Treatment of fractures of the atlas and axis by wiring without fusion

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Fractures and dislocations involving C-1 and C-2 vertebrae have usually been treated by prolonged external immobilization or by internal fixation and fusion. This is a report of 12 patients treated by internal fixation by wiring only. Follow-up studies, up to 4 years, demonstrated healing of the bone and no late neurological sequelae. The advantage of internal fixation in reducing hospitalization and immobilization is accepted. The authors believe that in most instances the addition of bone fusion to the operative procedure is not essential and may increase morbidity.

KEY WORDS odontoid fracture · hangman's fracture · cervical dislocation · cervical spine fusion · wiring

The traditional treatment for fractures and/or dislocations of the upper cervical spine involving the odontoid process has consisted of reduction, if necessary, followed by immobilization either by skeletal traction, a plaster cast, or both, or by surgical intervention to include internal fixation plus a bone fusion. The fusion advocated has consisted of either an occipitocervical fusion or a simple fusion of the upper cervical vertebrae, including at least C-1 and C-2. Similarly, fractures through the neural arches of C-2 (the so-called hangman's fracture) with or without dislocation of C-2 and C-3 have been treated by skeletal traction and immobilization or by surgical fixation and posterior fusion. Recently Cornish has advocated interbody fusion of C-2 to C-3 using a coronally placed bone dowel.

The advantages of early surgical treatment to avoid prolonged bed confinement or external immobilization are generally accepted, but the need for bone fusion is unproven. We believe that in most recent fractures of the upper two cervical vertebrae attempts to establish bone fusion by the use of grafts are unnecessary and increase morbidity. We are therefore advocating immediate reduction of the dislocation by skeletal traction followed by internal fixation consisting in most instances of the wiring of the posterior arch of C-1 to the spinous process of C-2 or C-3.

Case Material

During the past 4 years 23 patients with fractures and/or dislocation involving C-1 and C-2 vertebrae have been treated. Of the total group, 19 have been treated surgically while four were managed by skeletal traction and external immobilization. Of the cases treated surgically only 12 have had appreciable follow-up periods ranging from 13 to 50 months, and these constitute the basis of this report (Table 1). Included are eight cases of fracture of the odontoid process with or without displacement or associated fractures of the body of the axis, one case of congenital anomaly of the odontoid process with dislocation due to incompetence of the trans-
### TABLE 1

**Late results**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age, Sex</th>
<th>Diagnosis</th>
<th>Symptoms &amp; Signs</th>
<th>Treatment</th>
<th>Post-Op Hospitalization (days)</th>
<th>Follow-Up (mos)</th>
<th>Fusion</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52 M</td>
<td>fracture odontoid, ant. disloc. C1-2</td>
<td>pain, transient rt. hemiparesis</td>
<td>skeletal traction, wiring C1-2</td>
<td>8</td>
<td>17</td>
<td>yes</td>
<td>mild subocc. pain</td>
</tr>
<tr>
<td>2</td>
<td>62 M</td>
<td>fracture odontoid, post. disloc. C1-2</td>
<td>pain</td>
<td>skeletal traction, wiring C1-2</td>
<td>22</td>
<td>16</td>
<td>yes</td>
<td>none</td>
</tr>
<tr>
<td>3</td>
<td>16 M</td>
<td>fracture odontoid, lat. disloc. C1-2</td>
<td>pain, transient paraparesis</td>
<td>wiring C1-2</td>
<td>2</td>
<td>23</td>
<td>yes</td>
<td>none</td>
</tr>
<tr>
<td>4</td>
<td>36 M</td>
<td>fracture odontoid &amp; body C-2, no disloc.</td>
<td>pain</td>
<td>wiring C1-2</td>
<td>13</td>
<td>37</td>
<td>yes</td>
<td>mod. neck pain</td>
</tr>
<tr>
<td>5</td>
<td>43 M</td>
<td>3½ F</td>
<td>fracture odontoid, ant. disloc. C1-2</td>
<td>pain, transient dysphagia</td>
<td>traction, wiring C1-2</td>
<td>39</td>
<td>22</td>
<td>yes</td>
</tr>
<tr>
<td>6</td>
<td>53 M</td>
<td>fracture odontoid &amp; pedicle C-2, ant. disloc. D1-2</td>
<td>pain, bilat. Babinski, left arm weakness</td>
<td>skeletal traction, wiring C1-2</td>
<td>11</td>
<td>39</td>
<td>yes</td>
<td>mild neck pain</td>
</tr>
<tr>
<td>7</td>
<td>75 M</td>
<td>fracture odontoid &amp; arch C-1, post. disloc. C1-2</td>
<td>pain, transient dysphagia and hyperreflexia</td>
<td>skeletal traction, wiring C1-3</td>
<td>50</td>
<td>35</td>
<td>yes</td>
<td>none</td>
</tr>
<tr>
<td>9</td>
<td>14 M</td>
<td>congen. ossiculum terminale, ant. disloc. C1-2</td>
<td>pain, arm paresthesias</td>
<td>skeletal traction, wiring C1-2</td>
<td>6</td>
<td>13</td>
<td>no</td>
<td>none</td>
</tr>
<tr>
<td>10</td>
<td>45 M</td>
<td>fracture pedicles C-2, ant. disloc. C2-3</td>
<td>post. cervical and suboccipital pain</td>
<td>skeletal traction, wiring C1-2</td>
<td>35</td>
<td>23</td>
<td>yes</td>
<td>mod. neck pain</td>
</tr>
<tr>
<td>11</td>
<td>25 M</td>
<td>fracture pedicles &amp; facets, C-2, no disloc.</td>
<td>pain</td>
<td>wiring C1-3</td>
<td>14</td>
<td>16</td>
<td>yes</td>
<td>mod. neck pain</td>
</tr>
<tr>
<td>12</td>
<td>4 M</td>
<td>fracture arch of C-1, ant. disloc. C2-3</td>
<td>pain</td>
<td>skeletal traction, wiring C2-4</td>
<td>8</td>
<td>14</td>
<td>yes</td>
<td>none</td>
</tr>
</tbody>
</table>

verse atlantal ligament, and three cases of fractures through the pedicles and arches of C-1 or C-2 with or without dislocation.

Data relating to the age and sex of patients are given in Table 1; it is noteworthy that two were young children. Information concerning means of injury and associated injuries are also supplied. All 12 patients presented with moderate to severe pain in the upper cervical and suboccipital regions. The pain was such in most instances that the neck was kept rigid with splinting of the cervical muscles. In four instances the correct diagnosis was initially missed, but the persistence of occipitocervical soreness led to the diagnosis of fracture dislocation in the upper cervical spine. Six of the 12 patients were neurologically intact and without other symptoms. Two patients had dysphagia while one patient had arm paresthesias without sensory loss. The remaining three patients had transient weakness of the extremities.

Treatment consisted of immobilization, reduction of the dislocation if necessary, and then internal fixation using heavy wire. In two cases, one with posterior dislocation and the other a hangman's fracture, wiring of C-1, C-2, and C-3 was performed. In a case involving dislocation of C-2 on C-3, wiring was performed between C-3 and C-4. In the remaining 10 cases wiring was done between the posterior arch of C-1 and the spinous process of C-2. Treatment was initiated immediately in all patients except for four instances in which the diagnosis was initially missed; in these cases treatment was delayed several days.

Postoperatively traction was used in three cases. In two of these it was continued for 1 week only and in the other patient for 6 weeks because of cervical fusion. The re-
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remaining nine patients used collars for variable periods of time depending mainly on the degree of cervical discomfort present.

Method of Internal Fixation

Reduction of the dislocation is usually accomplished within a few hours by skeletal traction and judicious use of hyperextension in those patients with anterior dislocation. Even in those patients without dislocation, skeletal traction is used to provide immobilization in the preoperative period and to produce enough separation of the occiput from the posterior arch of C-1 to facilitate wiring during the operation. Internal fixation in cases of odontoid (Fig. 1) or hangman's fracture (Fig. 2) consists of wiring the posterior elements of the atlas and the axis.

General anesthesia is used and intubation must be accomplished without disturbing the alignment of the upper cervical vertebrae. In some patients, therefore, nasotracheal intubation is performed to prevent the necessary movement for visualization of the vocal cords. The patient is placed in a prone position taking care to maintain preoperative cervical alignment. Portable x-ray films confirm this alignment before the operation is begun.

The operative exposure (Fig. 3) is the same as that described by Alexander and Davis.\(^1\) As indicated by those authors, a minimum of blunt dissection is important to avoid postoperative neurological deficits. After exposure of the posterior rim of the foramen magnum, the arch of C-1, and the spinous process of C-2, the heavy wire (18 gauge, Sklar) is passed beneath the arch of C-1 on each side, the central portion is looped below the C-2 spinous process, and finally the ends are twisted together beneath the same spinous process. This twisting is used to tighten C-1 backward and downward in alignment with C-2. Another x-ray film is taken at this stage to confirm the alignment. Passage of the wire beneath the arch of C-1 can be difficult if there is not sufficient separation of the arch from the occipital bone, but no injuries to the cord have occurred.

After internal fixation has been completed, the skeletal traction is removed. The patient may then be ambulatory with a well-fitted Thomas collar, which is worn for several weeks only to minimize local discomfort. It has been our practice to obtain monthly lateral radiographs for 4 months and then obtain flexion-extension views.

Results

There were no deaths in the series. One patient had a postoperative wound infection, but the wire was left in place and the infec-

Fig. 1. Case 6. Left: Preoperative film showing fracture of the odontoid with anterior dislocation. Right: Postoperative film.
tion responded to antibiotic treatment. There has been no delayed neurological deterioration in this patient in the 22-month period of follow-up; radiographically his fracture fused, and there has been no abnormal movement at the C1-C2 level.

Hospitalization following wiring varied from 2 to 50 days, with a mean of 16 days. The cases uncomplicated by associated injuries remained in the hospital approximately 12 days postoperatively.

Each patient was reexamined clinically and radiographically (including flexion-extension views) after a period varying from 13 to 50 months (Fig. 4). None of the patients had developed any late neurological signs. Suboccipital and posterior cervical discomfort was present in six patients. In three of these it was mild and present only at intervals; in the remaining three it was of moderate intensity but in no instance was the patient forced to reduce his usual physical activity or miss work because of the pain.

The range of motion of the neck was evaluated. In only four patients was there clinical restriction of flexion and extension: in the patient who had wiring of C1-3 and in another patient who had moderately severe degenerative arthritis, the restriction was approximately 50%, while in two others it was less. Rotational movement was more limited and in the majority of patients was approximately half the normal range.

In three patients, follow-up x-ray films demonstrated that the wire had broken. In two breakage had occurred after 4 months while in the other patient it can be stated only that it had occurred between 1 and 33 months after wiring. In each case the wire broke only after fusion of the fracture site had occurred as no abnormal movement could be demonstrated on late follow-up studies. Thus, while metal fatigue may result in late wire breakage, this occurs only after sufficient time has elapsed to allow bone healing.

In all except one patient in this series internal fixation provided sufficient immobilization to lead to adequate healing and fusion of the fracture as judged by lack of motion on flexion-extension x-rays. In one patient (Case 9) dislocation of C-1 on C-2 by 9 mm could be demonstrated. This reduced the anteroposterior position to 18 mm in flexion. It is believed that neurological deficits occur when the spinal canal is reduced to about 13 mm. This patient remained asymptomatic and without objective deficit during a period.

**Fig. 2. Case 11. Left:** Preoperative film showing hangman's fracture. **Right:** Postoperative film.

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of observation of 13 months. He was exceptional in that his original dislocation was due to tearing of supporting ligaments and was associated with a congenital anomaly of the dens (ossiculum terminale) which included separation of the apex from the base and attachment of the apical segment to the base of the skull (Fig. 5).

Discussion

The literature contains many articles dealing with odontoid and other upper cervical fractures but most are presentations of a few case reports only. Two significant articles should be noted, however. Amyes and Anderson, in 1956, reported 63 cases of odontoid fracture treated nonoperatively in all but one. Alexander, et al., in 1958, reported 25 patients with dislocation of the atlas on the axis, 15 of which were treated surgically. In both series the operative treatment consisted of upper cervical or occipitocervical fusion.

The incidence of fracture and/or dislocation of the upper cervical spine is approximately 15% to 25% of all cervical frac-

Fig. 3. Artist’s drawing showing operative exposure and details of wiring.
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Since the diagnosis of odontoid fracture was initially missed in four of our 12 patients, it is worth emphasizing the importance of adequate radiological studies in the presence of persisting suboccipital and cervical pain or stiffness after trauma. If plain roentgenograms are inconclusive, laminography should be done and studies of flexion and extension may be employed under careful supervision.

No evidence of delayed neurological deterioration has occurred in our series in an average follow-up period of 25 months. Blockey and Purser, reviewing a total of 51 cases, noted that late neurological complications usually develop within a year after injury although the latest onset in their series occurred 28 years after trauma. Osgood and Lund collected a series of 56 patients of whom 10 died as a result of paralysis “not coming on at the time of injury.” They noted: “Some slight later accident, trivial in character, such as sneezing, or a quick turn or lift of the unsupported head, brought on the fatal paralysis in many, and in the rest a slowly developing paralysis took its toll.” It is evident, therefore, that prompt reduction and immobilization of the fracture is required to prevent late neurological sequelae.

Immobilization of cervical fractures may be achieved by external means or by surgical application of internal devices. External immobilization has been accomplished in the past by prolonged traction while the patient remains in a recumbent posture, by use of bulky and uncomfortable collars and jackets for periods of several months, or more recently by “halo” traction which also requires external plaster devices for long periods of time. Blockey and Purser, reviewing 46 cases of odontoid fracture, considered that adequate treatment consisted of skeletal traction for 6 weeks followed by a period of further immobilization with a Minerva jacket for another 6 weeks. Amyes and Anderson, reviewing 63 cases, suggested that treatment should include skeletal traction and “immobilization of the head and neck in a steel-reinforced leather collar.”

The alternative approach to immobilization consists of internal fixation. While various methods have been described, the most frequently used method at present is probably bone fusion of the upper three cervical vertebrae. Koskinen and Nieminen reported the results of treatment of 159 patients with 207 fractures and/or dislocations of the cervical spine. Twenty-six injuries involved the atlas and 35 the axis. Rogers reported 77 patients with 87 fractures of the cervical spine including two cases involving the atlas and nine fractures of the odontoid process. Thus, although most patients with cervical fractures who survive their injury have damaged the lower cervical spine, there remain a significant number whose injury involved only the upper two vertebrae. The relatively low incidence of recognized upper cervical injury may simply be a reflection of the lethal nature of any significant dislocation in that area. This also accounts for the relative paucity of early neurological signs in the patients included in most reports of upper cervical injury.

Fig. 4. Case 5. Upper Row: Lateral views of odontoid fracture with anterior dislocation before and after wiring. Center Row: Anteroposterior views. Lower Row: Flexion extension views 22 months later.
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Vertebrae as advocated by Alexander, et al. Another type of fusion, including the occiput as well as the upper cervical spine, was described by Lipscomb. Such procedures are based on the principle that fusion is necessary to prevent a significant incidence of instability due to non-union of the fracture. They offer the obvious advantages of early ambulation and minimal external devices. They carry, however, the potential hazards inherent in any bone fusion, including the added morbidity related to the donor site.

Our experience suggests that fusion is not necessary, and that healing of the fracture site does occur in most instances if early internal immobilization is achieved. Clinical and radiographic evidence indicates that the fractures healed in all patients. Although the wire may break later due to metal fatigue, this did not occur until after healing had occurred. Once bone union has occurred, the wire serves no further purpose, but we have seen no need to remove it. We believe that this method of treatment avoids the disadvantages of external immobilization and also simplifies the operative procedure by performance of internal immobilization without addition of fusion.
Certain authors have reported non-union of odontoid fractures despite early treatment. Blockey and Purser found four instances of non-union among their "adequately treated" group of 11 personal patients. Amyes and Anderson noted three cases among their 63 fractures of the odontoid that failed to heal following periods of immobilization varying from 4 to 9 months. Alexander, et al., found motion on flexion and extension in two patients in whom only C-1 and C-2 were fused. Rogers found non-union in two patients who had been managed conservatively, and Lipscomb reported three instances of unsuccessful fusion in nine cases. Thus, despite the fact that we detected no instance of non-union in our series, this complication must be considered as a definite, but probably remote, possibility.

Cornish, reviewing 14 cases of fracture through the neural arch of C-2 (hangman's fracture), found that all united soundly regardless of whether surgical or nonoperative treatment was used. Similarly, Schneider reported that fusion generally occurs if the patient is "retained in traction for 6 weeks and then immobilized in a Minerva jacket or well-fitting cervical brace for another 2 months."

We conclude that most fractures of the odontoid or neural arch of C-2 will unite if early immobilization is achieved. Bone union in good position is necessary to prevent late neurological complications. The advantage of internal fixation is that the period of hospitalization and immobilization of the patient is minimized. We believe that simple wiring is usually adequate to accomplish this internal fixation and that the addition of bone fusion may be unnecessary. Although other methods of treatment may be equally successful, this method has the advantage of relative simplicity.

References

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