Treatment of displaced supracondylar fractures of the humerus in children by a pin leverage technique

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This study aimed to evaluate the use of pin leverage in the reduction of Gartland type III supracondylar fractures of the humerus in children. The study comprised 95 children, who were split into three groups according to the type of method of reduction used. Group 1, had an open reduction, group 2, had closed reduction and percutaneous pin fixation and group 3, the pin leverage technique. Each group was analysed according to the time to surgery, the duration of the procedure, the incidence of complications, and the clinical and radiological outcome.

The mean duration of the operative procedure in groups 1, 2 and 3 was 119 minutes (80 to 235), 57 minutes (20 to 110) and 68 minutes (30 to 90), respectively. At a mean follow-up of 30 months (12 to 63) the clinical results were declared excellent or good in all children and the radiological results intermediate in five patients in group 2. The results of the closed reduction using the pin leverage technique was classified as failure in two children.

Our findings lead us to believe that the pin leverage method of reduction gives good results in the treatment of Gartland type III fractures.

Gartland type III supracondylar fractures of the humerus in children are usually treated by closed or open reduction. However, these two methods can be difficult because of the severe displacement and associated soft-tissue damage caused by this fracture. Minimally-invasive approaches to this fracture have been described in two recent papers. In this study, patients who had been treated by closed reduction and percutaneous pin fixation using a pin leverage technique, were compared with those treated previously by either closed or open reduction with percutaneous pin fixation (Fig. 1).

Patients and Methods
We studied 159 patients under the age of 13 who had sustained a supracondylar fracture of the humerus and who were treated at our hospital between January 2000 and October 2004. A total of 25 (16%) were classified as Gartland type I and 25 (16%) as Gartland type II. There were 14 (9%) who had a follow-up of less than one year and were thus excluded. The remaining 95 (60%), with a follow-up of more than one year, were included. The study was performed retrospectively by reviewing the hospital records. The patients were divided into three groups, based on the method of treatment. The first group (group 1) comprised 16 patients treated by open reduction; the second (group 2), had 58 patients treated by closed reduction and percutaneous pin fixation; the third (group 3), had 21 patients treated by closed reduction. The latter was carried out using a pin leverage method, first employed in August 2003, followed by percutaneous fixation. The criterion for inclusion in group 3 was any fracture that could not be satisfactorily reduced after three attempts at closed reduction. The following were noted in each group; the interval between injury and operation; the length of time under anaesthesia; the presence or absence of associated neurovascular injury; loss of reduction; infection; iatrogenic nerve injury; nonunion; myositis ossificans; Volkmann’s ischaemic contracture; and other post-operative complications.

We examined the cause of failure and the frequency of open reduction in the period after August 2003, when the pin leverage reduction method was introduced. There were 58 males and 37 females with a mean age of 6.5 years (2.6 to 13). The left arm was involved in 57 patients (60%) and the right in 38 (40%). All fractures were of the extension type. The most common cause of injury was a...
fall from a slide, exercise bar or other equipment in the playground. This occurred in 23 patients (24.2%). Falls from beds and other furniture occurred in 18 (19%), falls while running in 19 (20%), bicycle accidents in 13 (13.7%), falls from a height in ten (10.5%), injuries while playing ball games in six (6.3%), roller blade accidents in four (4.2%), and road traffic accidents in two (2.1%).

The pin leverage method of reduction. If satisfactory closed reduction under general anaesthesia using the image intensifier could not be achieved after three attempts, the pin leverage method was used. The arm was prepared and draped with the patient in the supine position. In order to minimise injury to the soft tissues by the pin, we designed and manufactured three Steinmann pins (U & I Corporation, Gyeonggi-do, Republic of Korea), 2.0 mm, 2.6 mm and 2.8 mm in diameter, respectively with a handle (Fig. 2). The tips of the pins were ground to a wider and blunter shape. A suitable pin was selected on the basis of the patient's age and arm size. Traction was applied to the forearm; the rotation of the distal fragment of the fracture and the medial and lateral displacement were corrected under image intensifier. With the shoulder externally rotated and the elbow flexed to 90˚, we viewed the lateral image of the fracture. Making a posterior skin incision approximately 5 mm in length at the level of the fracture, the pin was inserted above the distal fragment. It was advanced between the fragments of the fracture, and reduction attempted using it as a lever (Fig. 3). After achieving reduction in the lateral view, with the shoulder in neutral rotation, the elbow was flexed and satisfactory anterior reduction confirmed; two Kirschner (K)-wires (U & I Corporation) were then inserted from the lateral side for fixation. The leverage pin was removed and the stability of the fracture assessed. In unstable cases, a third K-wire was inserted from the lateral into the medial side of the distal fragment (Fig. 4). These were left exposed through the skin and the incision. With the elbow in 90˚ of flexion and the forearm in neutral rotation, a long-arm splint was applied. The K-wires were removed in the outpatient clinic four to six weeks after surgery, and active movements of the elbow commenced.

Results
The mean interval between injury and operation was 1.5 days in group 1, 1.7 days in group 2, and 1.6 days in group 3. There was no significant difference between the groups. In 85 of the 95 patients (89%), surgery was performed within 24 hours of the injury. The mean surgical time, from the start to the finish of anaesthesia, was 119 minutes (80 to 235) in group 1, 57 minutes (20 to 110) in group 2, and 68 minutes (30 to 90) in group 3. In group 3, pin leverage reduction was used after closed reduction had failed and thus the surgical times were analysed. There was no significant difference between groups 2 and 3. In 90 patients (94.7%) there was an anatomical reduction, and five (5.3%) in group 2 had a 15˚ varus deformity. At the first visit after injury, there was evidence of nerve damage without associated vascular damage in 12 patients (13%). There were signs of anterior interosseous nerve damage in seven patients (7.4%) and radial nerve damage in five (5.3%). All recovered within six months. The mean follow-up period was 30 months (12 to 63). In all patients, complete union was obtained. Movement at the elbow joint recovered to

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normal or almost normal in all patients. Using the outcome criteria of Flynn, Mathews and Benoit (Table I) the clinical outcome in all patients was excellent or good. The radiological outcome was also excellent or good, except for five patients (5.3%) in group 2 with a varus deformity. In these it was considered fair. Post-operative complications occurred in five patients (5.3%). These included one patient in group 1 and three in group 2 who all developed a superficial infection at the site of insertion of the K-wires, and one patient in group 2 who sustained an iatrogenic ulnar nerve injury. The superficial infections resolved rapidly after removal of the wires, and the ulnar nerve injury resolved completely within six months. In two patients, satisfactory reduction could not be obtained by pin leverage. Both were comminuted fractures and were treated by open reduction through an anteromedial approach. In the period between January 2000 and August 2003, before the pin leverage method was introduced, 43 patients were treated and open reduction performed in 12 of these (27.9%). After August 2003, when the pin leverage method was introduced, 52 patients were treated and open reduction was needed in only two (3.8%), in whom satisfactory reduction could not be obtained by the pin leverage method.

Discussion
It can be difficult to obtain and maintain reduction in supracondylar fractures of the humerus with severe displacement in children. Although some investigators have reported a satisfactory outcome with closed reduction and casting,5,7 the fracture may still be unstable, and excessive elbow flexion may cause a Volkmann’s ischaemic contracture.5,7,8 In the past, treatment with closed reduction or traction has been recommended1,5,9-11 but complications such as joint stiffness, long hospital stays and cubitus varus deformities have been reported.12-14 At present,
closed reduction and K-wire fixation is widely used. However, in patients with severe oedema and those who are in danger of developing a compartment syndrome, closed reduction can be difficult, and open reduction using a minimal incision has been suggested.  

Qidwai suggested the pin leverage method of open reduction for paediatric forearm fractures. This method of reduction was used in our study from August 2003, when closed reduction was difficult because of severe oedema and displacement. Reitman, Waters and Millis reported an 8% incidence of open reduction, indicated by a failure of closed reduction, damage to blood vessels, open fractures, nerve damage or paralysis after closed reduction. However, Lee et al did not need open reduction in 44 patients. In our study, open reduction was performed in 12 of 43 patients (27.9%) prior to the use of the pin leverage method, but in only two of 52 patients (3.8%) after the introduction of this method.

Mehlman et al reported no significant difference in the incidence of complications with respect to the interval between injury and operation. Similarly, in our study, the duration of time to surgery did not affect the treatment method or outcome. Lee et al reported a mean duration of surgery of 20 minutes, and Hur et al reported 25 minutes. The mean duration of surgery in our study was much longer and there was no significant difference between closed reduction and percutaneous pin fixation and the pin leverage method. We believe that the difference in operation time between our study and other studies was most likely as a result of differences in the criteria for measuring operation time. We measured operation time as the time from the start to the end of anaesthesia.

Satisfactory outcomes have been reported in most studies. Reitman et al described 55% good outcomes after open reduction and 24% fair. Hur et al had 95% good outcomes after open reduction with a minimal incision, and 5% fair. Lee et al found 88% good outcomes after closed reduction and percutaneous K-wire fixation, and 12% fair. Mulhall et al reported 81% good outcome and 19% fair. In our study, all 95 patients were clinically excellent or good, but five were only fair radiologically.

In the past, the incidence of complications such as Volkman's contracture, cubitus varus and iatrogenic ulnar nerve damage has been reported to be between 14% and 35%. The use of percutaneous pin fixation after a closed reduction is said to reduce this to approximately 3%. However, a number of authors have reported iatrogenic ulnar nerve damage after K-wire fixation. In our study only one patient (1%) in group 2 developed iatrogenic nerve paralysis, which resolved completely after removal of the pins. No patient developed a Volkman's contracture, loss of reduction or myositis ossificans. However, there were four cases of superficial infection at the site of insertion of the K-wires which resolved rapidly after their removal. The closed reduction pin leverage method failed in two patients with comminuted fractures, where it is probably inappropriate to use this method. However, it has proved very effective in patients with severe displacement (Gartland type III fractures) and oedema in which three attempts at gentle closed reduction had already failed.

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

