Surgical stabilization of cervical spinal fractures using methyl methacrylate

Technical considerations and long-term results in 52 patients

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This study analyzes the long-term outcome of 52 consecutively treated patients with acute cervical spinal fracture/dislocation who underwent posterior surgical stabilization using methyl methacrylate in the absence of bone grafting. The patients ranged in age from 15 to 93 years. In 40 patients the injury was located in the lower cervical spine; for these a previously described surgical format was employed. In 12 patients the fracture involved C-1 or C-2, and the modification used for these injuries is presented. The postoperative period of evaluation ranged from 6 months to 12 years. There was one case of infection, which eventually required removal of the acrylic, but there were no instances of new neurological injury or of operative mortality. Failure of stabilization occurred in two previously reported patients treated early in the series. Comparison of the patient outcome in this study with that of certain other reports suggests that at least four technical factors are important for the success of methyl methacrylate stabilization: 1) the acrylic inlay must be provided with an anchor to bone; 2) the anchor must be of a type that does not easily erode through bone; 3) the inclusion of wire must be done in a manner that allows each strand to be completely encased in the acrylic; and 4) the cross-sectional area of the inlay is critical.

KEY WORDS • cervical spine • spinal fracture • fracture/dislocation • methyl methacrylate

In a previous report we described the long-term outcome of 26 consecutively treated patients with traumatic cervical fracture/dislocations who had undergone surgical stabilization using methyl methacrylate as the principal supporting material. The injuries in that series were located exclusively within the lower cervical spine (C3–7), for which a single type of surgical format was applicable. The present report analyzes the results of acrylic stabilization in a larger population of patients, and describes modifications of the surgical technique required for stabilization of fracture/dislocations involving the upper cervical vertebrae.

Clinical Material and Methods

Patient Population

Fifty-two patients were treated, ranging in age from 15 to 93 years. Of these, 68% were under 30 years of age, and 10% were more than 60 years old. There were 43 males and nine females. Their injuries had resulted from a typical spectrum of accidents. Documentation of fracture/dislocation and the determination of instability were performed as described previously. The incidence of fracture/dislocation at each level is shown in Table 1. In 45 patients evidence of instability was present on x-ray films of the neck in the neutral position, and in the remaining patients the criteria were met on flexion-extension views.

Twenty-four patients were not neurologically impaired, three had nerve-root injuries, 12 had partial spinal cord injuries, and 13 were paraplegic. The initial management of patients was as described in the previous report except that magnetic resonance (MR) imaging was employed increasingly in patients treated more recently. As in our first series of patients, those whose imaging studies showed evidence of ventral cord compression from soft tissue or bone fragments underwent anterior cervical decompression and were not included in this series.

Surgical Procedure

Our operative technique for stabilization of fracture/dislocations of the lower cervical spine using methyl
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Fig. 1. Photograph of model spine showing placement of screws in the arch of C-1 and articular pillar of C-2.

Fig. 2. X-ray films of the cervical spine of a patient with hangman's fracture, obtained preoperatively (left) and 6 months postoperatively showing placement of stabilization wires and screws (right).

Discussion

Historical Review

Historically, there has been considerable variation in the way acrylic has been employed for posterior cervical stabilization. In broadest terms, there have been two types of procedures: those in which acrylic has been combined with a bone inlay, and those in which it has been utilized in the absence of bone. Hoppenstein was the first to report the use of acrylic in posterior spinal stabilization and, because of his concern that "any prosthetic device will loosen after approximately three months," bilateral bone inlays were included in his procedures. A number of subsequent reports have also argued that acrylic, if used at all for posterior cervical stabilization of traumatic dislocations, must be applied in conjunction with bone grafts. However, long-term methyl methacrylate stabilization without bone inlay has been demonstrated by several groups. Alexander and Branch, et al., reported successful stabilization of atlantoaxial dislocations using only acrylic and laminar wires, a technique that was later modified to include Kirschner wires passed through the spinous processes. Clark, et al., also employed acrylic alone in selected cases. Our initial experience in a consecutive series of 26 patients with cervical spinal fracture/dislocations

Results

The follow-up period for the 52 patients in this study ranged from 6 months to 9 years. Follow-up x-ray studies of the cervical spine were scheduled at 3, 6, 12, and 24 months postoperatively (Fig. 2). There were no instances of methyl methacrylate failure beyond the two cases described in the previous report. No patient suffered increased neurological impairment. One patient developed a wound infection, which subsided after administration of ampicillin for 10 days but recurred 8 months later. X-ray films at that time suggested complete healing of the fracture lines. The patient was hospitalized, the acrylic inlay and screws were removed under general anesthesia, and the wound healed without further complication.

<table>
<thead>
<tr>
<th>Vertebral Level</th>
<th>No. of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1</td>
<td>2</td>
</tr>
<tr>
<td>C-2 (odontoid)</td>
<td>6</td>
</tr>
<tr>
<td>C-2 (hangman's)</td>
<td>4</td>
</tr>
<tr>
<td>C-3</td>
<td>7</td>
</tr>
<tr>
<td>C-4</td>
<td>6</td>
</tr>
<tr>
<td>C-5</td>
<td>16</td>
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<tr>
<td>C-6</td>
<td>7</td>
</tr>
<tr>
<td>C-7</td>
<td>4</td>
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</tbody>
</table>

Table 1

Distribution of fracture levels among 52 patients undergoing acrylic stabilization
provided additional evidence that long-term stabilization could be achieved with methyl methacrylate. In contrast, other groups have found a disturbing degree of failure when acrylic was used in the absence of bone grafts. Therefore, it is important to consider possible reasons for this inconsistency.

Explanation for Disparate Reports

First, it could be postulated that the disparity in reported outcomes is due to a variation in the severity of spinal instability among the different series of patients. A second possible explanation is that studies reporting an unacceptable degree of failure reflect more careful analyses and/or were conducted over a longer period of time. Because not all studies have thoroughly defined the criteria used for determining instability or the rigor of postoperative evaluation, neither of these reasons can be completely eliminated as factors in the reported rates of success of acrylic stabilization; however, a comparison of the reports on both sides of the issue does not reveal obvious differences in severity of instability or in the thoroughness of the clinical and radiographic assessment. A third possible explanation is that there are critical differences in the manner in which methyl methacrylate has been employed in stabilization procedures. For the reasons stated below, we believe that these differences are primarily responsible for the variability in results.

With regard to the reports of high failure rates with methyl methacrylate, the lack of a full description of the techniques employed impedes attempts to pinpoint what may have been the causal factors. For example, although McAfee, et al. indicated that in certain cases flexible wires had been included in the construct, no information was given regarding the size or shape of the acrylic inlay itself. Furthermore, it appears that most of the patients reported in their series had been treated by procedures that relied upon flexible wires, not acrylic, as the primary stabilizing material. A more recent article by Whitehill, et al. supplied a more complete description of certain aspects of the surgical procedure used in a series of 20 patients with traumatic cervical spinal instability, 11 of whom were subsequently found not to be rigidly immobilized. In their technique, stainless-steel wires (No. 18 or 20) were looped around the posterior spinous processes prior to application of the acrylic. Holes or notches were made in the cephalad process to prevent the wires from slipping over its convex ridge. As with the previous report, however, the amount of acrylic employed and the elements to which it was intended to bind were not defined.

Principles of Acrylic Stabilization

Despite the incomplete description of surgical methods in these reports, their rates of failure suggest that certain principles need to be considered when acrylic is employed as a primary stabilizing material for cervical spinal fractures. Some of these principles apply more to the use of this material in the absence of bone, but others are necessary for achievement of short-term fixation until a bone inlay becomes solidly fused.

First, the mere application of acrylic, regardless of quantity, to the posterior surfaces of the cervical vertebrae does not provide reliable stabilization simply because these surfaces do not possess sufficient contours for anchoring. For this reason, acrylic needs to be attached to bone by some other means.

Second, the intermediating agent between acrylic and bone must be one that cannot loosen from either material. This principle brings into question the method of applying acrylic over wires looped around laminae or posterior spinous processes. While it can be assumed that the wires remain permanently encased within the acrylic, they nevertheless can, due to their thinness, erode through the bone surface and cease to provide rigid fixation. The addition of acrylic to this type of wiring cannot prevent erosion because the material does not penetrate the small interface where the wire is exerting its pressure on bone.

The third principle relates to the use of wires for any type of fixation. Because wire possesses a minimal ability to resist bending and compressive forces, it cannot by itself provide three-dimensional stability. Encasing wires in acrylic can overcome this limitation only if a sufficient amount of material completely surrounds the wire over its entire length. These conditions are difficult to meet with wire that has been tightened around laminae or spinous processes, since such strands lie directly against the adjacent bone surfaces.

Finally, the overall strength of any inlay, whether bone, acrylic, or other material, is dependent upon its geometry, particularly its cross-sectional area. As mentioned above, it is difficult to know how many reported cases of failure may have been due to the use of insufficient material since the geometry of the constructs has rarely been defined.

Stabilization Techniques

It may be possible to devise a number of acrylic stabilization techniques that could satisfy all of the above principles. The ways in which the procedure we have utilized meets these needs are discussed below, without implying that this is the only method for accomplishing that goal.

First, although the acrylic material is applied over the laminae and spinous processes, its fixation is to the upper shafts and heads of metal screws. Barring failure of the material, this attachment cannot loosen.

Second, the vertebra cannot pull away from the screws, because they are inserted not along the axis of movement but at an oblique outward angle. The orientation of the screws is also maintained by the acrylic. In this respect, the acrylic inlay overcomes one drawback of metallic plates, which is that they allow screws to wobble. For the screw, wire, and acrylic construct to loosen would require either extensive bone erosion along the entire length of the holes into which the screws had been inserted or that the acrylic fracture.
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Third, when wire is employed with this inlay, each loop exerts its hold on the exposed shaft of the screws, rather than on erosive bone. In addition, because the loops of wire are 3 to 4 mm above the bone surface, there is sufficient space for all strands to be completely embedded in the acrylic material.

Finally, the minimum amount of any inlay, whether bone, wire, metal strut, or acrylic, needed to provide reliable long-term stabilization of the cervical spine has traditionally been gauged by clinical experience. In the case of methyl methacrylate, our previous report suggested that each side strut should have a cross-sectional area of at least 2.25 cu cm (approximately 1.5 cm in depth and in width).

Conclusions

This study adds support to others indicating that methyl methacrylate can provide long-term stability of traumatic cervical spinal fractures, but it also emphasizes that certain technical principles are critically important. Even a high success rate, however, does not obviate what we judge to be an important concern of acrylic stabilization — the risk of infection. Although this risk appears to be quite low and may not exceed that of techniques employing other types of implant, it should not be ignored.

References


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