ATLANTO-AXIAL ARTHRODESIS

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Atlanto-axial instability is an important condition that often requires operation. Atlanto-axial subluxation may not only cause severe symptoms; it may threaten the integrity of the spinal cord, leading to tetraplegia or sudden death. The frequency of the condition is unknown. The causes are many. It is therefore essential that the orthopaedic surgeon should not only recognise this condition, but should know the indications for stabilisation and practise a safe and reliable technique of arthrodesis.

Only occasional reference is made in the literature to the technique of atlanto-axial arthrodesis. The “Gallie fusion” is frequently mentioned, but there is no detailed description of a precise technique employing the principles outlined by Gallie. He advocated skull traction, open reduction of the spinal subluxation, and stabilisation by a wire and bone graft (Gallie 1937, 1939). A careful review of the literature has also failed to reveal a clear understanding of the indications for atlanto-axial arthrodesis.

The purpose of this paper is to define the indications for atlanto-axial arthrodesis, to describe in detail a technique, and to examine the results of fifteen consecutive atlanto-axial arthrodeses performed at the Vancouver General Hospital.

INDICATIONS

The indications for atlanto-axial arthrodesis are logically considered according to etiology.

Congenital abnormality of dens—Congenital anomalies of the dens include total absence (Giannestras, Mayfield, Provencio and Maurer 1964), hypoplasia and congenital separation (Wollin 1963). They are potentially dangerous because minor trauma may initiate a severe atlanto-axial dislocation with resultant damage to the cord. Further, long-standing instability may lead to chronic myelopathy. Stabilisation is therefore indicated when there is definite instability, with or without neurological change.

Atlanto-axial rotatory subluxation—Rotatory subluxations are often overlooked. Fielding (1969) believed that the ligaments were so damaged that they might not be able to withstand a second injury. He thus recommended atlanto-axial arthrodesis.

Fracture of dens—Unstable fractures of the dens, fractures associated with evidence of damage to the cord, and non-union causing symptoms are all indications for arthrodesis (Grogono 1954, Blockey and Purser 1956).

Rheumatoid arthritis—The most common cause of atlanto-axial instability is rheumatoid arthritis. Twenty per cent of patients with rheumatoid arthritis who enter hospital have demonstrable instability (Sharp and Purser 1961). The pathogenesis of this condition is interesting. Figure 1 illustrates the proximity of the synovial tissue to the dens and cruciate ligament. The proliferative synovium erodes the bony attachment of the ligaments. The ligaments may eventually become detached, leading to instability, or the dens may be shortened by erosion, allowing the intact ligament to pass over the top (Martel 1968). The subluxation thus created may lead to interference with vertebral blood flow and basilar artery ischaemia (Fig. 2).

Compared with the fractured or separate dens, atlanto-axial subluxation in rheumatoid arthritis seems to be potentially more dangerous. The dens, being intact, does not slide forward with the atlas; so it compresses the spinal cord behind it (Fig. 3).
Arthrodesis is indicated in the patient with rheumatoid arthritis when the atlanto-axial subluxation is associated with abnormal features such as acute or chronic cord compression, increasing pain unrelieved by a collar, progressive subluxation or intermittent ischaemia of the brain stem.

Neoplasms of the atlas or axis—Neoplasms such as multiple myeloma or metastatic carcinoma may involve the first or second cervical vertebrae, as illustrated by Hastings, MacNab and Lawson (1968). Lesions involving the atlas or the axis associated with instability or potential instability may best be managed by this technique.

CONTRA-INDICATIONS

Atlanto-axial instability associated with defects of the posterior arch of the atlas resulting from fracture or laminectomy are obvious contra-indications to isolated atlanto-axial fusion
by the posterior route, as is a severe degree of basilar impression. In these instances, occipito-cervical fusion or anterior fusion is indicated.

PRE-OPERATIVE ASSESSMENT

In addition to a detailed history and physical examination, a number of special investigations are necessary before operation is undertaken. Plain lateral radiographs in flexion and extension permit measurement of the degree of slip (Fig. 4). Tomography may clarify the pathological process, affording information on congenital abnormality, fracture position and precise degree of subluxation. Cine-radiography may help to establish whether the subluxation is stable in flexion or in extension. In all these radiological studies the orthopaedic surgeon should assist the technician if a safe, accurate recording of the extent of the instability is to be achieved. Myelography is unnecessary.

Consultation with the anaesthetist is necessary, so that he may know in advance the degree and direction of instability, the hazards of intubation and the position of the patient at operation.

TECHNIQUE OF OPERATION

After insertion of skull calipers under local analgesia, intubation is effected with the neck in traction. The authors favour the routine use of skull calipers in this procedure in order to achieve fullest control. With the trachea intubated and axial traction maintained, the patient is placed in the prone position on bolsters. It is important to maintain the head and neck in the extended position with traction (Fig. 5). (Rarely the stable position is flexion, and if this is so a modification in positioning is required.) Constant attention must be directed to the eyes in this position as any direct pressure on the globe is dangerous and may lead to blindness from the increased intraocular pressure and consequent retinal ischaemia (Walsh and Hoyt 1969). The shoulders are depressed and immobilised by adhesive tape. It is tempting to flex the neck in order to facilitate the posterior exposure, but this is contra-indicated as it will lead to the loss of a stable reduction.

The atlanto-axial level is exposed by a midline posterior dissection. In the subperiosteal exposure of the arch of the atlas, the proximity of the vertebral vessels, approximately 1·5 centimetres from the midline, must be remembered (Fig. 6). The posterior atlanto-occipital
membrane is carefully separated from the anterior surface of the posterior arch of the atlas on its inferior and superior margins.

A 20 gauge (0.914 millimetre diameter) wire is folded upon itself and fashioned into the shape of a hook (Fig. 6). A small size Lower forceps or a blunt semi-curved needle may facilitate the passage of the wire from inferiorly, anterior to the posterior arch of the atlas.
The wire is then drawn distally, to loop around the spinous process of the axis (Fig. 7). It must again be emphasised that if the subluxation is not completely reduced at the time of passage of the wire, the spinal cord may be injured.

A rectangular cortico-cancellous graft is cut from the posterior iliac crest, measuring approximately 3 by 4 centimetres. Notches are fashioned in the graft to accommodate the spinous process of the axis and each wire laterally. The graft bed is prepared by curettage of the posterior arch of the axis and the lamina of the axis. Cancellous bone is placed in the interval and the cortico-cancellous bone graft is secured in place by tightly twisting the wire over the graft (Figs. 8 to 10). Stable fixation is secured. The wound is closed in layers.

**Fig. 9**
The completed wiring and grafting. Figure 9—Lateral view of a “dry” preparation. Note how the graft is held in contact with the bone by the wire. Figure 10—Lateral radiograph (after fusion had occurred). Note the role of the wire in holding the two bones together.

**Fig. 10**

**Fig. 11**
The type of brace worn after operation.

**Treatment after operation**—Skull traction maintains the head comfortably in extension with the patient nursed in an ordinary bed. After one or two days the calipers are removed and the...
patient begins walking with his neck immobilised in a brace (Fig. 11). Brace-and-collar immobilisation is maintained until there is clinical and radiological evidence of union. This period averages three to four months.

**CLINICAL REVIEW**

The effectiveness of this procedure is illustrated by fifteen consecutive arthrodeses performed at the Vancouver General Hospital. Table I summarises our clinical experience. The senior author (R. W. McG.) was associated with all the cases.

In our one case of failure there was difficulty at the time of operation with placement of the wire, and an inadequate bone graft.

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**DISCUSSION**

**Indications**—Most surgeons have little difficulty in making a decision in favour of stabilisation in those patients presenting with the more absolute indications for fusion—namely, evidence of cord compression, unrelieved pain, or progressive severe subluxation. The difficulty arises in patients, usually with rheumatoid arthritis, without severe symptoms, with only a moderate degree of subluxation. Numerous accounts in the literature describe the drastic complications of such cases without treatment. Sudden death (Martel and Abell 1963), vertebral artery thrombosis (Webb, Hickman and Brew 1968), and sudden tetraplegia are among the severe consequences. Less severe manifestations of early complications, such as headaches, upper extremity weakness and paraesthesia may be falsely attributed to other manifestations of rheumatoid arthritis. The insidious, chronic myelopathy associated with long-standing untreated instability must be recognised.
When one considers these possible complications in contrast to the ease with which relief of symptoms can be achieved by a carefully performed atlanto-axial arthrodesis, one should be encouraged to give more attention to the possibility of earlier surgical intervention as a more realistic course in cases of rheumatoid arthritis with early, but inevitably progressive, subluxation. On this point we are in complete agreement with Newman and Sweetnam (1969).

**Extent of the fusion**—In most cases there appears to be little justification for occipito-cervical fusion or transoral interbody fusion. Atlanto-axial arthrodesis is preferred to occipito-cervical fusion for the following reasons: 1) The accurate reduction and immediately stable fixation achieved in atlanto-axial arthrodesis is not afforded by occipito-cervical fusion. Atlanto-axial fusion does not require six weeks of immobilisation in skeletal traction as recommended in the case of occipito-cervical fusion (Newman and Sweetnam 1969). The advantages of immediate ambulation in an individual with polyarthritis or other associated injuries are obvious. 2) Inclusion of the occiput in the fusion reduces flexion and extension of the cervical spine by approximately 30 per cent (Fielding 1964). 3) We are in agreement with Forsyth, Alexander, Davis and Underdal (1959), who believed that inclusion of the occiput in the fusion added the weight of the head to what the bone graft and wire were already holding, so increasing the possibility of fracture. Hamblen (1967) reported two cases of graft fracture in thirteen patients treated by occipito-cervical fusion. 4) When each step of the technique is precisely followed, the incidence of pseudoarthrosis is low. This claim is well supported by the results of our series, and substantiated by Simmons and Fielding (1967). The morbidity is correspondingly low.

**Technique**—In assessing the technique the authors believe that fusion in the unreduced position is contra-indicated because passing the wire endangers the cord. The prognosis for fusion is less good if movement is not eliminated by complete reduction and internal stabilisation.

The sitting position is not recommended, because exposure of the spine at the base of the occiput is most difficult with the neck in the extended position. Other hazards of the sitting position, such as air embolism, must be considered. Multiple wires are not necessary.

Routine occipito-cervical fusion is not recommended for the reasons previously stated. The authors do not recommend the inclusion of the third cervical vertebra in the fusion.

**SUMMARY**

1. This report defines the indications, and describes in detail a technique for atlanto-axial arthrodesis. Open reduction, with wire fixation and bone grafting, achieves the objective of immediate stabilisation of an unstable C1–2 articulation.
2. The method is illustrated by fifteen consecutive patients who had atlanto-axial arthrodesis, fourteen of whom had excellent results.
3. When the indications are correct, atlanto-axial arthrodesis by the method described is a safe and effective procedure having an excellent success rate.

The authors wish to thank Dr F. P. Patterson, Professor and Head of the Division of Orthopaedic Surgery for stimulating interest in this subject and for permitting inclusion of several of his cases in the study.

**REFERENCES**


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