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ORIGINAL

Closed Reduction and Casting Versus K-wire Fixation of Gartland Type II Supracondylar Fracture Humerus in Children: Radiographic Outcome and Complications

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ABSTRACT

Background: Supracondylar fracture is the most common elbow fracture in children. There is substantial agreement on managing Gartland type I (conservative) and type III (operative) fractures. The treatment of type II fractures is still debatable. This study aimed to review the radiographic outcome and complications of type II supracondylar fractures in children treated by closed reduction & casting and closed reduction & K-wire fixation, respectively.

Methods: We retrospectively reviewed 61 children with type II fractures treated with closed reduction and casting (Group 1;32) and closed reduction K-wire fixation (Group 2;29). Radiographic outcomes and complications were analysed and compared between the two groups.

Results: Overall higher radiographic loss of reduction (LOR) was noted in group 1 compared to group 2 (40.62% vs 13.79%, *p*=0.0405). Higher LOR was observed in both IIA and IIB fractures in group 1, managed with closed reduction and casting (p=0.1257, *p=0.0437*).

We found higher LOR in group 1 with IIA fractures, where the anterior humeral line (AHL) was not intersected the capitellum (*p=0.0224*). We noted more complications in group 1 patients compared to group 2 (28.12% vs 17.24%, p=0.316), and most of these complications were due to reoperation following the loss of reduction.

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Conclusion: Higher LOR and complications were noted in type II fractures managed by closed reduction and casting (Group 1) alone. Our study supports K-wire fixation in some cases of type IIA fracture, where the AHL is not intersecting the capitellum and in all cases of type IIB fractures.

Keywords: Supracondylar fracture, Gartland type II, Closed reduction & casting, K-wire fixation, Radiographic outcome, Complications

Introduction:

Supracondylar humeral fractures are the most common elbow fractures among children and adolescents, about 85% of all elbow fractures [1]. These fractures typically occur transversely through the medial and lateral columns of the distal humerus [2]. This area of the bone is relatively weak because of the metaphyseal remodelling during the first 10 years of development; therefore, the incidence of this injury peaks between 5 to 8 years of age [2]. Gartland classified supracondylar fractures in type I (no displacement), type II (posterior displacement of the distal fragment without posterior hinge disruption) and type III (complete displacement) [3]. Wilkins modified this classification by dividing type 2 fractures into IIA (posterior displacement only) and IIB (displacement plus translation/rotation of the distal fragment) [4].

There is generally no controversy in the treatment of type I (conservative) and type III (surgical approach) supracondylar distal humerus fractures in children [5]. The treatment of type II fractures is, however, less well-defined. Although some authors have recommended treating all type II fractures operatively (reduction and pinning) to maintain reduction and avoid further deformity [6-8], others suggest treating some nonoperatively [9,10]. Some reported a higher risk of compartment syndrome and decreased range of motion (ROM) following nonoperative treatment; others reported satisfying clinical and radiological outcomes without exposing the patient to surgical and anaesthetic risks [8,11].

Wilkins modification has often been used to solve this dilemma, addressing type IIA to casting and type IIB to surgery; however, many doubts about the validity of this distinction. Several authors have reported low intra- and inter-observer agreement rates in distinguishing IIA and IIB [12,13]. Many of these fractures are stable after closed reduction and casting in 90°of flexion. If more than 90° of flexion is required to maintain reduction, fewer complications may be found with closed reduction and percutaneous pin fixation. Furthermore, percutaneous pin fixation is needed to address rotational deformities [14].

We are reporting our experience treating Gartland type II supracondylar fractures in children. The purpose of this study is to review the radiographic outcome and complications of Gartland type 2 supracondylar fractures in children treated by closed reduction & casting and closed reduction and k-wire fixation, respectively.

Materials and methods:

Sixty-one cases of Gartland type 2 fractures were retrospectively reviewed between January 2014 and July 2020. Data was collected from Electronic Medical records and PACS radiographs to identify demographics, side of the fracture, type of fracture, timing of surgery, type of fixation, number & size of K-wire, loss of reduction, pre-operative and iatrogenic neurovascular injuries, stiffness of elbow, number of weeks at K-wire removal, need for physiotherapy, cubitus varus deformity and other complications, numbers of weeks to final follow up.

Out of 61 cases, 32 children were treated with closed reduction and casting (Group 1) and 29 with closed reduction and cross or lateral wire fixation

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Table 1 Characteristics of all type II supracondylar fractures in Group 1 and Group 2

Variable	Closed reduction and casting (Group 1, n=32) *Mean/N/%/+/-SD*	Closed reduction and wire fixation (Group 2, n=29) *Mean/N/%/+/-SD*
Age Range	5.96+/- 1.42 (4-10 years)	6.17+/-1.94 (3-11Years)
Sex Boys Girl	 20 (62.5%) 12 (37.5%	 19 (65.5%) 10(34.5%)
Side Right Left	 17 (53.1%) 15 (46.%9)	 13 (44.8%) 16 (55.2%)
Fracture type IIa IIb	 22 (68.8%) 10 (31.3%)	 10 (34.5%) 19 (65.5%)
A/E presentation and surgery Interval <24hrs	 29 (90.6%)	 23(79.3%)
Pre op nerve injury	1(3.12%) (Ulnar N-sensory only)	0
Type of reduction Open Closed	 0 32	 0 29
Type of K-wire Fixation Cross Lateral	NA	10(34.5%) 19(65.5%)
Size of wire 1.6mm 2mm 1.6 mm & 2mm	NA	10(34.5%) 17(58.6%) 2(6.9%)
No of k wire 2 wires 3 wires	NA	25 (86.2%) 4 (13.8%)
Mean BA angle	73.96 (63-87 degrees)	73.65 (63-88 degrees)
Mean BA changes (3-6wks)	5.81+/- 4.76 degrees	4.13 +/- 3.79 degrees
Anterior Humeral Line (AHL) not intersecting capitellum (3-6wks)	10	4
Physiotherapy	7 (21.9%)	14 (48.3%)
Average follow-up	7.68 weeks (6-18)	11.48 weeks (6-36)

(Group 2). We excluded cases with type I and type III fractures, flexion type fractures, cases with inadequate follow-up or X-ray, and children under three years old.

Patients were reviewed in the follow-up clinic 5-9 days after the initial procedure for a complete cast and check X-ray. Both groups had a further x-ray done at 3-6 wks. We compared perioperative radiographs with postoperative radiographs taken at 3-6 weeks of all 61 children.

Loss of fracture reduction was determined by comparing the perioperative and post-operative follow-up x-ray. We reviewed radiographic loss of reduction (LOR) by evaluating changes in the Bauman angle (BA)>12 degrees in the coronal plane [15] and the Anterior humeral line (AHL) not intersect-

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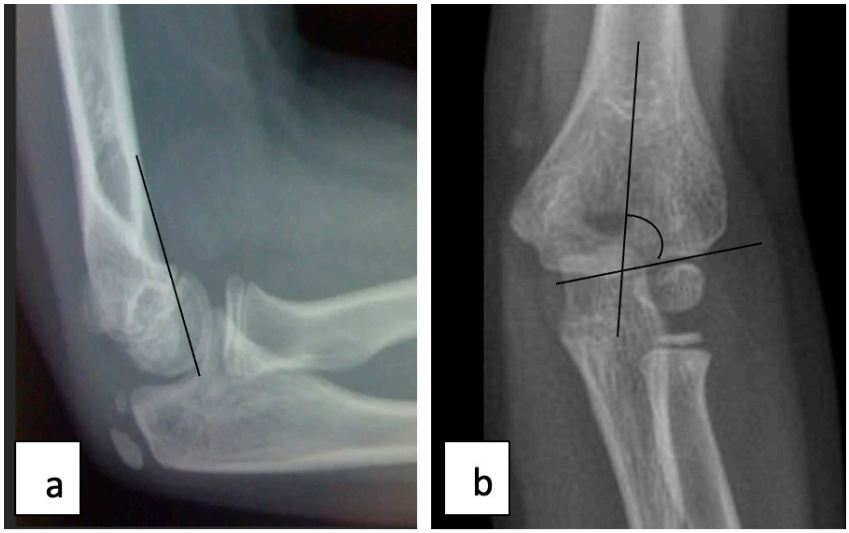

Figure 1 *a) Normal elbow X-ray –lateral radiograph showing Anterior Humeral line (AHL) intersecting capitellum. b) AP radiograph showing Bauman's angle*

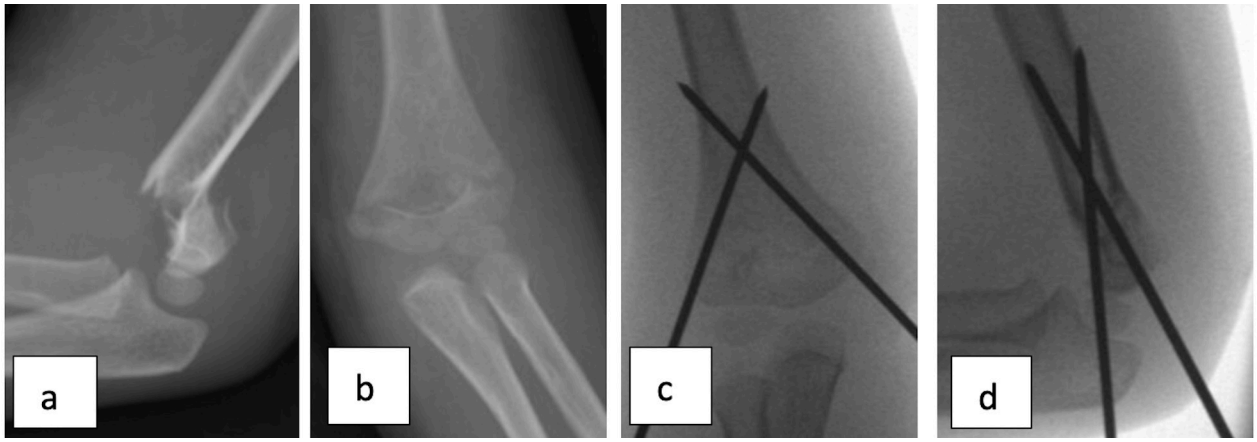

Figure 2 *(a, b) Pre-operative AP and lateral radiograph showing type IIb fracture. (c, d) Intraoperative AP and lateral radiograph showing adequate reduction and fixation with crossed K- wire*

ing capitellum in the sagittal plane (Figure 1) [15].

Statistical analysis was performed using open-source online resources. Data of all variables were analysed to determine differences between the closed reduction & casting and closed reduction & K-wire fixation group. Statistical significance was tested using Fisher exact test, and $P<0.05$ was set as the threshold for statistical significance.

Results

In group 1, the mean age was 6 years (range 4-10 years); there were 20 boys (62.5%) and 12 girls (37.5%), and the right arm was affected in 17 children (53.1%). In group 2, the mean age was 6.2 years (range 3-11 years); there were 19 boys (65.5%) and 10 girls (34.5%), and the right arm was affected in 13 cases (44.8%) (Table 1).

In group 1, 22 (68.8%) cases had Gartland IIA fractures, and 10 (31.3%) had Gartland IIB fracture.26 (81.3%) cases were treated with closed reduction and casting within 24hrs of presentation to the Emergency department.

In group 2, 10 (34.5%) cases had Gartland IIA fractures, and 19 (65.5%) had Gartland IIB fractures. 21(72.4 %) cases were operated (closed reduction and K-wire fixation) within 24hrs of presentation to

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Table 2 Loss of reduction in type II supracondylar fracture

Variable	Closed reduction and casting (Group 1, n=32) *Mean/N/%/+/-SD*	Closed reduction and wire fixation (Group 2, n=29) *Mean/N/%/+/-SD*	P value
Radiographic loss of reduction			
Yes	13(40.6%)	4 (13.8%)	***0.0404***
No	19	25	
IIA	7 (31.8%)	0	0.1257
IIB	6 (60%)	4 (21%)	***0.0437***

Table 3 Relationship of the preoperative intersection of AHL to capitellum and loss of reduction in closed reduction and casting (Group1)

	AHL intersecting capitellum	AHL NOT intersecting capitellum	P value
Radiographic loss of reduction in group 1 (Gartland 2A, n=22)			
Yes	1	6	*0.0224*
No	11	4	

of type IIA fractures. We found higher LOR in group 1 with IIA fractures, where the anterior humeral line (AHL) was not intersected the capitellum (p=0.0224) (Table 3).

the Emergency department. In Group 2, 19 (65.5%) cases were treated with lateral wire, and 10 (34.5%) cases were treated with crossed wire (Figure 2). Most commonly, the fracture was fixed with 2 wires (86.2%) using 2mm (58.6%) K-wires (Table 1).

Mean BA was 73.96 degrees (range 63-87 degrees) and 73.65 degrees (range 63-88 degrees) in group 1 and group 2, respectively. At 3-6 weeks follow up, mean changes in Bauman angle were 5.81degrees +/-SD 4.76 in group 1 and 4.13 degrees +/-SD 3.79 in group 2. At 3-6 weeks follow up, AHL was not intersecting capitellum in 10 (31.3%) cases in group 1, 4 (13.8%) cases in group 2, whereas BA changes >12 degrees in 3 cases in group 1 and none in group 2.

In our series, LOR was noted in 27.9% (17) cases. LOR was noted in 13 (40.6%) cases in group 1(Figures 3 and 4) and 4 (13.8%) cases in group 2. This was statistically significant (*p= 0.0405*) (Table 2).

We further analysed the LOR in group 1 cases. Higher LOR was observed in both IIA and IIB fractures in group 1, managed with closed reduction and casting (p=0.1257, *p=0.0437*) (Table 2).

In group 1, out of 13 cases with loss of reduction, 7 cases were type 2A (Figure 3), and 6 cases were type 2B (Figure 4). AHL was not intersecting the capitellum (Figure 3) in 6 cases

We reviewed all the complications in both groups (Table 4). Revision /reoperation (within three months) was done in 6 (18.75%) cases in group 1 but none in group 2. All instances of reoperation were due to loss of reduction. Remanipulation and casting were done in 4 cases, and 2 cases were treated with manipulation and K-wire fixation. One patient had the pre-operative ulnar nerve (only sensory) involvement in group 1, which improved fully in 6 weeks, but no pre-operative nerve injury was noted in group 2. There were no patients with vascular involvement or compartment syndrome in either group. Only one (3.4%) child had post-operative median nerve involvement in group 2, but none

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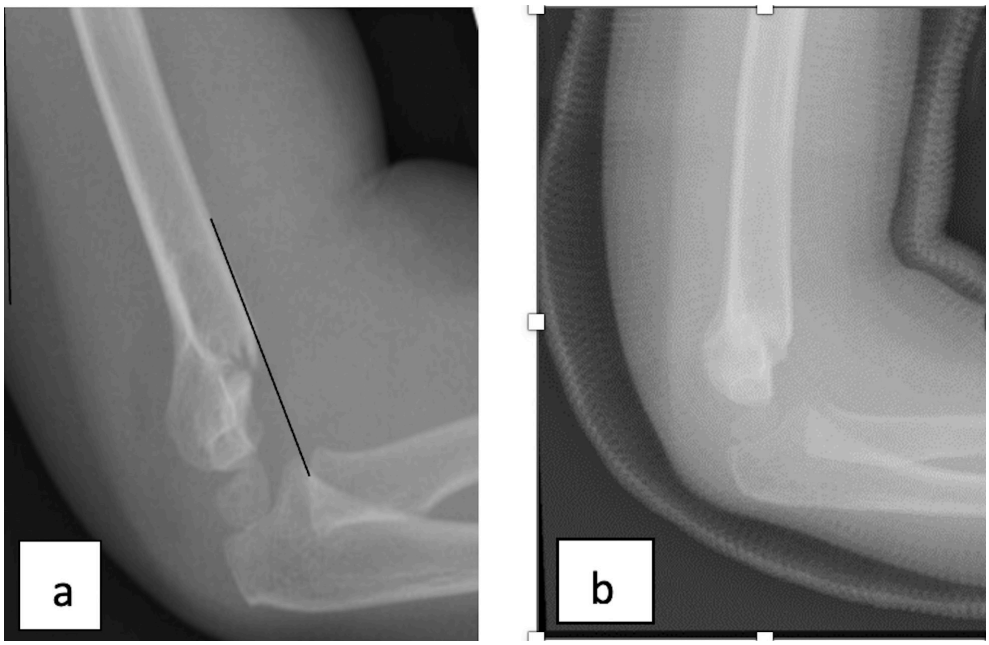

Figure 3 *a) Lateral radiograph showing type IIA fracture (AHL not intersecting capitellum). b) Lateral radiograph showing loss of reduction following closed reduction and casting*

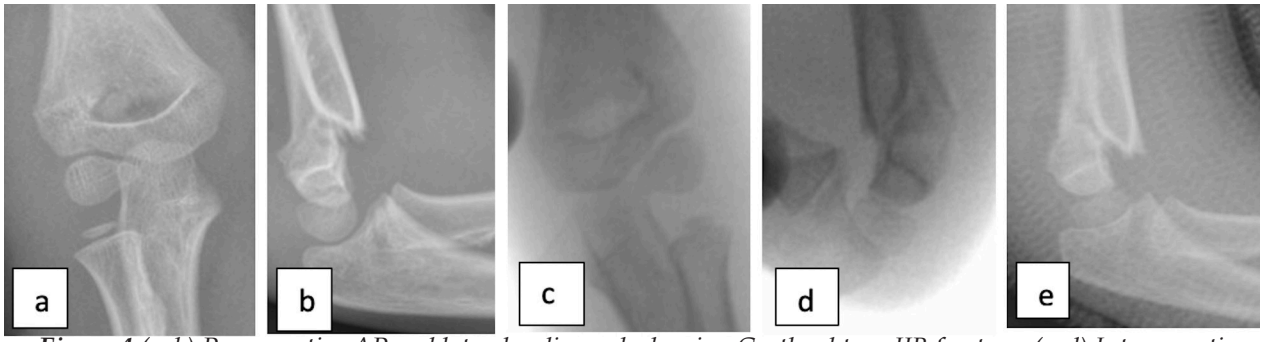

Figure 4 *(a, b) Pre-operative AP and lateral radiograph showing Gartland type IIB fracture. (c, d) Intraoperative AP and lateral radiograph showing adequate reduction (closed reduction and casting). (e) Lateral radiograph showing loss of reduction 3 weeks postoperatively*

was noted in group 1. It was resolved fully in 12 weeks. In 1 (3.4%) case, pin site infection was noted in group 2, treated with antibiotics. There was 1 (3.4%) case of cubitus varus in group 2 but none in group 1. Moderate elbow stiffness was noted in 1(3.4%) case in group 1 and 2 (6.9%) cases in group 2. Hyperextension was mentioned in 2(6.3%) cases in group 1 but none in group 2. None of the patients in our series had intraoperative complications related to anaesthesia. Higher overall complications were noted in group 1 compared to group 2 (28.1% vs 17.2%, p=0.316). The overall complication rate in our series with type II supracondylar was 23 %, and around 40 % were due to reoperation.

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Table 4 Complications in Group 1 and Group 2

	Closed reduction and casting (Group 1, n=32)	Closed reduction and wire fixation (Group 2, n=29)
Overall complications	9 (28.1%)	5 (17.2%)
Iatrogenic nerve injury		1(3.4%)
Elbow stiffness	1(3.12%)	2(6.9%)
Hyperextension	2 (6.25%)	0
Cubitus varus	0	1(3.4%)
Infection	0	1(3.4%)
Any Revision/reoperation procedure (within 3 months)	6 (18.8%)	0

Mean follow-up was 7.68 weeks (range 6-18 weeks) and 11.48 weeks (range 6-36 weeks) in group 1 and group 2, respectively.

Discussion

The treatment of Gartland type I and III fractures is commonly accepted as non-operative and operative treatment, respectively. However, controversy persists over the management of type II supracondylar fractures.

Overall, in our study, radiographic LOR was 27.9%. LOR was noted in 40.6% of group 1 and 13.8% of cases in group 2 (*P= 0.0405*). We recorded a LOR in the closed reduction and casting group higher than some of the reported literature. We further analysed the LOR in group 1 cases. Higher LOR were observed in IIA and IIB fractures in group 1, which were managed with closed reduction and casting (p=0.1257, *p=0.0437*). We also noted higher LOR in Group 1 with type IIA fracture where AHL did not intersect capitellum pre-operatively (Table 3).

Revision /reoperation (within 3 three months) was done in 18.8% of cases in group 1 (all due to loss of reduction) but none in group 2.

Lucas et al.[16] reported up to 48% chance of losing reduction without pinning for Gartland type 2 fractures. Parikh et al.[10] found that 28% of patients lost reduction after closed reduction and cast immobilisation. Hadlow et al.[9] reviewed 148 patients with type II supracondylar fractures treated with closed reduction and casting. Of these patients, 23% required a second procedure owing to loss of reduction (either re-manipulation with the placement of a new cast or closed reduction and pin fixation). In a retrospective review of 189 patients with type II supracondylar fractures treated nonoperatively, 21% of patients eventually underwent operative treatment [17]. Camus et al.[18] reported that 80% had radiographic evidence of extension deformity with long-term follow-up of 155 patients treated nonoperatively with cast immobilisation. In contrast, in a retrospective review of 189 cases of type II supracondylar fractures treated with percutaneous pin fixation, Skaggs et al. [8] found no loss of reduction. Most surgeons agree that Gartland type IIB fracture should be treated with K-wire fixation, but disagreement persists regarding the management of IIA fractures. In our study, we found a significantly higher loss of reduction of fractures in type IIA where AHL was not intersecting capitellum and in type IIB fractures treated without K-wire fixation.

Most type IIA fractures with AHL intersecting capitellum are stable after closed reduction and casting in 90° of flexion. However, if more than 90° of flexion is required to maintain reduction, fewer complications may be found with closed reduction and K-wire fixation.

In our cohort, one case had the pre-manipulation ulnar nerve (only sensory) involvement in group 1, which improved fully in 6 weeks, but none was noted in group 2. Only one (3.1%) child had (group 1) post-operative median nerve involvement, which was resolved fully by 12 weeks. Our finding is somewhat higher than previous reports (0%, 0/189

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Skaggs et al. [8]; 0.8%, 3/399 Larson et al.) [19].

In our series, there were no patients with vascular involvement or compartment syndrome in either group, and this is similar to other reported literature. Little data exist about the incidence of infection after percutaneous pinning, but rates up to 2.5% of superficial [8,21] and around 0.2% of deep[22] pin tract infections have been reported. Our series detected a single case (3.4%) of superficial pin site infection, successfully treated with oral antibiotics.

Moderate elbow stiffness was noted in 1(3.1%) case in group 1 and 2 (6.9%) cases in group 2. Hyperextension was mentioned in 2(6.25%) cases in group 1 but none in group 2. An extension malunion provokes an increase in extension and a lack of flexion. Hyperextension of the elbow causes only cosmetic problems. However, a lack of flexion can cause an inability to perform activities of daily living. It has been described that functional elbow motion is from 30° to 130°.

In our study, one patient (3.1%) developed cubitus varus deformity in group 2 but none in group 1. Most authors believe that cubitus varus is the consequence of malunion of the fracture rather than growth arrest. Angular deformity and rotational deformity are thought to cause cubitus varus deformity. Distal physis of the humerus has limited potential for remodelling. A child aged eight to ten years has only 10% of the total growth of the humerus remaining. While sagittal and coronal mild deformities can be remodelled in children aged < 4, rotational deformities cannot [23]. In literature, this percentage varies between 0% and 26.1% [24]; even though this deformity was considered an aesthetic problem, more recently, it has been linked to chronic pain [25], ulnar neuropathy [21], and late postero-lateral instability [25]. Hence, the best way to avoid cubitus varus seems to be to achieve and maintain anatomical reduction of the fracture with particular attention to replicating the contralateral rotation of the humerus.

Our study certainly has some limitations. It is a retrospective study, so it has some selection bias. Different surgeons have carried out procedures. No standard protocol was used; pin configuration depended on the surgeon's preference. Our patient sample size was relatively small, and we did not do long-term follow-up.

Conclusions:

Many studies support that satisfactory outcomes should be expected in closed reduction and casting or closed reduction & K-wire fixation management of Gartland type II supracondylar fractures as long as correct treatment criteria are known and applied.

In our study, higher radiographic loss of reduction (LOR) and complications were observed in type II fractures managed by closed reduction and casting alone. So current study indicates that the natural history of type II supracondylar is not entirely benign. It is essential to check the relationship of AHL to capitellum and the presence of any rotational deformities to decide the management of Gartland type II supracondylar fracture. Our study supports K-wire fixation in some cases of type IIA fracture, where the AHL is not intersecting the capitellum and in all cases of Type IIB fractures.

However, long-term prospective randomised studies comparing closed reduction and casting versus reduction and K-wire fixation are needed to define the best treatment options for Gartland type 2 supracondylar fracture in children.

Statements and Declarations:

Conflict of interest

The authors declared no potential conflicts of interest.

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Research involving human and animal rights statement

This article does not contain any studies with human or animal subjects.

Ethical approval

An ethics committee approval is not required for this study type.

Informed consent

No human subjects were used in this study which necessitates informed consent.

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