HIDDEN FLEXION INJURY OF THE CERVICAL SPINE

J. K. WEBB, R. B. K. BROUGHTON, T. MCSEWEENEY and W. M. PARK, OSWESTRY, ENGLAND

From the Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, Shropshire

This paper describes seven patients who developed late vertebral deformity after flexion injuries of the cervical spine. In four the clinical and radiological features were subtle and because the patients walked into an emergency department the severity of the injury was not initially appreciated. Certain specific clinical and radiological features of flexion injury are described and emphasis is placed on the importance of correct management. A radiological tetrad is described which should alert the surgeon to the possibility of damage to the posterior interspinous complex of the cervical spine and so lead to further radiological investigations. Despite the frequency of flexion injuries the alarming complications described in this paper are rare.

Flexion injury of the cervical spine and the mechanism involved are well documented (Davis 1945; Roaf 1960; Holdsworth 1963; Cheshire 1969; Braakman and Penning 1971), but few have noted the subtle changes of flexion injury to the cervical spine which, if unrecognised and untreated, may lead to late displacement with possibly disastrous consequences.

CLINICAL MATERIAL

Seven patients have been selected for this paper because the full extent of the damage to the posterior interspinous complex was not initially apparent (Table I). No patient with overt fracture or dislocation is included. There were five males and two females, and their average age was sixteen and a half years. At the time of injury, tetraplegia was complete in one patient and incomplete in another; a third patient had suffered transient tetraparesis.

RADIOLOGICAL FEATURES

The flexion injuries studied in this paper are anterior subluxations and the radiological features, we believe, indicate disruption of the posterior cervical complex. The posterior cervical complex consists of the posterior articulations stabilised by the capsule, intraspinous and supraspinous ligaments and the ligamenta flava. The difficulty is to decide whether the lesion is complete and unstable or whether there is only a partial tear, without instability (Figs. 1 and 2).

### TABLE I

<table>
<thead>
<tr>
<th>Case number</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Type of injury</th>
<th>Level of subluxation</th>
<th>Level of anterior vertebral compression fracture</th>
<th>Physical signs</th>
<th>Neurological state</th>
<th>Complications</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>20</td>
<td>Female</td>
<td>Road traffic accident</td>
<td>C.5-6</td>
<td>C.6</td>
<td>Pain and spasm</td>
<td>Initial</td>
<td>Late</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>Female</td>
<td>Road traffic accident</td>
<td>C.4-5, C.5-6</td>
<td>C.6</td>
<td>Pain and spasm</td>
<td>Initial</td>
<td>Late</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>Male</td>
<td>Rugby</td>
<td>C.5-6</td>
<td>C.7</td>
<td>Pain and spasm</td>
<td>Transient tetraparesis</td>
<td>Full recovery</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>Male</td>
<td>Rugby</td>
<td>C.4-5</td>
<td>C.5 and C.6</td>
<td>Pain and spasm</td>
<td>Transient tetraparesis</td>
<td>No improvement</td>
</tr>
<tr>
<td>5</td>
<td>14</td>
<td>Male</td>
<td>Somersaulted on ground</td>
<td>C.3-4</td>
<td>C.4, C.5 and C.6</td>
<td>Pain and spasm</td>
<td>Complete tetraplegia</td>
<td>No improvement</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
<td>Male</td>
<td>Wrestling</td>
<td>C.3-4</td>
<td>C.4 and C.5</td>
<td>Pain and spasm</td>
<td>Transient tetraparesis</td>
<td>Full recovery</td>
</tr>
<tr>
<td>7</td>
<td>12</td>
<td>Male</td>
<td>Trampoline</td>
<td>C.3-4</td>
<td>C.4, C.5 and C.6</td>
<td>Pain and spasm</td>
<td>Transient tetraparesis</td>
<td>Full recovery</td>
</tr>
</tbody>
</table>

T. McSweeney, M.Ch., M.Ch.Orth., F.R.C.S., Surgeon in Charge, Spinal Injuries Unit, The Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, Shropshire SY10 7AG, England.
Dr W. M. Park, Ch.B., F.R.C.R., Director of Radiology, The Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, Shropshire SY10 7AG, England.

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There are four characteristic radiological signs that suggest posterior cervical complex damage. Two of these occur at the level of the injury but two are associated features affecting other parts of the cervical spine. This radiological tetrad has been seen in the seven cases discussed in this paper.

**Localised features** — *Widening of the interspinous space*—This is recognised by isolated and wide separation of the interspinous processes at the level of the injury. The space is wide in comparison with that at other intervertebral levels and it persists in extension.

**Intervertebral subluxation**—Partial overriding of the apophysial joints permits forward and angular intervertebral displacement. The degree of abnormal movement will be most evident in a radiograph taken with the neck in flexion.

**Associated features** — *Vertebral compression fracture*—This fracture may be subtle and only evident as a minor protrusion from the upper anterior aspect of the vertebral body. In three cases, two vertebrae were affected. The compression fracture is not necessarily at the level of the injury; indeed it is usually below it. It may be accompanied by a minor degree of widening of the pre-vertebral soft-tissue space.

**Loss of normal cervical lordosis**—Paraspinal muscle spasm leads to loss of the normal lordotic curve and will also cause marked limitation of movement particularly in flexion.

**LATE COMPLICATIONS OF FLEXION INJURY**

Three types of complication were seen after severe flexion injury in this small group of patients: 1) persistent instability with pain (three cases); 2) late intervertebral displacement (one case); and 3) late vertebral deformity (three cases).

**Persistent instability with pain**—Three patients (Table I, Cases 1 to 3) presented with flexion injuries and the radiographs were considered to be normal. These patients continued to suffer neck pain. Radiographs at a later stage revealed obvious disruption of the posterior inter-spinous complex. The first patient continued to have discomfort in the neck for nine months after the injury, and at this stage lateral flexion and extension radiographs revealed increasing instability in the cervical spine. In the other two cases instability was evident at three and six months after injury.

**CASE REPORT**

**Case 1**—A woman aged twenty was injured when a passenger in a car that hit a tree. She complained of pain in the neck, and examination showed spasm and restriction of movement. Radiographs suggested subluxation of the fifth cervical vertebra on the sixth (Fig. 3) although these had been initially regarded as normal in the hospital that she first attended. The wearing of a plaster collar for three months did not relieve the pain. Radiographs later revealed instability (Fig. 4) and posterior fusion was performed nine months after injury.

**Late intervertebral displacement**—One patient came into this group.

**CASE REPORT**

**Case 4**—A nineteen-year-old man was hit on the head from behind during a game of rugby. He showed tetraparesis, and radiographs showed anterior subluxation of the fourth cervical vertebra on the fifth (Fig. 5). He was treated with skull traction for three months and thereafter was in a Minerva jacket for a further three months. Complete neurological recovery occurred. At this stage, lateral radiographs taken in flexion and extension were reported as normal (Fig. 6). Four months later he attended, unable to hold his head erect, and radiographs revealed complete dislocation of the fourth cervical vertebra on the fifth (Fig. 7).

**Comment**—The lateral projections taken in flexion and extension six months after the injury to assess the stability...
of the cervical spine were considered normal. It was not appreciated at that time that spasm severely restricted flexion. In retrospect, we would consider these flexion views as unacceptable and would undertake further flexion strain views under heavy sedation.

**Late vertebral deformity**—Three very similar cases (Table 1, Cases 5 to 7), all in patients aged between twelve and fourteen years, were studied in this department. One child was tetraplegic, another was tetraparetic and the third walked into the casualty department complaining of pain in the neck after a fall. The lateral radiographs taken in flexion and extension in the last two cases were reported normal and the patients were observed later as out-patients. It was four and six months after injury that the severity of the damage was fully appreciated. Review of all the original films showed the radiological signs of instability of the posterior elements.

**CASE REPORT**

**Case 5**—A fourteen-year-old boy somersaulted and landed on the back of his neck. There was pain, spasm and restriction of movement. Radiographs, including lateral projections taken in flexion and extension, were considered normal (Fig. 8). He presented six months later with a severe kyphosis but without symptoms (Fig. 9).

**Comment**—The radiographs taken on arrival, although reported as normal, definitely show the radiological tetrad suggesting damage to the posterior complex.

**MANAGEMENT**

Our method of treating flexion injury of the cervical spine without overt fracture or dislocation has been modified in the light of experience gained from the cases described in this paper.
A patient who has sustained direct or indirect violence to the head or cervical spine is examined for signs of injury, in particular, spasm and pain on neck movement. All patients undergo a standard radiographic examination of the cervical spine which includes anterior-posterior and lateral radiographs and trans-oral views of the dens. If these three radiographs reveal no fracture or dislocation, then lateral radiographs in flexion and extension are taken and examined for any abnormal features—in particular, widening of the interspinous space, intervertebral subluxation, vertebral compression fracture and loss of the normal lordotic curve or limitation of flexion.

If there is limitation of movement or suggestion of instability of the cervical spine a collar is provided. A few days later, further flexion and extension films are taken. If movement is restricted, and particularly if the radiological signs previously described are present, it is essential to assess whether the cervical spine is unstable. The neck is subject to strain while under vision with the image intensifier. If spasm restricts the range of movement the examination is repeated with the patient well relaxed by sedation. General anaesthesia has not been necessary in any of our cases. The surgeon must see the interfacetal joints while flexing and extending the neck. If instability is recognised, the segments involved should be fused. Discography has been done: it may provide further information about the number of segments involved (Fig. 10).

DISCUSSION

Flexion injury of the cervical spine is relatively common, but the complications described in this paper are rare. The diagnosis of flexion injury may be difficult: clinical and radiological examination must be performed meticulously so that all signs, however subtle, will be recognised. If the radiological tetrad is present a decision must be made about the integrity of the posterior interspinous complex. If this is completely disrupted and instability is recognised, the patient is at risk of late complications. If a partial disruption is present and the spine is stable, late complications do not occur. Fusion at the involved level or levels should be considered in the presence of complete disruption of the posterior cervical complex.

In the interpretation of cervical spinal injury it is often hard to decide whether radiographic appearances are normal. The normal cervical spine is lordotic in the neutral position. Hadley (1944), Davis (1945) and Nagle (1957) reported that the cervical spine was straight after minor injury without ligament damage. On the other hand, Juhl, Miller and Roberts (1962), Fineman, Borrelli, Rubinstein, Epstein and Jacobson (1963) and Cattell and Filtzer (1965) found that the cervical spine could be straight, kyphotic and angulated in a proportion of patients without any history of trauma. In our small group there was no doubt that the cervical spine was damaged. The difficulty in three instances (Table I, Cases 1 to 3) was in deciding whether or not there was complete destruction of the posterior cervical complex.

Spasm is an important physical sign associated with restriction of movement. Hubbard (1974) describing injury of the cervical spine in children and adolescents found spasm in 42 per cent of patients with unstable injuries. In every patient in the present series, the presence of spasm could be deduced in lateral flexion and extension radiographs by loss of normal lordotic curvature and marked decrease in the range of total cervical movement. Limitation of cervical motion or angular kyphosis...
of the cervical spine may be produced if the patient flexes and extends incorrectly (Juhl et al. 1962; Fineman et al. 1963). The correct method of flexing and extending the head must, therefore, be demonstrated to every patient. If movement is restricted and the other features of the radiological tetrad are present, it is important to see the effect of strain on the cervical spine under vision with the image intensifier.

The recommendation regarding strain views may be controversial. Holdsworth (1963) stated "when the posterior ligament complex has been ruptured, healing such as to restore the original strength does not occur". Although some might disagree with this statement, it is a safe concept with which to initiate the management of cervical injury. We have found that strain views enable us to identify the unstable posterior cervical complex through marked interspinous opening and forward subluxation, particularly of the apophyseal joints (Fig. 11). Since we have been aware of this clinical entity, a number of patients have presented with similar radiological signs but the strain views have not always shown increasing intraspinous widening or forward subluxation. The frequency with which the latter group of patients have appeared suggests to us that the incomplete type of lesion is more common than the very rare complete rupture. The patients with incomplete rupture have now been followed for an average of eighteen months and have not developed any of the complications described in this paper.

Operative fusion was performed in five patients. A posterior approach was preferred for a number of reasons; in particular because the extent of the injury could be assessed and the necessary length of fusion determined. Anterior cervical fusion is a relatively easy procedure and most workers claim a high success rate (Cloward 1958; Robinson, Walker, Ferlic and Wiecking 1962; Connolly, Seymour and Adams 1965; Simmons and Bhalla 1969), but where an attempt is made to fuse more than one segment the failure rate is significantly higher (Cloward 2 per cent, Robinson 12 per cent, Connolly

Fig. 10
Figure 10—Discograph showing disruption of a disc one level below the level of visible subluxation. Figure 11—Strain views of a cervical spine showing severe subluxation at a level C 5–6 previously suspected of injury. The patient was heavily sedated with Diazepam.

Fig. 12
Section of the posterior interspinous ligament showing disruption of the normal architectural pattern of the collagen fibres. (×100.) (a) Normal collagen fibres. (b) Pale staining degenerate collagen fibres.
21 per cent). It may be argued that an anterior approach could weaken the vertebral complex still further, particularly if the graft is absorbed or extruded. Simmons and Bhalla (1969) showed experimentally that anterior keystone grafts were extruded when disruption of the posterior cervical complex was produced on a stress machine.

Operation confirmed damage to the posterior inter-}

spinosus ligament and it was found that in each case the normal architectural pattern of the fibres had been disrupted. An example of the histological findings is shown in Figure 12. Degenerate collagen and excessive fibrous tissue can be seen. All the posterior fusions have been successful and the patients are now asymptomatic with no significant limitation of movement after an average follow-up of twenty months.

It is a great pleasure to record our gratitude to Mr D. Jones of the Photography Department, Institute of Orthopaedics, for the illustrations.

REFERENCES