Retrosternal displacement of the medial aspect of the clavicle after physeal fracture is rare. We treated six patients with this injury between 1995 and 1998, all as an emergency in order to avoid complications associated with compression of adjacent mediastinal structures. Attempted closed reduction was undertaken, but all required open reduction and internal fixation using a wire suture. There were no associated complications. Five were reviewed clinically and radiologically at a minimum of one year after operation. All had regained full use of the affected arm without pain and had resumed their preinjury level of activity including sports. Follow-up radiographs showed union in the anatomical position in all patients. We recommend attempted closed reduction in the operating room, followed, if necessary, by open reduction. Internal fixation after open reduction gives stable fixation with minimal morbidity.

The clavicle is the first bone in the body to ossify, in the fifth week of fetal life, but the medial clavicular physis is the last to close, typically at 22 to 25 years of age. The physis is the weakest link in the sternoclavicular joint and injuries to this area in patients aged less than 25 years old are often physeal. Adjacent ligamentous structures are considerably stronger than the physis and may remain attached to the periosteum. The small size of the medial clavicular epiphysis can lead to misdiagnosis. Plain radiographs may suggest that there is a dislocation of the sternoclavicular joint when in fact a fracture of the medial clavicular physis has occurred and the sternoclavicular joint is intact. CT can delineate the true nature of the injury.

The treatment of sternoclavicular dislocation and fracture of the medial clavicular physis has been discussed. The great vessels, the trachea, and the oesophagus lie in a vulnerable position behind the clavicle. Potential injury to these structures makes prompt diagnosis and treatment of this injury crucial. Eight years ago, the senior author (GSB) developed a technique of open reduction and internal fixation with wire to treat this unusual injury. Our aim in this study was to evaluate our experience with this technique over the last three years, to discuss the method and review the literature.

Patients and Methods

Between January 1995 and December 1998 we treated six patients with an acute fracture of the medial clavicular physis with retrosternal displacement. All had been evaluated by plain radiography (Fig. 1) and CT (Figs 2 and 3) before and by plain radiography alone after operation (Fig. 4). The medical records and radiographs were retrospectively reviewed. Assessment of the range of movement of both shoulders and manual muscle testing were performed either by the physiotherapist or the attending surgeon when the patients returned for follow-up.

The mean age of the patients at the time of injury was 12 years and 8 months (7 to 16). All were boys and the dominant arm was involved in two of the six. All had sustained the injury from high-impact blunt trauma, but the mechanism was different in each patient. They all presented between 12 and 24 hours after the injury and when first seen complained of medial clavicular or sternal pain....
Fig. 1

Plain radiograph of the chest in a patient with a medial clavicular physeal injury on the right. There is asymmetry between the sternoclavicular joints.

Fig. 2

CT of the injury. The retrosternal location of the clavicle on the right is evident.

Fig. 3

Three-dimensional CT reconstruction of a physeal fracture with posterior displacement.

Fig. 4

Postoperative radiograph at one year. The open medial physis is on the right. The figure-of-eight, 22-gauge wire is intact without evidence of injury to the sternoclavicular joint.
often had a swelling overlying the medial aspect of the clavicle. There were no associated injuries. One patient had signs of mediastinal compression with dysphagia, hoarseness and shortness of breath. These symptoms suggested pressure on the vital structures by the posteriorly displaced clavicle. This patient was treated urgently. Details of the patients are given in Table I.

Operative technique. Under general anaesthesia, closed reduction was attempted by placing a sandbag between the shoulders and applying gentle longitudinal traction to the involved arm. Reduction was not attempted outside the operating room because of the risk of damage to the adjacent mediastinal structures. We were able to achieve closed reduction of the fracture in most patients, but in none was it stable. Open reduction was therefore carried out. Before this procedure we ensured that a thoracic surgeon was present in the hospital, but his assistance was never actually required. An incision 4 cm long was made over the medial clavicle, the medial epiphysis of which was identified and the joint left intact (Fig. 5a). The fracture was identified by limited dissection through the periosteum which was often still in continuity with the epiphysis. The clavicle was reduced by gentle traction using a bone clamp. If this failed, an elevator was carefully placed in the medullary canal of the medial clavicle and used to lever the bone into an anatomical position. Although we were able to achieve this it was always unstable and internal fixation was necessary. A 22-gauge sternal wire was placed through drill holes in a figure-of-eight fashion across the site of the fracture (Figs 5b and 6). The sternoclavicular joint was not violated. After securing the wire, gentle anterior and posterior pressure was used to check the stability which in every case was markedly improved. Postoperative radiographs were obtained to assess the fixation and to exclude a pneumothorax. All patients remained in hospital overnight. They wore a shoulder immobiliser for a mean of three weeks.

Results

At presentation there was often a palpable depression overlying the posteriorly displaced clavicle before the development of significant local swelling. The neck was usually flexed towards the side of the injury with the elbow flexed and supported by the contralateral arm. All patients were neurologically intact at the time of the initial examination. If physical examination suggested the diagnosis, a plain chest radiograph and four views of the shoulder were obtained. Several specific radiological views have been suggested in order to establish the diagnosis of this injury; the 30° tangential, the Heing view, the Hobbs axillary view and the Kattan view. All aid in the diagnosis, but

<table>
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<tr>
<th>Case</th>
<th>Age (yr+mth)</th>
<th>Side</th>
<th>Dominance</th>
<th>Symptoms*</th>
<th>Mechanism</th>
<th>Follow-up (mth)</th>
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<tr>
<td>1</td>
<td>16+0</td>
<td>Right</td>
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<td>None</td>
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<td>14</td>
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<tr>
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<td>7+3</td>
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<td>None</td>
<td>Thrown from a horse</td>
<td>Lost</td>
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<td>Right</td>
<td>Dysphagia/hoarseness</td>
<td>Tackled playing soccer</td>
<td>24</td>
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<tr>
<td>4</td>
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<td>None</td>
<td>Thrown from a bicycle</td>
<td>19</td>
</tr>
<tr>
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<td>Wrestling</td>
<td>26</td>
</tr>
<tr>
<td>6</td>
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<td>Left</td>
<td>Right</td>
<td>None</td>
<td>Ran into a mailbox</td>
<td>21</td>
</tr>
</tbody>
</table>

* symptoms aside from pain and referable to compression of a vital mediastinal structure
we used CT to confirm this, to evaluate the crucial mediastinal structures, identify the remaining medial clavicular epiphysis, and plan the operative intervention. In every patient the medial clavicular epiphysis was located normally with an intact sternoclavicular joint.

There were no operative complications and no pneumothoraces. Five of the six patients were available for follow-up at a minimum of one year after operation (Table I). The mean follow-up was 21 months (14 to 26). When last seen all were free from pain and had resumed full activities including unlimited sports, and all had a full, pain-free range of movement at the shoulder. Radiological examination showed no broken wires and none has become painful or been removed. One patient had a keloid scar.

Discussion

Traditionally, closed reduction of fractures of the medial clavicle has been accepted as the optimal method of treatment.13-15 Sanders and Rockwood16 when considering medial clavicular dislocation and medial physeal fractures as a single entity stated that “chronic instability of the sternoclavicular joint and non-union of this fracture are not reported”. They further advised that “open reduction with internal fixation is never indicated, the use of internal fixation at the medial clavicle or across the sternoclavicular joint is hazardous and unnecessary”. We believe that dislocation of the joint and fracture through the physis are different entities. The use of a wire suture to stabilise the reduction without crossing the highly mobile sternoclavicular joint allows stable and safe fixation of this rare injury. We feel that the risks associated with an unreduced fracture, particularly in the presence of symptoms of mediastinal compression, outweigh those of open reduction and internal fixation. This method seems to be safe and effective.

We prefer closed reduction under general anaesthesia in the operating room, but have been unable to achieve a stable reduction in any of our patients without internal fixation. We believe that most of these injuries are unstable and require fixation after reduction.

Several manoeuvres to aid reduction are reported in the literature. Closed reduction may fail because of the regional anatomy in this area. Brooks and Henning17 reported nine patients, seven of whom required surgical fixation. They felt that “closed reduction may fail because of local ligamentous injury and the cephalad pull of the sternocleidomastoid, soft tissue interposed at the fracture site and the long lever arm of the upper extremity which tends to displace the medial end of the clavicle”. It has been our experience that the thick periosteum can impede reduction and the severe soft-tissue disruption may make the fracture unstable after reduction. The role of open reduction is controversial. Those favouring it describe improved healing with anatomical reduction and cite potential complications related to impingement from a malunited fracture. The mediastinal structures may be damaged acutely by the initial injury or chronically after an unrecognised or untreated injury. Thoracic outlet syndrome,8 pneumothorax,9 tracheo-oesophageal fistula causing death19 and venous thrombosis20 have all been reported. For these reasons, many feel that, if closed reduction fails, open reduction and internal fixation is required.21-23

Many different methods of fixation have been described, most of which have been abandoned. These include fascial and tendon slings,24,25 fascial sutures,5 capsular repair8 and fixation by Kirschner wires, The high incidence of serious complications associated with migration of Kirschner wires around the shoulder prohibits their use.22,26 Several reports describe the use of heavy sutures for fixation.21-23 We prefer a more substantial repair. Our experience has been that the periosteum is often damaged and may not contribute to stability. We supplement our fixation with suture of the periosteum when possible. Tentative or no fixation requires prolonged immobilisation. Selesnick et al22 reported four patients, three of whom required open reduction and repair with heavy suture. Dacron tape was used for reinforcement in one. They used a plaster body jacket for four to six weeks after operation. Others have employed prolonged immobilisation in a Velpeau bandage.21,23-25 Fixation by wire sutures allows the use of a sling for comfort only and minimises patient morbidity.

We recommend CT of the area because of the potentially catastrophic complications of unrecognised retrosternal displacement of a medial clavicular fracture. This is not necessarily to delineate the injury, but to assess the vascular and visceral structures in the area before open or closed treatment. Many authors have recognised the importance of the timing in achieving reduction. A delay of more than 48 hours appears to increase the incidence of failed closed reduction.19,27 Of the four patients reported by Selesnick et al22 one presented before 48 hours and was successfully
treated by closed reduction. The other three were first seen after 48 hours and required open reduction and internal fixation. All our patients presented between 12 and 48 hours. Some authors feel that open reduction is contra-indicated because of the risk of associated problems. Zaslav, Ray and Neer advised that the risk of surgery in this “dangerous area” was too great and recommended conservative treatment based on the remodelling potential of the physis. The latter, however, is often limited because these fractures usually occur in older children or adolescents. Surgery in this region does carry risks, but pre-operative CT can define the local anatomy and pre-existing injury. The procedure is minimally invasive and the technique of fixation uncomplicated. We feel that internal fixation of these injuries improves the chance of complete recovery. The five patients whom we were able to follow-up all showed rapid and complete subjective and objective recovery. Heining, the only author to report outcome, noted that 50% of his patients treated by closed reduction continued to be mildly symptomatic. Most of these injuries occur in adolescence and every effort should be made to minimise future morbidity by combining anatomical reduction with open internal fixation.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References