Surgical stabilization of traumatic cervical spine dislocation using methyl methacrylate

Long-term results in 26 patients

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Twenty-six patients with traumatic cervical spine fracture-dislocations had spinal stabilization with methyl methacrylate (acrylic) as the primary support. In most cases a ½-in. stainless steel screw was inserted into the articular pillars of the fractured vertebra and of the two adjacent vertebrae, followed by application of the acrylic in the form of an oblong mold over the heads of the screws. The follow-up period in these 26 patients ranged from 6 months to 7 years. There were no instances of wound infection or increased neurological impairment. Vertebral elements remained aligned in 25 of the 26 patients. Breakage of the acrylic support was documented in two patients, but in only one was surgical repair required. The results of this study indicate that the procedure is a safe and effective method for both immediate and long-term stabilization of cervical spine fracture-dislocations.

KEY WORDS • cervical spine • acrylic spine stabilization • fracture-dislocation • methyl methacrylate

Methyl methacrylate (acrylic) has not generally been used as the sole stress-bearing material for surgical stabilization of spinal fractures. Although Knight employed acrylic alone when he introduced its application to spinal stabilization in 1959, the patients in his series were limited to those suffering chronic pain due to spondylosis, osteoarthritis, or unhealed fractures. Theories regarding the necessity of bone grafts for achieving long-term fixation appear to be the chief reason why acrylic inlays have generally been restricted to cases of metastatic disease. This may also explain why acrylic has nearly always been employed as an adjunct to bone grafts in cases of traumatic injuries, and often in combination with wire or metal plates. This report describes the long-term results of using an acrylic inlay as the primary stabilizing element for acute fracture-dislocations of the cervical spine in a consecutive series of 26 patients.

Summary of Cases

Clinical Material
The patients ranged in age from 17 to 53 years, but 78% were under the age of 25 years. Their injuries had resulted from a variety of accidents, including diving into shallow water, vehicular collisions, and falls from high levels. There were 23 males and three females.

Fracture-dislocations were documented by plain spine films, tomography, or computerized tomography (CT). All fractures described in this report were below the C-2 vertebral level, bore the earmarks of hyperflexion or hyperextension injury, and were deemed unstable when assessed using a modified version of criteria established by White and Panjabi. By this version, spinal fracture-dislocations are considered unstable when: 1) one vertebral body is displaced more than 40% of the anteroposterior (AP) dimension of the next lower body; 2) subluxation of one vertebral body is greater than 20% of the AP dimension of the next lower body during the course of movement from the neutral to the flexed or extended position; or 3) angulation between adjacent vertebrae is greater than 11%. The incidence of fracture-dislocation at each level is shown in Table 1, and representative plain films are presented in Fig. 1. In 17 patients evidence of instability was present on radiographs of the neck in the neutral position, and in the remaining nine the criteria were met on flexion-extension views.
TABLE 1

| Location of spinal fracture-dislocation in 26 patients |
|---------------------------------|-----------------|
| Level of Subluxation            | No. of Cases    |
| C3-4                            | 4               |
| C4-5                            | 5               |
| C5-6                            | 7               |
| C6-7                            | 7               |
| C7-T1                           | 3               |

Twelve patients were neurologically unimpaired, three had nerve-root injuries, eight had partial spinal cord injuries, and three were paraplegic but manifested motor or sensory sparing suggesting residual cord function at the level of dislocation. All patients were initially treated with traction using skull tongs. Unilateral or bilateral “locked” facets were detected in four patients, and in three of these unlocking occurred within the initial 48 hours of traction; in the remaining patient unlocking was accomplished intraoperatively. Cervical myelography and/or CT scanning was performed prior to surgery in all patients with spinal cord or nerve-root injury. Patients with radiological evidence of ventral cord compression from soft tissue or bone fragments underwent anterior cervical decompression and were not included in this series.

Each patient was informed that the long-term results of three different treatment methods were probably equal. These methods included: 1) 6 weeks of skull traction in a rotatable bed followed by wearing a rigid cervical collar; 2) wearing a halo-type brace for 6 weeks followed by a rigid collar; or 3) surgical stabilization. Those who chose surgery did so because of a desire to avoid immobilization and other inconveniences attendant with the alternative forms of treatment.

Operative Procedure

Patients were taken to the operating room on a Stryker frame bed and underwent nasotracheal intubation while still awake and in traction. Following induction of anesthesia, they were turned to the prone position. Intravenous nafcillin (30 mg/kg) was administered prior to skin incision and was continued for 48 hours.
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at a dose of 120 mg/kg/day. Skull traction (10 lb) was maintained throughout the surgical procedure.

Exposure of the posterior vertebral elements was accomplished using a standard midline approach. Drill holes for screws were placed in the articular pillars of the fractured vertebra and in the pillars of the vertebrae immediately above and below. Particular attention was given to extending the hole into the cortical bone on the ventral aspect of the pillar. Stainless steel bone screws (3-in. long, 0.138-in. diameter) were inserted into these holes to a depth of $\frac{1}{2}$ in. (Fig 2 left). Acrylic was then applied in the form of an oblong doughnut over the heads of these screws and around the spinous processes of the upper and lower vertebrae (Fig. 2 right). In situations where the vertebrae possessed relatively large spinous processes (especially C6-T1) and the acrylic could be snugly molded to the concavities of the processes, it was sometimes applied in the absence of screws. At the start of this series, the cross-sectional area of each acrylic side strut was not strictly controlled, but in general measured more than 2.0 sq cm. Skull tongs were removed after the wound had been closed. Patients were allowed to walk or to begin physical therapy on the 1st postoperative day; most wore a soft cervical collar for 3 to 7 days.

A lateral view radiograph of the cervical spine was routinely obtained in the recovery room, and thereafter flexion-extension views were obtained prior to discharge or transfer (7 to 10 days postoperatively), and at 3 and 6 months following surgery. Additional radiographs were obtained at 2 years in 13 patients and at 5 years in eight patients. Three patients were lost to follow-up review after 6 months.

Operative Results

There were no instances of wound infection or increased neurological impairment. During the follow-up period, which ranged from 6 months to 7 years, the vertebral elements remained aligned in 24 of the 26 patients (Fig. 3), and all patients have recovered to the full extent of their physical capabilities. However, in two patients (Cases 9 and 10), acrylic side struts broke within a few weeks after surgery. The first of these patients was involved in an altercation 10 days after discharge from the hospital and felt a “cracking” sensation in his neck when struck on the jaw. Nine weeks

Fig. 2. Dorsal operative views of the exposed cervical vertebrae. Left: Stainless steel screws are inserted into the articular pillars. Right: The methyl methacrylate has been applied.
later when he returned to the clinic for routine assessment, cervical spine radiographs revealed vertebral subluxation with a fracture through the acrylic mold (Fig. 4). This inlay was subsequently repaired. The second patient, rendered quadriplegic by his injury, had been transferred to the rehabilitation service following surgery, and had developed the habit of using forceful head movements to shift himself from wheelchair to bed. On one such occasion, 4 weeks after surgery, he sensed “something snap” in his neck. A lateral view radiograph of the cervical spine demonstrated a fracture line in the acrylic, but there was no subluxation and no movement could be detected on flexion-extension films. This patient was treated with 3 weeks in a stiff collar, and subsequent radiographs showed no evidence of instability. Review of these two cases suggested that failure of the acrylic was due to the use of insufficient material, and therefore represented technical error. As a result of these two complications, greater attention was paid to achieving uniform thickness of the acrylic side struts, and no further failures occurred.

Discussion

Cervical spine fractures have been classified by a variety of schemes, most of which initially divide injuries of the “upper” level (occiput through C-2) from those of the “lower” level (C3-T1). Since the absence of a spinous process and of easily accessible articular pillars on the C-1 vertebra limits the use of acrylic as the sole support in this region, and since methods that combine the use of wire and acrylic for upper level fractures have been described by others, the discussion here is restricted to treatment of fractures in the lower cervical spine.

The Diagnosis of Instability

Any report describing the results of a stabilizing procedure would carry little weight if the spinal injuries had not, in fact, been unstable. It has been the opinion of some that criteria for assessing instability are frequently ignored, and that “operations are done because surgeons think spines may be unstable and it is safer to advise fusion.” More recently, Van Peteghem and Schweigl commented that “the indications for surgical stabilization of cervical spine fractures are not universally defined ... in part because no concise definition of what constitutes an unstable fracture exists ...” While there are certain fractures about which reasonable and experienced physicians might disagree, the stability of most fractures can be reliably determined. The radiological criteria employed in the present series represent minor modifications of those proposed by White and Panjabi. Instead of measuring subluxation by a fixed unit, which cannot take into account differences in vertebral body size or in magnification, a percentage figure, as described above, was employed. All 26 patients in this series had suffered a hyperflexion or hyperextension type of injury, both of which carry a significant risk of prolonged instability as determined by dynamic views after 12 weeks of partial immobilization. Although it is generally agreed that bilateral facet dislocation produces instability, results in the present series do not support the contention that this type of injury inevitably leads to greater than 50% subluxation.

Conservative Versus Surgical Management

There is no information that allows meaningful comparison of outcome following conservative compared with surgical management. Recent reports have indicated a high success rate with halo-type fixation, even in injuries traditionally regarded as requiring bone grafts. In the present series of patients, therefore, the
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decision regarding surgery as opposed to external tong support was most commonly a matter of patient preference.

Methods of Surgical Stabilization

The method of stabilization described in this report diverges from certain strongly advocated procedures. Many surgeons have insisted that bone grafting is necessary to assure long-term stability. This position has usually been predicated upon the belief that cervical dislocation injuries frequently entail an extensive, persistent loss of ligamentous support. Since it is reasonable to expect eventual loosening of nonbiological materials, it is often argued that long-term stability cannot be assured in the absence of a bone inlay. Holdsworth has argued that “after accurate [sic] reduction and prolonged immobilization of dislocations of the cervical spine, late redisplacement often occurs.” Yet, as Cheshire commented, such statements are “imprecise and emotive,” with the imprecision relating to the terms “prolonged,” “late,” and “often.” From a review of his own series, Cheshire found that only 5.4% of patients continued to have instability following 6 to 8 weeks of traction plus 4 to 6 weeks of cervical collar support. Of the 52 cases of extension-rotation injury, none was found to be unstable after 12 weeks of conservative management, and Cheshire’s explanation for this finding was not that the ligamentous damage was less (in fact he regarded it as unusually extensive), but that these patients were much more rigorously immobilized than those with anterior subluxation. He concluded that “if a torn ligamentous system be immobilized well enough, and for long enough, satisfactory healing will occur.” This position has been strengthened by several recent reports of successful results using a halo-type brace.

The implication of these findings for the present report is that, within a relatively short period (which might be arbitrarily defined as 3 to 4 months), fracture lines will have healed and ligamentous repair will be sufficient to prevent abnormal movement, even if the acrylic implant subsequently loosened.

It can be safely stated that no stabilizing procedure carries a 100% success rate, and, in the absence of randomized studies, the relative success of most procedures cannot be determined precisely. Interfacet wiring of bone struts is a more involved procedure than is often depicted in textbook drawings. In addition, there is relatively little information about the success rate of the fusion per se. Radiographic evidence of long-term stability in patients treated by this method does not, in itself, prove that stability resulted from fusion of the bone strut rather than from the temporary fixation which allowed healing of vertebral elements and soft tissues. Finally, even when fusion occurs between bone strut and articular pillars, the strength of such bonds remains unknown and could vary considerably from case to case.

Although it is well recognized that wire wrappings can fail, either by breakage or by erosion through bone, the actual incidence of this complication is not known. Some particular disadvantages of wiring procedures are: 1) they require removal of ligamentum flavum; 2) threading beneath laminae carries the risk of spinal cord injury; 3) the tension placed upon each wire is difficult to control, with the possibility that one strand bears considerable stress; 4) only a narrow interface exists between wire and bone, increasing the likelihood of erosion; and 5) rigid stabilization with wire is difficult to achieve since it resists tension to a far greater degree than it does compression or bending.

The potential disadvantages of the acrylic inlay technique are that: 1) the mold occupies more space than does wire, and may limit the amount of reapproximation between soft tissue and bone; and 2) failure can occur at points where insufficient material is applied. The principal advantages are that the procedure is relatively simple and safe to perform and that, as indicated by this study, it can provide both immediate and long-term stabilization.

In the present series of cases, screws were frequently used as a convenient anchor for the acrylic. It could be argued that these elements might loosen over time, and that they present at least a theoretical source of weakness in the support. However, even if the threads no longer provided a secure anchor to the bone, there are three factors that serve to prevent disengagement of the screws: 1) the cervical vertebrae tend to move in an angular rather than linear direction; 2) the screws are inevitably inserted along different axes; and 3) the non-parallel axes, both maintained by bone and by fixation of the screw heads to the acrylic, effectively lock the screws into the vertebrae. Nevertheless, the security of the screws can be maximized by extending the drill hole into the anterior cortex of each articular pillar.

The findings of this study suggest that a large percentage of patients with fracture-dislocations of the lower cervical spine can be satisfactorily stabilized by an acrylic implant in the absence of a bone graft. But this report, like many others, also points out the need for greater information about the mechanical properties of stabilizing materials, about the long-term durability of these materials, and about the degree and duration of spinal instability associated with different types of injuries.

References

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