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Case Series

Mid-term clinical and radiological outcomes of patients with type III supracondylar humerus fracture treated with cross pinning *versus* lateral only pinning technique-A randomized study

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Statistics

Figures	05
Tables	05
References	29

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Abstract

Background: Closed reduction and percutaneous K-wire pinning is the standard management of type III supracondylar humerus fracture, however there is still lack of consensus with regards to optimal pinning technique (crossed *vs* lateral only pinning). The aim of the present study was to assess and compare functional and radiological outcome in these fracture patients treated with cross pinning vs lateral only pinning till mid-term follow up.

Methods: A randomized study was conducted on all eligible pediatric patients with Gartland type III supracondylar fracture treated with cross pinning (Group I, n=29) and lateral only pinning (Group II, n=31) at a single tertiary care center between February 2016 and April 2019. The continuous variables were assessed using the independent student t test while the Chi square test was used to analyze the categorical data. The Flynn's criteria at each follow-up were assessed using the Analysis of Variance (ANOVA) test. Level of significance was set at 5% and all p-values less than 0.05 were treated as significant.

Results: A Sixty patients met the inclusion criteria with a Mean age of 6.86 ± 2.40 years. In Group I, excellent outcomes were observed in 79.3% (functional) and 75.9% (cosmetic) of patients; while in Group II, excellent outcomes were seen in 80.6% (functional) and 77.4% (cosmetic). The average surgical time in Group II (32.781 ± 11.056) was significantly less compared to that in and in Group I (42.844 ± 20.100) (t=2.481, p=0.016). No significant difference was seen with respect to functional outcome of Flynn's criteria at final follow up, although cosmetic outcome was significantly better in Group II.

Conclusion: Both cross pinning and lateral only pinning techniques are preferable and provide stable fixation of SCH fracture with comparable outcomes. Moreover, lateral only pinning is less time consuming and avoids iatrogenic ulnar nerve injury.

Keywords: supracondylar humerus, K-wire pinning, gartland classification, flynn criteria, fracture

INTRODUCTION

Supracondylar Humerus (SCH) fracture is one of the most common fractures seen in paediatric age group accounting for 50%-70% of all elbow fractures and 30% of all extremity fractures [1-3]. These fractures mostly occur in mean age group of 5-6 years with the incidence being more common in boys than girls in most studies [4]. SCH fractures are broadly divided into two broad categories: flexion and extension type. Gartland sub-classified extension type fractures as undisplaced (Type I), partially displaced with intact posterior hinge (Type II) and completely displaced (Type III) [5]. This classification system has stood the test of time to help decide various treatment options. Wilkins further classified Type III fractures on the basis of coronal displacement as Gartland IIIA-posteromedial and IIIB-posterolateral type respectively [6,7].

Depending upon the fracture type management of SCH fracture can be either conservative or operative. For extension type III SCH humerus fracture standard treatment is closed reduction and percutaneous pin fixation using Kirschner (K) wires [6]. This can be achieved with either crossed pins (with at least one pin inserted from medial and lateral epicondyle each) or from lateral only entry pins [8]. However, optimal pin configuration to achieve maximum fixation stability is still debatable [6,8,9]. Although earlier biomechanical studies have shown that conventional cross pinning technique provides enhanced fixation stability as compared to lateral only pins, they are associated with increased incidence of ulnar nerve damage of upto 6%, a complication not encountered with lateral only entry pins [10].

The primary objective of the present study was to assess the functional and radiological outcome of type III SCH fractures treated with cross pinning *versus* lateral only pinning at minimum 2 years follow-up. The secondary objective was to compare the complications and surgical variables associated with both the techniques.

Our hypothesis was that the lateral only pinning would have similar outcomes as the cross pinning technique with fewer complications.

MATERIALS AND METHODS

The present trial was performed as per the CONSORT checklist [11].

STUDY DESIGN AND POPULATION

The study commenced after Institutional Ethics Committee approval was granted (N-EC/2016/02/18). Written informed consent for the study was obtained from the patients' guardians. This prospective randomized study was conducted on all paediatric patients undergoing percutaneous K-wire pinning for SCH fracture at a tertiary care center between February 2016 and April 2019. Out of 153 paediatric supracondylar humerus fractures who presented during to emergency department during the study period, 60 patients were included in the study (Figure 1).

INCLUSION AND EXCLUSION CRITERIA

All the paediatric patients with extension type III SCH fractures as per modified Gartland classification system were included in the study. Patients with type I and II fracture, compound fractures, associated ipsilateral arm or forearm fractures and those with associated neurovascular deficit were excluded.

SAMPLE SIZE CALCULATION

A pre-hoc analysis was carried out based on a previous study reference [12]. In order to achieve 80% power, at a 5% level of significance and at the absolute margin of error as 1.25, the pooled estimate of common standard deviation as 3.5 and 3.3 as the variability in the outcome of interest, a minimum required sample size was 27. Assuming a 5% dropout rate the minimum required sample size was 29.

RANDOMIZATION PROCESS

A block randomization technique was used in the present study (block 4, randomization). The envelopes were opened in the operation theatre after closed reduction of the fracture was attempted. The whole process of randomization was done by a person who was not part of the study. Thus, the patient was divided into Group I (cross pinning) and Group II (lateral only pinning) based on the primary technique used.

DATA COLLECTION

Demographic characteristics of patients such as age, gender, mechanism of injury, fracture side and hand dominance were recorded. A detailed history and thorough clinical examination with careful assessment of neurovascular status was performed on all patients. Radiographs of injured elbow in Antero-Posterior (AP) and lateral views were obtained to determine fracture pattern and enable its classification. Surgery related variables including time from injury to surgery (time to surgery), duration of surgery and operative complications were also recorded. Time to surgery referred to the time calculated from injury till the start of surgery and was divided as early (<8 hours) or late (≥ 8 hours).

SURGICAL TECHNIQUE

All surgeries were performed by two senior trauma surgeons, 1 and 2. With patient in supine position under general anesthesia, the affected arm was placed on a side-arm board away from the torso to aid visualization under image intensifier prior to surgical preparation of operative site. Initially traction was applied with the elbow in slight flexion to avoid tethering of neurovascular structures over the edge of proximal fracture fragment. Following this the elbow was hyper-flexed while simultaneous pushing the olecranon in anterior direction. Rotation of distal fragment especially internal rotation is frequently associated with unstable fracture patterns. To correct this, selectively pressing on the medial side and pronation of the forearm while hyper-flexing the elbow aided in reduction. An opposite manoeuvre was performed for externally rotated distal fragment. An AP, lateral and Jones view to visualize medial and lateral columns were taken to confirm satisfactory reduction. Two 1.6 mm or thicker K-wires were used for stabilizing the fracture.

MEDIAL ENTRY PINNING TECHNIQUE

The medial pin of the crossed pin configuration was inserted through a minimal medial incision approach. After making a small stab incision over the medial epicondyle and blunt dissection the pin was inserted as anterior as possible under direct vision with elbow in semi-flexed position (45°-60°) in order to avoid iatrogenic ulnar nerve injury. Lateral entry pinning technique: The lateral pin was inserted from the lateral epicondyle with the elbow hyper-flexed, one directed up the lateral column and other towards the medial column. An additional lateral only third pin was inserted if fracture stability on intra-operative fluoroscopy was found to be inadequate.

Both medial and lateral entry pins were made to cross the opposite cortex for better fixation stability. After verifying acceptable alignment on image intensifier the pins were cut shortened and an above elbow cast was applied in 90° of elbow flexion. Patients were discharged after 24 hours provided there were no post-operative complications.

POST-OPERATIVE PROTOCOL

Post-operatively radiographs were taken routinely at 1 week followed by at 6 weeks. All K-wires were removed after 4 weeks and cast was continued till 6 weeks at which time range of motion of elbow was commenced. (Figures 1 and 2).

DATA COLLECTION AND ASSESSMENT

All the data was electronically collected and stored in Microsoft Excel spreadsheet (Microsoft Excel© 2019 Version 16.0, USA). The primary objective of functional assessment was done using the Flynns' criteria consisting of functional and cosmetic component at 12 weeks, 24 weeks,

Fig. 1. (a): Palpable Gartland Type III Supracondylar fracture Antero-posterior and Lateral views; (b): cross pinning technique; (c): post-operative follow up radiograph at 12 weeks

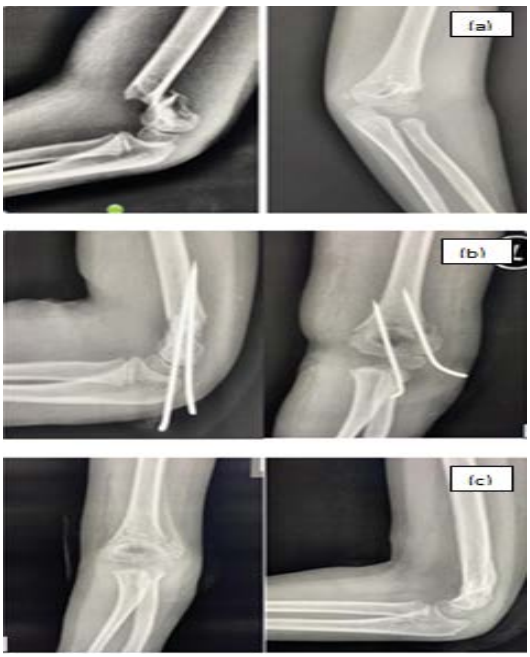

Fig. 2. (a): Gartland Type III Supracondylar fracture Antero-posterior and Lateral views; (b): lateral pinning technique; (c): post-operative follow up radiograph at 12 weeks

52 weeks and 104 weeks post-operatively [3]. The functional component of Flynns' criteria is a measure of the arc of motion in sagittal plane, while the cosmetic component measures the carrying angle indicating coronal plane deformity at the elbow joint. Each component was rated as excellent, good, moderate and poor at an interval of five degrees. Subjects with poor rating were classified as having unsatisfactory outcome with loss of motion of >15° or carrying angle loss of >15°. The radiological outcome was assessed with regards to time required for fracture to unite on AP and lateral elbow radiographs. For the secondary objective, factors such as time between injury and surgery, surgical duration, stay in hospital and complications associated with both the techniques were assessed.

STATISTICAL ANALYSIS

The statistical analysis was done using IBM SPSS Statistics for windows version 26.0 (Chicago Inc.). The qualitative variables were presented as frequency and percentage and quantitative variables were summarized as mean and standard deviation. The continuous variables were assessed using the independent student t test while the Chi square test was used to analyze the categorical data. The Flynn's criteria at each follow-up were assessed using the Analysis of Variance (ANOVA) test. The differences were shown in box plots wherever applicable. Level of significance was set at 5% and all p-values less than 0.05 were treated as significant.

RESULTS

In the present study 60 patients met the inclusion criteria and were included. The demographic characteristics were as described in Table 1.

Comparison of surgery related variables between both the groups is shown in Table 2. No significant difference was seen with respect to functional outcome of Flynn's criteria at final follow up. Nevertheless, the cosmetic outcome was significant indicating better results in group II. The average surgical time in group I was 42.844 ± 20.100 and in group II was 32.781 ± 11.056 indicating that the surgical time in group II was significantly less as compared to that in group I (t=2.481, p=0.016). The results are also shown (Figure 3). No significant difference between the two groups was observed for variables including time between injury and surgery, stay in hospital and fracture union. The association between pin configuration and time to surgery is further represented in Table 3. The Association was tested using Chi-square test and results indicate that there was no significant association between the pin configuration and time between injury and surgery (Chi-square=1.08, p=0.29).

The result using Flynns' criteria at final follow up in both the groups is shown in Table 4. In group I patients, excellent outcomes were observed in 79.3% (functional) and 75.9% (cosmetic); while in group II subjects excellent outcomes were seen in 80.6% (functional) and 77.4% (cosmetic). The Flynns' criteria were also assessed for group I and II separately and compared between follow up visits in each group

Table 1. Demographic Information of Study Participants (n=60)

Variable		Cross Pinning technique (n=29)		Lateral Pinning technique (n=31)		Total (n=60)	
		n	%	N	%	N	%
Age (Years)	Mean ± SD	6.86 ± 2.53		6.03 ± 2.22		6.43 ± 2.40	
Sex	Male	18	62.1	18	58.1	36	60
	Female	11	37.9	13	41.9	24	40
Side	Right	16	55.2	15	48.4	31	51.7
	Left	13	44.8	16	51.6	29	48.3
Dominant Side	Right	23	79.3	21	67.7	44	73.3
	Left	6	20.7	10	32.3	16	26.7
Mechanism	Fall	24	82.8	27	87.1	51	85
	RTA	5	17.2	4	12.9	9	15

Table 2. Comparison of surgical variables in both groups

Variable	Group	N	Mean	SD	SEM	t-stat	p-value
Time to Surgery	Cross Pinning	29	10.788	5.679	1.055	1.878	0.065, NS
	Lateral Pinning	31	8.331	4.413	0.793		
Surgical time	Cross Pinning	29	57.931	17.198	3.194	9.156	<0.001**
	Lateral Pinning	31	26.581	7.974	1.432		
Stay in hospital	Cross Pinning	29	4.241	1.64	0.305	-0.339	0.736, NS
	Lateral Pinning	31	4.387	1.687	0.303		
Union (Weeks)	Cross Pinning	29	15.672	2.417	0.449	0.29	0.773, NS
	Lateral Pinning	31	15.49	2.443	0.439		
Flynn (Functional) 6 weeks	Cross Pinning	29	4.69	3.577	0.664	-0.317	0.753, NS
	Lateral Pinning	31	4.935	2.351	0.422		
Flynn (Cosmetic) 6 weeks	Cross Pinning	29	4.897	3.244	0.602	-1.086	0.282, NS
	Lateral Pinning	31	5.742	2.781	0.499		
Flynn (Functional) 24 weeks	Cross Pinning	29	4.379	3.427	0.636	0.033	0.974, NS
	Lateral Pinning	31	4.355	2.317	0.416		
Flynn(Cosmetic) 24 weeks	Cross Pinning	29	3.931	3.173	0.589	-2.107	0.039*
	Lateral Pinning	31	5.516	2.644	0.475		
Flynn (Functional) 52 weeks	Cross Pinning	29	4.241	3.291	0.611	0.666	0.508, NS
	Lateral Pinning	31	3.742	2.49	0.447		
Flynn (Cosmetic) 52 weeks	Cross Pinning	29	3.793	2.782	0.517	-2.106	0.040*
	Lateral Pinning	31	5.258	2.607	0.468		
Flynn (Functional) 104 weeks	Cross Pinning	29	3.897	3.233	0.6	0.338	0.737, NS
	Lateral Pinning	31	3.645	2.511	0.451		
Flynn (Cosmetic) 104 weeks	Cross Pinning	29	3.759	2.773	0.515	-1.356	0.180, NS
	Lateral Pinning	31	4.71	2.661	0.478		

**: Significant at 1% level of significance, NS: Not Significant

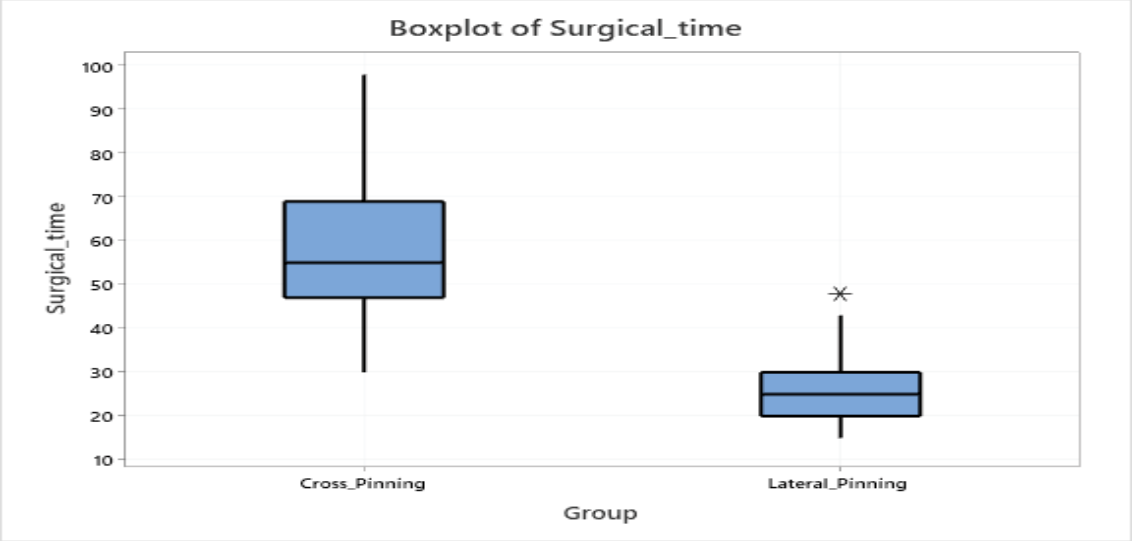

Fig. 3. Comparison of 'surgical time' between both the groups

Table 3. Association between 'pin configuration' and 'time to surgery'

Group	Time to Surgery		Total
	< 8 hrs	≥ 8 hrs	
Cross Pinning	12 (41.4%)	17 (58.6%)	29 (100%)
Lateral Pinning	17 (54.8%)	14 (45.2%)	31 (100%)
Total	29 (48.3%)	31 (51.7%)	60 (100%)
Chi-square=1.087, p=0.297, Not Significant			

(Table 5). A significant difference in the mean Flynns' functional as well as cosmetic component scores was observed between 6 weeks and 24 weeks while no significant difference was observed at subsequent follow ups (Figure 4). The results are also depicted in Figure 5.

Table 4. Post-operative outcomes using Flynns' criteria at final follow up

Component	Result	Rating	Group I (n=29)	Group II (n=31)
Functional (Motion loss in degrees)	Satisfactory	Excellent	23(79.3%)	25(80.6%)
		Good	4(13.8%)	3(9.7%)
		Moderate	1(3.4%)	2(6.4%)
	Unsatisfactory	Poor	1(3.4%)	1(3.2%)
Cosmetic (carrying angle loss in degrees)	Satisfactory	Excellent	22(75.9%)	24(77.4%)
		Good	4(13.8%)	4(13%)
		Moderate	2(6.9%)	2(6.4%)
	Unsatisfactory	Poor	1(3.4%)	1(3.2%)

Table 5. Flynns' criteria scores at various follow up visits for each group

Group	Component	Follow up visit (weeks)	N	Mean	SD	F-stat	P-value
I (Crossed pins)	Functional	6	29	4.691	3.577	3.27	0.034, NS
		24	29	3.379	3.427		
		52	29	4.241	3.291		
		104	29	3.897	3.233		
	Cosmetic	6	29	4.897	3.244	3.27	0.034*
		24	29	3.931	3.173		
		52	29	4.793	2.782		
		104	29	3.759	2.773		
II (Lateral only pins)	Functional	6	31	4.935	2.351	3.91	0.024*
		24	31	3.155	2.317		
		52	31	3.742	2.49		
		104	31	3.645	2.511		
	Cosmetic	6	31	5.742	2.781	3.785	0.031*
		24	31	4.216	2.644		
		52	31	5.258	2.607		
		104	31	4.71	2.661		

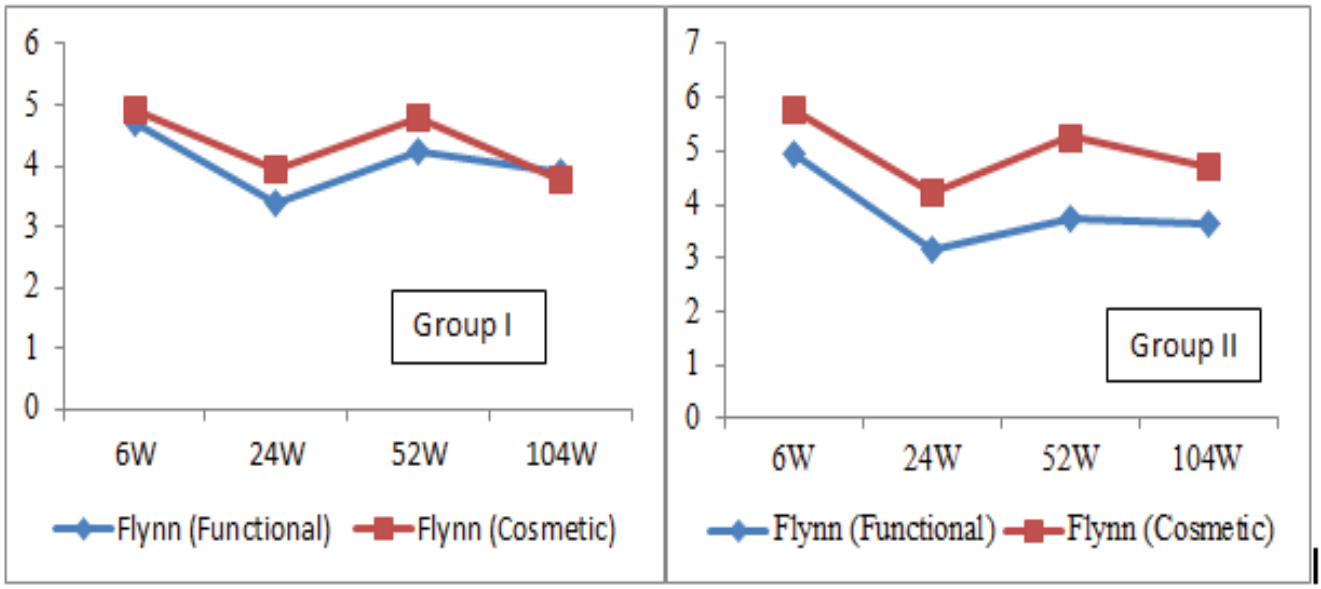

Fig .4. Comparison of mean Flynns' scores at each follow up in each group

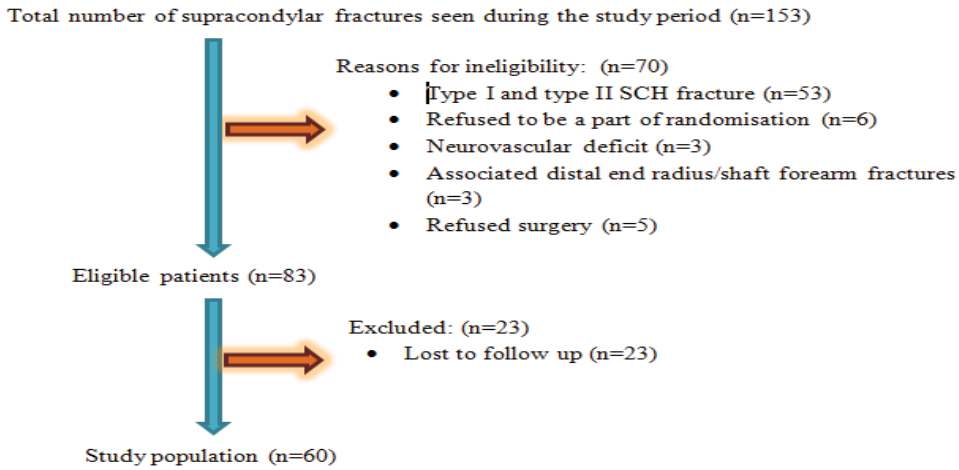

Fig. 5. Flowchart showing patient enrolment and follow up

DISCUSSION

In the present study, excellent outcomes using the Flynn's criteria were seen in more than three-fourth of patients in both the groups which are similar to results reported by Kocher, et al. who reported excellent outcomes in 79.1% of patient undergoing cross pinning and 82.1% of patients undergoing lateral only pinning [6]. Moreover, no superiority amongst either type of pin configuration technique could be established with regards to functional and cosmetic outcomes using Flynns' criteria in the present study.

Closed reduction and percutaneous K-wire osteosynthesis is regarded as the standard treatment for SCH fracture. However, there is still no consensus over the long term debate with regards to optimal pin configuration in present literature [13]. Earlier studies on biomechanical testing have shown that crossed pin configuration offers superior fixation stability than lateral only pins [14,15] with the associated risk of iatrogenic ulnar nerve injury [16]. However, on clinical evaluation lateral only pin configuration have proved to be as stable as crossed pinning in several studies [17,18]. Nevertheless, in patients with medial cortex communition and unstable fracture pattern, many authors prefer inserting a medial pin and reserving lateral only pin configuration for stable fracture pattern post reduction with primary aim of avoiding ulnar nerve injury [19,20]. In the present study there was one case with major loss reduction in each of the pin configuration group with unsatisfactory Flynns' outcome. There were three patients of group II in whom a third pin was inserted laterally in addition to two lateral only pins when intra-operative stability was questionable on fluoroscopy. In their series of 124 SCH fracture patients undergoing lateral only entry pinning, Skaggs DL, et al. too reported no case of loss of reduction. They opined that wide placement of two lateral only entry pins is more crucial for fixation stability than either their parallel or divergent configuration with an additional third pin reserved for technical failure in optimal previous two pins placement [17].

Male predominance was seen in the present study consisting of more than half (60%) of all the patients which was comparable to a meta-analysis study done by Babal JC, et al. [21]. The mean age of patients in the present study which was 6.86 (± 2.53) years in group I and 6.03(± 2.22) years in group II was also comparable. Incidence of fracture was however marginally more common on the right side (51.70%) in the present study as opposed to predominant left side (58.2%) involvement as reported in their study [21].

The average surgical time recorded for patients undergoing cross pinning was significantly more than those with lateral only pins (p=0.016). This expected observation can be attributed to the time required for minimal medial incision approach for insertion of K-wire from the medial epicondyle during cross pinning technique [22]. In the present study, time to surgery, either early (<8 hours) or late (≥ 8 hours) did not affect functional outcome irrespective of pin configuration (Chi-square=1.087, p=0.297). Thus in case of closed SCH fracture without neurovascular deficit, we support the opinion made by other authors with similar results that patients of SCH fracture can be operated as first case next day morning with the availability of trained surgical staff and optimal resources [23,24]. Both the groups were comparable with no significant difference in terms of other study variables such length of stay in hospital and radiological outcome based on fracture union.

In group I patients (n=29) undergoing cross pinning, two patients (6.89%) developed partial ulnar nerve palsy post-operative which resolved completely at the end of 3 months. This was comparable with the incidence of ulnar nerve injury in two large series at 5%-6% [10] although rates can vary between 1.4% to as high as 15.6% in other studies involving crossed pin configuration [25]. Similar to results reported in other studies there was no incidence of iatrogenic ulnar nerve injury in patients undergoing lateral only pinning [17]. Ulnar nerve is vulnerable for injury because it may not have palpated in its normal anatomical location in SCH fracture as reported in 32% of cases by Wind WM, et al. [26]. Additionally, hyperflexion of elbow to achieve fracture reduction by closed methods causes the ulnar nerve to sublux anteriorly resulting in compression [27,28]. We recommend using the minimal medial incision approach to keep the incidence of iatrogenic ulnar nerve injury to lowest possible while inserting pin from the medial epicondyle as also advised by Brown and Zinar [29].

Two patients in each group developed superficial infection of pin tracts which settled by oral antibiotics. None of the patients in either group developed complication including deep infection, pin loosening, major loss of reduction, permanent functional deficit, non-union or compartment syndrome. Consequently, no revision surgery was required for any patient in the present study.

LIMITATIONS

This study is not without limitations. Firstly, the sample size in present study was small. Although, a pre-hoc sample size determination was done before commencement of the present study, the authors believe that a larger sample size might be helpful. Secondly, the randomized control trials are inherently associated with selection bias. However, to avoid this, the block randomization method was used here. Lastly, no fixed protocol of fixing two or four cortices as well as convergent or divergent pinning during lateral only entry technique was followed in the present study. The authors do feel that theoretically, the four cortices pin and divergent pinning should be more biomechanically stable.

CONCLUSION

Both cross pinning and lateral only pinning techniques are preferable and provide stable fixation of SCH fracture with comparable post-operative functional, cosmetic and radiological outcomes. While lateral only pinning technique can avoid iatrogenic ulnar nerve injury altogether, cross pinning technique using the medial minimal incision approach although time consuming is associated with meagre incidence of ulnar nerve palsy.

ETHICAL STATEMENT

The study was approved by MGM Medical College, Navi Mumbai IEC committee (Ethical approval number N-EC/2016/02/18).

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