

Modified Pinning and External Tension Band Treatment of Gartland III Kids' Supracondylar Humerus Fracture

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Abstract

Objective: The purpose of this study is to retrospectively analyze the efficacy of modified cross pinning fixation and external tension band technique in the treatment of Gartland Type III supracondylar humerus fractures in children.

Methods: From February 2008 to August 2011, 62 children suffered to Gartland III kids' supracondylar humerus fracture aged 7.1 (2.5 - 12) years were treated with open reduction through lateral approach and modified cross pinning fixation (cross pinning with lateral assisted pin) and lateral external tension band technique (lateral cross pins bent and ends hook mutually), of these 62 patients, 48 had sufficient clinical and radiographic follow-up to be included in our study. There were 35 boys and 13 girls, 6 cases were flexion type and 42 cases were extension type, 4 cases were open fractures and the others were closed. Left side was involved in 27 patients, the right side in 21. Twenty-seven closed fractures in the series had underwent failed closed reduction. The time from injury to operation was 2h-8d. The casts were removed then the patients were discharged one week post operation and began exercise at that time. The pins were removed 4 or 5 weeks' post operation in most patients, if necessary, the pins were removed until 6th post-operative week in elder child.

Results: The follow-up period varied from 15 to 29 months, with an average of 19.3 months. ROM of both elbows were measured at follow-up and the carrying angles were measured according to humeral-ulnar-wrist angle at late stage, the data of each side was compared. Flynn's criteria was used to evaluate outcome of treatment. According to Flynn's criteria, 45 cases got excellent result, 2 got good result and 1 got fair result.

Conclusion: It is an ideal way to use modified cross pinning fixation and lateral external tension band technique to treat kids' supracondylar fracture of the humerus. The firm fixation is beneficial for early activity for recovery, anatomical reduction and compression produced by lateral tension band were effective for avoidance of cubitus varus and other complications.

Keywords: *Supracondylar humerus fracture; Fracture fixation; Child; Elbow joint; Operation*

Supracondylar humerus fractures are the most common elbow fractures in children and it occurs more in boys aged 5~8 years old. There are 2 basic types of supracondylar fracture based on mechanism: flexion and extension types, the extension type fracture accounts for the vast majority of supracondylar fractures. Supracondylar humerus fractures can be classified based on the Wilkins modification of Gartland classification [1]. Type 3 fractures in this classification are unstable fractures with no intact posterior cortex and require operative stabilization. Although some authors have reported success with closed treatment of Type 3 injuries [2], the mainstay of current treatment of Type 3 injuries consists of closed or open reduction with percutaneous pinning [3-5]. However, controversy still persists about optimal pin configuration [3,6-8]. The method of medial-lateral cross pin fixation provides good stability of fixation but carried the risk of ulnar nerve injury, 2-lateral pins was also recommended by scholars but the stability it provides might not be adequate to maintain reduction [9]. Much attention has been directed to cubitus varus or valgus because of malreduction or loss of reduction by unstable fixa-

tion, so obtaining as anatomical a reduction as possible and rigid fixation are necessary especially in the prevention of cubitus varus for its higher rate. We have employed open reduction and cross pinning fixation and lateral external tension band technique (cross pin ends hook mutually) for several years in the treatment of type 3 fractures with highly satisfactory results. In this paper, we describe the method and our results in 102 patients.

Materials and Methods

From February 2008 to August 2012, 62 type III supracondylar elbow fractures according to Wilkins modification of Gartland classification were treated with open reduction and pin fixation [1]. Of these 62 patients, 48 had sufficient clinical and radiographic follow-up to be included in our study, the transcondylar fractures were excluded in this series because it is unsuited for cross pinning and tension band in our opinion. There were 29 boys and 19 girls, with a mean age of 7.1 years (range: 2.5-12 years), 6 cases were flexion type and 42 cases were extension type, 4 cases were open fractures and the others were closed. Left side was involved in 27 patients, the right side in 21. The follow-up period varied from 15 to 29 months, with an average of 19.3 months. Three patients showed median nerve symptoms and two patients showed radial nerve symptoms were documented at the time of initial examination. Two patients had a loss of pulse in their arms at the initial examination. Thirty-six patients involving the 4 open fractures and the cases complicated with nerve or vascular damage underwent surgery within 12 hours of presentation to our hospital, surgery of the remaining 54 were postponed according to the status of soft tissue. Twenty-seven closed fractures in the series had underwent closed reduction with splint or cast in other medical institutions, some patients' X-ray showed unacceptable reduction just post closed reduction and others showed reduction loss when they were rechecked in our hospital, their operations were postponed for severe swelling. The time from injury to operation was 2h-8d.

All operations were performed under general anesthesia after application of a tourniquet. Prophylactic antibiotics was used in all patients half-hour before surgery. A lateral incision length less than 5cm was used in all the patients, a second incision on the medial side could be used in patients with neurovascular complications. In the severely swollen cases the medial epicondyle was exposed by stab wound 5-millimeter-long just on medial epicondyle or located by continuous massaging with thumb on the soft tissue of medial epicondyle. Laterior and anterior of fractures were exposed by subperiosteal dissection of brachioradialis and extensor carpi radialis longus, long-standing blood or blood lumps were cleaned with the continuity of posterior periosteum being protected. There was no need to open joint capsule. Exposing the medial edge of fracture by removing anterior adherent soft tissue to facilitate anatomic reduction under direct vision, employing gentle traction without hyperextension and with manual manipulation of condylar fragment, then the forearm was pronated and elbow was flexed. After verification of right anteversion angle of distal humerus and carrying angle, the lateral divergent pins crossing fracture site and opposite medial cortex were carried out with electric drill and 2 or 1.5-millimeter smooth stainless steel pin correspond to the age of patient was used [10] (Figure 1), the first pin was thrust through the lateral skin without using a stab wound, the pin point was moved gently under the skin until it was engaged against the lateral epicondyle. The pin was the directed upward and medially at an angle of 35 to 40 degrees to the sagittal plane of the humerus and at an angle less than 5 degrees to the coronal plane of the distal humerus. The second smooth pin was used in the same way with enter point a little distal and anterior to the lateral epicondyle and at an angle of 15 degrees posterior to the coronal plane of the humerus for the forward curve of the distal end of the humerus, after placed it was bent over and cut outside the skin. The third smooth pin was medial crossed pin inserted 2mm anterior to the apex of the medial epicondyle and paralleled to the coronal plane of distal humerus throughout the opposite lateral cortical bone with tail end sunk into the medial skin, it was bent over outside the lateral skin and the tip was hooked, the first pin was also bent and hooked in the end, they were hooked around in their end to form external tension band, then the pressure stress between lateral side of fracture site generated and the stability of fixation was improved. Image intensifier was used to reconfirm the reduction of fracture sit, placement of pins, restoration of carrying angle and anteversion angle of distal humerus.

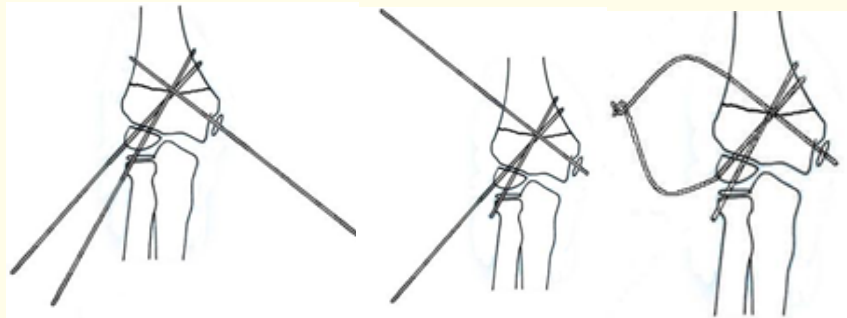


Figure 1: 1a. medial cross pin was used 1b. medial cross pin throughout the opposite lateral cortex and its medial end sunk into subcutaneously, the lateral distal pin was cut 1c. the lateral segments were bent and ends hooked together.

A long arm plaster splint was applied at the elbow in approximately 90° of flexion. Prophylactic antibiotic was used for 48 hours' post-operation. The cast was removed then the patients were discharged one week post operation and begin exercise at that time. All the patients were instructed return visit 2, 4, 6 and 8 weeks after operation, the radiographs were obtained in both the anteroposterior and lateral planes just post-operatively and at each follow-up to observe the bone healing and ascertain the time of removing pins. The pins were removed 4 or 5 weeks' post operation in most patients, if necessary, the pins were removed until 6th postoperative week in elder child.



Case 1: A 7-year-old girl with extension supracondylar humeral fracture showing medial nerve symptoms 1a. Pre-operation 1b. 8 weeks after operation.



Case 2: A 7-year-old boy with flexion supracondylar humeral fractures underwent failed reduction 2a. X-ray after failed reduction 2b. Post-operation 2c. 10 days after operation.

The maintenance of fracture reduction in the coronal plane was determined on an AP radiograph by measuring the Baumann's angle at the early stage before the range of motion (ROM) of elbow had not get right. This angle is formed by the physeal line of the lateral condyle of the humerus and the long axis of the humeral shaft. Maintenance of fracture reduction in the sagittal plane was confirmed on a lateral radiograph by measuring the condyle-shaft angle, which is formed by the long axis of the humerus and the long axis of the lateral condyle. The healing time of fracture were recorded by radiograph, ROM of both elbows were measured and at the last follow-up the carrying angles were measured according to humeral-ulnar-wrist angle at late stage, the data of each side were compared. Flynn's criteria was used to evaluate outcome of treatment [11]. [Table 1] Loss of ROM was determined by comparing with the normal side.

| Result | Rating | Cosmetic factor: Carrying-angle loss (°) | Functional factor: ROM loss (°) |
|----------------|-----------|--|------------------------------------|
| Satisfactory | Excellent | 0-5 | 0-5 |
| | Good | 5-10 | 5-10 |
| | Fair | 10-15 | 10-15 |
| Unsatisfactory | Poor | Over 15 | Over 15 |

Table1: Flynn Criteria for Grading of Elbow.

Results

The results were excellent in 45 patients, good in 2 patients, and fair in 1 patients. No results were classified as poor. Thus, a satisfactory result was reached in 97.9% of the patients. The reduction was adequate in all patients and no subsequent loss of reduction was observed. In three patients (3.4%), full range of motion was not achieved; there were one patients with loss of 5° of extension, one patient had loss of 5° of flexion and loss of 10° of extension, this child had had 3 times failed manipulation before pinning and myositis ossificans occurred after operation. Carrying-angle increased over 5° appeared in one patients and loss between 5° and 10° appeared in one patients.

Pin site infection occurred in one patient and healed one week after the pins were removed. There was no pin withdrawal or loss. One patient with radial nerve symptoms recovered at 4th post-operative week, two patients with medial nerve symptoms of impairment flexion of index finger recovered at 8 weeks and 11weeks post-operation respectively, ulnar nerve irritation occurred in one patient at early stage post-operation and recovered in two month. There were no cases of arterial disruption or compartmental syndrome, the patients with pulselessness in their arms at the initial examination that was recovered after reduction of fracture.

Discussions

Since the favorable effects of percutaneous pinning of supracondylar humerus fractures in children to maintain an anatomic reduction after closed reduction of an unstable fracture was reported [11], closed reduction and percutaneous pin fixation have become the care of standard with an evolution of techniques seen through the years [12], various pin fixation techniques including crossed pins and all lateral pins have been described and compared [13-15]. Current controversy exists over which technique provides the best fixation and outcomes. The superiority of cross pins to lateral pins in rotational stability were revealed by biomechanical studies [16], ulnar nerve injuries are well known complications seen with medial pin placement [17]. Brauer reported a five times higher risk of ulnar nerve injury, but 0.58 times lower risk of loss of reduction with medial/lateral pins than with lateral alone. As the only factor predictive of postoperative iatrogenic ulnar nerve injury, the medial pin placement and direction were taken into consideration, its entry point was located 2mm anterior to the apex of medial epicondyle and the ulnar nerve was palpated and protected by being pressed back under fingertip. When the medial epicondyle and ulnar nerve cannot be palpated in the swollen or extremely obese elbow, a stabing wound followed with blunt

dissection could be used in exposing medial epicondyle and drill guide could be used for avoidance of ulnar nerve injury when the medial pin was inserted, it is advisable in shortening duration of operation and reducing complications [18]. In the operation on Gartland type III supracondyle fracture medial side of fracture could not be reduced under direct vision by lateral incision was reported by Jin and his points was that the fixation was unstable because the pin can only be inserted from lateral epicondyle, so he recommended that the medial incision could be used for its superiority in curative effect and reducing complication [19]. The medial incision was inconvenient in practice and in our experience the anatomic reduction of medial side of fracture was not primary factor for restoration of carrying angle, stable fixation could be obtained by cross pin from medial epicondyle.

The retroversion angle of inserting direction should be considered for the curve of the distal end of humerus, because the entry point of the second pin is located a little in front and distal relative to the first pin, it could be inserted at one bigger retroversion angle to the coronal plane of the humerus, the spatial angle formed by the lateral two pins is superior to paralleled lateral pins in biomechanical stability and the absolute stability could be obtained after the medial cross pin is placed as the primary stability have been produced by lateral pins. Michalis, *et al.* [20] reported that rotational stability was showed in only 26% cases in their test, so after the lateral two pins were applied, the rotational stability was tested and in our most cases the third medial cross pin was inserted from medial epicondyle throughout the lateral bone cortex. The third cross pin was inserted from lateral proximal cortex throughout the fracture line toward the medial epicondyle in the cases showed rotational stability after lateral pinning, the cortex of medial epicondyle could be penetrated or not, but an anteversion angle approximately 5° to the coronal plane should be used in pinning to avoid stabbing the ulnar nerve and it should be applied with the elbow extended to lower the tension of ulnar nerve. One of the cases treated with lateral cross pin showed ulnar nerve symptom of numbness of little finger and ulnar half of ring finger, the ulnar nerve may be stabbed or tented by the pin [21], so the lateral cross pin was not suggested. The lateral cross pin the external tension band formed by bending and ends hooked pins could be used to improve the fixation stability and the compressive stress in the lateral part of fracture.

The pins were cut and then bent into hooks to leave in external in the traditional pinning treatment of kids' supracondylar humerus fracture, early rehabilitation exercise may result in loss or withdrawing of pins on account of rotational and axial instability between the pin and its track, the fixation strength may be reduced. The compressive stress always centralizes in the medial side in the supracondylar humerus fractures and the medial cortical bone is more inclined to be compressed in fractures [22], the fracture instability was exacerbated in this situation and these are the formative factors of angulation and medial displacement after fracture reduction, it is reasonable to use external tension band in the treatment of kids' supracondylar humerus fracture.

The cross pins were bent face to face at lateral side and ends hooked together, compressive stress could be produced at both the medial and lateral side of the fracture with the elastic forces of the bent stainless steel pins, the elastic force is related to the bending deformation of pins, the compressive stress in the lateral side of fracture is bigger than that in the medial side, because the bending deformation of the segment between bilateral cortex was limited by the cortical bone and cancellous bone of the distal end of humerus, it cannot generate elastic force, so there is little compressive stress at the medial side of fracture. Compression at the lateral side of fracture can offset the residual fracture interspace of radial part and improve the stability. The horizontal rotation predisposes to coronal tilting, and a combination of horizontal rotation, coronal tilting, and posterior displacement can result in a three-dimensional deformity of cubitus varus [23]. A plane structure is formed by the two cross pins, and it is enforced after the two pins hooked together in their ends, anti-rotational and shear force are improved and the loss of reduction on coronal plane can also be limited. The angle between the plane formed by cross pins and the coronal plane should be as small as possible to avoid the torque force following to unbalanced compression after angulation. The loss and withdrawing were not observed in these two cross pins, the elastic force of the hooked pins should be limited for avoiding over compression of lateral side and resulting cubitus valgus, so this technique is unsuited in the treatment of fractures in which the lateral part is comminuted. The stability of fracture after fixation can meet the requirement of early exercise, the plaster splint can be used for comfort in the first week post-operation.

Wessel, *et al.* reported that spontaneous correction of a primarily displaced fracture was found in 13.0% fractures in the sagittal plane, spontaneous correction in the frontal plane could not be shown; the growth disturbance was discovered in 10.5% fractures in the frontal plane while no growth disturbance was demonstrated in the sagittal plane [24]. The forerake of distal end of humerus should be reduced as far as possible, but anatomical reduction should be obtained in the carrying angle. The Baumann angle is the most frequently cited method of assessing fracture reduction and has been reported to correlate well with the final carrying angle, not to change significantly from the time of initial reduction to final follow-up, and not to be obscured or invalidated by elbow flexion or pronation. The humeral- ulnar-wrist angle is the most consistent and accurate method of approximating the true carrying angle, in our study this angle was used at final follow-up when the patients could get full extension of injured elbow. O'Brien *et al.* ever reported that the metaphyseal-diaphyseal angle was more accurate than the Baumann angle in determining the adequacy of reduction [25]. We evaluated the quality of reduction by measuring the metaphyseal-diaphyseal angle after reduction intraoperatively, orientation of the fragments is easy when the image intensifier is being use.

It is convenient to use external tension band technique in the treatment of kids' Gartland type III supracondyle fracture, the key point is reduction of carrying angle and pinning direction, the compression produced by cross pinning and lateral external tension band is effective in avoiding loss of reduction and cubitus valgus.

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