Poster Rearatlantoaxial facet screw fixation in rheumatoid arthritis

MOHAMMED ALY ELLERY, M.D., ROBERTO MASFERRER, M.D., AND VOLKER K. H. SONNTAG, M.D.

Division of Neurological Surgery, Barrow Neurological Institute, Mercy Healthcare Arizona, Phoenix, Arizona

Object. This retrospective review was conducted to determine the efficacy of transarticular screw fixation in a group of patients who were treated for rheumatoid atlantoaxial instability.

Methods. Thirty-six patients (mean age 63 years) with rheumatoid atlantoaxial instability were treated with posterior atlantoaxial transarticular screw fixation supplemented with an interspinous C1–2 strut graft–cable construct to provide immediate three-point fixation to facilitate bone fusion. Previous attempts at fusion by using bone grafting with wire fixation at other institutions had failed in six of these patients. Six patients underwent transoral odontoid resections for removal of large irreducible pannus as a first-stage procedure, which was followed within 2 to 3 days by the posterior procedure. Postoperatively, 33 patients were placed in hard cervical collars and three required halo vests because of severe osteoporosis. Of eight patients categorized as Ranawat Class II preoperatively, all eight returned to normal after surgery; of eight patients in Ranawat Class III-A preoperatively, four improved to Class II and four remained unchanged. All 20 patients classified as Ranawat Class I preoperatively recovered completely. Pain decreased or resolved in all patients, and there were no complications related to instrumentation. At follow-up review (mean 2 years), 33 patients (92%) had solid bone fusions, and three (8%) had stable fibrous unions.

Conclusions. Posterior atlantoaxial transarticular screw fixation provides a good surgical alternative for the management of patients with rheumatoid atlantoaxial instability. This technique provides immediate three-point rigid fixation of the C1–2 region, thus obviating the need for halo vest immobilization in most cases.

Key Words • atlantoaxial subluxation • cervical spine • rheumatoid arthritis • transarticular screw fixation

Clinical Material and Methods

Patient Characteristics

The charts of 36 consecutive patients (30 women and six men) in whom rheumatoid atlantoaxial instability had been diagnosed and who were treated surgically with transarticular screw fixation from 1992 through 1996 were reviewed retrospectively. These patients' mean age was 63 years (range 38–77 years), and at presentation they had experienced symptoms of rheumatoid arthritis for a mean of 15 years (range 4–20 years). All patients reported neck and suboccipital pain, 16 had myelopathy, and six patients had an irreducible anterior pannus formation. Thirty patients were receiving steroids, four were being treated with methotrexate, and two were receiving colloidal gold injections. All patients had been treated intermittently with a variety of nonsteroidal anti-inflammatory agents.

Six patients had cardiac and pulmonary problems, four had hypertension, and one had hypothyroidism. Twenty-five patients had undergone previous surgery for joint replacements, two had undergone a previous lumbar decom-
pression with placement of instrumentation, and one had undergone previous anterior cervical fusion. In six patients treated initially at a different medical facility, a previous attempt at C1–2 stabilization by using autologous iliac bone graft–wire construct had failed.

Pre- and postoperatively, all patients were graded according to the Ranawat classification system. Preoperatively, 20 patients were Class I, eight were Class II, and eight were Class III-A.

Radiographic Evaluation

Plain radiographs, including flexion–extension views of the cervical spine, were obtained preoperatively in all patients to assess the range of motion of the C1–2 segment. All patients also underwent computerized tomography (CT) scanning to evaluate the lateral masses of C-1 and C-2 and their relationship to the vertebral artery (VA), as described elsewhere. Sagittal CT reconstructions with 1-mm slices of the C1–2 region are essential to assess the relationship of the VA and the lateral masses of C-2. A tortuous VA can sometimes erode significantly into the lateral mass of C-2, precluding the passage of the transarticular screw (Fig. 1). The predental space on the CT scans was also measured in all patients. The mean predental space was 9 mm (range 6–12 mm, Fig. 2). Magnetic resonance imaging was used to evaluate the relationship of the spinal cord to the cervical spine at the cervicomedullary junction and the size and degree of compression produced by pannus formation.

Patients with demonstrated atlantoaxial instability were considered candidates for C1–2 transarticular screw fixation if there was no abnormality of the C1–2 facets and no anomalies in the course of the VA at this level. All patients were evaluated by means of plain radiographs immediately after surgery and again at 2, 6, and 12 weeks postoperatively. The stability of the bone fusion was assessed with the aid of flexion–extension views of the cervical spine between 6 and 12 weeks.

Operative Technique

Intraoperatively, controlled flexion of the patient’s neck is required to obtain the proper trajectory for insertion of the drill and screws. Consequently, the head is fixed in a Mayfield skull clamp and the patient is placed prone. Lateral fluoroscopic visualization with a C-arm is used to avoid increasing the atlantoaxial dislocation during positioning and screw placement. A posterior cervical incision is made and extended to the C-7 spinous process. A wire cable is then placed around the ring of C-1 for traction and subsequent fixation of the interspinous bone graft. Traction on the C-2 vertebra is applied by means of an Allis clamp attached there. The atlas and axis are realigned by manual reduction after the vertebrae are exposed subperiosteally. For an anterior atlantoaxial subluxation, C-2 is gently displaced anteriorly and C-1 is pulled posteriorly; opposite forces are applied for a posterior subluxation.

With the aid of lateral fluoroscopic monitoring, the drill is positioned to enter the posterior cortex of the C-2 vertebral body 2 to 3 mm lateral to the medial border of and 2 to 3 mm above the C2–3 facet. A trajectory of between 0% and 10% medially is required to prevent injury to the VA after screw placement. A bicortical interspinous bone graft is fitted and wired into position between C-1 and C-2.

Cytotoxic agents, steroid drugs, and antiinflammatory medications were discontinued or reduced 1 week before surgery and started again 2 weeks after surgery in patients being treated with these drugs.

Results

All patients underwent transarticular screw fixation at C1–2 supplemented by an interspinous C1–2 bone graft–titanium cable construct. Twenty-two patients underwent a two-screw fixation; 14 patients had only one screw placed because the course of their contralateral VA was anomalous. Fully threaded screws were used in 15 patients and lag screws were used in the remainder, because lag screws are preferred to facilitate reduction if C-1 is subluxated anterior to C-2. The transarticular screw fixation was performed as a second-stage procedure in the six patients who had an irreducible anterior pannus; a transoral odontoidectomy was required in these cases as the first-stage procedure.

Pain was relieved completely in 28 patients, and the other eight improved but had residual neck pain. All 20 patients classified as Ranawat Class I preoperatively recovered completely, as did the eight patients in Class II. Of the eight patients in Class III-A, four improved to Class II, and four remained unchanged. None of the patients has
complained of noticeable limitation in their range of neck motion.

Thirty-two patients (88%) wore a rigid cervical orthosis for 6 to 12 weeks after surgery, depending on the appearance of the bone graft on the follow-up radiographs. Three patients in whom a previous attempt at fusion had failed were placed in halo braces after severe osteoporotic changes were encountered intraoperatively. One patient (3%) was placed in a sternal–occipital mandibular immobilization (SOMI) brace 3 weeks postsurgery.

Thirty-three patients (92%) developed solid bone fusions. Three patients (8%, including the one treated with the SOMI brace) had stable fibrous unions (Fig. 3): one screw was placed in two of these patients and two transarticular screws were placed in the other. No screws were malpositioned in this series.

No patient has required reoperation (mean follow up 2 years, range 14 months–4 years), and there have been no postoperative complications related to instrumentation. In the patient who wore the SOMI brace, the cable loop slipped from under the C-2 spinous process 3 weeks postsurgery. Three patients had superficial wound infections that responded well to wound care and antibiotic therapy. Four patients developed postoperative pneumonia, and one had a myocardial infarction; all recovered completely with no sequelae. One patient had a cerebrovascular accident 1 year postsurgery, which resulted in a left-sided hemiparesis.

**Discussion**

Pain in the affected joints is a common manifestation of rheumatoid arthritis. In patients with atlantoaxial instability, suboccipital pain from compression of the C-2 nerve root is the most common symptom. Hyperreflexia, weakness, spasticity, and gait dysfunction correlate with the degree of subluxation, the extent of upward migration of the odontoid, and the size of the associated pannus formation. In addition to their neurological dysfunction, these patients often have complex, multiple-system medical problems associated with the disease process and the side effects of related drug therapies.

**Surgical Indications**

Patients with severe rheumatoid arthritis often require posterior cervical fusion for the treatment of severe pain, progressive atlantoaxial instability, severe basilar invagination, and/or progressive radicular or myelopathic symptoms. Early neurological deficits may be difficult to assess in these patients. Because of the severity of their disease, most of them already have articular deformities. They have also lost muscle mass because of decreased strength from the prolonged use of steroids and a limited ability to exercise. Hyperreflexia can be camouflaged by the accompanying severe changes in the peripheral joints.

The primary purpose of spinal arthrodesis in patients who have rheumatoid arthritis and an unstable cervical spine is to prevent neurological compromise and to decrease pain. The indication for surgical intervention in patients with C1–2 instability and an impending risk of neurological deficit is a subluxation shown to be more than 6 mm on radiographic studies.

**Types of Fusion**

In an attempt to achieve more solid fusions, wiring techniques were added to the simple fusion techniques. Gallie introduced the C1–2 interspinous fusion with an iliac crest bone–wire construct, which was modified later by Brooks and Jenkins. The Brooks technique provides immediate stability, but the sublaminar passage of wires under C-2 can produce irreversible and devastating spinal cord injury. The use of two bone grafts with this technique allows additional rotational movement.

More rigid devices were also created to increase fusion rates. These devices include laminar clamps and more extensive metal constructs with wires or cables, some-
times supplemented with methylmethacrylate. Rigid internal fixation increases the degree of internal immobilization. The use of laminar clamps eliminates the potential hazard of sublaminar wire passage, but these clamps can become dislodged and decrease the area available for bone grafting. Clamp failure has been reported in more than 20% of the published series.

Fusion Rates

The fusion rates of early series in which the basic bone graft and/or bone with wire techniques were used have varied: some have been as low as 50%. Possible factors leading to fusion failure include demineralization of bone, severe laxity of the ligaments (with spinal malalignment and abnormal motion segments), and poor vascularity. The use of steroid drugs, cytotoxic agents, and nonsteroidal antiinflammatory medications has also been implicated in poor fusion rates.

As early as 1979, Ranawat, et al., observed that the more stable the fixation obtained during surgery, the more satisfactory the fusion. Patients need prolonged bedrest or immobilization in a halo brace to augment the fusion rate by lowering the risk of movement at the surgical site. However, because of their compromised medical status, these patients do not tolerate either of these complementary measures well.

Fusion rates of 100% (Table 1) have been reported in only two series of C1–2 arthrodeses in patients with rheumatoid arthritis. In both series, patients were treated by means of the Brooks technique. However, both of these series were small: one had nine patients and the other had five patients. All of these patients were immobilized in a halo brace for 3 months after surgery. In one of these series a 20% rate of neurological complications was reported.

Fusion rates in series in which techniques other than that of Brooks were used have ranged from 62 to 82%. Madawi, et al., for example, used posterior transarticular screws in 37 patients with rheumatoid arthritis and their fusion rate was 81%. Screws were malpositioned in 11 patients, two patients sustained VA injuries, and screws broke in four patients. This group’s complication rate seems to be related to incomplete reduction before screw placement, which accounted for two-thirds of their complications and all of their cases of injured VAs. They also used cables in only 60% of their cases. In contrast, in all of our cases we used interspinous bicortical bone grafts and wiring techniques to achieve three-point fixation, which promotes fusion.

The typical site of osseous failure is the interface between the bone graft and the posterior arch of the atlas. The posterior ring and atlas often migrate upward and rotate as a result of the disease process. Once the posterior ring is exposed and the inferior portion is decorticated, minimal surface area is available for a graft interface. Stability is then threatened by rotational strain. However, a single bicortical interspinous graft and wire provide immediate segmental and rotational stability.

In previous published series, neurological improvement has been reported as less than 50%. In our series the patients categorized as Ranawat Class II returned to normal. Of the eight patients in Ranawat Class IIIA, four

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Type of Fusion</th>
<th>External Immobilization</th>
<th>No. of Cases</th>
<th>Fusion Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glynn &amp; Sheehan, 1983</td>
<td>Gallie</td>
<td>halo</td>
<td>7</td>
<td>66.6</td>
</tr>
<tr>
<td>Heywood, et al., 1988</td>
<td>Gallie</td>
<td>SOMI</td>
<td>12</td>
<td>75</td>
</tr>
<tr>
<td>McCarron &amp; Robertson, 1988</td>
<td>Brooks</td>
<td>halo</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Clark, et al., 1989</td>
<td>sublaminar wire &amp; bone grafts, methylmethacrylate orthosis</td>
<td>20</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Papadopoulos, et al., 1991</td>
<td>interspinous graft, wire</td>
<td>halo</td>
<td>17</td>
<td>82</td>
</tr>
<tr>
<td>Boden, et al., 1993</td>
<td>Brooks</td>
<td>halo, cervicothoracic orthosis</td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td>Maniker, et al., 1995</td>
<td>Halifax clamps, bone graft; added methylmethacrylate in 3 cases</td>
<td>hard collar</td>
<td>9</td>
<td>62.5</td>
</tr>
<tr>
<td>Madawi, et al., 1997</td>
<td>postatlantoaxial transarticular screw</td>
<td>collar</td>
<td>37</td>
<td>81</td>
</tr>
</tbody>
</table>

FIG. 3. Anteroposterior (upper) and lateral (lower) radiographs obtained 8 weeks after surgery demonstrating the trajectory of the facet screw and a solid bone fusion between C1–2.
improved to Class II and four remained unchanged in their Ranawat classification. Overall, 88% of the patients treated with three-point fixation improved.

The major hazard associated with the techniques discussed here is injury to the VA. Consequently, surgeons must verify that a patient’s VA does not follow an anomalous course. The extrardinal portion of VAs arises from the subclavian artery and enters the transverse foramina of C-6. The VAs ascend through the transverse foramina of the upper six cervical vertebrae. At C-2, they course through the transverse foramina superolaterally to that of C-1. At this point, the arteries cross posteromedially behind the upper half of the C-1 lateral mass and pass anteromedially in a groove in the superior surface of the posterior arch of the atlas. The arteries then penetrate the dura adjacent to the articulation of the occipital condyle and C-1 lateral mass. A high-riding VA or one with a tortuous course can erode the lateral mass of C-2, precluding the safe passage of a screw because of a narrow pars interarticularis. Meticulous preoperative planning and intraoperative fluoroscopic monitoring are mandatory to avoid complications related to the VA.

Posterior transarticular screw fixation represents an important option in the management of patients with rheumatoid atlantoaxial instability. The great mechanical strength of the instrumentation and the three-point fixation it offers result in high fusion rates when supplemented with a C1–2 interspinous iliac crest–titanium cable construct. Although performing the technique is challenging, it can be mastered with adequate training. Using this technique avoids prolonged bedrest for the patient and can reduce significantly the use of a halo brace for external immobilization. Early patient ambulation can be achieved only with a rigid cervical orthosis, and it will decrease complications such as pneumonia and pressure necrosis of the skin associated with bedrest or craniocervical orthoses.

Conclusions

Posterior transarticular screws in C1–2 are more rigid than wiring techniques or laminar clamps and provide immediate atlantoaxial stability. These screws also resist translational and rotational forces that could be responsible for fusion failures in other constructs. The placement of a C1–2 interspinous iliac crest–titanium cable construct provides not only three-point fixation but also increases the amount of rigid contact surfaces for bone grafts, facilitating the formation of a solid fusion. Based on our experience, it appears that transarticular screw fixation, once mastered and supplemented with bone grafting, is superior to other techniques used in the surgical management of atlantoaxial instability associated with rheumatoid arthritis.

References


Address reprint requests to: Volker K. H. Sonntag, M.D., c/o Neuroscience Publications, Barrow Neurological Institute, 350 West Thomas Road, Phoenix, Arizona 85013.