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THE OUTCOME OF THREE LATERAL DIVERGENT PINNING VS PARALLEL PIN FIXATIONS FOR THE TREATMENT OF DISPLACED SUPRACONDYLAR HUMERUS FRACTURES IN CHILDREN.

Orthopaedics

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ABSTRACT

Supracondylar humerus fracture is the most common type of elbow fracture in children younger than 15 years. This hospital based prospective study evaluated different pinning fixations which is used in the treatment of Gartland Type II and Gartland Type III supracondylar humeral fractures in children with closed fractures ≤7 days old, extension type, for comparing clinical, radiological and functional outcome of lateral parallel and divergent pinning for displaced supracondylar fractures in children.The study was conducted from May 2021 to May 2022. The mean age was 8.2 years for Divergent pinning group and for Parallel pinning group, the mean age was 9.2 years. Functional outcome were measured using Flynn's criteria & radiological outcome measured using Baumanns angle & carrying angle. Divergent pinning group had 12 males and 7 females while Parallel pinning group had 15 males and 5 females. The time interval between injury and surgery was less than 12 hours in 84.21% of Divergent pinning group & 95% in Parallel pinning group. In our study the duration of surgery was less than 35 minutes in 68.5% in Divergent pinning group and 85% in Parallel pinning group. Patients were followed up clinicoradiologically at 3 weeks, 6 weeks, 3 months & 6 months post operatively & assessed for elbow function, carrying angle, rate of union etc., during each follow up. In our study divergent pinning gave better results than parallel pinning as the latter encountered slower rate of union and varus deformities (loss of carrying angle and baumanns angle).

KEYWORDS

Supracondylar fracture humerus, Divergent, Parallel.

INTRODUCTION

Supracondylar humeral fracture is the most common type of elbow fracture in children younger than 15 years[1]. Children are susceptible to this fracture by reasons of the bending structure and the weak metaphyseal sclerotin of the distal humerus as well as the thin ridge of metaphyseal bone between the coronoid fossa and the olecranon fossa. The fracture is classified most commonly, according to Gartland's criteria as Gartland type I which is stable and not displaced, and varying degrees of displacement and angulation are present in Gartland type II and III fracture[2].These injuries can be one of the most difficult to treat, owing to the presence of associated immediate and late complications like compartment syndrome, neurovascular damage, Volkmans ischaemic contracture and malunion.[3] In Supracondylar humeral fractures the impact transmitted to the outstretched wrist causes the elbow to hyperextend when falls lead the olecranon to gather most of the impact at the humeral supracondylar and the axial force is converted to a bending force at this region, resulting in the extension-type supracondylar humeral fracture. And a fall on the olecranon with elbow flexion leads to the flexion-type supracondylar fracture. It has been reported that 98% of the patients with the supracondylar humeral fracture are extension-type fracture in children.[4]

The contents of comparisons included ulnar nerve injury caused by pin placement, loss of reduction according to the radiographic outcomes, elbow functional outcomes assessed by Flynn's criteria, and short-term complication, such as superficial infection, as well as long-term complication, for instance, cubitus varus.We hypothezied that Divergent pinning group has faster rate of union, stability and less complications compared to Parallel pinning.

MATERIALS AND METHODS

This is a Hospital based prospective study conducted in the department of Orthopaedics of Assam Medical College And Hospital, Dibrugarh. The study was conducted from May 2021 to May 2022 and the patients selected were children younger then 15 years old with Gartland Type II and Gartland Type III supracondylar humeral fractures which are closed and ≤ 7 days old, extension type. The exclusion criterias were Old fractures ≥8 days.Flexion type.Supracondylar fractures in ≥ 15 years of age.Gartland type I.Open fractures. Patient's parents/ guardians who denied informed consent.Patients presented with nerve injuries. Patients in which closed manipulation is not possible under anesthesia were excluded.

A detailed complete history including demographic data of the subject was taken. Type of pin configuration for the first patient was done on the basis of opaque envelope method. The patient enlisted with odd number in our study was treated with the same pin configuration as used for the first patient and the patient with even number in our study population was treated with the same pin configuration as used for the second patient. Thorough clinical examination and X-ray of elbow joint – AP and Lateral view and other blood investigations were done. Baumannn's angle was measured.

All the patients were operated in a supine position on a plain operation table either under regional or general anesthesia. No tourniquet was used. Pre-operatively all the patients were given a single shot of broad spectrum antibiotic through intravenous route. With the patient in the supine position, fracture was reduced by applying the traction on the forearm and the assistant giving counter traction by holding the humerus with elbow in extension. With the elbow in extension, rotational malalignment and medio-lateral translation are corrected. The elbow was then hyperflexed to 120 degrees using thumb pressure over the olecranon to reduce the fracture, and the forearm was then fully pronated to lock the posterior and medial soft-tissue hinges. And reduction of the fracture was confirmed under image intensifier. One

pin was placed into the distal fragment, beginning laterally, directed obliquely toward the medial column, and then driven across the olecranon fossa, fracture site and through the medial cortex of the distal humeral metaphysis proximal to the fracture site. This pin was expected to have the same effect as a medial entry pin.

The first pin was inserted routinely across the olecranon fossa. The second pin was positioned up the lateral column in a direction divergent or parallel to the first, which maximizes pin separation at the fracture site. This was the key point of this procedure. If there was still significant motion, a third pin was inserted between the first and second pins. The extra length of K-wires was cut and tip of the remaining wires was bent outside the skin. After K-wire fixation a posterior plaster of Paris splint was applied for 3 weeks in all the patients followed by a check X-ray immediately after the surgery.[5]

Post-operative Protocol:
Intravenous analgesic and antibiotics were administered for the first 24 h after the surgery. A routine check radiograph including AP and lateral views of the operated elbow were done on the next morning in all the patients. On the next day all the patients were switched to oral analgesics and antibiotics. Patients were routinely discharges on the second post-operative day.

Follow up and outcome assessment :
All the patients were called for routine follow-up in the outdoor department for clinicoradiological assessment of union and for any possible complication at 3weeks, 6weeks, 3months & 6months. After 3 weeks POP splint was removed in all the patients and elbow range motion were started. Removal of K-wires was done after confirmation of clinico-radiological union at the fracture site.

Final assessment of the results was done according to Flynn's criteria based on motion loss and carrying angle (Functional outcome) & Baumann's angle (Radiological outcome).

Statistical Analysis:
The statistical analysis of data was performed using the computer program, Statistical Package for Social sciences (SPSS for Windows, version 20.0.Chicago, SPSS Inc.) And Microsoft Excel 2010. Results on continuous measurements are presented as mean+ standard deviation are compared using the student's t-test. Discrete data are expressed as numbers (%) and are analyzed using the Chi-square test and Fischer's exact test (where the cell counts <5 or 0). For all analyses, the statistical significance was fixed at 5% level ($p<0.05$).

RESULTS:
In our study the age at injury varied from 3 years to 15 years for DP group with a mean age of 8.2 years and 4 years to 14 years for PP group with mean age group of 9.2 years. out of 19 patients in group DP 12 were boys (63.16%) & 7 were girls (36.85%). In group PP among 20 patients , 15 were male patients (75%) and 5 were female patients (25%). Gartland type III, 17 in DP group (85%) & 15 in PP group (75%) & Others were gartland type II injuries.

The time interval between injury and surgery was less than 12 hours in 84.21% of DP Group & 95% in PP Group. In our study the duration of surgery was less than 35 minutes in 68.5% in DP group and 85% in PP Group. In our study we encountered no pin tract infections, which is a good outcome clinically and statistically in both the DP & PP groups.

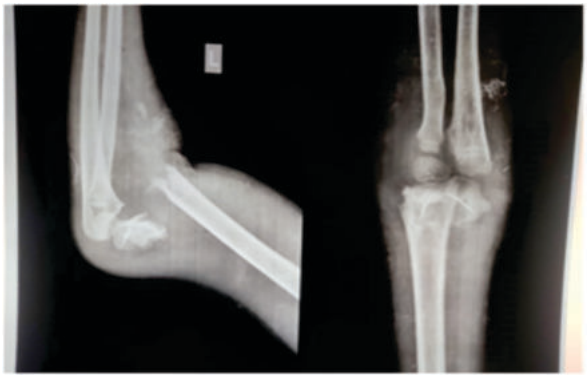


Fig 1- Pre Operative X Ray Images Lateral And Anterio-posterior View.

Fig 2-Typical 'S' shaped deformity of elbow.

Fig 3 Immediate Post Op X Rays Showing 2 Pins Running In Parallel Manner

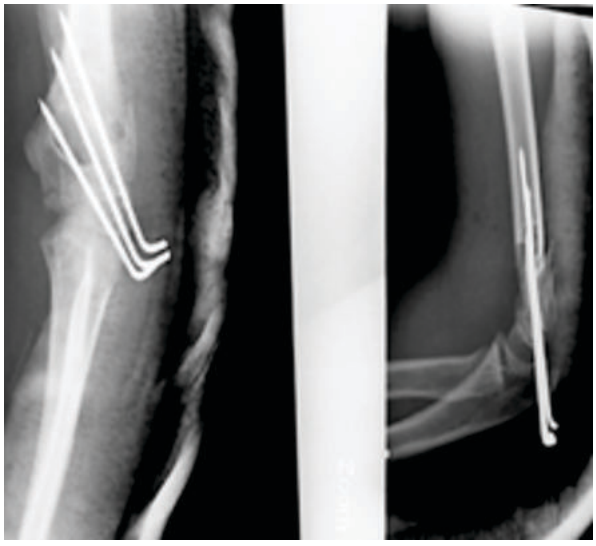


Fig 4 Immediate Post Op X Rays Showing 3 Pins Running In Divergent Manner.

Varus deformity is the most common complication associated with Supracondylar fractures regardless the type of fracture, which is manisfested in our study, as 2 patients developed varus deformity in PP group whereas no one developed it in the DP group. No cases were manifested with valgus deformity in our study in both DP & PP Groups. In our study, we had no ulnar nerve or radial nerve injury in both DP & PP groups. The mean time of union in our study was found to be 3.84 ± 0.360 in DP & 4.45 ± 1.10 in PP group. This showed clearly that DP had a faster rate of union clinically and radiologically compared to PP group**.** In our study, mean loss of Baumann's angle at the end of three months was found to be 2.38 ± 0.78 with DP and 3.80 ± 2.40 with PP.

The functional outcome was measured by motion loss in degrees. At 3 weeks the mean motion loss with DP is 11.84 ± 2.99 and with PP is 11.80 ± 6.07. At 6 weeks the mean motion loss is 8.32 ± 4.42 with DP and 10.30 ± 5.20 with PP. At 3 months the mean motion loss with DP is 6.79 ± 4.09 and with PP is 9.74 ± 4.56. At 6 months the mean motion loss is 5.37 ± 3.74 with DP and 8.25 ± 4.67 with PP Group.

Table 1- : Mean Functional Outcome (Motion Loss)

Motion Loss (in degrees)	Lateral Divergent		Parallel pin fixations		p value*
	Mean	±S.D.	Mean	±S.D.	
At 3 weeks	11.84	2.99	11.80	6.07	0.9784
At 1½ months	8.32	4.42	10.30	5.20	0.2085
At 3 months	6.79	4.09	9.74	4.56	0.0430
At 6 months	5.37	3.74	8.25	4.67	0.0408

The cosmetic factor loss of the carrying angle was measured in degrees. At 3 weeks the mean cosmetic factor loss with DP is 9.05 ± 2.55 and with PP is 11.10 ± 5.78. At 6 weeks mean cosmetic factor loss is 5.68 ± 1.95 with DP and 9.80 ± 5.98 with PP. At 3 months the mean cosmetic factor loss with DP is 3.74 ± 2.51 and with PP is 9.40 ± 5.83. At 6 months the mean cosmetic factor loss is 3.47 ± 2.67 with DP and 8.00 ± 5.48 with PP. The results using Flynn's criteria which is 57.89% satisfactory at 3 weeks, 89.47% satisfactory at 6 weeks and 3 months, 94.74% satisfactory at 6 months in DP group. 55% unsatisfactory at 3 weeks, 55% satisfactory at 6 weeks, 70% satisfactory at 3 months and 70% satisfactory at 6 months in PP group.

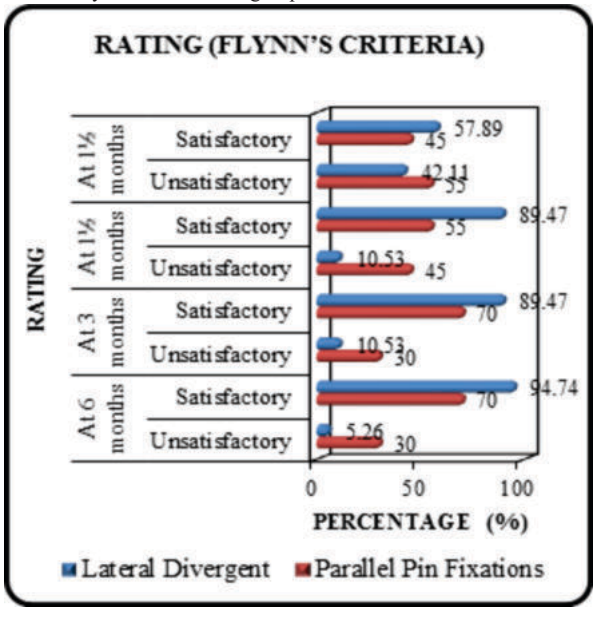
Table 2- Mean Cosmetic Factor (loss Of Carrying Angle)

Loss Of Carrying Angle (in degrees)	Lateral Divergent		Parallel Pin Fixations		p value*
	Mean	±S.D.	Mean	±S.D.	
At 3 weeks	9.05	2.55	11.10	5.78	0.1649
At 1½ months	5.68	1.95	9.80	5.98	0.0069
At 3 months	3.74	2.51	9.40	5.83	0.0004
At 6 months	3.47	2.67	8.00	5.48	0.0025

Table 3- Flynn' Criteria

Results	Cosmetic factor (Loss of carrying angle in degrees)	Functional factor (Loss of motion in degree)
Excellent	<5	<5
Good	6-10	6-10
Fair	11-15	11-15
Poor	>15	>15

The results using Flynn's criteria which is 57.89% satisfactory at 3 weeks, 89.47% satisfactory at 6 weeks and 3 months, 94.74% satisfactory at 6 months in DP group. 55% unsatisfactory at 3 weeks, 55% satisfactory at 6 weeks, 70% satisfactory at 3 months and 70% satisfactory at 6 months in PP group.6666



DISCUSSION:

The treatment of supracondylar fractures aims to restore anatomical or near anatomical reduction, early restoring elbow function with good ROM, avoid complications like neurovascular, deformity, elbow stiffness.

Studies have shown an increased incidence of iatrogenic ulnar nerve injury when a medial wire is used. Skaggs *et al* (2013) observed no loss of reduction when comparing two groups using crossed wires and lateral wires[6].

The lateral technique in the literature is itself not without iatrogenic nerve problems. Foead *et al*. recognised no loss of position comparing medial/lateral pin fixation to lateral pin fixation.[7]

In our study the age at injury varied from 3years to 15 years for DP group with a mean age of 8.2 years and 4 years to 14 years for PP group with mean age group of 9.2 years, which was comparable to Mahar *et al*[8], who noted the average age to be 8.9 years. Lee *et al* noted the average age to be 5 to 6 years.[9] Gopinathan *et al* noted the average age to be 7.6 years.[10] Ahmed *et al* found it to be 5.1 years.[11] Witit *et al* found it to be 6.3 years.[12]

In our present study, out of 19 patients in group DP 12 were boys (63.16%) & 7 were girls (36.85%). In group PP among 20 patients , 15 were male patients (75%) and 5 were female patients (25%) ,which was comparable to similar studies like Noora *et al* who noticed the gender distribution to be 61% in boys and 59% in girls.[13] Ritesh *et al* (2021) who noticed the gender distribution to be 77% in boys and 33% in girls.[14]

In our study the most common type of fractures treated were Gartland type III, 17 in DP group (85%) & 15 in PP group (75%) & Others were gartland type II injuries which was comparable to Lin guo *et al*,[15] Lu *et al*[16].

The time interval between injury and surgery was less than 12 hours in 84.21% of DP Group & 95% in PP Group. Ramachandra *et al* observed it to be 8.9 hours as average in his study.[3] Hai zhou *et al* observed it to be 9.8 hours in his study.[17]

In our study we encountered no pin tract infections. This observation in our study was comparable to Ritesh *et al* who noted only one patient developing pin track infection among the 18 patients (5%) he studied.[14] Krishna *et al* (2018) observed 4 out of 35 patients he studied had developed pin track infections (11%).[18]

In our study, as 2 patients developed varus deformity in PP group whereas no one developed it in the DP group. However, Mahar *et al*,[8] (2002) stated varus stiffness was greatest with divergent lateral pins. No cases were manifested with valgus deformity in our study in both DP & PP Groups. Abuzer *et al* noted no valgus deformity in his study.[19] Several other studies too stated no valgus deformity after lateral pinning in children who had supracondylar fractures.

In our study, we had no ulnar nerve injury in both DP & PP groups. This is similar to Hai Zhou *et al* in which no ulnar nerve injury was encountered.[17] Only one patient in the study of Abuzer *et al* (2020) developed ulnar nerve injury which recovered completely later on.[19]

In our study, the functional outcome was measured by motion loss in degrees.At 3 weeks the mean motion loss with DP is 11.84 ± 2.99 and with PP is 11.80 ± 6.07. At 6 weeks the mean motion loss is 8.32 ± 4.42 with DP and 10.30 ± 5.20 with PP. At 3 months the mean motion loss with DP is 6.79 ± 4.09 and with PP is 9.74 ± 4.56. At 6 months the mean motion loss is 5.37 ± 3.74 with DP and 8.25 ± 4.67 with PP Group. This was comparable to the study by Ahmed *et al* who found it to be 3.2±1.2 in DP & 3.1±2.1 in PP group.[11] Both the study results are found to be excellent at 6 months of follow up.

In our study, the mean carrying angle loss in DP is 2.38 ± 0.78 and PP is 3.80 ± 2.40, whereas by Gopinathan *et al*, the mean carrying angle was found out to be 9.21.[10]

The rating based on the Flynn's criteria is good at 3 & 6 weeks and excellent at 3 & 6 months in DP group. It shows fair at 3 weeks, good at 6 weeks, 3 months & 6months in PP group. This is similar to Ahmed *et al*[20] in which according to Flynn`s criteria following lateral divergent pinning, excellent results were found in 14 cases (93.33%), and good results in 1 case (6.67%). Following lateral parallel pinning, excellent results were found in 13 cases (86.67%), and good results in 2 cases (13.33%).

Limitations-

It is a Hospital-based prospective study without a long term follow up. So, we cannot find the long term effect of the treatment in the children and the sample size is also relatively small.

CONCLUSION:

Our study demonstrates that both lateral divergent and parallel pin

fixations are effective and safe for avoiding iatrogenic ulnar nerve injury and are appropriate treatment options for displaced or angled supracondylar humeral fractures in children, which is relatively simple and uncomplicated. There was a statistically insignificant difference between lateral divergent and parallel pinning technique in terms of stability, duration of bone healing, loss of reduction and neuro-vascular injuries at 3 & 6 months. However in our study divergent pinning gave better results than parallel pinning as the latter encountered slower rate of union and varus deformities (loss of carrying and baumanns angle). Both techniques are good options for providing stable fixation of displaced or angled supracondylar humeral fractures in children.

Recommendation:

We hypothesized that children undergoing lateral divergent pinning showed faster rate of union, functional stability & less complications compared to children undergoing lateral parallel pinning for the treatment of displaced supracondylar humerus fractures in children. To better illustrate the study a longer duration follow upwill help us in finding out various complications such as nerve injuries, deformity.

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