Halo immobilization of cervical spine fractures

Indications and results

Paul R. Cooper, M.D., Kenneth R. Maravilla, M.D., Frederick H. Sklar, M.D., Sarah F. Moody, R.N., and W. Kemp Clark, M.D.

Division of Neurological Surgery and Department of Radiology, University of Texas Health Science Center at Dallas, Dallas, Texas

Thirty-three patients with a spectrum of cervical spine fractures or subluxations were treated with immobilization by a halo apparatus. All spines were assumed to be unstable because of the nature of the fracture or because of a subluxation noted on spine films. Treatment consisted of immobilization and fracture reduction followed by application of a halo plaster cast or molded halo plastic vest. Patient acceptance was high. Complications were few and minor. No patient experienced neurological deterioration during treatment. Reduction was well maintained during an average halo immobilization period of over 3 months. Use of the halo resulted in healing of bone and ligament and restoration of stability in 85% of the patients. Halo immobilization was efficacious in the treatment of odontoid and hangman's fractures as well as complex fractures involving multiple areas of a single vertebra. It was also used successfully as an adjunct to posterior cervical fusion. Although several patients with subluxations or angulation without bone injury were treated successfully, two of the four therapy failures occurred in this group of patients, and the halo must be used with caution in this clinical setting. Contraindications to the use of the halo include complete cervical spinal cord injury with anesthetic skin, tomographic and/or myelographic evidence of disc or bone within the spinal canal, and unsatisfactorily reduced subluxations. The halo has provided more effective and reliable immobilization than other orthoses. It is an acceptable alternative to cervical fusion for the achievement of stability in a wide variety of cervical spine fractures and dislocations avoiding both the short-term and perhaps long-term complications of spinal fusion.

Key Words • halo device • cervical spine injury • hangman's fracture • odontoid fracture

The use of the halo apparatus for immobilization of the cervical spine was first described by Perry and Nickel in 1959. Since that time reports have documented the use of halo immobilization in the management of a number of traumatic entities of the cervical spine. In spite of this, however, there has been a paucity of information in the neurosurgical literature regarding the indications, contraindications, and results of halo immobilization for a wide variety of posttraumatic disorders of the cervical spine. In this report, we document our experience with the halo apparatus in the therapy of these disorders.

Clinical Material and Methods

In the past 3 years, 33 patients admitted to Parkland Hospital with acute, traumatically induced fractures or subluxations of the cervical spine have been managed with the use of the halo apparatus. Twenty-eight were males and five were females. They ranged in age from 9 to 66 years, with the average age of 27 years. Their neurological status is shown in Table 1. Additional patients with malignancies, infectious processes, degenerative disease, or congenital anomalies involving the cervical vertebrae and ligaments were also treated with the halo apparatus during this time, but are not included in this report.

The presence of a cervical spine fracture and/or subluxation was initially recognized on anteroposterior and lateral roentgenograms taken in the emergency room suite. Twenty-seven patients were placed in skeletal traction for stabilization or reduction of subluxations. The remaining six patients were initially managed with bedrest and a Philadelphia collar, either because it was believed that their injuries were...
relatively stable, or because the nature and extent of their fractures were not appreciated on the basis of admission cervical spine films. Patients with systemic injuries were kept in cervical traction and their diagnostic studies were deferred until their condition had been appropriately treated. In the remainder of patients, hypocycloidal tomography and/or flexion-extension films of the cervical spine were obtained as described previously. If the patient's cervical spine was felt to be unstable based on these studies, a plaster halo apparatus or a low profile, preformed plastic halo vest* was fitted (Fig. 1). If repeat x-rays indicated recurrent subluxation, alignment was corrected by adjusting the rods connecting the halo to the jacket. Patients without neurological deficit were progressively ambulated and discharged after a final lateral cervical spine film was taken to confirm adequate alignment in the upright position. Patients with neurological deficit were treated on the rehabilitation service and then discharged.

*Halo vest manufactured by Ace Orthopedic Co., Hawthorne, California.

Summary of Cases

Length of Hospitalization

Table 2 shows the length of hospitalization both before and after halo application in patients who were neurologically intact and those who had neurological deficit. The average time for all patients was 20 days in hospital.

Length of Time in Halo

The average length of time in halo immobilization was 95 days, but it was preceded by a 15-day period of immobilization by skeletal traction or collar. The length of time of halo immobilization according to diagnosis is seen in Table 3.

Complications

Complications are summarized in Table 4. Three patients suffered superficial skin breakdown or excoriation as a result of localized pressure from the halo vest. In two of these, windowing of the vest or placing additional padding between the vest and the patient's skin resulted in relief of symptoms. In the third case, a patient with subluxation at two levels without fracture, the halo was removed after 42 days at which time her spine was stable. Three patients had local infections around the pin sites in their scalp. In each case the halo was left in place but the pins were changed with prompt clearing of the inflammation. One patient fell and bent a bar connecting the halo apparatus to the vest and loosened several connections; a recurrent subluxation resulted. There were no neurological sequelae. The halo apparatus was readjusted and satisfactory alignment was re-established.

Neurological Deficit

Of eight patients admitted with neurological deficit, five became neurologically intact following halo immobilization. Three others improved markedly but have residual deficit. No patient had neurological deterioration while in halo immobilization.

Healing of Bone and Ligament Structures

Of 33 patients fitted with the halo, follow-up data on ligament and bone healing are available in 26
Halo immobilization of cervical fractures

**TABLE 1**
Initial neurological status in 33 patients

<table>
<thead>
<tr>
<th>Status</th>
<th>No. of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>neurologically intact</td>
<td>26</td>
</tr>
<tr>
<td>neurological deficit</td>
<td>7</td>
</tr>
<tr>
<td>central cord syndrome</td>
<td>2</td>
</tr>
<tr>
<td>hemiparesis</td>
<td>1</td>
</tr>
<tr>
<td>quadriparesis</td>
<td>1</td>
</tr>
<tr>
<td>radiculopathy</td>
<td>1</td>
</tr>
<tr>
<td>paraparesis</td>
<td>1</td>
</tr>
<tr>
<td>Brown-Séquard syndrome</td>
<td>1</td>
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**TABLE 3**
Average length of immobilization according to diagnosis (days)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Pre-Halo Immobilization</th>
<th>Immobilization in Halo</th>
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<tbody>
<tr>
<td>complex fracture</td>
<td>20</td>
<td>102</td>
</tr>
<tr>
<td>hangman's fracture</td>
<td>16</td>
<td>86</td>
</tr>
<tr>
<td>odontoid fracture</td>
<td>13</td>
<td>125</td>
</tr>
<tr>
<td>subluxation/angulation only</td>
<td>7</td>
<td>57</td>
</tr>
<tr>
<td>adjunct to fusion</td>
<td>10</td>
<td>81</td>
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</table>

**TABLE 2**
Length of hospitalization (days)

<table>
<thead>
<tr>
<th>Patient Group</th>
<th>Pre-Halo Hospitalization</th>
<th>Post-Halo Hospitalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>neurologically intact</td>
<td>14.1</td>
<td>3.2</td>
</tr>
<tr>
<td>neurological deficit</td>
<td>22.4</td>
<td>5.8</td>
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</table>

**TABLE 4**
Complications with halo immobilization

<table>
<thead>
<tr>
<th>Complications</th>
<th>No. of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>pin infections</td>
<td>3</td>
</tr>
<tr>
<td>skin breakdown (halo removal in one patient)</td>
<td>3</td>
</tr>
<tr>
<td>loss of reduction after a fall</td>
<td>1</td>
</tr>
</tbody>
</table>

Fig. 2. Left: Lateral plain film of the cervical spine showing a fracture of the body of C-3 (arrow). Subluxation at C2-3, present on admission, has been reduced. Tomography (not shown) revealed also a fracture of the lamina of C-2, and the right pedicle and left facet of C-3. Center and Right: Post-treatment flexion and extension films show a slight step-off at C2-3 which does not change with movement. The fracture of the body of C-3 is nearly healed.
TABLE 5
Ligament and bone healing in 26 patients treated with halo immobilization

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Success</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>complex fracture</td>
<td>9</td>
<td>2*</td>
</tr>
<tr>
<td>hangman's fracture</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>odontoid fracture</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>subluxation/angulation only</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>adjunct to cervical fusion</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>total</td>
<td>22 (85%)</td>
<td>4 (15%)</td>
</tr>
</tbody>
</table>

*One patient considered a failure had healing of a pedicle fracture at C-2, but a non-contiguous subluxation without bone injury at C4-5 remained unstable.

(Table 5). Halo therapy was successful in restoring bone and ligament stability in 22, or 85%, of these patients. Two patients were lost to follow-up review. An additional five patients are currently immobilized in the halo and the success or failure of their therapy cannot currently be determined.

Complex Fracture. A complex fracture includes those injuries involving multiple areas of a single vertebral body and/or fractures involving multiple vertebral bodies. A fracture at a single site, if associated with a subluxation, was considered in this category as well. There were 11 patients in this group. All but two had fracture healing with restoration of cervical spine stability after treatment with the halo.

TABLE 6
Sites of complex fractures

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Body</th>
<th>Pedicle</th>
<th>Lateral Mass†</th>
<th>Lamina</th>
<th>Subluxation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C-2</td>
<td>C-3</td>
<td>C-3</td>
<td>C-3</td>
<td>C2–3</td>
</tr>
<tr>
<td>2</td>
<td>C-3</td>
<td>C-3</td>
<td>C-3</td>
<td>C-2</td>
<td>C3–4</td>
</tr>
<tr>
<td>3</td>
<td>C-5, 6</td>
<td>C-3</td>
<td>C-5, 6</td>
<td>C-4</td>
<td>C4–5</td>
</tr>
<tr>
<td>4</td>
<td>C-4</td>
<td>C-3</td>
<td>C-3</td>
<td>C-2</td>
<td>C3–4</td>
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<tr>
<td>5</td>
<td>C-5, 6</td>
<td>C-6</td>
<td>C-3</td>
<td>C-6</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>C-2</td>
<td></td>
<td></td>
<td></td>
<td>C1–2</td>
</tr>
<tr>
<td>7</td>
<td>C-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>C-6, 7</td>
<td>C-2</td>
<td>C-6</td>
<td>C-7</td>
<td>C4–5</td>
</tr>
<tr>
<td>9</td>
<td>C-7</td>
<td></td>
<td></td>
<td></td>
<td>C6–7</td>
</tr>
<tr>
<td>10</td>
<td>C-5</td>
<td>C-5</td>
<td>C-5</td>
<td>C-5</td>
<td>C5–6</td>
</tr>
</tbody>
</table>

*One patient considered a failure had healing of a pedicle fracture at C-2, but a non-contiguous subluxation without bone injury at C4-5 remained unstable.

The sites of complex fractures are seen in Table 6. The cervical spine films of a patient whose complex fracture was treated successfully are shown in Fig. 2. Another example of the successful treatment of a complex fracture involving both anterior and posterior elements is seen in Fig. 3. A third example of a complex fracture is seen in Fig. 4. In two patients with complex fractures (Cases 3 and 9), halo immobilization did not result in stability.

Fig. 3. Left: Tomogram taken before halo therapy reveals a fracture through the lamina and spinous processes of C-2 (arrow), and a subluxation at C3–4. Additional tomographic cuts (not shown) showed a fracture of the body of C-4, and lateral mass and pedicle of C-3 as well as a partially locked facet at the C3–4 level. Center and Right: Flexion and extension films taken following therapy show stability and good alignment at the C3–4 level.
Halo immobilization of cervical fractures

_Hangman’s Fracture._ Seven patients had hangman’s fractures. Varying degrees of C2-3 subluxation were present. Halo immobilization resulted in fracture healing and spine stability in all seven patients. Figure 5 illustrates a successful result.

_Odontoid Fracture._ Three patients with odontoid fractures were treated with halo immobilization, and healing occurred in two. The third patient, a 52-year-old man with 4 mm of distraction of the odontoid from the body of C-2, did not show x-ray evidence of fusion after 144 days of immobilization and the patient underwent posterior cervical fusion of C1-3.

_Subluxation/Angulation Only._ Two patients had evidence of subluxation without bone injury, and both healed in halo immobilization. A third patient had angulation of the spine, which was corrected by halo immobilization; however, cervical spine flexion-extension films after halo removal showed recurrent angulation, unchanged from that seen on admission films. This patient has remained asymptomatic and is being followed for any progression of his deformity.

_ADJunct to Cervical Fusion._ In one patient the halo was successfully used as an adjunct to posterior cervical fusion. This patient had suffered subluxation at the C4-5 level. A persistently locked facet prevented adequate reduction. There were fractures involving the C-3 pedicle and lamina and the C-6 lamina. The subluxation was surgically reduced, and posterior fusion and wiring was performed. Because the posterior element fractures might have prevented optimum immobilization and healing, a halo was applied postoperatively. Fusion was successful.

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_Fig. 4._ Tomogram showing a vertical fracture through the bodies of C-6 and C-7 (arrow). Additional views (not shown) revealed fractures of the lateral mass of C-6 and lamina of C-7.

_Fig. 5._ Left: Lateral films of cervical spine show a hangman’s fracture of C-2 (arrow). Admission films (not shown) revealed also subluxation at the C2-3 level. Center and Right: Following treatment flexion and extension films show healing of fracture, good alignment, and stability at the C2-3 level.
Discussion

The development of skeletal traction as described by Crutchfield\(^7\) represented a significant advance in the management of cervical spine injuries. When used as the sole treatment of these injuries, however, Crutchfield traction necessitates hospitalization lasting weeks or months.

The advent of anterior cervical fusion as described by Robinson and Smith\(^8\) and Cloward\(^9\) allowed early ambulation in most cases. The operation is safe, but is nonetheless associated with complications.\(^9\) In traumatic entities, whether fusion is performed from an anterior or posterior approach, the goal of immediate stability is not always achieved, and a variety of external bracing devices may have to be used postoperatively. In addition, non-union, extrusion or bone graft resorption, subluxation, and angulation may occur in the postoperative period.\(^6\) Whichever approach is used, fusion results in abnormal immobility at levels of bone union and increased stresses at levels above and below the fusion.

The disadvantages of prolonged skeletal traction or fusion are in large measure eliminated by halo immobilization. Patient acceptance has been high. Although initially distressed by the cumbersome nature and bizarre appearance of the halo, most patients quickly adapt to the device.

In the present series, the length of hospital stay before halo application was increased when there were systemic injuries, neurological deficit, or difficulty in the reduction of subluxations. Lack of immediate availability of the halo apparatus also served to increase the hospital stay for some patients. Hospitalization following halo placement was short and represented only that time needed for gradual return to the upright position, rehabilitation in those patients with neurological deficit, and halo adjustment for both comfort and optimum cervical alignment in others. Hospital stays in the present series are comparable to those of Norrell and Wilson's\(^10\) series of patients treated with anterior cervical fusion (20 days for patients treated with the halo versus 18 days in patients treated with surgery). On the other hand, the hospital stays in our series are considerably shorter than those of the series reported by Forsyth, et al.,\(^6\) for patients treated with posterior fusion. Most recently, our patients have been placed in halos sooner, ambulated shortly thereafter, and discharged sooner than earlier in the present series.

Complications were few and minor. In one case it was necessary to discontinue halo immobilization because of skin breakdown. Changes of pin sites always resulted in cessation of inflammatory problems where the pin pierced the scalp. Pain at pin sites was not uncommon and was almost always associated with loosening of the pins in the scalp and was relieved by tightening of these pins.

Some neck movement can occur during halo immobilization. Koch and Nickel\(^11\) showed that in a change from the upright to the recumbent position, motion did occur in spite of the halo and averaged 31% of non-immobilized controls. Moreover, compression and distraction forces may vary by as much as 30 lb. In the present series, a loss of reduction occurred infrequently and was usually early in the course of immobilization. Recurrent subluxations were minimal and were easily corrected by adjustment of the halo apparatus.

The use of the halo for specific traumatic entities deserves comment.

**Hangman's Fracture**

Seljeskog and Chou\(^12\) in a series of patients with hangman's fractures successfully managed all but one with a variety of nonoperative external immobilization techniques. Two of these patients were treated with the halo for periods of 4 to 6 weeks. Brashear, et al.,\(^2\) also thought that surgical intervention was rarely necessary for this fracture. On the other hand, Norrell\(^13\) has advocated anterior cervical fusion for subluxation at the C2-3 level. Experience from the present series confirms the results of Seljeskog and Chou.\(^2\) Regardless of the degree of subluxation, all fractures healed and have remained stable. Our total immobilization time averaging 14 weeks is more than the 6 weeks advocated by Seljeskog and Chou.\(^2\) It is evident in retrospect that some patients were in halo immobilization long after bone union had occurred. The decision to remove the halo was for the most part based on plain-film evidence of fracture healing.

While other external immobilization devices have been used successfully for hangman's fracture, the halo permits the least cervical movement of any device now available.\(^11\) The halo has the additional advantage of being extraordinarily difficult to remove or manipulate without special wrenches. Unreliable patients who might remove other forms of cervical orthoses will therefore be maintained in continuous and dependable immobilization.

**Odontoid Fracture**

Alexander, et al.,\(^1\) advocated posterior surgical fusion of C1-3 for this entity. More recently, Apuzzo, et al.,\(^2\) have defined the relative place of surgical therapy and external immobilization for this fracture. It appears from their data and the present series that non-displaced odontoid fractures and fractures displaced less than 4 mm after skeletal traction in patients under the age of 40 years are likely to heal with external immobilization alone. Displaced fractures in patients over the age of 40 years have a high rate of non-union and should probably be fused. All patients with displacement greater than 4 mm should undergo fusion. The halo is an ideal form of immobilization since it allows for more exact and reliable adjustment of the cervical alignment than other orthoses.
Halo immobilization of cervical fractures

**Subluxation/Angulation Only**

The experience with patients with subluxation and/or angulation only has been smaller. Two patients with subluxation achieved stability and presumably healing of the ligaments. In a third patient with angulation without subluxation, the spine remained angulated. In this instance, therapy must be considered a failure, although the cervical deformity has not increased on follow-up review. An additional patient listed as failing to heal a complex fracture (Table 5) has persistent subluxation at a site of ligament injury, although a non-contiguous fracture went on to heal. Thus, two of four patients with a ligament injury without a fracture or not adjacent to a fracture remained unstable after halo removal. Whether halo treatment will be appropriate in large numbers of patients with subluxations or angulations in the absence of fracture cannot now be determined from the data in the present series. It is disconcerting that Cheshire et al. has noted a late instability rate of 21% in patients with anterior cervical subluxations without fracture treated in skeletal traction followed by a collar. In a group of patients with similar injuries, Rogers has noted instability in two of six patients treated with "prolonged external fixation." In both cases reported by Rogers spontaneous interbody fusion eventually occurred.

**Adjunct to Cervical Fusion**

The halo was used as an adjunct to posterior cervical fusion in one patient. Treatment was successful and provided additional insurance against subluxation in the postoperative period. It cannot be said with certainty whether the patient's spine would have remained stable without the halo. Rogers has noted that stabilization of cervical spine fractures did not occur until 8 to 12 weeks after posterior cervical fusion. He also reported a 5% fusion failure, which may have been avoided by better postoperative immobilization as is provided by a halo apparatus.

We had no patients in whom the halo was used as an adjunct to anterior cervical fusion. However, removal of the longitudinal ligaments, disc, and body in the presence of already injured posterior elements can result in an inherently unstable situation in which subluxations, angulations, and slipped bone graft plugs may occur. Halo immobilization may preclude these complications and allow earlier and safer patient ambulation. Prolo, et al., successfully used halo immobilization in 14 patients who had previously undergone anterior or posterior cervical fusion.

**Complex Fracture**

This group of patients presented the most difficult management problems. In the past, most of these patients would have been managed by operative stabilization. Indeed, Petrie thought that these complex fractures were all unstable and fused them from a posterior approach. Nevertheless, in many cases immediate stability following surgery has been difficult to achieve because of injury to both posterior and anterior vertebral elements. Experience shows that restoration of stability and fracture healing will occur in these patients with halo immobilization. Although patients with complex fractures often require surgery, satisfactory results with the halo alone have led us to use this non-operative treatment with increasing frequency.

Persistent instability of the cervical spine in two patients after halo removal is significant. One patient (Case 3) had a particularly severe injury, involving three vertebrae. The second patient (Case 9) had injury to two noncontiguous sites. The pedicle fracture had healed but rotatory subluxation at C4–5 persisted. This patient was treated with halo immobilization for 68 days. It is possible that the ligament might have healed with a longer time in the halo.

Complications such as instability and angulation may occur long after halo removal. This has not occurred to date in our series, although the follow-up period is relatively short. Late disc degeneration, spondylosis, and spontaneous fusion have been noted at the site of trauma in patients treated non-operatively with skeletal traction. The severity of degenerative changes in patients treated with the halo as compared to patients treated with surgery cannot be determined from the data presented here or from the literature. Additional experience will be needed to predict the circumstances in which halo therapy will be unsuccessful in the treatment of these complex fractures.

**Contraindications**

There are certain clinical situations in which the halo device should not be used. Patients with spinal cord injuries and anesthetic skin are at high risk for the development of cutaneous ulcerations beneath the plaster cast or halo vest. Thus, there are no patients in the present series with total spinal cord transections. Tomographic and/or myelographic evidence of bone or disc material within the spinal canal is a contra-indication to the use of the halo as initial therapy, since surgery is required in these patients. However, the halo may be used as an adjunct to decompressive surgery. Patients with subluxations or fractures that are not satisfactorily reduced in cervical traction are not candidates for halo immobilization as initial treatment of choice. In addition, patients with a gibbus should not be placed in the halo, since skin breakdown is likely to occur over the bone prominence. The plaster cast or plastic vest both restrict respiratory expansion of the chest and should be used with caution in patients with chronic pulmonary disease. The halo should not be used when there is pre-existing infection of the scalp.

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Summary

In the present series, 85% of the patients with follow-up review achieved satisfactory bone or ligament healing and have remained stable without pain up to 2 1/2 years. The halo is a safe and effective treatment modality for a spectrum of cervical spine injuries, although specific contraindications should be observed. In addition, the halo should be used with caution when ligament instability occurs without bone injury.

Addendum

Three of five patients in our series who were immobilized at the time of submission of this report are now out of the halo, and their spines are stable. All three had complex fractures.

References


Address reprint requests to: Paul R. Cooper, M.D., Department of Neurosurgery, Downstate Medical Center, Box 1189, 450 Clarkson Avenue, Brooklyn, New York 11203.