakage at the lowest level. These cases were all treated by extending the fixation inferiorly with a contoured metal loop. The atlantocervical fixation failures (three patients) were secondary to an atlantoaxial sublaminar wire cutting through the bone, a failed Gallie fusion, and a failed Halifax clamp fixation.

**Surgical Complications**

There was significant morbidity associated with these procedures, consistent with the patient’s multisystem disease. The operative complications are listed in Table 3. Most of these are related to general debility rather than direct operative complications such as wound infection, cerebrospinal fluid leak requiring resuturing, or meningitis. Chi-square analysis failed to reveal a significant difference in any of the individual complications listed between the two different surgical approaches, namely transoral decompression followed by posterior fixation compared with posterior decompression and fixation. There was a tendency to develop more chest infections in the former group (not significant). The incidence of meningitis was only three of 116, and in two of these patients it arose from the posterior cervical fixation, because no transoral procedure had been performed. We routinely prescribe prophylactic broad-spectrum antibiotics (cefuroxime and metronidazole) for our patients treated with transoral procedures.

**Mortality Rates**

Postoperative mortality, defined as that occurring within the first 30 days, was 10.3%. There was no significant difference in mortality rates related to the two types of surgery (posterior fixation with or without transoral decompression) ($p = 0.26$), although patients undergoing a transoral procedure had more severe disease. Analysis of long-term survival rates postsurgery is shown in the Kaplan–Meier curve (Fig. 1). By 15 months postoperatively, 25% of the patients were dead.

**Postoperative Outcome**

Outcome within the 1st year according to the outcome measures previously defined is shown in Table 1.27 Forty-five percent of patients improved by one or more Ranawat classes. The improvement in neurological class was not overtly influenced by the type of surgery, whether it was a posterior fixation alone (46% improved) or combined with a transoral decompression (44% improved). Neurological and functional outcome is not a static process, and long-term follow-up results are illustrated graphically in Fig. 2.

Overall, 97% of patients experienced decreased pain postoperatively, with the level of pain reduced by more than half in 56% of patients. The mean preoperative pain levels of 68 of 100 were reduced overall to 34 of 100 (95% CI for the difference, 25.8–41.6). This difference was highly significant ($p = 0.0001$).

**Predictors of Surgical Outcome**

Several clinical and radiological measures were used to predict outcome by means of univariate analysis. Significant variables included the patient’s age ($p = 0.014$), the degree of preoperative weakness ($p = 0.001$), and the previous or current use of azathioprine ($p = 0.032$). No such effect was observed with patients taking steroids at the time of surgery. Of the various clinical scoring systems used to define preoperative severity and postoperative outcome (the MDI, Ranawat neurological classes, ARA grades, and the Stanford HAQ score)34,11,32,27 all showed fairly similar predictive powers ($p < 0.0001$). The better the preoperative grade, the more likely a satisfactory outcome would result. The MDI was also seen to correlate moderately with the spinal cord area (r = 0.4, $p < 0.0001$).

Significant radiological variables that influenced postoperative neurological outcome included the degree of vertical translocation as assessed by the Redlund-Johnell method ($p < 0.0001$, Fig. 3). This effect was not seen using the McRae method ($p = 0.737$), which measures the level of the odontoid peg with reference to McRae’s foramen magnum line.24 This may indicate that the degree of spinal canal compromise and reduction in spinal cord area...
(Fig. 4) occurring with progressive vertical translocation that is the more important pathological process, rather than the dramatic appearance of an odontoid peg poking through the foramen magnum (Fig. 5).

The spinal cord area was predictive of postoperative neurological class (p = 0.002, Fig. 6). The atlantodens interval (ADI) did not predict outcome (p = 0.269), nor did the space available for the cord (posterior ADI, p = 0.774).

A multiple logistic regression model was constructed that initially required the clinical findings alone. This revealed that only the MDI score was significant (p < 0.0001). An additional regression model requiring only radiological parameters revealed that spinal cord area (p = 0.01) and vertical translocation (p < 0.0001) were significant determinants of outcome. When these two models were combined, the degree of vertical translocation and myelopathy remained independent predictors of outcome, but the effect of cord area was lost, which is no doubt related to the fact that this parameter correlates with the MDI (r = 0.4, p < 0.0001).

Discussion

Literature Review: Management Strategies

There have only been two studies in which investigators have looked exclusively at the surgical management of vertical translocation. Indeed it was a coauthor of one of these reports, Menezes, who first highlighted the importance of this condition in two seminal studies: the first describing the radiological findings in 12 patients, of whom two underwent surgery, and the second detailing the surgical management of 45 patients with vertical translocation over a 6-year period (1978–1984). In the latter article he outlined his management strategy, advocating a trial of cervical traction using Gardener-Wells tongs or halo ring apparatus for a period of up to 2 weeks. Of the 45 patients in his series, 36 had translocation that was reducible and he was able to perform an occipitocervical fusion without the need for an anterior transoral decompression.

In our experience, and that of others, traction does not improve the degree of vertical translocation. It has been poorly tolerated by our patients with rheumatoid arthritis and we have been reluctant to subject them to prolonged periods of incumbency. From a theoretical point of view and based on the results given in our companion article, we would not expect dramatic changes in the vertical bone relationships with traction. Because of the erosive
Changes to the occipitofrontal or occipitofrontal complex the lateral masses were completely destroyed in the most severe cases and in others, autofusion has since occurred between the atlas and axis. The only thing that can stretch with traction in these cases is the intervening soft tissue, including the vertebral artery, sometimes with dire results. Improvement in these patients' neurological condition posttraction is probably caused by improved horizontal alignment and the immobility of the craniocervical junction, which prevents further traumatic insults to a damaged spinal cord. The same result can be achieved by careful operative reduction and internal fixation.

In our series the use of the transoral procedure did not result in a significant increase in morbidity, and we had a relatively low incidence of direct surgical complications. Many surgeons are reluctant to perform a transoral decompression in the presence of severe anterior compression, not wanting to visit an already very sick patient with the additive insult of two major surgical procedures. They cite evidence from Zygmunt and coworkers that peri-odontoid pannus may resolve after successful posterior fixation. These views deserve comment. We also believe that pannus is related to excessive mobility and that with time it will resolve after successful immobilization. However, as shown in the companion article, the major component of anterior compression in patients with vertical translocation is osseous in nature. Pannus is not usually a major problem when significant vertical translocation is present. The translocated odontoid peg will not disappear. It is therefore illogical to fix a spine when the major compression or deforming force has not been removed. If the surgeon has inadequate experience with the transoral procedure, this should be an indication to refer the patient elsewhere rather than to perform inadequate surgery. Our study has shown that transoral surgery does not result in any significant increase in morbidity. However, we cannot claim that patients in our series who underwent transoral decompression had a greater degree of neurological improvement compared with those who underwent posterior fixation alone; the differences between the two groups were negligible (44% compared with 46% who improved by at least one Ranawat class).

**Surgical Results and Comparisons**

It is not possible to compare our results with those of Menezes, et al., who have reported the largest surgical experience so far published in the world literature because there are no details in their study concerning the age of the patients.
patients, the duration of rheumatoid arthritis, and, more important, preoperative neurological or functional grade. They report that all of their patients improved to a functional level (ARA\textsuperscript{37}) two grades above their preoperative level. The description of the ARA grades is summarized in Table 2 with our results. Our own results contrast with their experience, with only nine (7.8%) of 116 patients improving by two grades.

The problem with the ARA functional grading system\textsuperscript{37} and, to a lesser degree, with the Ranawat neurological classification system\textsuperscript{32} is that they both fail to differentiate quite significant clinical changes between Classes II and III and they are also subject to great interobserver error. The use of an objective scoring system such as the MDI\textsuperscript{1} may improve matters and allow multicenter comparisons.

The results of surgery for vertical translocation have been described en passant in some of the larger surgical series and are listed in Table 4.\textsuperscript{1,6,26,32,36} Standard grading systems allow some broad comparisons but it should be noted that the definition of vertical translocation is not uniform between or even within the individual studies summarized in Table 4.

### Predictors of Outcome

The identification of several prognostic indicators provides useful information for the spine surgeon with which to counsel patients with regard to neurological and functional recovery. The identification of the spinal cord area together with the degree of vertical translocation as major predictors of outcome lends support to the hypothesis that the damage to the spinal cord is incremental and progressive in nature.\textsuperscript{2} The clinical manifestations of myelopathy only become apparent after a certain level of spinal cord damage has occurred and ultimately this may be irreversible.

Long-term follow up in this prospective study reveals that neurological outcome postsurgery is not a static process (Fig. 2) and there are fluctuations in the neurological grades with time. Generally speaking, patients who improve to Ranawat Classes I or II have a stable course, whereas patients who are Ranawat Classes IIIA or IIIB run a less satisfactory course, with many dying within the follow-up period. This would argue strongly for surgical intervention before permanent damage to the spinal cord has occurred.

An important negative finding of this study is that the ADI is not a predictor of final neurological outcome. The pathomechanical forces of vertical translocation will result in a decrease in the ADI, with increasing degrees of vertical translocation, as has been fully discussed.\textsuperscript{5}

Nine patients required surgical revision. This was more likely if the original construct had not incorporated the occiput. The patients involved had only minimum cranial settling according to the Redlund-Johnell criteria. Based on these experiences, we would advise that patients with vertical translocation should not have an atlantoaxial fixation alone, rather that an occipitocervical fixation should be performed. We would advise that the construct should involve the lowermost level of subaxial disease on a prophylactic basis. The loss of neck mobility for each extra motion segment involved is comparatively small, with most mobility having been lost by the occiput–C2 fixation.\textsuperscript{20}

### Conclusions

We have described the surgical outcome in a prospective study of 116 patients with myelopathy and vertical translocation undergoing surgery for cervical myelopathy. The level of preoperative disability measured by the MDI is the most significant determinant of outcome. The degree of vertical translocation and spinal cord area also have a direct bearing on neurological outcome.

### References


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### Table 4

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Patients W/ VT</th>
<th>Criteria for VT</th>
<th>Ranawat Class (no. of patients)</th>
</tr>
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<tbody>
<tr>
<td>Ranawat, et al., 1979</td>
<td>4 of 30</td>
<td>Ranawat</td>
<td>Preop: II (5) Postop: II (5)</td>
</tr>
<tr>
<td>Menezes, et al., 1985</td>
<td>45 of 45</td>
<td>Chamberlain</td>
<td>Preop: NA Postop: IIA (3)</td>
</tr>
<tr>
<td>Slättis, et al., 1989</td>
<td>18 of 18</td>
<td>McRae</td>
<td>Preop: I (1) Postop: I (1)</td>
</tr>
<tr>
<td>Boden, et al., 1993</td>
<td>19 of 35</td>
<td>McGregor</td>
<td>Preop: II (2) Postop: II (2)</td>
</tr>
<tr>
<td>Peppelman, et al., 1993</td>
<td>36 of 110</td>
<td>McGregor</td>
<td>Preop: II (9) Postop: II (9)</td>
</tr>
<tr>
<td>Casey, et al., present study</td>
<td>116 of 116</td>
<td>Redlund-Johnell</td>
<td>Preop: IIIB (37) Postop: IIA (37)</td>
</tr>
</tbody>
</table>

* NA = not available; VT = vertical translocation. \( \dagger \) Improved by two ARA grades. \( \ddagger \) All improved by two ARA grades.

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