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Original Research Article

Comparison of the radiographic and functional outcome in pediatric orthopaedic patients with Gartland type II supracondylar fracture treated by operative versus non operative management

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ABSTRACT

Background: The non-operative method of closed reduction and application of long arm posterior splint and the operative method of closed reduction and percutaneous pinning are both putative management for Gartland II supracondylar fracture. The purpose of this study is to compare which method is superior in the management of this type of fracture thru the comparison of the radiographic as well as the functional outcome.
Methods: This study includes 51 pediatric patients undergoing supracondylar fracture treatment. The enrolled participants were randomly allocated to one of the two groups to receive either non operative or operative treatment. Radiographic and functional outcome was assessed post treatment.
Results: The operative group exhibited significant superiority versus the non operative group as reflected by the results of the post-treatment radiographs utilizing the anterior humeral line while the Baumann's angle showed no significant difference between the two groups. Moreover, the operative group demonstrated a better Mayo elbow performance score total per follow up, only in the first 3 months but showed no significant difference thereafter.
Conclusions: We therefore conclude that non operative and operative management are both effective treatment for Gartland II supracondylar fracture. The operative group showed significant superiority with results of the anterior humeral line falling mostly at the central one-third of the capitellum. The operative group manifested a better Mayo elbow performance score total only during the first 3 months of follow up.

Keywords: Gartland II fracture, Supracondylar fracture, Long arm posterior splint, Percutaneous pinning, Baumann's angle, Anterior humeral line, MEPS

INTRODUCTION

Supracondylar fractures (Figure 1) of the humerus are the most common elbow fractures in children, with a peak at ages 5-6 years.[1-6] These fractures are the result of trauma to the elbow, most often sustained as a result of a fall from a height or during sports and leisure activities.[1] The extension type is the most common which is caused by a fall onto an outstretched hand with elbow hyperextended.

Of many supracondylar fractures classification systems created, Wilkins modification of Gartland classification is simplest and is widely used to describe extension-type fractures.[9] Table 1 shows modified Gartland classification.

On anteroposterior radiograph of the elbow, Baumann's angle (Figure 2) is commonly used to evaluate fractures as it maintains an estimation of the carrying angle (the varus or valgus attitude of the distal humerus and elbow). Anterior humeral line (Figure 3) is a radiographic marker drawn along the anterior humeral cortex and extended to the capitellum on the lateral radiograph. This line intersects the middle 3rd of capitellum in healthy children

older than 4 years of age but may lie in the anterior one third of the capitellum in those aged <4 years.[6]

Table 1: Classification of supracondylar fractures of the humerus in children after Gartland and Wilkins.

Type	
I	Undisplaced fracture
IIA	Greenstick fracture with posterior angulation
IIIB	Greenstick fracture with malrotation + posterior angulation
IV	Completely displaced fracture

The Mayo elbow performance score, which is one of the assessment tools, is a widely used performance index for the evaluation of a variety of elbow disorders.[13]

The treatment of Gartland type I and type III fractures are commonly accepted as non-operative and operative, respectively. However, some controversy persists on how to manage type II fractures. Some authors advocate closed reduction and casting alone (Figure 4), whereas others recommend closed reduction and percutaneous pinning (Figure 5).[8,14-18]

In this paper, our objective is to determine the comparative effectiveness between closed reduction percutaneous pinning versus closed reduction and application of long arm posterior splint as an interventional management for pediatric orthopedic patients with Gartland type II supracondylar fracture.

Figure 1: Supracondylar fracture.

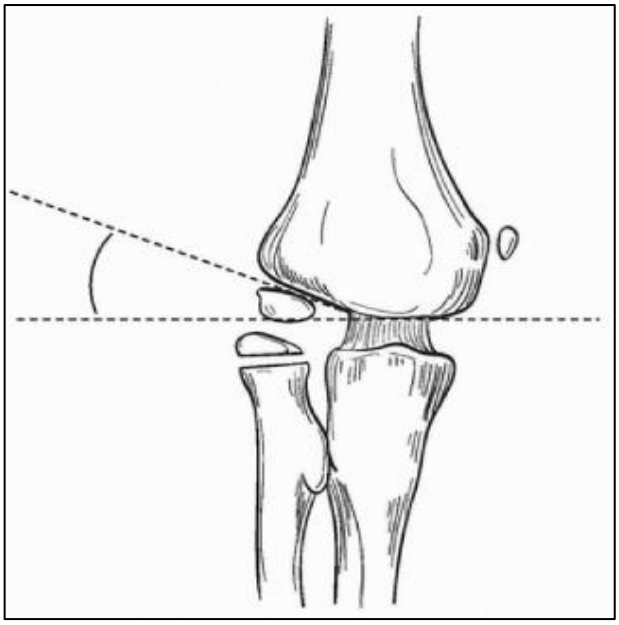

Figure 2: Baumann's angle.

Figure 3: Anterior humeral line.

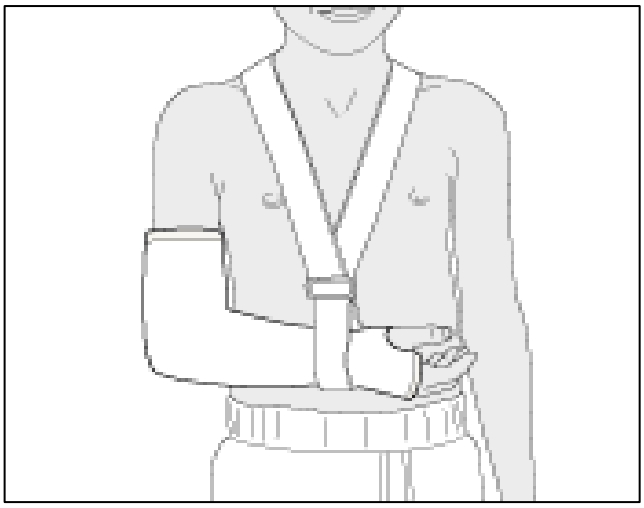

Figure 4: Closed reduction and casting.

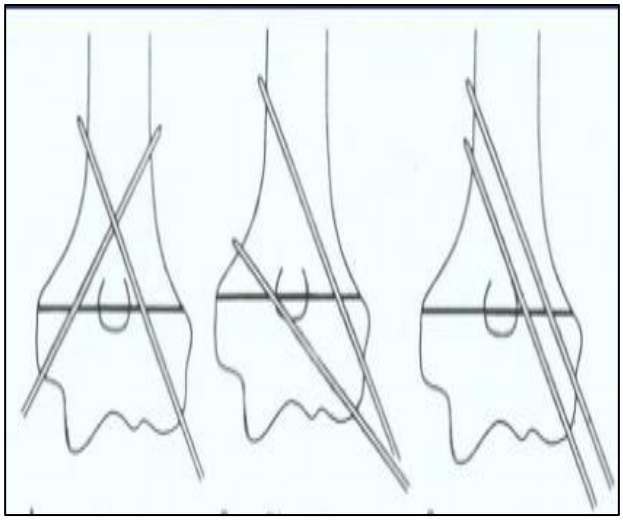

Figure 5: Percutaneous pinning.

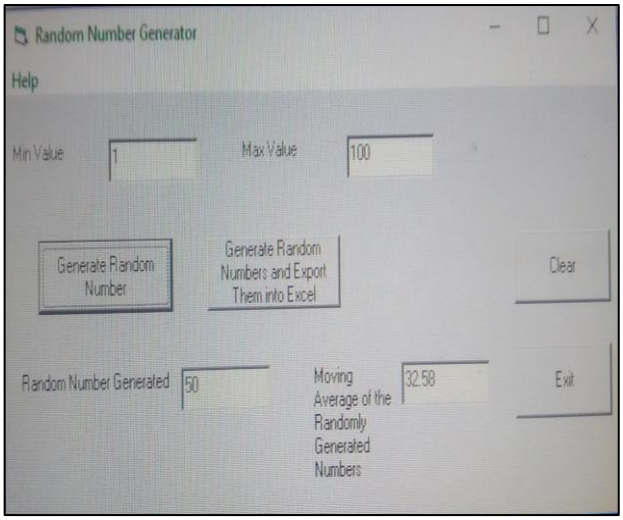

Figure 6: Intelligent master's program.

METHOD

This is a prospective randomized clinical trial done at Jose R. Reyes memorial medical center, a tertiary hospital between November 2017 to October 2018. This study includes patient ages from three to ten years of age presenting with closed Gartland II supracondylar fracture and classified as pediatric ASA I or II. Exclusion criteria were open fractures, multiply injured patients, Gartland I and Gartland III supracondylar fracture, a syndrome affecting the musculoskeletal system, a growth abnormality, a congenital abnormality of the upper extremity of any kind and a history of previous fracture of the humerus, elbow, or forearm.

This study was approved by the institutional review board of Jose R. Reyes memorial medical center. Written informed consent will be obtained from the parents, assent form will be obtained from children >6 years of age. The enrolled patients were randomly allocated to one of the two groups either operative or non-operative management, using a computer-generated table of random numbers. Intelligent master's program (Figure 6) was used, a utility that generates random numbers. Patients assigned to an odd number generated by the program were included in the non-operative group and even numbers were in the operative group. Upon enrollment therein, the study and procedure to be performed were explained mainly by the principal investigator to the parents/guardian as well as to the patient.

Upon presentation at the emergency room with full history taking and physical examination done by the principal investigator, a preoperative radiograph imaging was taken to confirm and document Gartland II supracondylar fracture. Also included in the preoperative assessment was the American society of anesthesiolgists (ASA) physical status classification of the respondents to determine if the patient is fit for the administration of anesthesia. Only ASA 1 and 2 respondents were included in this study.

Table 2: ASA physical status classification.

ASA class	Description	Examples
Class I	Normal health	
Class II	Mild systemic disease	Mild asthma, controlled diabetes
Class III	Severe systemic disease	Pneumonia, moderate to severe asthma, poorly controlled diabetes
Class IV	Severe systemic disease, constant threat to life	Severe CHF (LVEF<15%)
Class V	Critically ill patients	Septoc shock, severe trauma

Subsequently a treatment protocol was performed by the principal investigator for the non-operative management which involves placing the fractured arm in a long arm posterior splint. A manipulation is performed to at three to sixdays' post injury, flexing the elbow to 110 degrees, securing and protecting it in an above elbow cast.

Treatment protocol for the operative technique involves initial attempt by the principal investigator at closed reduction for all displaced closed fractures. The patient necessitated the aid of sedation at the operating theater. For this, the fracture was first extended in the frontal plane and then reduced under fluoroscopy. The elbow was flexed and the sagittal deformity was reduced with careful pressure onto the olecranon. Acceptable rotation was reached once the medial and lateral columns are intact, the anterior humeral line is passing through the middle third of the capitellum. A 0.62 mm Kirschner wires were placed using a power drill. Two divergent K wires were placed on the lateral aspect of the involved elbow.

The preoperative radiographs were compared to the postoperative radiographs at 3 weeks, 3 months, 6 months

and 9 months after treatment, with subsequent MEPS score for functional outcome evaluation. All measurements and parameters post operatively were measured and documented by an associate senior orthopaedic resident aside from the principal investigator to eliminate bias.

The Baumann angle was measured using the lines and angle tool by drawing a line perpendicular to the longitudinal axis of the humeral shaft, and a line following the physical line of the lateral condyle. The angle between these two lines was used as the Baumann angle.[3] Normal values: 64-82 degrees males, 69-81 degrees females. For the anterior humeral line, a line will be drawn along the anterior surface of the distal humerus. The lines were recorded based on its relationship with the capitellum as central 1/3rd, anterior 1/3rd, or posterior 1/3rd.

All patients had completed MEPS questionnaire that was administered by associate senior orthopaedic resident. Patients who garnered a score of 90 and above was graded as excellent, good for scores 75-89, 60-74 means fair and a poor MEPS for patients with score of 60 and below. Parents/guardians advised to subsequently bring patient for follow up at 3 weeks, 3 months, 6 months and 9 months for post-operative monitoring and follow-up. Fischer's Exact test and chi-square test have been used, and statistically significant level has been set at 5% ($p<0.05$).

RESULTS

A total of 51 patients aged three to ten years of age were enrolled and screened in this study who presented at the emergency room with Gartland II supracondylar fracture of the humerus based on radiographic assessment. A total of 26 patients were analyzed in the operative group (Closed reduction percutaneous pinning) while 25 patients were analyzed in the non-operative group (Closed reduction and application of long arm posterior splint). No patient was excluded during the intraoperative course of both interventions.

Table 3: Profile distribution of patients.

Variables	N	Percentages (%)
Age (In years)		
3 to 5	28	54.9
6 to 10	23	45.1
Sex		
Male	30	58.8
Female	21	41.2
ASA classification		
ASA 1	51	100

For the demographic distribution of the respondents, 54.9% of the patients were ages 3 to 5 years old (preschool years) and 45.1% were from ages 6 to 10 years old (growing child: school-age). Gender distribution comprised of 58.8% male patients and 41.2% female patients. All the patients included in this study were classified as ASA physical classification 1.

Table 4: Radiographic outcome of post-operative measurement of the Baumann's angle and the anterior humeral line between the two subject groups.

Variables	Closed reduction percutaneous pinning, n (%)	Closed reduction and application of long arm posterior splint, n (%)	P value
Baumann's angle (Degrees)			
3 weeks			
≤63	0 (0)	0 (0)	1.00
64-80	26 (100)	25 (100)	
≥ 81	0 (0)	0 (0)	
3 months			
≤63	0 (0)	0 (0)	1.00
64-80	26 (100)	25 (100)	
≥ 81	0 (0)	0 (0)	
6 months			
≤63	0 (0)	0 (0)	1.00
64-80	26 (100)	25 (100)	
≥ 81	0 (0)	0 (0)	
1 year			
d≤63	0 (0)	0 (0)	1.00
64-80	26 (100)	25 (100)	
≥ 81	0 (0ds)	0 (0)	
P value	1	1	
Anterior humeral line			
3 weeks			
Central 1/3rd	23 (88.5)	15 (60)	0.03
Anterior 1/3rd	3 (11.5)	10 (40)	
Posterior 1/3rd	0 (0)	0 (0)	
3 months			
Central 1/3rd	23 (88.5)	15 (60)	0.03
Anterior 1/3rd	3 (11.5)	10 (40)	
Posterior 1/3rd	0 (0)	0 (0)	
6 months			
Central 1/3rd	23 (88.5)	15 (60)	0.03
Anterior 1/3rd	3 (11.5)	10 (40)	
Posterior 1/3rd	0 (0)	0 (0)	
1 year			
Central 1/3rd	23 (88.5)	15 (60)	0.03
Anterior 1/3rd	3 (11.5)	10 (40)	
Posterior 1/3rd	0 (0)	0 (0)	
P value	1	1	

There was no significant difference on the radiographic outcome of the Baumann's Angle between the two groups post three weeks, three months, six months, and one-year of follow up (p=1.00). The resultant Baumann's angle of the respondents in both interventions from the third week to one-year post operatively were within the 64 to 80 degrees.

A significant difference was noted with the radiographic outcome of the anterior humeral line on both interventions post third week, third month, sixth month and one-year of follow up respectively (p=0.03). The operative group from three weeks to one year was noted to have a higher rate of patients with resultant anterior humeral line falling on central 1/3rd of the capitellum at 88.5 percentages compared to the non operative group with a result of 60 percentages.

On the other hand, 40% of the patients on the non operative group had their anterior humeral line falling on the Anterior 1/3rd of the capitellum compared to the 11.5% of the patients from the operative group.

Comparison of the post three weeks to one year on the radiographic findings on both groups proved to be non-significant (p=1.00)

Table 5: Mayo elbow performance scoring between the operative versus non operative group.

Variables	Closed reduction percutaneous pinning, n (%)	Closed reduction and application of long arm posterior splint, n (%)	P value
Pain			
3 weeks			
None	16 (61.5)	11 (44)	0.27
Mild	10 (38.5)	14 (56)	
Moderate	0 (0)	0 (0)	
Severe	0 (0)	0 (0)	
3 months			
None	26 (100)	23 (92)	0.24
Mild	0 (0)	2 (8)	
Moderate	0 (0)	0 (0)	
Severe	0 (0)	0 (0)	
6 months			
None	26 (100)	25 (100)	1.00
Mild	0 (0)	0 (0)	
Moderate	0 (0)	0 (0)	
Severe	0 (0)	0 (0)	
1 year			
None	26 (100)	25 (100)	1.00
Mild	0 (0)	0 (0)	
Moderate	0 (0)	0 (0)	
Severe	0 (0)	0 (0)	
P value	0.00	0.00	
Motion (Degrees)			
3 weeks			
Arc >100	16 (61.5)	10 (40)	0.16
Arc 50-100	10 (38.5)	15 (60)	
Arc <50	0 (0)	0 (0)	
3 months			
Arc >100	22 (84.6)	18 (72)	0.32
Arc 50-100	4 (15.4)	7 (28)	
Arc <50	0 (0)	0 (0)	
6 months			
Arc >100	26 (100)	25 (100)	1
Arc 50-100	0 (0)	0 (0)	
Arc <50	0 (0)	0 (0)	
1 year			
Arc >100	26 (100)	25 (100)	1
Arc 50-100	0 (0)	0 (0)	
Arc < 50	0 (0)	0 (0)	
P value	0.00	0.00	

Continued.

Variables	Closed reduction percutaneous pinning, n (%)	Closed reduction and application of long arm posterior splint, n (%)	P value
Stability			
3 weeks			
Stable	26 (100)	25 (100)	1
Moderate instability	0 (0)	0 (0)	
Gross instability	0 (0)	0 (0)	
3 months			
Stable	26 (100)	25 (100)	1
Moderate instability	0 (0)	0 (0)	
Gross instability	0 (0)	0 (0)	
6 months			
Stable	26 (100)	25 (100)	1
Moderate instability	0 (0)	0 (0)	
Gross instability	0 (0)	0 (0)	
1 year			
Stable	26 (100)	25 (100)	1
Moderate instability	0 (0)	0 (0)	
Gross instability	0 (0)	0 (0)	
P value	1.00	1.00	
Function of elbow			
3 weeks			
Comb hair	26 (100)	25 (100)	1.00
Feed self	26 (100)	25 (100)	
Hygiene	26 (100)	25 (100)	
Shirt	26 (100)	25 (100)	
Shoe	26 (100)	25 (100)	
3 months			
Comb Hair	26 (100)	25 (100)	1.00
Feed self	26 (100)	25 (100)	
Hygiene	26 (100)	25 (100)	
Shirt	26 (100)	25 (100)	
Shoe	26 (100)	25 (100)	
6 months			
Comb Hair	26 (100)	25 (100)	1
Feed self	26 (100)	25 (100)	
Hygiene	26 (100)	25 (100)	
Shirt	26 (100)	25 (100)	
Shoe	26 (100)	25 (100)	
1 year			
Comb hair	26 (100)	25 (100)	1
Feed self	26 (100)	25 (100)	
Hygiene	26 (100)	25 (100)	
Shirt	26 (100)	25 (100)	
Shoe	26 (100)	25 (100)	
P value	1.00	1.00	
Total MEP score			
3 weeks			
Poor	0 (0)	0 (0)	0.330
Fair	0 (0)	0 (0)	
Good	10 (38.5)	14 (56)	
Excellent	16 (62.5)	11 (44)	
3 months			
Poor	0 (0)	0 (0)	0.453
Fair	0 (0)	0 (0)	
Good	0 (0)	2 (8)	
Excellent	26 (100)	23 (92)	
6 months			

Continued.

Variables	Closed reduction percutaneous pinning, n (%)	Closed reduction and application of long arm posterior splint, n (%)	P value
Total MEP score			
Poor	0 (0)	0 (0)	1
Fair	0 (0)	0 (0)	
Good	0 (0)	0 (0)	
Excellent	26 (100)	25 (100)	
1 year			
Poor	0 (0)	0 (0)	1.000
Fair	0 (0)	0 (0)	
Good	0 (0)	0 (0)	
Excellent	26 (100)	25 (100)	
P value	0	0	

This table presents the tallied Mayo elbow performance score for each (total MEP score for each variable of the operative group alone, non-operative group alone and comparison of both) and both groups (comparison of the total MEP scores between the operative and non-operative group) after three weeks, three months, six months and one year of post-operative follow up.

Pain variable

Mild pain post operatively was noted to have a higher incidence in the non-operative group with 14 (56%) versus 10 (38.5%) for the operative group after three weeks, while 16 (61.5%) were reported to be pain-free in the operative group versus with the 11 (44%) in the non-operative group. Yet this proved to be not significant (p=0.27). Three months after follow up, 2 (8%) of the respondents reported lingering mild pain in the non-operative group, while all of the respondents in the operative group were reported be pain-free. Yet there is no significant difference in the pain scores between the two groups (p=0.24). Six months to one year after follow up reported complete absence of pain between the two groups.

Motion variable

Comparing the two interventions, the operative group with 16 (84%) was noted to have a higher number of respondents who can perform an arc >100 degrees three weeks post-operatively compared to the 10 (40%) respondents of the non operative group. Whereas 15 (60%) of the respondents in the non operative group can perform an arc of 50-100 degrees compared to the 10 (38.5%) of the remaining respondents in the operative group. There is no significant difference in motion after three weeks between the two groups (p=0.16). Three months post operatively, the operative group still reported a higher number of respondents who can perform an arc of >100 degrees at 22 (84.6%) compared to the 18 (72%) in the non operative group. Only 4 (15.4%) of the respondents in the operative group remained in the 50-100 degrees arc performance compared to the 7 (28%) of the respondents in the non operative group. No significant difference was noted in the motion scores between the two groups three months after follow up (p=0.32). After six months to one year all of the respondents in both groups can perform an arc of >100 degrees.

Stability variable

All of the patients in both groups manifested good stability three weeks post operatively, 26 (100%) for the operative group versus 25 (100%) for the non-operative group which continued until after one year of follow up.

Function of elbow variable

All of the respondents in both groups can perform combing of hair, feeding one self, simple hygiene, wear a shirt all alone and tie a shoe lace three weeks post operatively, 26 (100%) for the operative group versus 25 (100%) for the non-operative group which continued until after one year of follow up.

Total Mayo elbow performance score

The operative group reported with excellent scores (91-100 points) third week post operatively with 16 (62.5%) amongst its respondents while 10 (38.5%) were with a good score (90-81 points). Three months to a year after follow up, all of the respondents were given an excellent score. Improvement of the total MEP scores proved to be clinically significant with a p=0.00.

For the non operative group, 11 (44%) garnered excellent scores three weeks postoperatively while the remaining 14 (56%) had a good score. Three months after, an increase of 23 (92%) of the respondents were with an excellent score while the remaining 2 (8%) had a good score. Six months to one-year post follow up all the respondents had an excellent scoring. Comparison of total MEP scores per follow up in this group proved to be statistically significant with a p=0.00.

No statistical difference was noted on comparing the two interventions (p=1.00). More patients had excellent scores in the operative group with 16 (62.5%) compared with the 11 (44%) of the non operative group three weeks post

operatively, while the remaining 10 (38.5%) in the operative group had good scores in lieu with the remaining 14 (56%) respondents in the non operative group. Yet this proved to be not statistically significant (p=0.330). After three months of follow up, all of the respondents in the operative group scored as excellent, while in the non operative group an increase of 23 (92%) scored as excellent with a remaining 2 (8%) in the good scoring bracket. Still this proved to be non-significant (p=0.453). Both groups showed excellent scores post six months and one-year of follow up (p=1), respectively.

DISCUSSION

This study failed to find a significant difference in the comparative effectiveness between the operative group versus the non operative group as an interventional management to pediatric orthopedic patients with Gartland type II supracondylar fracture. Despite this, the operative group exhibited significant superiority as an intervention thru results in the post-operative radiographic outcome on the lateral view utilizing the anterior humeral line falling mostly at the central one-third of the capitellum. The Baumann's angle measured in the anteroposterior view of the post-operative radiograph have no significant difference between the two groups. Moreover, the operative group exhibited a better Mayo elbow performance score total per follow up, particularly with clinically significant good pain control and improved range of motion.

For the post-operative radiographic parameters, our study found no significant difference in the Baumann's angle between the two techniques but we gathered a significant higher rate of patients with resultant anterior humeral line falling on central 1/3rd of the capitellum for the operative group and with the non operative group with a higher rate of their anterior humeral line falling on the anterior 1/3rd of the capitellum. Anterior humeral line crossing the anterior third of the capitellum can be an under reduction that has similar elbow motion as anterior humeral line anterior to the capitellum. Anterior humeral line posterior to the capitellum is a warning sign of overreduction and should be avoided. It was suggested that the AHL should bisect the capitellum within its middle third.[3] This rule was based on radiographic measurements of normal elbow anatomy. However, position of the AHL for acceptable fracture reduction has not been validated by clinical elbow function. It is not reasonable to attempt.

Gagliardi and colleagues disclosed that the advantage of using MEPS is that it can be completely patient-administered. Our study reported mild pain present to be higher in the non-operative group.

Range of motion post-operatively manifested as performance of an arc of >100 degrees is significantly higher in the operative group in our study. Mulpuri and colleagues' noncritical outcomes of their study showed that pin fixation was statistically superior to non-operative treatment in meta-analysis of Flynn criteria. This outcome incorporates both range of motion and carrying angle.[19]

In summary, this study resulted in both the operative and the non-operative technique proved its efficacy as a treatment to Gartland type II fractures, with the closed reduction with percutaneous pinning giving superior results to the closed reduction with application of posterior splint.

Currently, the trend is to treat all type II supracondylar humerus fractures with closed reduction and percutaneous pinning with 2 or 3 laterally based pins.[17] Also, the AAOS guidelines suggest pinning all type II fractures.

Limitations

Our study has several limitations. First, one potential weakness of the MEPS compared with other systems is that it does not include strength or deformity calculation in the overall score, but excluding these factors allows the MEPS to be completely patient-derived, which can be viewed as an advantage. Yet because only one observer collected the data of the post-operative radiographic results and MEPS, this study did not include evaluation of inter-observer and intra-observer reliability, and it did not assess the test-retest reliability. Second, we did not further classify the fractures of our respondents whether if it falls from the type IIa or type IIb Gartland fracture. All fractures were generally classified as type II Gartland fracture. Lastly, this study was only done to pediatric orthopaedic patients with Gartland type II fractures in Jose R. Reyes memorial medical center.

CONCLUSION

In summary, this study resulted in both the operative group (closed reduction percutaneous pinning) and the non-operative group (closed reduction application of long arm posterior splint) proved to effective as a technique in managing Gartland II fractures thru post-operative radiographic and functional outcome results. The operative group, however, showed significant superiority by which the anterior humeral line was falling mostly at the central one-third of the capitellum based on the post-operative radiographic lateral view results. Also, the Baumann's angle measured in the anteroposterior view of the post-operative radiograph proved have a negative co-relationship between the two groups. Moreover, the operative group manifested a better Mayo elbow performance score total per follow up intervals, particularly with clinically significant good pain control and improved range of motion.

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