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ORIGINAL PAPER

Open reduction and bioabsorbable pin fixation for late presenting irreducible supracondylar humeral fracture in children

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Abstract The objective was to evaluate the availability and efficacy of internal fixation with absorbable poly-D,L-lactic acid (PDLLA) pins for the treatment of late presenting irreducible Gartland type III supracondylar fracture of the humerus in children. Fifty-six cases of late presenting irreducible Gartland type III supracondylar fracture of the humerus in children were treated by open reduction and bioabsorbable PDLLA pin fixation from March 2005 to March 2008. The outcome of treatment was evaluated by the Mayo Elbow Performance Score (MEPS) and the criteria of Flynn. Fifty-six patients were followed up from 24 to 36 months (mean: 22 months). No displacement of bone fracture occurred, and all fractures healed within a normal time without wound infection; there were no cases of Volkmann's ischaemic contracture, myositis ossificans or iatrogenic injury of the ulnar nerve. No residual vascular deficits or iatrogenic nerve injury were noted; cubitus varus deformity occurred in one case. There were 49 excellent, four good and three fair results according to the MEPS; the rate of excellent and good outcome was 94.6%. All children but one had excellent cosmetic results according to the criteria of Flynn. All of the children and their parents stated that they would choose this treatment again. Treatment of late presenting irreducible Gartland type III supracondylar fracture of the humerus in children with bioabsorbable PDLLA pins provides sufficient stability and satisfactory efficacy. The absorbable implant has become popular for its avoidance of a second operation to remove the internal fixation, and the degree of patient satisfaction is high.

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Introduction

Supracondylar fractures of the humerus are the commonest types of elbow fractures in children and adolescents accounting for 50–70% of all elbow fractures and are seen most frequently in children between the age of three and ten years [1]. In most cases, closed reduction with manipulation followed by percutaneous pinning with either cross-pins or multiple lateral pins [2–5] is the accepted primary treatment modality. These techniques usually produce a satisfactory cosmetic and functional result and have become a standard method of treatment for types II and III supracondylar fractures during the past 20 years [6, 7].

However, there are occasions in which a more aggressive approach is needed. For example, delay in presentation and the lack of an imaging facility precluding successful closed management. The problem becomes more difficult when the patients present after a delay of a few days with a grossly swollen elbow, particularly after receiving massage and manipulation by traditional practitioners. In developing countries, this is a common situation. If anatomical reduction is not possible by closed means, open reduction and internal stabilisation with K-wires ensures a safe anatomical restoration and maintenance of alignment [8].

Generally, fixation can be achieved either with use of bilateral crossed K-wires or multiple K-wires that are

inserted through a lateral approach [9]. In most practices, the K-wires are left outside the skin so they can be removed in the clinic or office without the need for a second anaesthetic. Excessive granulation tissue formation around the wire, superficial/deep infections and skin/nerve irritation were often noted in these patients. Moreover, some children may suffer from fear and anxiety about the extracutaneous K-wires and cannot perform early functional exercise. In order to avoid the disadvantages mentioned above, the K-wires are usually left within the subcutaneous fat, so they can be retrieved easily. But the second admission for the removal of the metallic implants, often under general anaesthesia, will increase not only the economic burden but also the psychological/physiological pressures on the family and child.

The problems faced with metallic wires, together with the cost of the second admission and its psychological effects on the family and child, and the problems of increasing numbers of patients and long waiting lists, have stimulated investigation into the application of bioabsorbable pins for the fixation. Bioabsorbable devices gradually lose their strength during the healing process of the repaired tissue. Finally, they are completely absorbed through hydrolysis and normal metabolic pathways. Therefore, their use overcomes long-term problems associated with metallic implants, and there is no need for implant removal.

In this study, we report our experience with open reduction and internal fixation with poly-D,L-lactic acid (PDLLA) bioabsorbable pins for late presenting irreducible Gartland type III injuries. We present our experience with this method, the technical details of applying the bioabsorbable pins and our initial results. We propose this method as an alternative technique for the treatment of supracondylar humeral fractures in cases in which open reduction and internal fixation may be needed.

Materials and methods

From March 2005 to March 2008, 56 cases of irreducible supracondylar fractures of the humerus in children were treated by open reduction and bioabsorbable pin fixation in the authors' hospital. The GRANDFIX™ PDLLA bioabsorbable pins manufactured by Gunze Limited (Osaka, Japan) were used: the diameter is 2.0 mm and the length 30–50 mm. This study was reviewed and approved by our Institutional Review Board, and informed consent was provided by all of the parents of the children in the study.

According to Gartland's classification, only the children with late presenting irreducible Gartland type III supracondylar fracture of the humerus were included in the study (Fig. 1a, b). Children presenting with a vascular or nerve injury were excluded, as were those with other fractures or head injury. The results were evaluated by the Mayo Elbow Performance Score (MEPS) [10] and the criteria of Flynn [11].

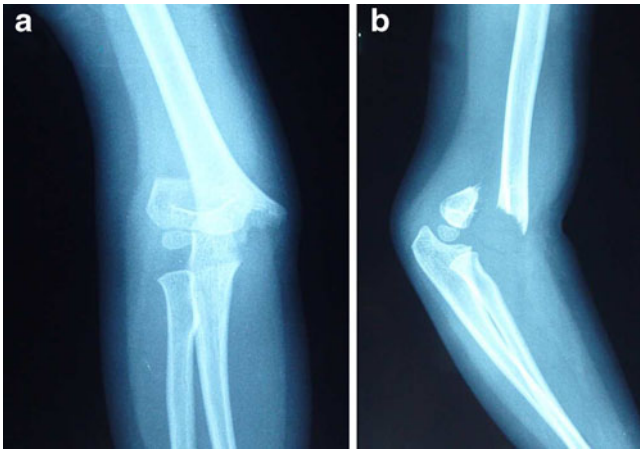

Fig. 1 X-ray showing Gartland type III supracondylar fracture of the humerus in a 5-year-old girl

Surgical technique

Operations are carried out under general anaesthesia with tourniquet control. A standard medial incision is made starting 3–5 cm proximal to the elbow crease and extending 2 cm beyond it [8]. The ulnar nerve is identified and mobilised to the length of the skin incision. The brachialis is elevated from the proximal fragment and the fracture haematoma drained. The entire anterior breadth of the proximal humerus is well visualised due to periosteal stripping of the brachialis by the haematoma. After the entire breadth of the distal fragment is visualised anteriorly 2–3 mm distal to the fracture line, the fracture is reduced by adequate traction and flexion with the thumb pressing the olecranon anteriorly. The quality of reduction is assessed by inspecting the medial column anteriorly, medially and posteriorly and the fracture line anteriorly. A pair of artery forceps may be used to feel for a step in the lateral column. Maintaining the elbow in 60–80° flexion with gentle traction is essential to prevent posterior tilt. Cross K-wires are passed medially and laterally, distal to proximal. A C-arm X-ray is used for confirmation of the reduction and location of the K-wires (Fig. 2a, b). If reduction of the fracture and location of the pins are satisfactory, the K-wires are replaced with the bioabsorbable pins through the primary pin tracks. A hammer is used to strike the piston of the applicator to introduce the pin completely into the channel, and the length of the bioabsorbable pins can be adjusted according to the depth meter. The periosteum or ligaments are sutured around the channel to avoid exodus of the pins. We did not find any difficulties during application of the absorbable pins, using the described technique. Elbow movements and primary stability of the fixation are checked. After checking

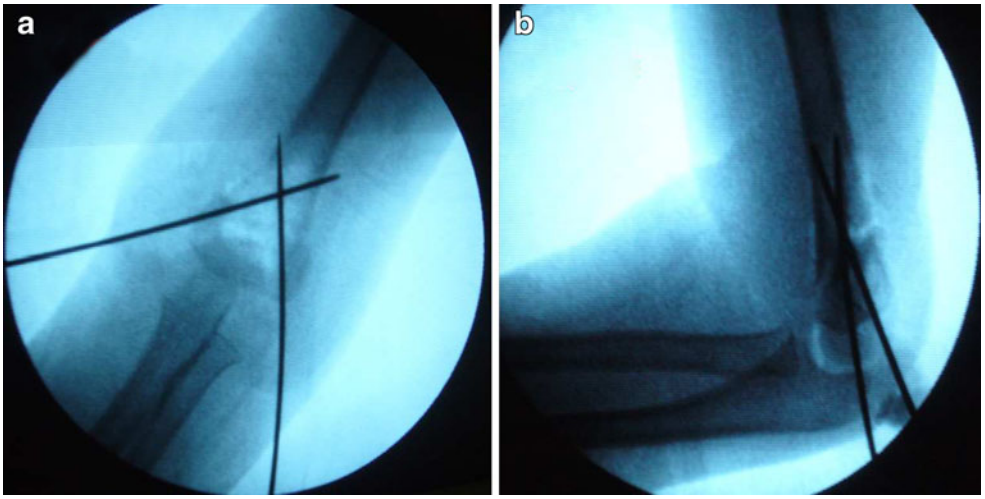

Fig. 2 C-arm X-ray was used for confirmation of the reduction and location of the K-wires. Anteroposterior (**a**) and lateral (**b**) views showed acceptable fracture reduction

the capillary refill the subcutaneous fascia and skin are closed. The elbow is immobilised at less than 90° flexion in supination. A check film is obtained finally (Fig. 3a, b).

Postoperative care and follow-up

The skin was sutured intracutaneously in all cases. The sutures were removed at two weeks and the posterior cast reapplied at 90° flexion in the mid-prone position. The cast was removed at the three to four week follow-up appointment and elbow mobilisation started.

All patients returned for both clinical and radiographic evaluations at three and six weeks and then at three weekly intervals until maximal recovery of movement. Clinical evaluation included assessment of the carrying angle, measurement of the passive range of elbow motion, neurological and vascular examination of the extremity, and determination of any complications such as superficial infection, deep infection, and the need for a further operation [12]. The clinical results were graded according to the criteria of Flynn and the MEPS (Fig. 4).

Radiographic evaluation included an anteroposterior radiograph of the distal part of the humerus and a lateral radiograph of the elbow. The Baumann angle was calculated on the anteroposterior radiograph using the method of Williamson et al. [13] at the final follow-up examination. Student's *t* test was used to compare continuous data between the groups. Statistical analysis was performed with SPSS software (version 14.0; SPSS, Chicago, IL, USA).

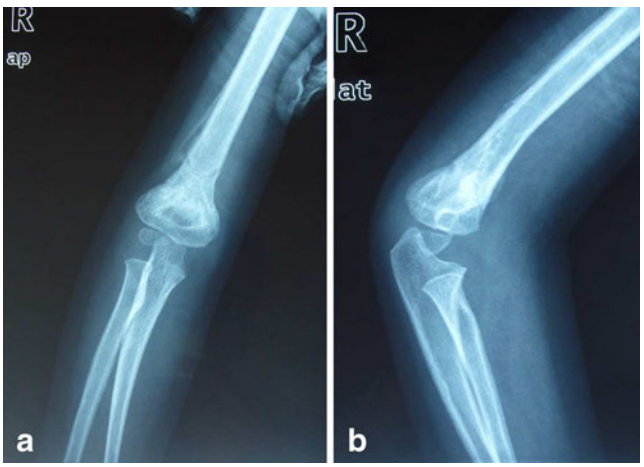

Fig. 3 Radiographic evaluation included an anteroposterior radiograph of the distal part of the humerus and a lateral radiograph of the elbow

Results

There were 26 boys and 30 girls included in the study. The average age was 6.2 years (range: 3–10 years) and the left side was involved more often than the right side (32 vs 24). Falls while playing and falls from a height were the predominant modes of injury. The reasons for late presentation were referral (n=28), lack of transport (n=13) and ignorance (n=15). The mean delay in presentation was five days (range: 2–7 days); all patients had received either manipulation without general anaesthesia or massage by a traditional bonesetter.

All fractures were closed, extension type, with 34 (60.7%) involving the left elbow; 55.4% (31/56) of the fractures occurred in girls. The displacement was posterolateral in 16 of the 36 patients, posteromedial in 14 and directly posterior in six. Visible medial column comminution was seen in eight cases.

The mean follow-up period was 48 months (range: 24–60 months). All fractures healed within six to eight weeks; there were no cases of infection, nonunion, myositis ossificans or Volkmann's contracture. No residual vascular

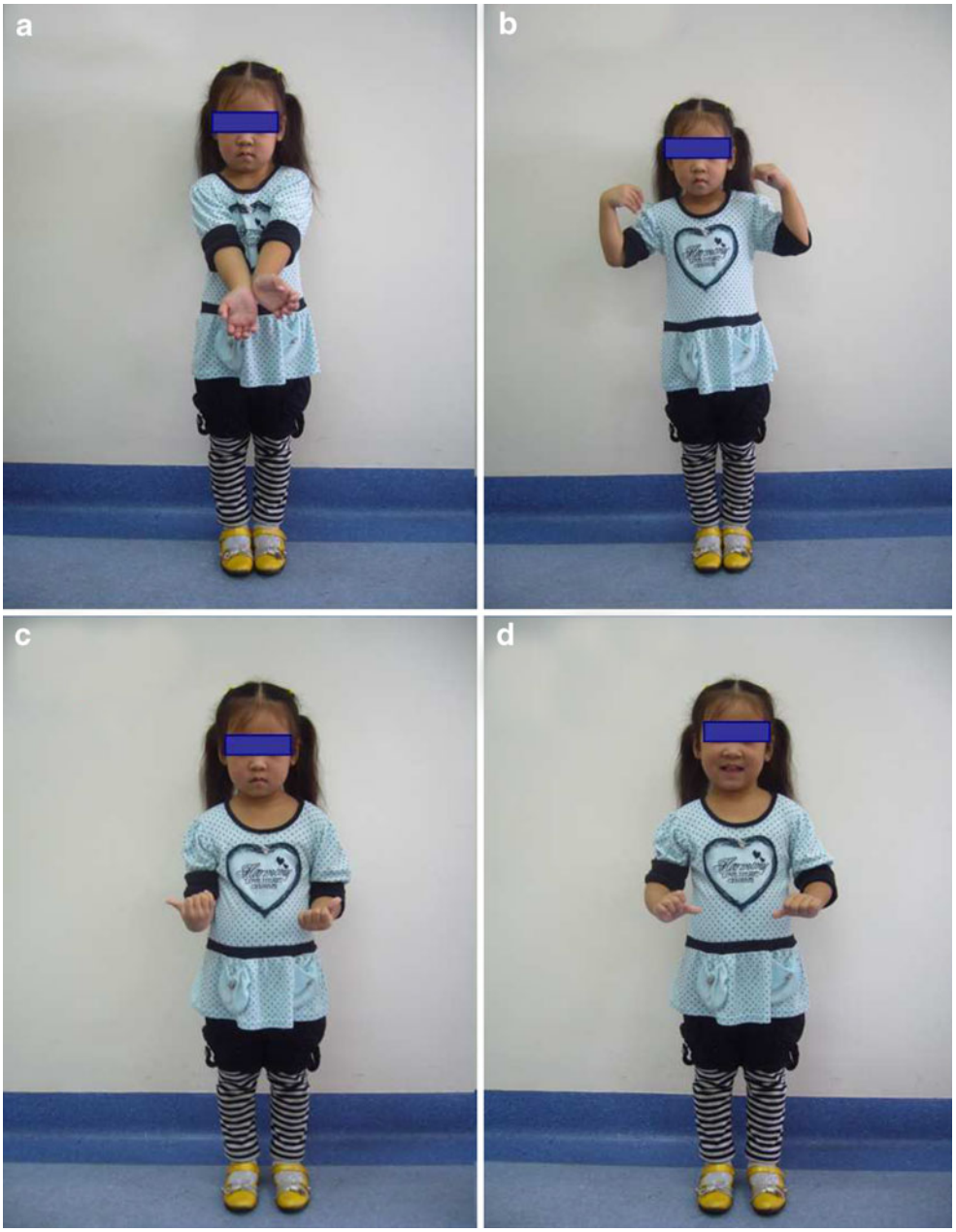

Fig. 4 Clinical evaluation showed acceptable carrying angle and range of elbow motion. The extension (**a**) and flexion (**b**) of the elbow is excellent as well as the pronation (**c**) and supination (**d**) of the forearm

deficits or iatrogenic nerve injury were noted. The cosmetic result was excellent in all cases except one case of cubitus varus deformity, scar revision was not requested and the acceptance of the bioabsorbable pins was considered excellent by both the children and the parents. Asked if they would accept the same type of treatment again, all parents replied that they would.

The mean postoperative Baumann angle was 76.2±0.8° in the operated elbow and 75.1±0.4° in the normal elbow. The Baumann angles measured immediately after surgery and at final follow-up were not significantly different. The carrying angle of the operated and normal sides was measured at the final follow-up: 50 (89.3%) patients had 0–5° reduction of the carrying angle, three (5.4%) had 6–10° reduction and two (3.6%) had 11–15° reduction; one patient had cubitus varus deformity (1.8%). Of the patients, 48 (85.7%) lost less than 5° of movement in the flexion-extension arc, five (8.9%) lost 6–10°of flexion and three (5.4%) lost 11–15°of flexion. There were 49 excellent, four good and three fair results according to the MEPS; the rate of excellent and good outcome was 94.6% (Table 1).

Discussion

Supracondylar fracture of the humerus is the second most common fracture in children and the most common fracture in children younger than seven years [14]. Late presentation,

Table 1 Surgical outcome according to the criteria of Flynn and MEPS

Grading	Cosmetic factor (change in carrying angle)	Functional factor (loss of motion)	MEPS
Satisfactory			
Excellent	0–5° (50/89.3%)	0–5° (48/85.7%)	>90 (49/87.6%)
Good	6–11° (3/5.4%)	6–11° (5/8.9%)	75–89 (4/7.6%)
Fair	11–15° (2/3.6%)	11–15° (3/5.4%)	60–74 (3/5.4%)
Unsatisfactory	1 (1.8%)		
Poor	>15°	>15°	<60 (0)

MEPS Mayo Elbow Performance Score

defined as more than two days after injury [15], of displaced supracondylar humeral fracture in child is common in developing countries such as China. Closed reduction and cast immobilisation is not feasible in late presenting supracondylar humeral fractures as the injury is usually associated with severe swelling that obstructs the safe flexion needed to maintain reduction in a cast. It is usually treated with continuous skin or skeletal traction, with unavoidable prolonged hospitalisation, or allowed to become malunited and then corrected by osteotomy at a later stage. A higher incidence of stiffness, neurological and vascular complications, and failure of closed reductions are encountered in late presenting cases, particularly after repeated manipulations. Tiwari et al. [15] consider operative treatment the best option for such late presenting fractures.

In the past, open reduction led to concerns regarding elbow stiffness, myositis ossificans, unsightly scarring and iatrogenic neurovascular injury. However, several studies [16] have recently demonstrated a low rate of complications associated with open reduction. Absorbable fixation devices made of biodegradable synthetic polymers were developed for use in orthopaedic surgery in the 1980s as an alternative method of internal fixation for human fractures and osteotomies [17]. In fractures in children, the advantages of bioabsorbable fixation devices, abolishing the need to remove the implants, are clear.

Most physeal fractures and small fragment fractures that require open reduction and internal fixation are suitable for bioabsorbable rod fixation. Rod fixation with small diameter (1.5 or 2.0 mm in diameter) rods appears to be safe even after transphyseal placement of the fixation rods. In previous experimental studies, it was shown that a bioabsorbable pin of 2.0 mm in diameter implanted across the central portion of the distal growth plate of the femur caused no bone growth disturbance in growing New Zealand white rabbits [18].

Rokkanen et al. [18] reported a series of 140 fractures in children treated successfully with bioabsorbable rod fixation. The complications recorded were loss of reduction (2.8%), inaccurate position of fixation or minor redisplacement (1.4%) and superficial infection (1.4%). Transient reactions seem to be quite rare in children (2.1%) and always mild in character. There are many other investigations on paediatric fractures with successful results. In this study, no displacement of bone fracture occurred, and all fractures healed within a normal time without wound infection; there were no cases of Volkmann's ischaemic contracture, myositis ossificans and iatrogenic injury of the ulnar nerve.

One of the drawbacks of bioabsorbable implants is the added price. However, the cost of the bioabsorbable rods is far outweighed by the benefit of avoiding further surgery to remove the K-wires in addition to obtaining a better skin scar. Cost analysis study shows that absorbable fixation devices are more economical than metallic implants. We concluded that bioabsorbable rods could safely replace K-wires in fixing supracondylar fractures of the humerus in children.

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