

Paraplegia

Anterior Plating of Unstable Cervical Spine Fractures

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Summary

Medical records and radiographs of 16 patients who had anterior decompression, bone grafting, and plating of grade III and IV (Allen 1982) unstable cervical spine injuries were reviewed. Surgery was performed within 15 days of injury, reductions were achieved and maintained at follow-up, and fusion occurred in all cases. Neurologic function stabilised or improved in all cases. However, 3 patients (19%) had complications that necessitated additional surgery: one patient with undiagnosed non-contiguous posterior instability, and 2 patients for broken plates. These complications, in retrospect, could have been avoided.

Key words: Cervical spine; Fractures; Anterior bony fusion; Plate fixation

Anterior cervical decompression and fusion, popularised by Robinson (1958), Cloward (1958), and Bailey (1960) for the treatment of disc disease, has also been used to treat unstable fractures of the cervical spine. However, studies comparing this technique with posterior procedures show that anterior decompression and fusion has a higher incidence of complications (Bedbrook, 1966; Cheshire, 1969; Meyers, 1967; Stauffer, 1977; Van Peteghem 1979). Two prior studies have documented a low incidence of graft displacement or late kyphosis, but they included only a limited number of patients with unstable injuries (Cloward, 1969; Meyers, 1967). Three subsequent studies of failed anterior interbody fusions demonstrated a high incidence of graft dislodgement and late kyphosis (Stauffer, 1977; Bohler, 1980; Van Peteghem, 1979), but in those studies, the grafts had either no or only minimal internal fixation. Use of current internal fixation has reduced the incidence of late graft dislodgement and kyphosis (de Oliveira, 1987; Brown, 1988; Cabanela, 1988).

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However, in the studies cited above, injuries were not classified in terms of stability and results were not based on measurements of the post-operative radiographs. In this study, strict radiographic criteria were used to evaluate the quality and maintenance of the reductions achieved; injuries were strictly classified (Allen, 1982) and only unstable (grade III-IV) fractures were included.

Materials and Methods

Between 1979 and 1986, 25 patients with anterior decompression and spinal plating of unstable fractures of the cervical spine at our hospital were reviewed. All surgeries were performed by one of the authors (ABL), and the results were reviewed independently by the other authors. Of these 25 patients, 3 died within 3 weeks of their injury, none directly related to the surgery, (2 from sepsis and 1 from disseminated intravascular coagulopathy) and 6 had less than 3 months follow-up, and thus, 16 patients were the basis for this study.

The average age of the patients was 26 years (range, 16–52 years) and average follow-up was 10 months (3 months–5 years). The cause of injury was: diving in 7 patients; motor vehicle accidents in 6; falls in 2; and a farm accident in 1 patient. The neurologic status of the patients on admission to the hospital was: no deficit in 4; quadriplegia in 4; incomplete neurologic syndrome in 4; and single nerve root

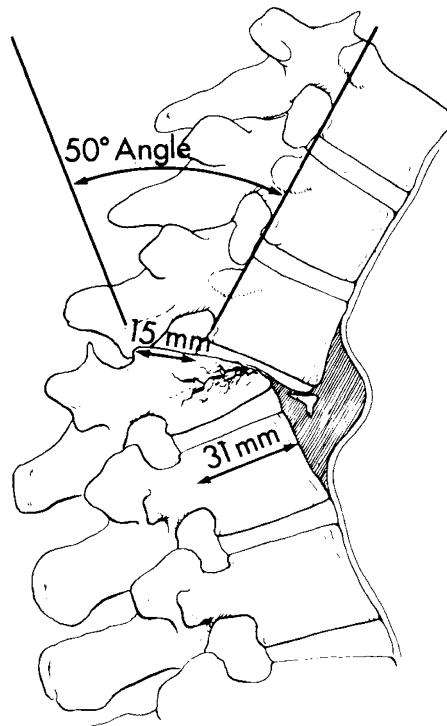


Figure 1 Diagrams of measurement for displacement percentage and angle of deformity. Refer to text for details.

radiculopathies in 4. Patients with neurologic deficit were treated with Gardner-wells tongs until the spine was stabilised. The involved motion segment (level of injury) was C3-4 in 3; C4-5 in 5; C5-6 in 7. In 1 patient, two motion segments (C4-C5-C6) were injured.

Radiographs obtained at the time of admission were reviewed, and the injuries were classified according to Allen *et al.* (1982). Based on Allen's criteria, there were 6 compression flexion injuries, 9 distractive flexion injuries, and 1 distractive extension injury. The injuries were also staged according to Allen's criteria: The 6 compressive flexion injuries were stages IV (3 patients) or V (3 patients); the 9 distractive flexion injuries were stages I (1 patient), II (1 patient), III (2 patients) or IV (5 patients); and the 1 distractive extension injury was stage II. All of these stages are considered to be unstable by Allen's criteria (Allen *et al.* 1982).

Radiographic evaluation included measurements of the angle of deformity and the displacement percentage, as described by Dickson *et al.*, in 1978 (Fig. 1), and measurements of vertebral tilt and displacement, as described by White *et al.* in 1976 (Fig. 2A and 2B). These measurements were made on the pre-operative, immediate post-operative, and final follow-up radiographs.

Between 1979 and 1986, anterior decompression and plating was used exclusively for unstable cervical spine injuries because of the earlier experience by the operating surgeon in which retropulsed disc material and bone, not evident on pre-operative CT scans or myelograms, were found at surgery.

Surgery was performed as soon as the patient's condition was physiologically stable, and on average was done 15 days after injury (range 5-21 days). The average

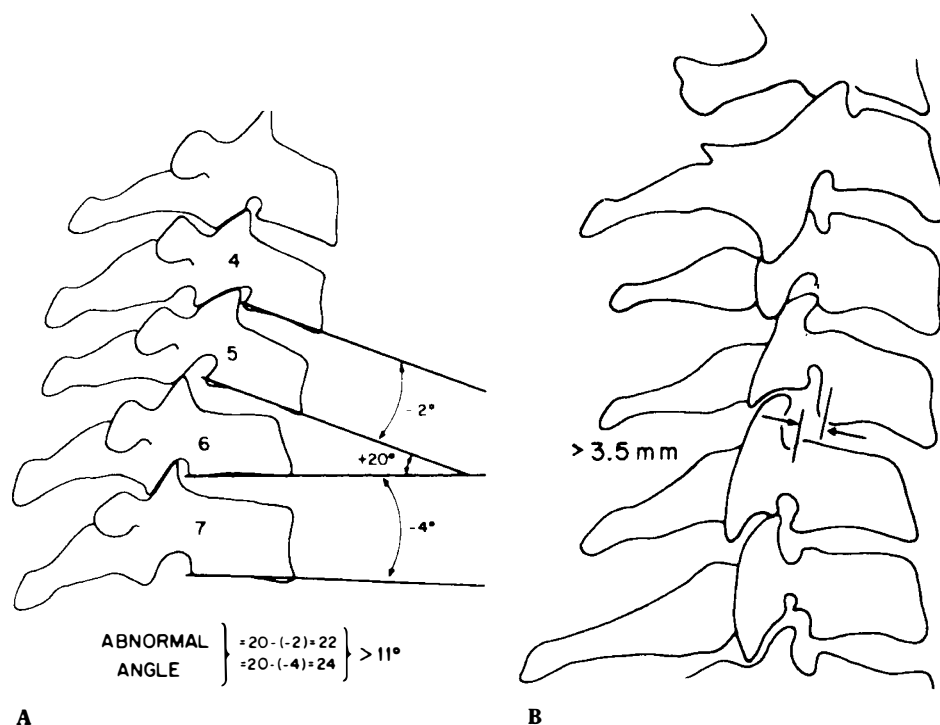


Figure 2A and 2B Diagrams showing measurement of tilt and displacement. Refer to text for details.

operation time was 136 minutes (range 115–163 minutes) and average operative blood loss was 163 ml (range 130–192 ml). In all cases, surgery was performed by one neurosurgeon (ABL) according to the technique described by Cloward (1958). Autogenous iliac bone grafts were used in all cases. The grafts were keyed in place, as a rectangular strut or countersunk as a bone plug. Plate fixation was limited to one motion segment (two vertebral levels) in 9 patients, and spanned two motion segments (three vertebral levels) in 7 patients because of severe comminution of the vertebral body. Decompression was performed at the time of surgery, and 12 patients (75%) had disruption of the posterior longitudinal ligament and retro-pulsed disc material and bone fragments in the spinal canal. In 4 of these cases with retro-pulsed disc material or bone fragments, the pre-operative CT scan and/or the myelogram did not demonstrate this pathology. In the 4 patients where the posterior longitudinal ligament was intact, no attempt was made to expose the spinal cord.

During the time period encompassed by this study various types of stainless steel plates were employed: Dynamic compression plates (1979–1983); Synthes multi-fragment plates (1983–1985); and Synthes cervical H-plates (1985–1986). With each type of plate, the screws were inserted to a depth that did not violate the posterior cortex of the vertebral body.

Post-operatively, patients were immobilised for 2 to 4 months in a Philadelphia collar and in a soft cervical orthosis for an additional 1 to 2 months, until free of pain.

Results

Radiographic measurements

At surgery, vertebral body displacement was improved from an initial deformity of 4.4 mm (sd \pm 2.7 mm) to 1.6 mm (\pm 1.2 mm) (Table I). Mean displacement at the final follow-up was 1.9 mm (\pm 1.7 mm), a loss of only 0.3 mm of correction. However, 2 patients lost more than 2.0 mm of correction by the time of the final follow-up exam.

Tilt angle was corrected from an initial deformity of 17.3° (sd \pm 12.3°) to 2.4° (\pm 7.0°) at the time of surgery. Mean tilt angle at final follow-up was 4.9° (\pm 5.3°). Two patients lost more than 5° of correction, and had 8° and 10° at final follow-up.

Table I Radiographic measurements

	Pre-operative	Post-operative	Follow-up	Follow-up Post-operative
Displacement				
x \pm s.d. (mm)	4.44 \pm 2.71	1.63 \pm 1.20	1.94 \pm 1.69	0.31 \pm 1.78
Tilt				
x \pm s.d. (degrees)	17.31 \pm 12.25	2.38 \pm 7.04	4.87 \pm 5.33	2.49 \pm 3.61
Angle of Deformity				
x \pm s.d. (degrees)	7.69 \pm 7.01	3.13 \pm 3.50	3.13 \pm 3.54	0.0 \pm 4.97
Displacement %				
x \pm s.d. (percentage)	19.3 \pm 11.87	8.00 \pm 6.61	8.69 \pm 7.64	0.69 \pm 9.10

The angle of deformity was corrected from 7.7° (sd $\pm 7.0^\circ$) to a post-operative and follow-up angle of 3.1° ($\pm 3.5^\circ$). In 2 patients, the angle of deformity increased to 7° and 13° , respectively, by the time of final follow-up exam.

Displacement percentage was improved at surgery from 19.3% (sd ± 11.9) to 8.0% (± 6.6). At the final follow-up, average displacement was 8.7% (± 7.6). In 4 of the 16 patients, displacement percentage had increased to more than 9% (Table I).

Complications

Twelve patients had no complications and 4 (25%) had complications related to the

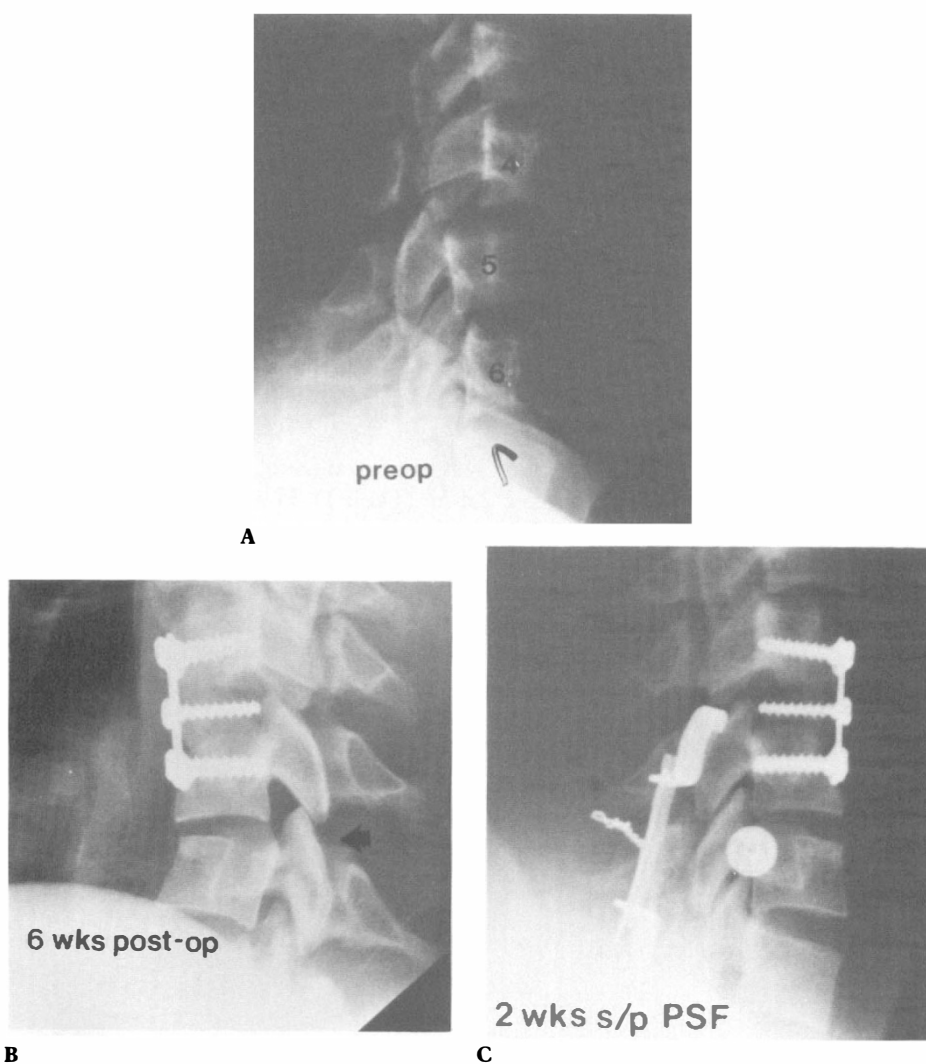


Figure 3A, 3B, and 3C A. Initial post-injury radiograph. B. Six weeks post C4-5 anterior spinal fusion. C. Immediate post-operative posterior fusion over C5, 6, and 7.

procedure. One patient had 2 broken screws (noted at 9 month follow-up), which did not affect the clinical or radiographic result. In this patient, the plate spanned 3 vertebrae, but the fusion was limited to only 2 vertebrae (one involved motion segment).

Three patients (19%) required a second operation. One patient (Figs 3A-C) had a second procedure within 2½ months because of an unrecognised posterior injury one level below the involved anterior motion segment. This patient was ultimately stabilised posteriorly with clamp fixation and fusion. The second patient had the plate removed 9 months after the operation because it was broken and possibly causing dysphagia. In this patient, the plate spanned two motion segments (3 vertebrae), but only one motion segment (2 vertebrae) had been fused. The plate

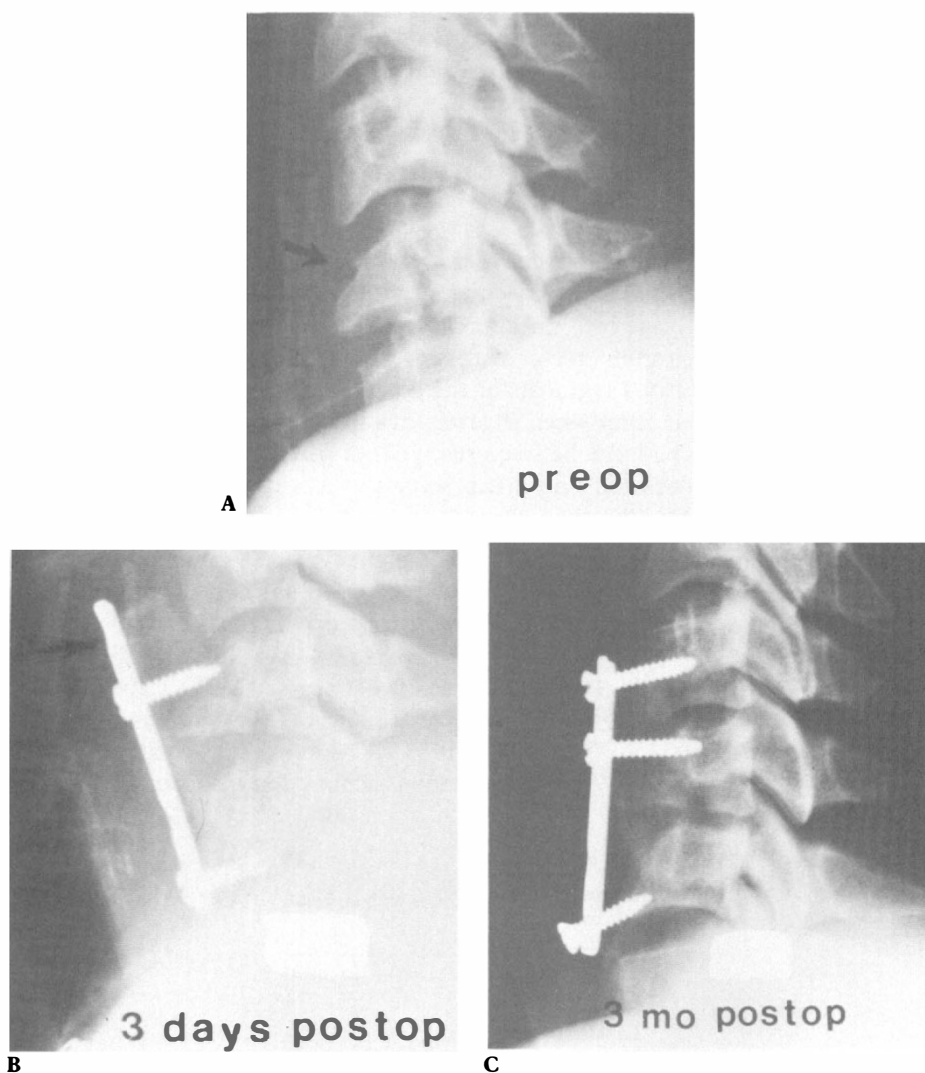


Figure 4, 4B, and 4C A. Initial post-injury radiograph. B. Three days post-surgery #1. C. Three days post-surgery #2.

failed at the junction of the fused and unfused motion segments. The third patient had a second operation because the superior portion of the graft dislodged in the immediate post operative period (Figs 4A–C).

Discussion

Anterior decompression, plate fixation, and fusion of cervical spine injuries have been advocated in a number of studies (Gassman, 1983; Bremer, 1983; Bohler, 1980; de Oliveira, 1987). Earlier studies of anterior cervical fusion did not evaluate radiographic results with the measurement techniques used in this study. These measurements allowed us to critically examine the quality and maintenance of reduction achieved.

Similarly, earlier studies only classified the injuries into three broad categories: Flexion, extension, and vertical compression (Durbin, 1957; Whitley, 1960) and did not classify the injuries according to Allen *et al.* (1982). We believe that Allen's (1982) classification scheme more accurately describes the various types of cervical spine injuries. In this study, we analysed only unstable injuries, and we believe that by excluding injuries and by utilising the measurement criteria described above, we have achieved a more objective analysis of the results of anterior plate fixation.

Although in vitro studies have shown that the most secure fixation for the anterior screw-plate construct is obtained with bicortical purchase of the screws (Caspar, 1984), no reports advocate bicortical purchase because of the potential risks of spinal cord injury. In this study, plate breakage occurred only in those patients where the plate spanned unfused segments of the spine 6 to 9 months post-operatively; these problems did not occur when all levels encompassed by the plate were fused. No correlation could be made between the types of plates and subsequent failure. Graft dislodgement occurred only when screws were secured mainly in the disc space (Fig. 4B). Specifically, the technical errors made early in the series were: (1) screws placed in disc spaces and not in bone, and (2) plates spanning motion segments that had not been fused. Although the complication rate (25%) was similar to other studies that have reported results of this technique (Brown, 1988; Van Peteghem, 1979) (Table II), it is appreciably higher than the 6 to 10% rate of complications reported for posterior procedures (Rogers, 1957; Capen, 1985). However, we believe this anterior technique is indicated for compressive flexion injuries, as shown by Cabanela *et al.* (1988). Currently, the Synthes cervical H plate is used for fixation. Although reductions achieved in the distractive flexion

Table II Complications with anterior cervical fusion

	Per cent
Brown	31
Cabanela	3
Van Peteghem	29
de Oliveira	3
Mann	25

injuries in this series were maintained, posterior cervical fusion is the treatment of choice for this type of injury.

Multilevel, non-contiguous injuries of the cervical spine have been reported in 7 to 24% of individuals with cervical injuries (Hadden, 1985). Thus, careful assessment of the cervical spine should be performed before selecting either an anterior or posterior approach. Computerised tomography and/or magnetic resonance imaging may be necessary for this assessment. However, standard lateral radiographs that show all seven cervical vertebrae and the cervicothoracic junction provide the most accurate survey of the cervical spine. Although the non-contiguous injury in the patient in this series necessitated an additional posterior procedure, Hadden *et al.* (1985) concluded that multilevel cervical spine injuries rarely do need surgery.

Summary

Anterior decompression and plating provides a method of stabilisation of traumatic injuries of the cervical spine. Neurologic status did not deteriorate in any patient. Solid fusions were achieved in all cases, and the observed complications appear avoidable. Screw loosening and plate breakage should be anticipated if the plate spans unfused segments of the spine. We do not recommend plating unfused motion segments.

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