ATLANTO-AXIAL FRACTURE-DISLOCATIONS

Failure of Posterior C.1 to C.2 Fusion

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Several different operations have been advocated for the treatment of atlanto-axial fracture-dislocations (Cone and Turner 1937; Gallie 1939; Lipscomb 1957; Alexander, Forsyth, Davis and Nashold 1958; Dunbar and Ray 1961; Schatzker, Rorabeck and Waddell 1971; McLaurin, Vernal and Salmon 1972). Posterior fusion of C.1 and C.2 vertebrae seems to be the procedure most often chosen (Cone and Turner 1937, Gallie 1939, Schatzker et al. 1971). There are advocates of posterior fusion of C.1 to C.3 (Alexander et al. 1958) and those who believe that the occiput should be included in the fusion (Lipscomb 1957, Dunbar and Ray 1961).

Mixter and Osgood (1910) originated the concept of posterior fixation of C.1 to C.2. They described an operation using a strong silk thread wound around the posterior arch of the atlas and tied to the spinous process of the axis.

Cone and Turner (1937) were pioneers in the use of wires and bone grafts for C.1 to C.2 fusions. Gallie (1939) fused the adjacent articular facets while also wiring C.1 to C.2. Although they reported good results with early fusion for the treatment of atlanto-axial fracture-dislocations, neither Gallie nor Cone and Turner published sufficient details for comparison with other methods of treatment.

Alexander et al. (1958) claimed that fusion of C.1 and C.2 gave unsatisfactory results. In two cases recurrent dislocation occurred several months after operation. Dunbar and Ray (1961) stated that C.1 to C.2 fusions were inadequate because they had seen "several recurrent dislocations following this procedure". Schlesinger and Taversas (1958) demonstrated two cases in which wiring of C.1 to C.2 was ineffective; furthermore, they found that subsequent radiographs often revealed broken wires.

However, Schatzker et al. (1971) found generally successful results from the Gallie fusion in fourteen cases. Only two of these cases were considered failures, from recurrent atlanto-axial dislocation; but they stressed that successful fusion did not prevent slight malalignment of the dens nor prevent non-union of the fracture. Sound atlanto-axial fixation was the goal of their fusions.

MATERIAL

From 1968 to 1972 ten consecutive posterior C.1 to C.2 fusions for atlanto-axial fracture-dislocations were done. Although the patients were under the care of several surgeons, they were managed in a similar fashion. All patients except one, upon discovery of the injury, were placed in Crutchfield's traction. After reduction and stabilisation of the fracture-dislocation, and when the general condition of the patient was satisfactory, fusion was done. The time of operation varied from three days to six weeks after the date of injury. Fusions were done under general anaesthesia with the patient prone. Cervical traction was maintained during operation, and portable radiographs were taken before the end of the operation. Fixation of the arch of C.1 to the lamina of C.2 was achieved with either one wire wound in a figure-of-eight or with multiple wires. Wire size varied from 18 to 24 gauge. Articular cartilage was removed on both sides and replaced with small blocks of iliac bone after the method of Gallie (1939). The type and duration of post-operative bracing varied according to the preference of the surgeon responsible, but in no case was a plaster cast used initially.
Case 1. Figure 1—Before operation. Figure 2—After attempted fusion.

Figure 3—Case 2. After fusion. Figure 4—Case 3. After fusion. Figure 5—Case 4. After fusion.

Case 5. Figure 6—Before operation. Figure 7—After operation.
Case 1—A man aged twenty-nine sustained a fracture of the dens in December 1968, when his car went off the road. He was treated at first with a neck brace. Radiographs, however, showed posterior dislocation of the atlas-dens segment. C.1 to C.2 posterior fusion was done in February 1969. He did well after operation and was kept in a neck brace for six weeks, when radiographs revealed the same dislocation that was present before operation (Figs. 1 and 2). Despite this, he did well until October 1971, when he complained of progressive weakness in both upper extremities. Examination revealed diffuse hyperreflexia and mild weakness of the triceps, biceps and wrist extensors on the right. A myelogram was attempted unsuccessfully. The patient refused any further surgical intervention.

Case 2—A man aged twenty-six sustained a fracture of the dens with anterior displacement in a traffic accident in April 1969. There was no associated neurological deficit. He was placed in Crutchfield’s traction and a week later posterior C.1 to C.2 fusion was done. After operation he was kept in a brace for six months, when the radiograph (Fig. 3) revealed slight anterior displacement of the fracture. The patient was doing well one year after operation except for persistent pain in the suboccipital region.

Case 3—A fifty-six-year-old Negro man fell down a flight of stairs in April 1969. He complained of suboccipital pain and tenderness but no neurological deficit was found. Radiographs revealed a dens fracture displaced 3 millimetres anteriorly. The patient was put in Crutchfield’s traction. A week later posterior fusion of C.1 and C.2 was done. Radiographs two weeks later showed 4 millimetres displacement of the dens anteriorly (Fig. 4). The patient did not return for follow-up examinations.

Case 4—A woman aged fifty-seven was injured in a road accident in January 1971. In addition to multiple rib fractures she sustained a fracture of the dens. There was no neurological deficit. She was kept in Crutchfield’s traction for six weeks and in February 1971 a posterior C.1 to C.2 fusion was done. Radiographs showed a 3-millimetre posterior displacement of the dens fragment (Fig. 5). After operation the patient was kept in Crutchfield’s traction for an additional three weeks. The patient was discharged wearing a Thomas collar. Radiographs taken in May 1971 revealed good alignment and fusion of the dens fragment.

Case 5—A thirty-nine-year-old Negro man sustained a fracture of the dens in a road accident in April 1970 (Fig. 6). There was no neurological deficit. Traction through Crutchfield calipers was applied for ten days; then posterior fusion of C.1 and C.2 was done. He was discharged home wearing a neck brace. Subsequent radiographs showed anterior atlanto-axial dislocation (Fig. 7). The patient was readmitted to the hospital and traction was reapplied. Five weeks after the first operation re-exploration of the fusion site revealed loosening of the wires. The patient wore a cervical collar for three months after operation. Progress has been satisfactory, but the dens fragment has not fused.

Case 6—A man of fifty-nine fractured the dens in a road accident in November 1971. He complained of pain in the back of the neck and in the left shoulder. There was no neurological deficit. He was treated with Crutchfield’s traction. Three weeks later he had operative fusion, but during this the dura was inadvertently torn. After operation he developed a spinal fluid leak; he had an intermittent fever and became confused and lethargic. A lumbar puncture showed 4,000 white blood cells per cubic millimetre. Candida albicans was grown on culture. The patient improved spontaneously. In December he was put in a neck brace; the radiographs (Fig. 8) revealed persisting instability. In January he was placed in a Minerva jacket, and was discharged after one week, but, after a further week he returned to hospital with confusion, lethargy and fever. Lumbar punctures disclosed chronic candida meningitis. Over the next forty-eight hours the patient rapidly deteriorated and died.

Case 7—A sixty-year-old Negro man was admitted in July 1969 with multiple bruises and complaining of numbness in all four extremities. He improved while in the hospital but radiographs of the cervical spine showed subluxation of C.1 on C.2 (Fig. 9). He was placed in Crutchfield’s traction and in August posterior fusion of C.1 and C.2 was done. Radiographs one week later showed the subluxation still to be present. He was put in a plaster jacket until November 1969. Radiographs in May 1970 showed instability between C.1 and C.2 (Fig. 10). In 1971 the patient died from a stroke.

Case 8—A Negro woman aged thirty was injured in a car in October 1970. She had a flail chest, haemopneumothorax and a 9-millimetre subluxation of C.1 on C.2 (Fig. 11). Treatment was by tracheostomy, chest drainage and Crutchfield’s traction. After six weeks posterior cervical fusion was done. After operation she was kept in a cervical brace which was removed one month later. She then complained of suboccipital pain and radiographs showed the same subluxation. Cervical traction was replaced for one month, after which she wore the neck brace for a further two months.
Radiographs showed persistent subluxation (Fig. 12). In May 1972, eighteen months after injury, the patient had limitation of head rotation to the left. There was generalised hyperreflexia but Babinski's test was negative. She had occasional transient weakness of all four extremities.

Case 9—A twenty-four-year-old Negro man injured his neck while playing football in a prison yard. He complained of stiffness and tenderness in the suboccipital area. Neurological examination was essentially normal. The radiographs revealed a 5-millimetre anterior dislocation of the atlas. He was kept in Crutchfield's traction for one week, and had a fusion of C.1 and C.2. Recovery was uncomplicated. One week later he was put in a neck brace. When seen one month later radiographs showed the dens fragment to have slipped significantly (Fig. 13). At a further operation the wires holding C.1 and C.2 were tightened. Again he was discharged wearing a brace. However, one month later, new radiographs revealed persistent displacement of C.1 on C.2. The patient refused further surgery.

Case 10—A Negro man aged fifty-four was injured in April 1971 by a wooden plank which hit the back of his head. There was no neurological deficit. Cervical spine radiographs showed atlanto-axial dislocation. In April 1971 posterior fusion of C.1 to C.2 was done. He was kept in a Thomas collar until November 1971 when radiographs showed a 4-millimetre separation between the atlas and the dens. The patient was doing well except for occasional attacks of syncope of unknown etiology.

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RESULTS

The results from posterior fusion of C.1 and C.2 vertebrae with interarticular facet fusion for the treatment of atlanto-axial fracture-dislocation have been disappointing. In eight of ten cases redislocation occurred after attempted fusion, so that further operation (Cases 5 and 9), skeletal traction (Cases 4 and 8), or prolonged immobilisation in the form of a plaster jacket or neck brace was deemed necessary. Furthermore, two patients (Cases 1 and 8) complained of transitory neurological disturbances years after the initial treatment. One patient (Case 6) died as a direct result of the operation. Another patient (Case 7) died from a stroke two years after operation. Death was apparently unrelated to the previous spine injury, although one cannot be certain because necropsy was not done.

If we refer to the criteria of Schatzker et al. (1971) for evaluating the adequacy of fusion, Cases 2 and 10 might be considered adequate, although the patient in Case 10 was observed for only a short time after operation.

Those who insist on complete or nearly complete reduction of the dislocated elements after fusion would probably consider Cases 2 and 10 as surgical failures.

DISCUSSION

The aims of operation for atlanto-axial fracture-dislocations are: 1) reduction of the fracture-dislocation; 2) fixation of C.1 to C.2; 3) healing of the dens fragment. Even if reduction of a fracture-dislocation is incomplete, sound fixation of C.1 to C.2 may still ensure a successful outcome. How much malalignment of the fracture-dislocation should be tolerated? Unfortunately, there are no definite guidelines to follow. Some have been arbitrary, accepting displacements of up to 2 to 3 millimetres. It is unlikely that delayed neurological signs would develop with this small amount of displacement. However, incomplete reduction would not be acceptable if the sagittal diameter of the spinal canal were not sufficiently large to accommodate the encroachment. Sometimes this margin for error may be substantial. Nachemson (1960) found a displacement of 10 millimetres without any neurological complaints in some cases. McRae (1953) believed that neurological signs were always present if the antero-posterior diameter of the canal at the level of the dens was 19 millimetres or less. However, Wolf, Khilnani and Malis (1956) found the canal at the atlas to range from 16 to 33 millimetres in sagittal diameter in 200 normal adults. Greenberg (1968), in three cases of high cervical cord compression, found the canal diameter to be less than 15 millimetres. He predicted that cord signs would be present if the sagittal diameter of the canal of the atlas was 14 millimetres or less but he was considering chronic atlanto-axial dislocations in which hypertrophic changes may have reduced the canal diameter. We believe that patients may be asymptomatic with a sagittal diameter of the canal at the atlas of less than 14 millimetres. Four out of our ten patients had no neurological symptoms, although the canal diameter was 14 millimetres or less.

The purpose of the fusion is defeated if there is residual movement of C.1 on C.2. Breakage or loosening of the wire is a frequent problem according to Alexander et al. (1958), Schlesinger and Taveras (1958) and Dunbar and Ray (1961). McLaurin et al. (1972) apparently did not have this problem when treating atlanto-axial fractures by wiring without fusion: seven cases of fracture of the dens were treated by wiring C.1 to C.2, but the wires broke in three out of twelve cases of atlanto-axial fracture-dislocations but with no ensuing instability. All seven cases of dens fracture ultimately showed good bony union. These results have not been achieved by other surgeons.

The healing of dens fractures has been studied by Blockey and Purser 1956, Rogers 1957, Nachemson 1960 and Schatzker et al. 1971. Blockey and Purser found bony union of the dens in four out of nine cases treated conservatively; later, one was fused and the other four patients had slight movement of the dens fragment on flexion-extension radiographs, but were clinically
well. Rogers described non-union of the dens in four of nine cases. He fused two old dens fractures but neither united. Nachemson believed that stable healing of the dens could occur without bony union and in tomographic studies of eighteen patients, only eight patients had bony union but the rest had a stable, fibrous union. Schatzker et al. compared the results of fractures of the dens treated by immobilisation with those treated by posterior fusion. They found no significant difference; both methods gave a rate of non-union of about 60 per cent which is in agreement with the other studies described.

A higher incidence of bony union was described by Amyes and Anderson (1956), who claimed that only three of fifty-eight fractures of the dens failed to unite. Braakman and Penning (1971) found that only one out of six cases treated conservatively failed to unite. All seven cases treated surgically by McLaurin et al. (1972) healed by bony union. In this small series of fractures of the dens, three of four patients who had been adequately followed had evidence of bony union.

Although bony union of the dens is desirable, its importance for a successful fusion may have been over-emphasised. The complication of delayed myelopathy caused by a mobile dens fragment is invariably found in unsuspected and untreated cases (Bachs, Barraquer-Bordas, Barraquer-Ferré, Canadell and Modollel 1955; Blockey and Purser 1956). Schatzker et al. (1971) treated a patient who had a posteriorly displaced dens fracture with several weeks of skeletal traction followed by six weeks in a Minerva jacket. Three months after the injury the patient developed weakness in the upper limbs. The dens fragment was sufficiently mobile to permit reduction and atlanto-axial fusion was successfully done.

Because the results of posterior C.1 to C.2 fusion are not uniformly acceptable and the behaviour of a dens fracture-dislocation is unpredictable, a more selective approach to the treatment of these injuries seems justified.

Mortality and morbidity particularly in the elderly or poor risk patient might be reduced by conservative treatment. operative fusion being reserved for those patients in whom conservative treatment fails. Secure external bracing after operation, until the fusion site is stable, is indicated.

SUMMARY

1. Ten consecutive cases of acute atlanto-axial fracture dislocation were treated by posterior C.1-C.2 fusion.
2. In eight cases there was significant redislocation warranting further therapy.
3. Operative fusion together with prolonged firm immobilisation are recommended only after a trial of conservative therapy.

REFERENCES


