Fixation of odontoid fractures by an anterior screw

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We have reviewed 81 patients with fractures of the odontoid process treated between May 1983 and July 1997, by anterior screw fixation.

There were 29 patients with Anderson and D'Alonzo type-II fractures and 52 with type III. Roy-Camille's classification identified the direction and instability of the fracture. Operative fixation was carried out on 48 men and 33 women with a mean age of 57 years. Associated injuries of the cervical spine were present in 15 patients, neurological signs in 13, and 18 had an Injury Severity Score of more than 15. Nine patients died and 11 were lost to follow-up. Of 61 patients, 56 (92%) achieved bony union at an average of 14.1 weeks. Two patients required a secondary posterior fusion after failure of the index operation. A full range of movement was restored in 43 patients; only six had a limitation of movement greater than 25%.

We conclude that anterior screw fixation is effective and practicable in the treatment of fractures of the dens.

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Fracture of the odontoid process of the axis is a common injury. Its treatment remains controversial. Nonunion, stiffness of the neck, cervical myelopathy and poorly tolerated external fixation are some of the problems associated with treatment.

Current non-operative management includes cervical orthoses,¹ halo vests^{2,3} and jackets.⁴ These do not provide rigid immobilisation, have rates of nonunion of between

4% and 64%,⁴⁻¹⁴ and are poorly tolerated in the elderly and the multiply injured patient. Other complications are pin-track infection, loosening of the pins, penetration of the skull, secondary displacement, pressure sores, respiratory arrest and death.^{2,15-19}

Surgical treatment of the fractured dens has usually been carried out by way of a posterior fusion of C1 and C2, with excellent rates of bony union between them. It is, however, associated with considerable mortality and morbidity and results in a decrease in the range of movement of the neck.²⁰⁻²⁵

The classification of Anderson and D'Alonzo⁷ provides a guide to prognosis for healing. Type-I and type-III fractures give a good rate of union, while type II has a poor prognosis. Roy-Camille et al²⁶ analysed prognostic factors concerning the initial displacement, obliquity of the fracture, and rotational deformity (the 'Bobby-helmet' fracture). Horizontal or posterior oblique fracture lines, posterior displacement, and rotation deformity are all bad signs. Other factors associated with nonunion are age,^{13,23} posterior displacement,^{13,27} the degree of displacement,^{3,11,13,23,28} fractures through the waist^{3,7,11,13,26,29} and inadequate immobilisation.³

Reports by Nakanishi et al³⁰ and by Böhler³¹ describe a direct anterior approach using a screw to fix the fractured dens. Between 1987 and 1991 further studies described the use of this technique.³²⁻³⁷ The rates of union are comparable with those for C1 to C2 fusion, with few complications and good functional results.^{32,34,35,38,39}

We have reviewed a series of 81 patients to establish the place of anterior screw fixation in the treatment of fractures of the odontoid process.

Patients and Methods

We included all patients with fractures of the dens, treated by anterior screw fixation between May 1983 and July 1997. There were 48 men and 33 women. Their mean age at presentation was 57 years (15 to 92). We found a marked difference in age distribution according to gender; 67% (32) of the men were younger than 60 years, while 88% (29) of the women were over this age. The causes of the injury were motor-vehicle accidents (20 patients), motor-cycle accidents (6), pedestrians being hit by cars (6), falls

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Table I. Patterns of fractures²⁶ for the 81 patients according to the Anderson and D'Alonzo classification

	Type II	Type III
Horizontal	17	23
Anterior oblique	-	7
Posterior oblique	11	17
Bobby-helmet	-	3
Spiral	1	-
Others	-	2
Total	29	52

from a standing position (21), falls from a height (9), falls down stairs (12), and a mountaineering accident (1). A further five patients had an established nonunion and one had a pathological fracture due to metastatic disease.

There were 29 type-II and 52 type-III fractures (Table I). Using the classification of Roy-Camille we found 40 horizontal, seven anterior oblique, 28 posterior oblique, three Bobby-helmet, one spiral and two unclassified fractures (Fig. 1).

Instability and the direction of displacement were determined using the method described by Roy-Camille et al.²⁶ Instability is anterior when displacement occurs in flexion, and posterior when in extension. Bidirectional instability was present when displacement occurred in both flexion and extension, typically with a type-II horizontal fracture. Sagittal displacement was measured perpendicularly from a line through the posterior margin of the fracture, drawn parallel with the posterior wall of the vertebral body to the dorsal aspect of the dens, as recommended by Lind, Nordwall and Sihlbom.⁴⁰

Any stenosis was expressed as a percentage of the relationship between the space available for the cord (SAC) and the intact ring of C2. Instability was anterior in 22, posterior in 47, and bidirectional in four, the mean displacement being 33%, 35% and 15%, and the stenosis being 20%, 24%, and 10%, respectively. One fracture was unclassified and in seven, no instability could be demonstrated. There was a total of 19 associated injuries to the cervical spine in 15 patients (Table II). Nineteen patients had evidence of

Fig. 1a

Fig. 1b

Fig. 1c

Fig. 1d

Fig. 1e

Patterns of odontoid fracture (Roy-Camille) showing a) horizontal fracture, b) an anterior oblique fracture, c) posterior oblique fracture, d) a Bobby-helmet fracture (rotational deformity with the odontoid fragment in an AP configuration on a lateral view and e) a spiral fracture (as seen on linear tomography).

closed-head injury, 15 with loss of consciousness, of whom five were admitted in a coma, 13 had neurological signs (Table III) and 18 (22%) had major associated injuries with an Injury Severity Score (ISS) of greater than 15.

The primary indications for surgery were all type-II fractures and those type-III fractures with a shallow base.³ Secondary indications were type-III fractures with a displacement greater than 30%, any posterior displacement and patients with multiple injuries (ISS >15). The only criterion for exclusion was refusal of the patient to accept surgical treatment.

Patients were reviewed over a minimum period of three months. Assessments of the time to union and overall

function were recorded together with complications and any adverse sequelae.

Operative technique. We used the retropharyngeal approach of Louis⁴¹ and Robinson and Smith,⁴² employing the technique and instruments described in detail by Grosse et al.³⁵ We used only one 3.5 mm (Fig. 2) or 4.5 mm (Fig. 3) partially-threaded self-tapping screw.^{11,31,33,37} Some surgeons prefer a technique using two screws.^{34,38,39} After the operation patients were fitted with a soft collar for six weeks. A Minerva plaster was used for between eight and 12 weeks when other injuries to the cervical spine were present.

Careful attention to surgical detail is essential to help to avoid potential pitfalls with this technique. Two high-resolution image intensifiers should be available. Since anteroposterior (AP) views may be difficult to obtain, a radiolucent bite block is used. If the open-mouth view is unsatisfactory a Waters³⁵ view, which projects the dens through the foramen magnum, is taken. Adequate reduction must be achieved before surgery is started. The patient's head is secured using Gardner Wells tongs or a similar device with 2 kg of traction applied and stabilised on a padded occipital ring. Reduction is then achieved with gentle flexion and extension manoeuvres observed on the screen. The entry point for the screw is at the anterior aspect of the inferior endplate of C2 (Fig. 2), so that removal of a small amount of the C2-C3 disc is needed to create a recess. The correct angle of the screw is nearly in line with the cervical spine and therefore adequate clearance of the sternum is needed. This may be difficult to obtain in patients with a short neck, stiffness of the cervical spine, barrel-chest deformity or pronounced kyphosis in the

Table II. Associated cervical spinal fractures in 15 patients

Fracture	Number
Jefferson's	3
Hangman's	2
C1 anterior arch	3
C1 posterior arch	4
C2 vertebral body	3
C3 to C7	4
Total	19

Table III. The neurological signs seen in 13 patients

Neurological sign	Number
Monoparesis, upper limb	2
Paraesthesia, upper limb	5
Monoplegia, upper limb	1
Brown-Sequard syndrome	2
Hemiparesis	1
Posterior cord syndrome	1
Pyramidal syndrome	1
Total	13

Fig. 2a

Fig. 2b

Anteroposterior (a) and lateral (b) radiographs of an odontoid fracture fixed with a 3.5 mm screw. The correct entry point in the inferior vertebral endplate is shown.

Fig. 3a

Fig. 3b

Anteroposterior (a) and lateral (b) radiographs of an odontoid fracture fixed with a 4.5 mm screw. The thread can be seen fully across the fracture line.

thoracic region. To provide compression the thread of the screw must be well into the odontoid fragment (Fig. 3).

Results

Between May 1983 and July 1995, 81 patients were operated on. The period of continued follow-up varied from three to 120 months (mean, 16.6); nine patients died before two months and 11 were lost to follow-up. The remaining 61 patients showed a mean time to radiological union of 14.1 weeks (8 to 50; SD 6.8). Three patients with nonunion (5%) all refused further surgery; they all had excellent function at the last follow-up.

A full range of cervical movement was maintained in 43 patients. Limitation of less than 25% was found in 12 patients and of greater than 25% in only six. Pain was occasional in four patients and one had pain at rest. One patient with a preoperative left hemiplegia and one with a Brown-Sequard syndrome did not recover. All other patients with preoperative neurological signs recovered fully after surgery.

Only one major complication was directly related to the technique. This was in an 83-year-old woman who was tetraparetic after the operation. She died from respiratory failure six days later. Other complications were postoperative dysphagia in two patients and pharyngeal oedema in one. Mechanical failure of the internal fixation occurred early in three patients, two with an anterior-oblique-type fracture and one a horizontal fracture. Two were treated with an immediate posterior fusion of C1 to C2 and in the other union occurred in an anteriorly displaced position. Two of the failures are attributed in retrospect to the fact

that we did not recognise the potential for displacement in anterior oblique fractures. In five subsequent patients in this series, we used an anterior buttress plate to overcome this difficulty (Fig. 4).

A total of 16 general complications occurred in 11 patients. These were cardiac failure in two, pulmonary atelectasis in three, pneumonia in four, endocarditis in one, infections of the urinary tract in two, a cerebrovascular accident in one, arterial thrombosis of the lower limb in one, septicaemia in one and a pressure sore in one. Of nine patients who died, eight were 79 years of age or older. Their causes of death were respiratory failure in three, pulmonary embolism in one, cardiac arrest in one, congestive heart failure in one, septic shock secondary to infection of the urinary tract in one and metastatic disease in one. Except for the patient who was rendered tetraparetic, we do not relate the causes of death directly to the technique, but rather to hazards of surgery generally in patients of this age group. The remaining patient was a 39-year-old homeless man who died two months later from multiple injuries sustained in another quite unrelated accident.

Discussion

Our study has shown that direct anterior screw fixation is a practicable method of treatment for fractures of the dens. The rate of union in our series was 92%. This compares favourably with non-operative treatment and with fusion of C1 to C2 carried out posteriorly. The rate of nonunion of odontoid fractures after conservative treatment has varied between 0% and 64% with a mean of approximately 25%.¹¹ One reason for this low figure is that stable immobilisation

Fig. 4

Postoperative radiographs of an anterior oblique fracture showing the added use of a buttress plate.

by external fixation devices is difficult to obtain.^{13,19,43,44}

The use of a Gallie Brooks fusion of C1 to C2 has given rates of union above 80%^{7,13,22,45,46} and a mean complication rate of 19%. These posterior fusions compromise axial rotation by 47° and flexion/extension by 10°. Grob and Magerl⁴⁷ have combined a Gallie Brooks fusion with posterior transarticular screws. They claim a rate of fusion of 100% but at the expense of a rigid C1 to C2 junction. Other studies using a fusion of C1 to C2 have also shown limitation in the range of movement after successful union.²⁰⁻²⁵ In our series, a full range of movement was obtained in 43 (69%) of patients and only six (10%) had a global limitation greater than 25%. Residual pain was reported by four patients, but in only one was the pain present at rest.

Many studies recommend surgical treatment of odontoid fractures in elderly patients because they tolerate external fixation devices so poorly. We were concerned by the death rate found in our elderly patients. Pepin et al¹⁸ made special reference to 19 odontoid fractures in patients older than 60 years. In their series, three (16%) who died were all older than 78 years and had been treated with a halo device. They found this treatment to be poorly tolerated in the elderly and recommended early surgical treatment. Lewallen et al¹⁷ describe four patients with respiratory arrest which they related directly to conservative treatment; two of their patients died. Other studies^{23,48,49} have shown a similar experience of conservative methods.

We conclude that anterior screw fixation is a valid option for the treatment of odontoid fractures. There are several pitfalls with the technique but scrupulous preliminary planning and strict attention to detail should enable the experienced surgeon to obtain good results.

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