Outcome of displaced supracondylar fractures in children after manipulation and backslab

Dr JL Pretorius MBChB(Stell)
Registrar, Department of Orthopaedics, University of KwaZulu-Natal
Dr P Rollinson, MBChB(Sheff), FRCS
Chief Orthopaedic Specialist, Ngwelezane Hospital, Empangeni, KwaZulu-Natal
Dr MN Rasool MBChB(UKZN), FC(Orth)SA, PhD
Paediatric Orthopaedics, Nelson Mandela School of Medicine, University of KwaZulu-Natal, Durban, South Africa

Corresponding author:
Dr JL Pretorius
Department of Orthopaedic Surgery
University of KwaZulu-Natal
Email: johan.doc@gmail.com

Abstract

Aim:
To assess the functional and cosmetic outcome of displaced supracondylar fractures in children treated by closed reduction and plaster backslab.

Method:
We retrospectively reviewed 53 patients with Gartland type II and type III fractures that were treated by closed reduction (Blount's technique) and immobilisation in a collar and cuff and above-elbow plaster backslab between December 2011 and May 2012. The mean age was 6.6 years. The mean follow-up time was 12 weeks (range, 6–20). All open injuries and undisplaced fractures were excluded from the study. Flynn's criteria were used to assess functional and cosmetic outcome.

Results:
The median loss of motion was 10 degrees and the median change in carrying angle was 4 degrees. Fifty-one patients (96.2%) had satisfactory results, with 87% graded as excellent or good according to the Flynn's criteria for grading of the carrying angle. A range of motion of 100 degrees was achieved in 92.5% of patients at 12 weeks.

Conclusion:
This method appears to produce less satisfactory results in comparison to closed reduction and fixation with Kirschner wires (K-wires), but it does provide satisfactory results according to Flynn criteria with regard to cosmetic deformity and range of motion at short-term follow-up. It is an acceptable and safe option with which to treat displaced supracondylar fractures.

Key words: supracondylar fractures, closed treatment, outcome

Introduction

Supracondylar fractures of the humerus in children are the commonest elbow injuries. The treatment of these fractures is controversial. The average age at fracture is 6.7 years, and the non-dominant hand is more commonly affected. The mechanism of injury is a fall on an outstretched hand, either from a height or at ground level. Ninety-eight per cent are extension-type injuries. Complications include neurological deficit, vascular injury, compartment syndrome, elbow stiffness, myositis ossificans, non-union, avascular necrosis, angular deformity and rotational deformity.[1]

Treatment of supracondylar fractures in children is generally determined by using the classification described by Gartland.[2] Type I fractures are undisplaced. Type II fractures have partial displacement, but a certain degree of contact is maintained between the proximal and distal fragments. Type III fractures have complete displacement with no bony contact.

Treatment of supracondylar fractures in children is generally determined by using the classification described by Gartland

Various methods of treatment have been described and are based on the degree of displacement. They include immobilisation in an above-elbow backslab or even collar and cuff for undisplaced fractures (Gartland I). In displaced fractures (Gartland II and III) cast immobilisation in either flexion or extension,[3-9] various forms of traction, including horizontal traction, vertical traction, Dunlop traction,[3,6,10–13] skeletal traction through an olecranon pin and traction in pre-fabricated braces have been used.[3,6,14,15] The commonly accepted method involves closed reduction and Kirschner-wire (K-wire) fixation, with variation in number of pins and configuration, either medial and lateral wires or only lateral wires, which can be either parallel or crossed.[3,6,16–21]

Open reduction is generally reserved for irreducible fractures, vascular compromise and open injuries, but can also be used when attempted reduction is delayed.[22,23]

The use of Flynn's criteria is a widely accepted method of assessing the results of supracondylar fractures and incorporates a functional element, i.e. range of motion and a cosmetic component with change in carrying angle.[24] The Baumann angle after reduction, measured on plain radiograph between the long axis of the humerus and the growth plate of the capitellum, can accurately predict the final carrying angle.[25]

Over the last 25 years a relatively simple treatment method was used in the orthopaedic department at a regional hospital, which serves as a referral centre for 14 district hospitals as well as serving as a district hospital for a local population of approximately 500 000. Supracondylar fractures are commonly seen in the orthopaedic department each year, approximately 200, and many of these are referred late, often with marked swelling (48 hours).

A treatment protocol was devised which involves placing the fractured arm on vertical skin traction on a drip stand alongside the bed to distract the fracture and reduce swelling

The department is generally staffed by relatively junior medical officers and registrars, and resources are limited. Subsequently a treatment protocol was devised to accommodate these factors. This involves placing the fractured arm on vertical skin traction on a drip stand alongside the bed (*Figure 1*) to distract the fracture and reduce swelling. A manipulation under anaesthesia is performed at five to six days post injury, flexing the elbow to 110 degrees, securing the reduction with a collar and cuff, and protecting it in an above-elbow backslab.

Patients and method

This is a retrospective review of the functional and cosmetic outcome of all displaced supracondylar fractures in children younger than 13 years of age for a period of 6 months (01 December 2011–31 May 2012) treated by closed reduction, collar and cuff, and protected in an above-elbow backslab.

Clinical records and radiographs were reviewed for the demographic details, site and mechanism of injury, clinical and radiographic presentation, mode of treatment before presentation, duration of hospital stay, theatre time and final treatment. Functional outcome was determined by comparing the range of motion and carrying angle with the unaffected arm (*Figures 2–5*).

Inclusion criteria included: all displaced (Gartland II and III) fractures admitted to the department in the six-month period.

Figure 1. Elevated vertical traction

Figures 2

Figure 3

Figures 2 and 3. Radiographs of one of the Gartland III injuries treated by our method

Figure 4

Figure 5

Figures 4 and 5. Radiographs at 12-week follow-up of the same patient shown in Figures 2 and 3. This patient had 130 degree range of motion (poor) and change in carrying angle by 3 degrees (excellent), giving him an overall poor result.

Exclusion criteria: undisplaced supracondylar fractures (Gartland I), fractures that required open reduction and K-wire, open fractures, and patients with poor documentation.

A total of 89 patients with unilateral supracondylar fractures were treated during the study period. Forty-six patients were excluded (undisplaced [30] or needed K-wire fixation [5], or incomplete documentation [11]). There were 53 patients in the study with full documentation and a mean follow-up of 12 weeks. Twenty-nine (54.7%) of the patients were from referral hospitals and the remaining 24 (45.3%) came from the local drainage area. The mean age at time of injury was 6.6 years (13 months to 13 years). Forty-four were male (83%) and nine were female (17%). There were 37 (69.8%) left-sided fractures compared to the right 16 (30.2%). There were no open injuries in the study group.

Neurological examination was documented in all patients; six patients (11.3%) had anterior interosseous nerve palsy and one (1.9%) had a radial nerve palsy. Vascular examination revealed two patients who presented with a pink pulseless hand with normal capillary refill.

These were managed by frequent vascular assessments with the elbow maintained straight on traction and then with reduction and in flexion as per normal with a collar and cuff and backslab when the swelling had diminished, usually after five to six days of straight-arm traction.

Five patients (9.4%) had concomitant fractures; four distal radius fractures and one Salter-Harris II fracture of the distal radius. Fifty-two patients (98%) sustained extension-type injuries. They were classified into Gartland type II 13 (24.5%) or Gartland type III 40 (75.5%) fractures.

Treatment

All patients received five to six days of vertical traction suspended over a drip stand to allow the swelling to subside and distract the fracture. Thereafter the fracture was reduced in theatre under general anaesthesia under fluoroscopy guidance using Blount's technique, which entails positioning the child at the edge of the operating table with the arm over the image intensifier. Firm traction was applied with a steady continuous force with the elbow in full extension. Once the deformity in the coronal plane was corrected, the surgeon applied countertraction to the proximal fragment while the thumb reached the olecranon and applied an anterior force to the distal fragment to push back the distal fragment to restore the sagittal plane deformity. Concurrently, the other hand flexed the elbow up to 110 degrees.[26,27] The reduction was confirmed on Jones view and lateral, a collar and cuff was applied with the elbow maintained strictly at 110 degrees of flexion and then an above-elbow plaster backslab was applied to stabilise the elbow in the flexed position. A neutral position in terms of pronation/supination was used. The radial pulse was assessed after reduction.

The neurovascular status was reviewed again in the ward. Reduction of the fracture was confirmed on plain radiographs, and the child was discharged on the first or second post-operative day.

The collar and cuff and plaster backslab were removed after three weeks and active mobilisation of the elbow encouraged. The patients were then seen at six and twelve weeks after reduction, where the range of motion and carrying angle were measured with a goniometer and documented on a datasheet, and radiographic evaluation was done. If the results were good/excellent (according to Flynn's criteria) before 12 weeks, the patients were discharged.

Results

The mean follow-up period was 12.3 weeks (6 weeks to 20 weeks). All neurological deficits resolved by six weeks. The average theatre time was 14.8 minutes (range 3–40) and the average duration of hospital stay was 4.8 days (range 3–8 days). One patient had a failed MUA and had 17 days of vertical traction. The functional and cosmetic outcome was tabulated using Flynn's criteria (*Table I*).

Table I: Flynn's criteria			
Results	**Rating**	**Loss of carrying angle**	**Loss of motion**
Satisfactory	Excellent	0°–5°	0°–5°
	Good	5°–10°	5°–10°
	Fair	10°–15°	10°–15°
Unsatisfactory	Poor	>15°	>15°

The median loss of carrying angle was 4 degrees. The majority of fractures drifted into varus compared to the unaffected elbow, with only five patients increasing their carrying angle (all within excellent/good range). Fifty-one patients (96.2%) had satisfactory results with 87% graded as excellent or good according to the Flynn criteria for the carrying angle. The two patients who had unsatisfactory results had an 8 and 10 degree varus deformity; they also had unsatisfactory results with regard to range of motion despite the fact that they still had a functional range, i.e. 125 degrees and 135 degrees respectively (*Table II*).

The median loss of range of motion was 10 degrees. The mean arc of motion was 141 degrees for the Gartland II fractures and 126 degrees for the Gartland III fractures.

In the Gartland II fractures group, 85% of the patients had a satisfactory result with a median loss of motion of 5 degrees, 76% of which were lost at the end range of extension. In the Gartland III fractures group, 55% of the patients had a satisfactory result with a median loss of motion of 10 degrees, again with the majority lost at extreme extension (74%) (*Table III*).

When the carrying angle and loss of motion scores were combined, 60.4% of the patients had a satisfactory result (*Table IV*).

Discussion

The treatment of supracondylar fractures continues to stimulate interest, especially Gartland III fractures. Various methods have been used to treat supracondylar fractures. Closed reduction and immobilisation in flexion have been used by several surgeons.[3-6] Pirone *et al.* reviewed the results of numerous methods of treatment at a mean of 4.6 years. In the group treated with closed reduction and backslab in flexion, they found 80% satisfactory results.[3] The majority of the poor results in this group were due to cubitus varus. De Gheldere *et al.* used Blount's technique with a cast around the wrist to immobilise the forearm in pronation with the elbow in full flexion.

Table II: Carrying angle loss*					
Results	**Rating**	**Degrees**	**Grade II**	**Grade III**	**Total**
Satisfactory	Excellent	0°–5°	8	23	31
	Good	5°–10°	4	11	15
	Fair	10°–15°	0	4	4
Unsatisfactory	Poor	>15°	1	1	2
(*one patient's carrying angle could not be measured due to FFD)					

Table III: Total range of motion loss					
Results	**Rating**	**Degrees**	**Grade II**	**Grade III**	**Total**
Satisfactory	Excellent	0°–5°	8	13	21
	Good	5°–10°	2	8	10
	Fair	10°–15°	1	1	2
Unsatisfactory	Poor	>15°	2	18	20

Table IV: Combined Flynn score				
	Satisfactory			**Unsatisfactory**
	Excellent	**Good**	**Fair**	**Poor**
Gartland II	5	5	0	3
Gartland III	10	10	2	18
Total	32			21

Our method yielded overall satisfactory results with regard to restoration of the carrying angle

They found that 8% of Gartland III patients had a poor result while all the Gartland II fractures had satisfactory results. They suggested that most Gartland II and III fractures can be treated in this manner but only the postero-lateral Gartland III fractures require K-wires due to their inherent instability in pronation.[4]

Nejad *et al.* investigated the effect of supination and pronation on the incidence of cubitus varus deformity after closed reduction and immobilisation in flexion and found no relationship between the position of the forearm and the incidence of deformity but suggested that it is the fracture type and the quality of the reduction that are important.[5]

Several authors have used various methods of skin traction.[6,11–13] Piggot *et al.*[11] treated 98 children with displaced supracondylar fractures of the humerus by straight lateral traction. After a mean follow-up period of 3.5 years there were 90 satisfactory and only eight unsatisfactory results; four of these had cubitus varus at final follow-up. Sadiq *et al.*[12] treated 20 children with displaced supracondylar fractures with lateral traction in 90 degrees abduction and supination and found no cases of cubitus varus. Urlus *et al.*[13] treated 33 patients with reduction in theatre and Dunlop traction for an average of 18 days followed by plaster cast for an average of 16 days; they achieved 97% acceptable results with regard to change in carrying angle.

Immobilisation with plaster cast/moulded gutter-shape slab in extension has also been described.[7–9] Chen *et al.*[7] compared the incidence of varus in Gartland III fractures treated with either reduction and flexion or reduction and moulded gutter shape plaster slab in extension and 20–30 degrees of valgus. Fifty-seven per cent of his flexion group developed cubitus varus, while none of his extension group developed cubitus varus at 4.6 year follow-up. There was no difference in range of motion in either group. Babar *et al.*[8] used Chen's technique to treat 70 patients with Gartland III fractures and found 80% acceptable results; this group had a 5 degree change in carrying angle. Gandhi *et al.*[9] treated displaced Gartland III fractures with manipulation under anaesthesia and full above-elbow POP in extension and had 69% good/excellent results according to Flynn's criteria.

Traction through an olecranon pin either vertically or in a pre-fabricated brace yielded 84–98% satisfactory results.[3,14,15]

Young *et al.*[6] showed 94% satisfactory results using various techniques including plaster casting, overhead skeletal traction and casting and manipulation and K-wires; however, this included undisplaced fractures.

Closed reduction and percutaneous K-wire fixation is considered the gold standard for treatment of displaced supracondylar fractures and results in 99% satisfactory outcome and only a 2% complication rate. Numerous studies on K-wire configuration have been published and even though cross-pin configuration is biomechanically better fixation than lateral only pinning, satisfactory results can be obtained using either technique.[3,16-21]

O'Hara *et al.*[19] recommended the following conditions to prevent re-operation and malunion: 1) an experienced surgeon should be responsible for the initial management; 2) closed or open reduction of type IIB and type III fractures must be supplemented by stabilisation with K-wires; and 3) K-wires of adequate thickness (1.6 mm) must be used in a crossed configuration.

Neurological injury associated with supracondylar fractures of the humerus in children is a well-known complication. The incidence of traumatic nerve injury varies between 12% and 20%, commonly affecting the anterior interosseous and radial nerve. Iatrogenic nerve injuries associated with this fracture have been reported as being between 2% to 6%, commonly affecting the ulnar nerve; these injuries are a result of blind K-wire placement and ulnar nerve instability in elbow flexion. The majority of these injuries are neuropraxias, and recover between 2–3 months.[28-38] The incidence is lowered by using the three lateral pinning technique instead of the cross-pinning or with a minimally open medial approach.[20,21,39]

A series of patients treated with closed reduction and plaster backslab immobilisation is presented. Our method yielded overall satisfactory results with regard to restoration of the carrying angle. Using the full Flynn criteria, only 60% achieved satisfactory results but this was mainly because of the Flynn's criterion related to range of motion loss. Limitations of the study are that the fractures were assessed only over a 12-week period. Those with a limited range of motion would almost certainly improve and increase their range of motion and consequently their Flynn grading over time. Previous studies looking at return of range of motion found that only 86–92% of range of motion returns by 12 weeks which improves to 98% of uninjured range by 52 weeks.[40,41] Baumann's angle, measured on the injured and compared with the uninjured arm would have been a more objective measurement of change in carrying angle, but due to the fact that the AP radiographs of both elbows were taken on the same film, the angle between actual beam and elbow was 30 degrees. This gave distorted views of the Baumann's angle and could thus not be included.[25]

The Flynn criteria are very 'severe' in that a carrying angle loss of 10 degrees or more is not regarded as a good result. A neutral carrying angle of a few degrees of varus (up to 5°) is generally accepted by patients/parents and is usually not even noticed. Mild varus deformity of the elbow seems to cause more anxiety to orthopaedic surgeons than to patients and parents and may not be as important as implied by Flynn's criteria.

The technique has been refined over 20 years at our institution with almost 100 cases per year managed. Corrective osteotomy for malunion/varus in the cases managed by this method was not indicated or demanded by the parents.

Conclusion

Closed reduction, collar and cuff and plaster backslab immobilisation under general anaesthesia in theatre is an acceptable technique to treat supracondylar fractures in children. It saves theatre time while obtaining anatomical reduction and results in a satisfactory outcome according to Flynn criteria for cosmetic appearance and a functional range of motion for the majority of patients in the short term. It also avoids the possible complications of K-wire fixation including iatrogenic ulnar nerve injury and pin-tract sepsis which could be catastrophic if the patient is lost to follow-up in the rural setting.

This method appears to produce slightly inferior results in comparison with closed reduction and fixation with K-wires, but it provides excellent results with regard to alignment and a range of motion that is comparable with return of motion found in other studies. It is thus a good and safe option to treat displaced supracondylar fractures.

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