ATLANTO-AXIAL FUSION WITH TRANSARTICULAR SCREW FIXATION

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From Spine Centres in Zurich, St Gallen and Berne

We reviewed 161 patients, from four centres in Switzerland, who had undergone posterior fusion of the upper cervical spine with transarticular screw fixation of the atlanto-axial joints. They were followed up for a mean 24.6 months. The vertebral artery and the medulla escaped injury and only 5.9% of the complications were directly related to the screws. The rate of pseudarthrosis was 0.6%.

In recent years a number of new techniques for internal fixation of the craniocervical junction have been defined (Magerl 1982; Magerl and Seemann 1986; Ransford et al 1986; Guyotat et al 1987; Roy-Camille, Mazel and Saillant 1987; Grob, Magerl and Seemann 1988; Privat 1988, Grob et al 1990, 1991). Little information on complications resulting from their use has been published.

Transarticular screw fixation with posterior atlanto-axial fusion has been said to be a dangerous and technically difficult procedure, providing no better results than conventional wiring techniques (Smith et al 1989). The present study was undertaken to evaluate the results and complications of the method in four spinal centres in Switzerland.

PATIENTS AND METHODS

There were 161 patients (100 men) from four spinal centres (Zurich, St Gallen and two hospitals in Berne). The mean follow-up time was 24.6 months (3 to 89). The average age at the time of operation was 49.7 years (15 to 88).

The indications for fusion are given in Table I. In 126 patients (78%) an isolated atlanto-axial screw fixation was performed and in the remaining 35 cases the fusion was extended to include segments caudally or rostrally.

Patients were mobilised on the first or second postoperative day if their general health permitted. Simple soft collars were used in 84 patients and Plastozote (A. Bühler, Orthopädiotechnik Zürich, Switzerland) collars in 68. Halo fixation was used in one case and a plaster cast of the minerva type in another. In seven patients no external support was used.

The operations were performed by eight orthopaedic surgeons and two neurosurgeons. Their experience varied considerably; three having operated on less than six patients each.

The review of complications was conducted by questionnaires completed by the surgeons. The clinical and radiographic follow-up examinations were done separately in each hospital.

OPERATIVE TECHNIQUE

The anaesthetised patient lies prone. A head fixation device, set with the axis of rotation at the level of the atlanto-occipital joints, holds the lower cervical spine in

<table>
<thead>
<tr>
<th>Indication</th>
<th>Total</th>
<th>Percentage</th>
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<tr>
<td>Trauma and post-traumatic instability</td>
<td>61</td>
<td>40.6</td>
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<tr>
<td>Rheumatoid arthritis</td>
<td>51</td>
<td>31.0</td>
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<tr>
<td>Congenital anomalies</td>
<td>20</td>
<td>12.4</td>
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<tr>
<td>Pseudarthrosis of the dens</td>
<td>18</td>
<td>11.1</td>
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<tr>
<td>Degenerative arthritis</td>
<td>7</td>
<td>4.3</td>
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<tr>
<td>Infections</td>
<td>2</td>
<td>1.2</td>
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<tr>
<td>Tumours</td>
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extension and the head in full flexion at the atlanto-axial joint (Fig. 1). An extensive skin incision is required to allow proper alignment of the drill bit.

The insertion point for each screw lies on the dorsal aspect of the axis at the junction of the lamina with the articular mass (Fig. 2). Drilling is done under fluoroscopic control with a 2.5 mm AO drill bit, directed strictly in the sagittal plane to avoid damage to the vertebral artery laterally and to the structures inside the spinal canal medially. The concavity of the medial arch of the lamina, exposed subperiosteally, serves as a landmark for the one side of the atlas. A 3.5 mm AO cortical screw is inserted, either as a positioning screw or as a lag screw after widening the proximal hole with a 3.5 mm AO drill bit.

A graft is then placed between the arch of the atlas and the spinous process of C2, secured in place by a wire loop or a strong suture (Fig. 2). In the case of an unstable arch of the atlas, the dorsal aspect of the C1/C2 joint is visualised, the cartilage is removed in the posterior third of the joint, and the graft is inserted directly into the joint. Immediate postoperative stability of the C1/C2 segment is assured by the three point fixation provided by the two screws and the posterior bone graft.

Postoperatively, most patients wore a soft cervical collar until fusion was confirmed radiologically.

**RESULTS**

Of the 161 patients who underwent transarticular atlantoaxial screw fixation, 137 had no complications.

The final outcome in the 24 patients who had complications was considered to be subjectively good (no serious pain, no restriction of activity) in 18, and fair (periods of pain, working capacity reduced) in six. No patient had a bad result (permanent severe pain and disability). The objective rating, by the surgeon, was good (no pain, solid fusion) in 18 cases and fair (moderate pain, solid fusion) in six. None was rated as bad (nonunion, with severe pain).

direction of the drill hole. The drill crosses the isthmic part of C2 and leaves the axis in the posterior third of the atlanto-axial joint. After crossing the joint, the drill enters the atlas approximately in the mid-part of the articular process. There must be neutral atlanto-axial rotation before drilling. Rotation of the atlas causes the lateral mass on one side to move backwards in relation to the axial joint. The screw may then leave the joint surface of the axis ventral of the dorsally displaced lateral mass on

Complications directly related to the technique

The position of the screws was assessed by transoral, anteroposterior and lateral radiographs. This was considered ideal when both the lateral and anteroposterior projections showed both screws lying entirely within bone and crossing the joint space in the anteroposterior view; 273 (85%) of the 322 screws were rated as ideal; 25 (7.7%) were positioned too far laterally, and seven (2.1%) too far medially. Eleven screws (3.4%) were too short, or
inserted at the wrong angle, and did not cross the joint (Fig. 3). Six (1.8%) were too long (Fig. 4), protruding through the lateral mass of the atlas ventrally. Only four patients with malpositioned screws had attributable complications.

Pseudarthrosis. Fusion was assessed from the radiographic appearances of the graft and from flexion and extension bending films. Bone union was present in 153 cases. Some calcification was seen between the arch of the atlas and the graft in eight patients and in these cases no motion was detected in the atlanto-axial segment on the flexion/extension films. Since these patients had no complaints we think that they had firm fibrous union. Pseudarthrosis, with pain and detectable movement between the atlas and the axis, was present four months postoperatively in one patient (0.6%). A conventional atlanto-axial fusion was performed after removal of the loose screws, which had been incorrectly inserted, and fusion resulted.

Implant failure. Loosening and displacement of the screws, compared to their immediate postoperative position, was found in three patients, three months postoperatively. All had developed solid fusion and were free of pain. All three had had occipitocervical fusions with Y-plate fixation from the occiput to C2, with the transarticular screws integrated into the plate (Fig. 5). At the latest follow-up, at eight, 13 and 19 months postoperatively, no further displacement of the screws had occurred and the patients were still free of pain.

In three other patients, broken screws were detected. One pair of broken screws was in a 34-year-old woman with severe rheumatoid arthritis. She had noticed an intensification of neck pain approximately eight months after the fusion. Flexion/extension radiographs showed no atlanto-axial movement (Fig. 6), but considerable neck pain persisted in spite of solid bony fusion, probably due to degenerative changes in the atlanto-occipital joint. The patient refused any further surgical procedure. In a second patient, in whom no bone graft had been used, breakage of the screws was noted three months postoperatively. Revision with grafting was performed and union occurred. In the third patient, screw breakage was detected three months postoperatively but flexion/extension radiographs demonstrated solid fusion and the patient was pain free.

Vascular and neurological complications: Injv to the vertebral artery or to the spinal cord or the dura mater did not occur. One patient developed a unilateral paresis of the hypoglossal nerve. This was probably due to a long screw projecting anterior to the occipital condyle. The paresis recovered following replacement of the screw with another of the correct length.

Complications not related to the technique. One patient had hypo-aesthesia in the area supplied by the greater occipital nerve due to tension on soft tissues by the retractors. It resolved spontaneously after six weeks.

There was one deep wound infection with Staphylococcus epidermidis that required revision at three months and removal of the screws. Fusion was solid.

In one rheumatoid patient, with spontaneous fusion of C3 to C5 and atlanto-axial instability, severe pain persisted after the C1 to C2 fusion. Some improvement was noted after a second operation to extend the fusion from the occiput to C3.

Postoperative death. There were five deaths. One 71-year-old patient had advanced rheumatoid arthritis with tetraparesis due to severe atlanto-axial instability and retrodental inflammatory tissue compressing the medulla. It was decided to undertake transoral decompression and posterior fixation, the patient being aware of the risk. Death occurred four weeks after the operation from pneumonia.

Cardiac arrest caused the deaths of two elderly patients. One occurred on the second postoperative day in a patient aged 81 years with advanced rheumatoid arthritis.
arthritis and the other at three days after operation in an 88-year-old patient whose atlanto-axial fusion had been performed following a neck injury.

Two further deaths were related to the anterior decompression rather than to the concomitant posterior fusion. A 54-year-old rheumatoid patient with anterior medullary compression due to vertical settling of the odontoid peg underwent transoral decompression and posterior fusion from the occiput to C2. At the time of extubation on the eighth postoperative day, pharyngospasm occurred and reintubation was made difficult by swelling of the pharynx and the fixed neck. A 72-year-old patient, who had had a laminectomy from C2 to C7 for degenerative spinal stenosis four months earlier, deteriorated progressively and was tetraparetic on admission. Anterior decompression from C2 to C5 was combined with posterior occipitocervical fusion down to T1. Three hours after extubation, acute dyspnoea occurred and immediate reintubation was performed. Seven days postoperatively she died following cardiac arrest.

Miscellaneous complications. One patient on corticosteroid medication required reoperation for infection and skin necrosis at the pelvic donor site and another developed a haematoma that required evacuation. Two patients complained of dysphagia after occipitocervical fusion. One improved after reoperation to fuse the neck in a more extended position and the second improved spontaneously.

A 15-year-old patient developed a subaxial kyphosis after C1 to C2 fusion which had to be corrected surgically.

**DISCUSSION**

Reviewing the literature of atlanto-axial fusion we have found no previous description of the complications related to specific operative procedures. There are, therefore, no published data to compare with our study. We have demonstrated that the technique of transarticular atlanto-axial screw fixation of Magerl (1982) does not cause serious complications such as injury to the vertebral artery or the medulla.

The five deaths in this series need to be analysed. First, there were the three postoperative deaths, two due to cardiac arrest and one to pneumonia in patients aged 81, 88 and 71 years respectively. The other two patients had required prolonged laryngeal intubation, one following transoral decompression and the other for throat oedema after anterior vertebrectomy. The indication for surgery in three of these five patients was advanced rheumatoid arthritis. In none of these patients did death occur because of the operative technique. We conclude that intervention in the suboccipital region, especially if it is combined with an anterior surgical approach, is hazardous in elderly debilitated patients. If stabilisation of the atlanto-axial joint is performed at an early stage of rheumatoid disease intervention may be restricted to the posterior approach.

The low incidence of nonunion (0.6%) in this series reflects the reliable mechanical stability already demonstrated in vivo and in vitro by Grob and Magerl (1987a,b) and Grob et al (1990). Even in adverse situations, as in rheumatoid patients with osteoporosis, the fusion rate was high. In previous reports of other methods the pseudarthrosis rate ranged from 3% (Griswold et al 1978) to 23% (Roy and Gibson 1970).

Broken implants usually testify to instability, but fusion may take place after breakage which may explain why two of our three patients with broken screws were pain free. However, compared to the reports of broken and loose wires in atlanto-axial fusions (Schlesinger and Taveras 1958; Brooks and Jenkins 1978; Clark, Goetz and Menezes 1989), intraosseous screws seem to be less dangerous, since significant migration of screw fragments did not occur in our series.

The anatomy of the occipitocervical region makes correct insertion of the screws technically difficult and proper positioning of the patient is therefore important. Forty-nine of the screws (15%) were incorrectly inserted but in only two patients was this the cause of a complication. In one case a screw was too long and
probably irritated the hypoglosseal nerve and in the other, both screws were too short and provided inadequate stability. Nonunion did not follow incorrect placement of one screw, so bilateral fixation is not an indispensable condition for a satisfactory outcome.

Each patient was reviewed by the surgeon who had performed the fusion, because practical difficulties forced us to undertake this study under these subjectively influenced conditions. However the similarity of the technique-related complication rates in all the three major contributing hospitals (0%, 3.3% and 4%) suggests a uniform experience.

Conclusions. Transarticular screw fixation of the atlanto-axial joints, with posterior bone grafting, provides good fixation and has proved successful even in cases in which the laminae are deficient.

In a large series of operations performed by several surgeons the vertebral artery and the spinal cord were never injured.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES


