Outcome of distal clavicular fracture separations and dislocations in immature skeleton

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Introduction

Fractures of the clavicle are very common in the immature skeleton, especially in the middle third, but the rate of distal clavicular injuries is only 10–20% of all clavicle fractures.14 Fractures of the distal clavicle in children are analogous to metaphyseal–epiphyseal fractures,13 as the distal clavicle epiphyseal ossification centre appears after the age of 18 years. For this reason, the above fractures sometimes mimic acromioclavicular separations in adults (pseudodislocation) because distal metaphysis is displaced separately. The medial clavicular fragment peels off the periosteal sleeve like a banana from its skin, while the coracoclavicular and acromioclavicular ligaments usually remain intact and attached to the inferior periosteal sleeve.12 True acromioclavicular dislocation rarely occurs in children.14,2 There are variations in the fracture pattern and different degrees of displacement,13 and the Dameron and Rockwood classification exists for acromioclavicular injuries. This classification has outlined six types of acromioclavicular injuries. Types I and II are mild sprains with no or partial superior displacement of the distal clavicle. Type III injuries have definite dorsal displacement of the distal clavicle, with the coracoclavicular interval 25–100% greater than normal. In type IV injuries, the distal clavicle is also displaced posteriorly and penetrates into or through the overlying trapezius. In type V injuries, the coracoclavicular distance is 100% more than...
normal. In type VI injuries, which are very rare, the distal clavicle is displaced inferiorly. This classification appears to be inconvenient for children's acromioclavicular injuries because of the difficulty in distinguishing types III–V. Furthermore, it does not include the fracture pattern of the distal clavicle.

The treatment of displaced fractures remains controversial, although closed reduction is the general principle in these ages. Being very osteogenetic, the periosteal sleeve may fill in any gap between the periosteum and the metaphysis, which may lead to clavicular duplication.

There are only a few studies with long-term follow-up of these injuries in the international literature. The purpose of our study is to suggest a new classification system according to the fracture pattern and the degree of the displacement, to evaluate the long-term follow-up and also to propose an algorithm for treatment.

Patients and methods

This study was approved by the scientific review board of our hospital and all the patients who were included were informed that their data will be submitted for publication, and they or their parents consented depending on their age during the follow-up period.

From 1983 to 2008, 75 children and adolescents, aged from 3 to 16 years (average 10.4 years), having a distal clavicular injury, were treated in our department. Fifty-four out of 75 patients were boys and 21 were girls. The left shoulder was affected in 44 patients, whereas the right was affected in 31. The mechanism of injury was a direct blow on the shoulder in all the patients. The cause was a bicycle-traffic accident (39%), fall from a height (32%), or accident during sport activity (21%) and other reasons (8%). All patients complained of pain at the distal clavicle and were unable to lift their arm. Haematoma and local tenderness were common findings. The clinical examination was followed by an X-ray control. To obtain a better view of the acromioclavicular joint, we performed X-rays with the centre of the beam slightly higher while the radiation was half compared with a common shoulder X-ray. In the last decade, a computerised tomography was carried out in five patients (older than 12 years) with greater displacement to determine the type of the fracture. Ultrasound examination was also helpful in two early childhood patients (<4 years old) with ambiguous X-rays showing a subperiosteal haematoma formation and a fracture line at the distal clavicle. Both cases were confirmed by subperiosteal bone formation in X-ray control after 10 days. The radiographic control could not reveal a fracture of the distal end of the clavicle in two cases where only an acromioclavicular dislocation was found and in the aforementioned two cases in which ultrasound examination was performed. We classified all these fractures were included in group II, while oblique fractures were included in group III. Comminuted fractures were included in group IV. True dislocation of the acromioclavicular joint composed group V (Table 1, Fig. 1).

Concomitant injuries existed in few patients, which were mild head injuries with no residual symptoms in seven patients, fracture of the upper third of the contralateral humerus in one patient who was treated non-operatively for both fractures and a fracture at the midshaft of the same clavicle (comminuted fracture) in a patient who was also treated with a sling.

Treatment

The treatment was non-operative in 63 patients and consisted of a sling applied for 4 weeks, followed by active exercises to gain full range of motion while passive movements were avoided. Return to normal activities and sports was permitted 2 months after complete healing of the fracture.

Three patients from group IIb, eight patients from group IIb and one from group V were treated with open reduction and fixation with Kirschner (K) wires, which were accompanied by superior periosteal repair in 11 cases (Table 1). One patient out of the 12 treated surgically had true acromioclavicular dislocation (group V), and no periosteal rupture was found during operation. All K-wires edges, which were left outside the skin, were flexed to avoid intrathoracic and spinal migration of the wires. Removal of K-wires was performed after 4 weeks. The decision for surgical treatment was taken when the displacement of the bony fragments exceeded two cortices due to the potential risk of skin perforation.

Results

All patients were examined until the healing of the fracture (4 weeks post-injury). Fifty-nine patients were re-examined after 2–18 years (average 4.5 years). Sixteen patients were lost during follow-up. During the follow-up examination, we noted the loss in the degrees of extension, flexion, abduction, adduction and internal and external rotation of the injured shoulder in comparison to the normal side. All patients included in groups I, IIa and IIb had no loss in the motion of their shoulder. Seven out of the 29 re-examined patients in groups IIb, IIIb, IV and V had a loss of less than 10–15° in at least one plane, apart from rotational movements. None of the patients complained of limitations in daily activities as well as demanding sport activities. Five patients in the non-operative group complained of visible prominence at the fracture site. A shoulder constant score was also noted for 52 patients, who could follow instructions during the follow-up examination, and all of them had the maximum score (100 out of 100).

A comparative radiograph of the shoulder was obtained to identify bony prominences, acromioclavicular arthritis, subluxation of the joint, shortening of the clavicle, malunion of the fracture or other complications. Six patients (in group IIb), who

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**Table 1**

Classification of acromioclavicular injuries in the immature skeleton.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
<th>Patients</th>
<th>Surgical treatment</th>
<th>Conservative treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>“Greenstick” fracture</td>
<td>4</td>
<td>0</td>
<td>4</td>
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<tr>
<td>Group IIa</td>
<td>Transverse non-displaced</td>
<td>23</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>Group IIb</td>
<td>Transverse displaced fracture</td>
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<td>3</td>
<td>2</td>
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<tr>
<td>Group IIIa</td>
<td>Oblique non-displaced fracture</td>
<td>19</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Group IIIb</td>
<td>Oblique displaced fracture</td>
<td>19</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Group IV</td>
<td>Comminuted fracture</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Group V</td>
<td>Acromioclavicular dislocation</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>75</strong></td>
<td>12</td>
<td><strong>63</strong></td>
</tr>
</tbody>
</table>
Discussion

The international literature relevant to acromioclavicular injuries in childhood is limited and only refers to a few case series or case reports. Because there is not enough evidence to support the treatment of this rare injury, we conducted this study aiming to suggest a new classification system and an algorithm for treatment.

Our functional clinical results were excellent for all patients, regardless of the treatment they sustained. The constant score was excellent and none of the patients had limitations in daily activities as well as in demanding sport activities.

During the follow-up examination, we detected restriction of less than 10°–15° in the range of motion of the injured shoulder in patients who were treated non-operatively, had hypertrophic callus formation during the radiographic control after 5–6 years. Another patient (in group IIb) with visible prominence, who was also treated non-operatively, had duplication of the clavicle (Fig. 2(a) and (b)). After 10 years of follow-up, one patient with group IIb type fracture, who was treated surgically, was found to have synostosis of the coracoclavicular ligaments (Fig. 3(a)–(c)). Acromioclavicular arthritis and subluxation of the joint were not seen in any of the patients, even in those who had a true dislocation of the joint.

comparison to the normal side as well as visible bony prominence at the distal clavicle in seven patients. These findings were related to complications such as shortening of the clavicle, duplication of the distal clavicle and hypertrophic callus formation. All these complications were found in patients with great displacement (IIb, IIIb, IV and V), who were older than 8 years; they were treated non-operatively. In the operative group, only one patient who had restriction in the range of motion of the injured shoulder (15°) had coracoclavicular synostosis.

Major late complications were not visible in our series although the mean follow-up period was greater than in other studies. In our opinion, arthritis and subluxation of the acromioclavicular joint are possible but are very rare due to the remaining lateral epiphysis during the injury, which provides an intact acromioclavicular joint, and due to the intact inferior periosteum, which provides axial reconstruction of the lateral clavicle.

Eidman et al.5 and Black et al.3 concluded that conservative treatment could have the same satisfactory results as the operative treatment. Havránek7 presented a series of 10 patients with distal clavicle fracture and concluded that surgical treatment is indicated for cosmetic reasons when there is greater displacement and shortening, whereas the functional outcome was not influenced by the way of treatment. Falstie-Jensen and Mikkelsen9 preferred operative treatment in two cases with a displaced fracture of the distal end of the clavicle. Kubik and Slongo10 presented five patients with distal clavicle fractures, who sustained surgery. They commented that the decision for surgery should not only be dependent on the type of fracture, and thus greater effort for reduction should be made during surgery by suturing the periosteal tube with or without fixation.

We preferred surgical treatment for 12 of our 75 patients taking into consideration their age (>8 years) due to less bone remodelling and the degree of the displacement (>2 cortices) (Fig. 4). In all 12 cases, we performed open reduction and fixation.

![Fig. 2](image1.png)  
Fig. 2. (a) Group IIb fracture of the distal clavicle in a 10 year-old boy. (b) Radiological appearance of the clavicle 6 years postinjury after conservative treatment. Duplication of the clavicle with intact acromioclavicular joint is obvious.

![Fig. 3](image2.png)  
Fig. 3. (a) Group IIb fracture of the distal clavicle in a 10 year-old girl. (b) Radiograph after surgical treatment with two K-wires. (c) Radiological appearance 10 years postinjury. Complete healing of the fracture and synostosis of the coracoclavicular ligaments is apparent.

![Fig. 4](image3.png)  
Fig. 4. Proposed algorithm for the treatment of distal clavicular injuries in the immature skeleton.
with K-wires accompanied with suturing of the periosteal sleeve in 11 cases. Although many authors\textsuperscript{1,8,11} report intrathoracic and spinal K-wire migration after clavicular fracture surgical treatment, we believe that when the K-wires are left outside the skin and are bent correctly, migration is impossible.

One strength of our study is the longer follow-up period (mean 4.5 years, 2–18 years) in comparison to other case series.\textsuperscript{3,7,10,12} Some complications of distal clavicle fractures are presented late and studies with longer follow-up periods are more accurate. Another advantage of this study is the simple classification system that is presented for distal clavicular injuries, based on the fracture pattern and the degree of displacement.

A limitation of our study is that the constant score was noted for 51 out of 59 patients who were re-examined. The patients’ age during this re-examination varied from 4 to 29 years and, thus, in younger patients, scoring was impossible. Another limitation is that 16 patients out of the 75 were not re-examined. Twelve out of 16 patients had fractures without displacement (group Ila and Illa) and were unwilling to turn up for examination after communication, as they were happy with the outcome of their injury; however, their absence during the re-examination does not affect our results.

In conclusion, the great osteogenetic capacity of the intact inferior periosteum and the intact acromioclavicular joint may predict that the functional results will be excellent, regardless of the preferred method of treatment. The age of the patient and the degree of the displacement are factors that should be taken into consideration during treatment decisions to have better cosmetic results. The proposed classification of these injuries is based on the fracture pattern and is simple, leading to decision making concerning therapy of these injuries.

Conflict of interest
None of the authors had any conflict of interest and there were no sources of funding.

References