Use of a titanium mesh cage for posterior atlantoaxial arthrodesis

Technical note

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The authors placed titanium mesh cages to achieve posterior atlantoaxial fixation in five patients with atlantoaxial instability caused by rheumatoid arthritis or os odontoideum. A mesh cage packed with autologous cancellous bone was placed between the C-1 posterior arch and the C-2 lamina and was tightly connected with titanium wires. Combined with the use of transarticular screws, this procedure provided very rigid fixation. Solid fusion was achieved in all patients without major complications. The advantages of this method include more stable fixation, better control of the atlantoaxial fixation angle, and reduced donor-site morbidity compared with a conventional atlantoaxial arthrodesis in which an autologous iliac crest graft is used.

KEY WORDS • titanium mesh cage • atlantoaxial fusion • atlantoaxial stabilization

POSTERIOR atlantoaxial fusion is a procedure widely used to treat atlantoaxial instability. In the treatment of this condition, the surgical options include the conventional posterior wiring techniques such as the Gallie method, the Brooks method,2 and their modifications; the clamp methods;11 and the transarticular screw fixation method developed by Magerl.9 A combination of transarticular screw and posterior wiring fixation has become the most widely performed method of atlantoaxial fusion because of the excellent mechanical stability it provides based on three-point fixation.3–5,9

Several problems associated with posterior atlantoaxial arthrodesis have been noted. Toyama, et al.,13,14 have reported that malalignment of the cervical spine developed after posterior atlantoaxial arthrodesis because of an increased atlantoaxial fixation angle (that is, hyperlordosis between C-1 and C-2); the increased angle was caused by excessive tightening of the posterior wires. They concluded that the ideal atlantoaxial angle and distance between the C-1 posterior arch and the C-2 lamina to prevent such postoperative malalignment were 20˚ and 8 mm, respectively. Kato, et al.,7 have reported that loosening of titanium cables and protrusion into the spinal canal occurred in 28 of 33 patients who underwent transarticular screw fixation combined with Brooks-type fusion. These problems may arise partly because of the nature of the graft materials placed between the C-1 posterior arch and C-2 lamina. If graft materials, such as autologous unicortical bone obtained from the posterior iliac crest, have been made biomechanically suboptimal due to the osteoporosis commonly seen in patients with RA, they may collapse and allow loosening or uncontrolled excessive tightening of the wires. Other problems associated with posterior atlantoaxial fusion include donor-site iliac bone graft–related morbidities1 and pseudarthrosis in which resorption of grafted bone occurs. Little attention, however, has been paid to the graft materials placed between the C-1 posterior arch and the C-2 lamina during posterior atlantoaxial arthrodesis. To obtain rigid posterior atlantoaxial fixation and to decrease the incidence of donor-site morbidity, the authors placed a titanium mesh cage as a spacer between the posterior arch of C-1 and the lamina of C-2. In this preliminary report, the authors discuss the clinical application of this new procedure.

Clinical Material and Methods

Patient Population

Posterior atlantoaxial fusion in which titanium mesh cages (Moss Titanium Mesh; Dupuy-Acromed, Leeds, England) were used was performed in five patients. There were one man and four women, with a mean age of 53 years (range 42–61 years). In four patients simultaneous transarticular screw and posterior wiring fixation was performed, and in one posterior wiring alone was performed because...
TABLE 1

Summary of clinical data in patients undergoing posterior atlantoaxial fusion in which a titanium mesh cage is placed*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Disease</th>
<th>Preop Symptoms</th>
<th>Surgical Procedures</th>
<th>Cervical Kyphosis</th>
<th>Radiographic Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>57, F</td>
<td>RA</td>
<td>neck pain</td>
<td>TMC</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>2</td>
<td>42, M</td>
<td>OO</td>
<td>neck pain</td>
<td>TAS + TMC</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>3</td>
<td>55, F</td>
<td>RA</td>
<td>neck pain, myelopathy (Ranawat IIIA)</td>
<td>TAS + TMC</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>4</td>
<td>61, F</td>
<td>RA</td>
<td>neck pain, myelopathy (Ranawat IIIA)</td>
<td>TAS + TMC</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>5</td>
<td>52, F</td>
<td>RA</td>
<td>neck pain</td>
<td>TAS + TMC</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

* OO = os odontoideum; TAS = transarticular screw fixation; TMC = titanium mesh cage.

FIG. 1. Case 3. Imaging studies before and after posterior atlantoaxial arthrodesis with a titanium mesh cage.  
Upper Left: Preoperative lateral x-ray film obtained with the patient in flexion, demonstrating marked anterior subluxation of the atlas.  
Upper Center: Sagittal T₂-weighted magnetic resonance image demonstrating severe compression of the spinal cord.  
Upper Right: Intraoperative photograph showing a titanium mesh cage packed with autologous cancellous bone obtained from the posterior iliac crest.  
Lower Left: Intraoperative photograph showing the titanium mesh cage placed between the posterior arch of C-1 and the lamina of C-2 and tightened with titanium cables.  
Lower Right: Postoperative lateral x-ray film obtained at 6 months, demonstrating solid osseous fusion with no malalignment of the cervical spine or loosening of the cables.
Use of titanium mesh cage

of difficulty in placing screws through the lateral mass of C-1 and C-2. The mean follow-up period was 1.6 years (range 0.5–3.25 years). Rheumatoid arthritis was present in four patients, and os odontoideum in the fifth patient. Preoperative symptoms included severe neck pain in all patients and cervical myelopathy (Ranawat Grade IIIA) in two. Clinical data are summarized in Table 1.

Radiography demonstrated a mean anterior atlantoaxial subluxation of 10.5 mm (range 8–13 mm). Postoperatively, solid bone union was confirmed both by the presence of continuous osseous trabeculae between C-1 and C-2 through a mesh cage and by immobility between C-1 and C-2 on flexion–extension lateral radiography. The mesh-type construct of the cage and the use of digital computerized radiography (Fuji Film Medical, Tokyo, Japan) enabled us to evaluate accurately the status of bone union, because this modality can provide fine images of bone.

Surgical Methods

Patients are placed in the prone position with the rostral side of the operating table tilted upward approximately 30°, and skull traction is applied with a 3-kg weight to stabilize the patient’s head and cervical spine and to widen the C1–2 interspace as a means of facilitating cage placement and wire passage. A midline incision is made from the occiput to C-4, and the C-1 posterior arch, C-2 lamina, and upper part of the C-3 lamina are exposed. The C2–3 facet joints are exposed bilaterally to clear the site of guide pin insertion. If reduction is not sufficient, the C-2 spinous process is grasped with a towel clip and gently pushed forward under image guidance. Guide pins are drilled bilaterally through the C-1 and C-2 lateral masses, as has been described.9 A double titanium cable (Atlas Cable; Sofamor-Danek, Memphis, TN) is passed under the posterior arch of C-1 and the lamina of C-2 and cut into two pieces. For stable positioning of the titanium mesh cage, a graft site is meticulously prepared using a diamond burr to drill the lower surface of the C-1 posterior arch and the upper portion of the C-2 lamina. A cylindrical titanium mesh cage is gently pressed with pliers into an oval shape so that it will fit into the C1–2 interlaminar space (Fig. 1). The height of the cage ranges from 8 to 10 mm, which appears to be the optimum height to prevent the development of postoperative malalignment, according to Toyama, et al.13,14 A small amount of cancellous bone is harvested from the posterior iliac crest via a small incision and packed into the cage. The cage is placed between the posterior arch of C-1 and the lamina of C-2 by gentle tapping, and the titanium cables are tightened bilaterally and locked temporarily with clamps. At this point, C-1 and C-2 are fixed securely so that, typically, no movement can be detected between them. Cannulated cancellous screws, 3.5 mm in diameter, are inserted over the guide wires, and the titanium cables are tightened and locked permanently. Finally, cancellous bone chips are placed across the posterior arch of C-1 and the lamina of C-2.

Postoperatively, the patients are allowed to sit up and walk the day after surgery without having to wear any braces. A soft collar is worn for a short period only if the patient cannot tolerate postoperative wound-related pain. The patient in whom transarticular screw fixation was not performed wore a soft collar for 6 weeks, which was exceptionally longer than the other patients in whom this fixation procedure was performed.

Results

The mean operative time was 113 minutes (range 93–140 minutes), and the mean blood loss was 39 g (range 25–50 g). No major intra- or postoperative complications were encountered.

At follow-up examination, solid osseous union and improvement of neck pain and cervical myelopathy (Ranawat Grade IIIA to Grade II in both cases) had been achieved in all patients. There were no cases of donor-site complications. Although mild postoperative cervical kyphosis developed in one female patient (Case 4), she never experienced recurrence of the neck pain. Loosening of the cables was noted in two of the patients with RA (Cases 1 and 4), but no obvious subsidence of the cage was detected (Fig. 2), and neither of the patients experienced neurological deficits. The mean preoperative atlantoaxial angle of 10° (range −6 to 28°) had increased to 24° (range 13–37°) at follow up.

Discussion

Several advantages are offered by posterior atlantoaxial fixation in which the titanium mesh cage is used. First, when combined with transarticular screw fixation, posterior atlantoaxial fusion can provide immediate and rigid mechanical stability by three-point fixation. We found that
this was corroborated by the intraoperative absence of any subtle movements after tightening the wires around the cage between the C-1 and C-2, even before placement of transarticular screws. In a biomechanical cadaveric study in which they compared cable-graft-screw fixation combinations, Naderi, et al.,12 found that transarticular screws were better able to prevent lateral bending and axial rotation than a posterior cable and graft; however, they also found that the cable and graft fixation prevented flexion and extension better than the screws. They concluded that it was mechanically advantageous to include as many fixation points as possible when surgically treating atlantoaxial instability. There have been several biomechanical studies in which investigators compared the mechanical strength among various posterior fixation methods;6,10,12 however, to date, there has been no study in which the focus was the effect of an implant placed between the C-1 and C-2 laminae. It may be speculated that a rigid interlaminar implant can provide stronger biomechanical stability against flexion–extension and lateral bending forces as well as against translational force. The titanium mesh cage, which is structurally far more rigid than autologous iliac bone, provides more stable fixation of the atlantoaxial joint and can eliminate the need for postoperative brace therapy. Second, because posterior atlantoaxial fixation maintains an interlaminar distance between C-1 and C-2, it prevents hyperlordotic atlantoaxial fusion, which may result in postoperative malalignment of the cervical spine.13,14 In our series, the mean follow-up atlantoaxial angle was 24°, which is an appropriately lordotic fixation angle.14 Third, the current method can decrease the incidence of donor-site morbidity, because it requires that a smaller amount of autologous bone be harvested from the posterior iliac crest than that necessitated in conventional unicortical autologous bone grafts.

This method is also applicable in patients with spinal cord and medullary compression caused by combination of the odontoid process and pannus. Once good reduction and rigid fixation have been achieved, the pannus spontaneously regresses with improvement of cervical myelopathy.8 Although dislodgement of the cage into the spinal canal is a potential disastrous complication, the jagged margins of the cage and tightened cables enable secure fixation of the cage between C-1 and C-2. Despite the loosening of the sublaminar wire demonstrated in two patients, subsidence of the cage was not observed. Wire loosening may occur as a result of the wires themselves cutting into the cortex of the laminae. Because cage subsidence is a potential complication, however, the cortical bone of the C-1 posterior arch and C-2 lamina should be spared as much as possible during preparation of the graft site for the cage. In conclusion, the results of this preliminary study suggest that posterior atlantoaxial fusion in which placement of the titanium mesh cage is combined with transarticular screw fixation can provide immediate rigid fixation, thereby eliminating the need for postoperative cervical brace therapy and, at the same time, minimizing postoperative malalignment of the cervical spine and donor-site morbidity.

References

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