FUNCTIONAL AND NEUROLOGICAL OUTCOMES OF CLOSED REDUCTION AND PERCUTANEOUS PINNING IN PEDIATRIC MONTEGGIA FRACTURE

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ABSTRACT

Introduction: The aim of this study was to assess the neurological and functional recovery of children with Monteggia fracture following closed reduction and percutaneous pinning.

Methods: It was a descriptive observational study, patients aged from 3 to 15 years with Monteggia fractures are taken in to consideration during the period between 2074/02/01 and 2074/7/30. Participants were selected on the basis of pre-determined inclusion/exclusion criteria. A total of 33 patients were included in the study. The demographics and pre- and post-operative outcomes were recorded in semi-structured proforma. Data entry, synthesis and descriptive analysis were done using MS EXCEL and SPSS version 16.0.

Results: Total of 33 patients met the inclusion and exclusion criteria. The mean age was 8.21±3.4 years, with sex ratio (m: f) of 1.75: 1. Majority of the patients (57.58%) injured their left elbow and the most common mechanism of injury was fall while playing (36.36%). According to modified classification system for children, 60.61% had class C and 39.39% had class B Monteggia fracture. Five patients (15.15%) presented with PIN injury. All patients were treated with closed reduction and percutaneous pinning (IM RUSH nail) within 2.27±1.30 days after injury. The average duration of surgery was 62.42±23.55 minutes. The average duration of fracture healing was 5.39±1.6 weeks. Jupiter's criteria for the evaluation of elbow function was used and at the time of cast removal, 6 (18.18%) had excellent, 10 (30.30%) had good, 13 (39.39%) had fair and 4 (12.13%) had poor functional recovery.

Conclusions: This study concludes that most of the pediatric Monteggia fractures (class B and C) can be treated with closed reduction and percutaneous intramedullary nailing using RUSH pins. This technique has very good functional and neurological outcomes with fewer complications.

Keywords: *children; functional recovery; Intra-medullary nailing; jupiter's criteria; Monteggia fractures.*

INTRODUCTION

The eponym "Monteggia" fracture is characterized as fracture of ulna (mostly upper one-third) and dislocation of radial head.[1,2] It is one of the fractures around the elbow in children that requires an urgent orthopedic assessment and accounts for 5% of all forearm fractures.[3-7] These fractures can result in serious complications, if not treated appropriately.

Monteggia fractures in children remains a controversial issue whether to manage conservatively or do surgical exploration for better functional and neurological outcome. Hence, observational prospective study is essential to know the recovery of Monteggia fractures (class B and C) in pediatric population after closed reduction of radial head and percutaneous pinning of ulnar fracture. As a General Practitioner working

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in the periphery, we are sure to encounter paediatricMonteggia fractures. This study will be a great value in the management of pediatric Monteggia fractures to obtain better functional and neurological outcomes.

The main aim of the study is to assess neurological and functional recovery of children with Monteggia fracture following closed reduction and percutaneous pinning.

METHODS

Both qualitative and quantitative research design was used. All the cases fulfilling inclusion criteria underwent this research which involved collecting data and information regarding demographic details, neurological and functional status. The cases were regularly followed up and in each follow up, patients were examined for radiological evidence of union and functional and neurological status. Ethical clearance was obtained from the IRB of the Institute of Medicine. Permission was taken from the Department of General Practice and Emergency Medicine TUTH and United Mission Hospital Tansen, Palpa.

Study area of this study was United Mission Hospital, Tansen, palpa. This Hospital is a referral center in western part of Nepal established in 1954 AD. The study was conducted from 2073/08/01 to 2074/07/30 (12 months).Sample collection duration was from 2074/02/01 to 2074/7/30 (6 months). Children of age 3-15 years with Monteggia fractures and variants attending the Hospital during the study period who met the inclusion criteria were included in the study

Sample size

Formula: $N = \frac{z^2pq}{d^2}$

Where,

N=minimal sample size for statistical significant survey

z = normal deviant at the portion of 95% CI= 1.96

p = prevalence of monteggia fracture in pediatric population= 2-4% (0.02)

q = 1-p = 0.97

d = allowable error = 5% (0.05)

Ideal sample size (N)= 30

Total sample size for obtained: N =33

Inclusion Criteria

- Age:3 to 15 years.
- Children with Monteggia fracture and its variants undergoing closed reduction and Percutaneous Pinning
- Acutely presented within two weeks of injury

Exclusion Criteria

Open Monteggia fractures

- Missed Monteggia fractures or late presented (>2weeks) cases
- Children with preexisting vascular or neurological deficits
- Children treated with closed reduction and cast only
- Children treated with open reduction and plate osteosynthesis

The study is based on primary data which is collected from the patient and is based on clinical examination.

The tools used in the study were Goniometer, measuring scale, blunt pin, hospital records, X-ray sheets, Pen, paper, and Proforma. Technique used in the study was interview (history) and clinical examination. All the collected data were checked, compiled, organized and analyzed by the investigator

himself. Descriptive statistical method was used to analyze and interpret the quantitative data. All analyzed data were shown in various table, chart and graph by using Microsoft EXCEL version 2010 and/or SPSS software version 16.0.

RESULTS

This chapter deals with the analysis and interpretation of the data that has been gathered to meet the objectives of the study. This study has been designed as a descriptive study.

The data were collected from hospital records between 2074/3/1 and 2074/7/30 B.S. There were a total of 42 patients, aged 16 years or less, presented with Monteggia fractures or its variants. During that period, total pediatric patient presented with trauma was 1158 that makes the prevalence of Monteggia fracture in pediatric population in UMHTP 3.6%. (Figure 1)

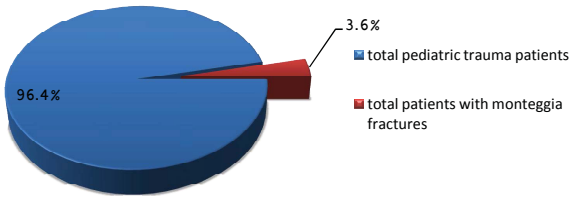

Figure 1. Prevalence of Monteggia fractures among pediatric trauma patients in UMHTP.

Table 1. Prevalence of Various Pediatric Trauma Patients presented in UMN, Tansen, Palpa Emergency Room.

S.No.	Trauma	Number	Percentage
1	Supracondylar Fracture	300	25.91
2	Soft Tissue Injury	275	23.75
3	Ankle Injury	103	8.89
4	Cut Injury	84	7.25
5	Clavicular Fracture	75	6.48
6	Lateral Condylar Fracture	51	4.40
7	Colle's Fracture	50	4.32
8	Monteggia Fracture	42	3.63
9	Head injury	36	3.11
10	Both Bone Fracture (forearm)	28	2.42
11	Blunt Abdominal Trauma	27	2.33
12	Gallezi's Fracture	20	1.73
13	Both bone Fracture (leg)	13	1.12
14	Humerus Fracture	12	1.04
15	Fracture Tibia	12	1.04
16	Fracture Neck of Femur	8	0.69
17	Fractuure Fibula	7	0.60
18	Metatarsal Fracture	7	0.60
19	Fracuture Shaft of Femur	5	0.43
20	Metacarpal Fracture	3	0.26
	Total	1158	100.00

Above table shows, out of 1158 various pediatric patients, prevalence of Monteggia fracture was 42(3.63%), which ranks 8th among all trauma. Most common trauma was Supracondylar fracture, 300 (25.91%), then Soft tissue Injury, 275(23.75%), and third being Ankle Injury 103 (8.89%).

Out of total 42 patients presented with Monteggia fractures, 33 met the inclusion/ exclusion criteria. (Figure 2).

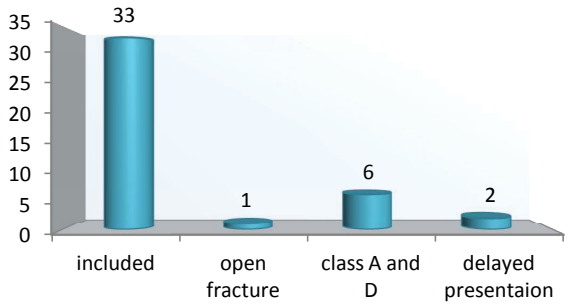

Figure 2. Stratification of included and excluded patients.

Above chart shows that out of 42 patients, 33 (78.57%) included and 9(21.43%) excluded. Among 9 excluded patients, 6 were of monteggia class A (Plastic Deformation)

and Class D (Comminuted or Long Oblique Fracture), 2 were delayed presentation and 1 was open fracture.

All included patients (n=33) provided informed consent and enter into the study and pre-determined pro-forma were filled to collect the required data.

Out of 33 patients, 21 (63.63%) were males and 12 (36.37%) were females. (Figure 3)

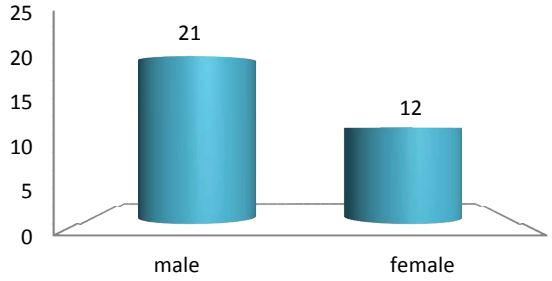

Figure 3. Sex Distributions

Above figure shows that the sex ratio (M: F) in this study was 1.75:1.

In this study, patients' age ranged from 3 to 15 years. (Table 1)

Table 2. Gender and Age-Wise distribution of Monteggia Fracture

Age Group	Gender		n(%)
	Male[n(%)]	Female[n(%)]	
3	1	1	2 (6.1)
4	2	1	3 (9.1)
5	1	2	3 (9.1)
6	1	1	2 (6.1)
7	3 (75)	1 (25)	4 12.1)
8	3 (60)	2 (40)	5 (15.2)
9	4 (80)	1 (20)	5 (15.2)
10	1	0	1 (3.0)
11	1	0	1 (3.0)
12	1	0	1 (3.0)
13	1	0	1 (3.0)
14	1	0	1 (3.0)
15	1	3	4 (12.1)
TOTAL	21 (63.63)	12 (36.37)	33 (100)

Above table shows, prevalence of trauma in male patients were almost double 21(63.63%) as compared to female 12(36.37%). Most commonly affect age group was 7-9 years with total of 14 patients from this group accounting for 42.42%, and in this age group also male gender were double prevalent as compared to female.

Table 3. Age distribution of the included patient (n=33).

Age of the patient (in years)	
Mean	8.21
SD	3.40
Maximum	15
Minimum	3

Above table shows that the maximum age of the included patient was 15 and the minimum age was 3. The mean age (±SD) was 8.21 (±3.4) years.

Among 33 patients, 14 (42.42%) had right-sided injury and 19 (57.58%) had left sided injury. (Figure 4)

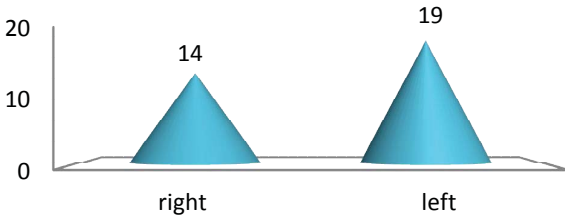

Figure 4 Side of injury

Above figure shows that most of the patient injured their left elbow, with right to left ratio (R: L) of 0.73:1. Among 33 patients, 17(51.51%) slipped while playing, 12(36.36%) fell from height, 3 (9%) fell from bicycle and 1 (3.13%) sustained injury via physical assault. [Figure 5]

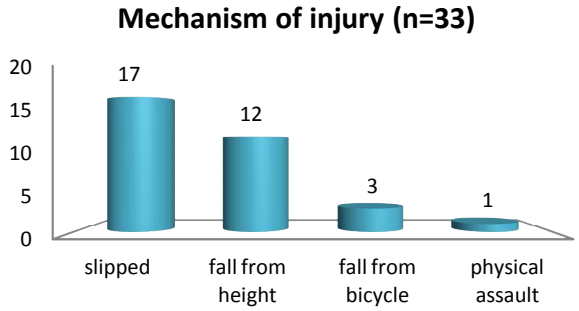

Figure 5. Mechanism of injury

Above figure shows that the most common mechanism of injury was "fall". Thirty two (96.96%) patients injured their elbow because of fall. Out of 32, 17 fell on level ground, 12 fell from height, and 3 fell from bicycle.

In this study, fractures were classified according to modified classification system for pediatric Monteggia fractures. Among 33 patients, 13 (39.39%) had class B Monteggia fracture and 20 (60.61%) had class C Monteggia fracture. (Figure 6)

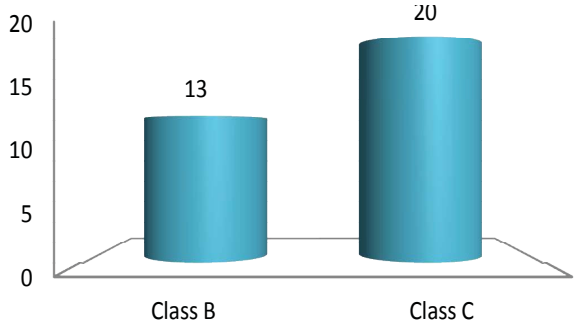

Figure 6. Fracture classification

Above figure shows that most of the included patients had class c monteggia fracture (60.60%). Out of 33 patients, 5 (15.15%) patients had PIN (Posterior Interossious Nerve) injury and no patient had vascular injury. (Figure 7)

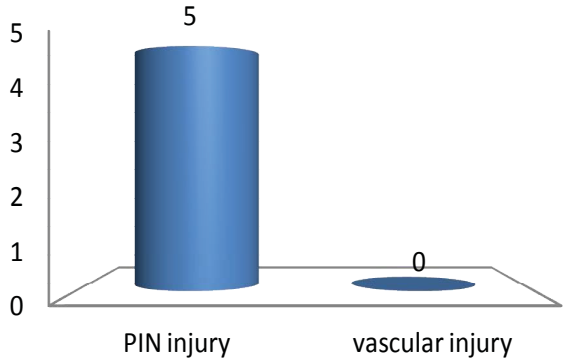

Figure 7. Neurovascular statuses of the patients.

Above figure shows that 5 patients presented with PIN injury and there was no case of vascular injury.

DISCUSSION

The purpose of this study was to assess the neurological and functional recovery of children with Monteggia fracture following closed reduction and percutaneous pinning (i.e. intramedullary RUSH nail through olecranon apophysis). In this study, pediatric Monteggia fractures (age </= 16 years) class B and C of modified classification system were included. Unlike adult Monteggia fractures,1 stabilization of fracture of ulna is of paramount importance in pediatric Monteggia fractures.[2]

In UMHTP, the prevalence of Monteggia fracture among all pediatric trauma patients was 3.5% which coincides with the prevalence of Monteggia fractures stated in the literature,2-3 i.e. 2 to 5%. During the time of study, 42 children presented with Monteggia fractures. Out of 42 patients, 33 were included in the study and 9 were excluded. Out of 9 excluded patients, 6 were of class A and D, 2 presented after one week of injury and 1 was open Monteggia fracture.

Majority of the patients in this study were male (63.63%), with sex ratio (m: f) of 1.75:1. Piero A et al[4] and Letts M et al[5] found similar sex ratio in their study of 2:1 and 1.9:1, respectively. Several other studies 6-8 have also found increased male predominance. Uncontrolled and unlimited sporting activities and playground injuries make the male gender more vulnerable to fracture in low socio-economic countries[8, 9.]

Monteggia fractures are common in children of age 4 to 12 years.9,10 In this study, average age of the patient was approximately 9 years with SD of 3.40. This study also found that most of the children injured their left arm (approx. 58%). There is no definitive etiology for the more common left sided Monteggia fracture but most studies [6-10] gives explanation that most patients are right dominant and since the left arm is weaker than the other arm, the force of the fall caused the fracture in the weaker arm. The mechanism of injury in most of the pediatric fracture is fall9. In

this study, most children (approx. 52%) injured their arm while playing and fell on outstretched hand.[1,10-12]

Bado et al.[1] gave the classification of Monteggia fractures according to the location of dislocated radial head. However, in pediatric Monteggia fractures location of dislocated radial head has very less importance as the annular ligament is very elastic and has very less chance of tear.[13] In addition, radial head almost invariably comes into place after adequate reduction of bowing of ulna.[14-18] Therefore, in children Monteggia fractures are classified according to ulna fracture, as:

Class A: Plastic deformation of ulna

Class B: Incomplete fracture, i.e. green stick or buckle

Class C: Complete transverse or short oblique fracture

Class D: Communited or long oblique fracture

In this study, patients with class B and class C Monteggia fractures were included. Majority of the patients (approx. 61%) had class C Monteggia fracture. There is no consensus based study available in the literature, but several studies[17-21] reporting pediatric Monteggia fractures had high prevalence (up to 70%) of class C Monteggia fracture.

Monteggia fractures are often complicated by neurovascular injury.[22-25] Neuropraxia[23,25] is most common neurological injury documented, usually posterior interosseous nerve branch of radial nerve (10-20%).[23] In this study, 5 (15.15%) out of 33 patients had PIN injury at the time of presentation. All of them presented with loss of senstation in dorsal aspect of 1st web space and loss of thumb raise.

Hagedron JM et al.[23] in their study obtained excellent neurological recovery following early stabilization of fracture of ulna. They suggested no requirement for surgical exploration of PIN for only neuropraxia and almost all patients get good recovery in long term follow-up, i.e. 1 year. Similarly, Hirachi K et al, in their study of 17 patients with PIN palsy observed excellent recovery in 16 (94%) patients after early operative stabilization of fracture of ulna. They did not perform nerve exploration as all patients had neuropraxia. The complete neurological recovery was obtained within the period of 6 months. In addition, Li H et al[24] et al. reviewed 8 patients with PIN injury and 6 (75%) did not require exploration. Out of 6 patients, 5(83%) recovered within 6 months.

In this study, 3(60%) patients recovered completely within 3 months post-op, 1(20%) recovered partially and no recovery was observed in 1(20%) patient. These outcomes were within 3 months of observation and those patients without satisfactory recovery had no signs of muscle atrophy and de-innervations suggesting only neuropraxia.[23,24] Hence, patients are expected to recover within 6 months to 1 year[23] and our outcomes are similar to that reported in the literature and we also recommend no surgical exploration of PIN for patients with neuropraxia symptoms.

Those patients with partial or no recovery (n=2)were asked to follow at 6 months post-op, but the outcome at that period could not be recorded because that time was not within the duration of the study.

Unlike adult Monteggia fracture, stabilization of fracture of ulna is of paramount importance in pediatric monteggia fracture. Operative stabilization can be obtained using various techniques following adequate closed reduction. These techniques include, percutaneous k-wires, RUSH pins, and plates. Out of several options, most studies[26-30] supported intramedullary fixation of fracture of ulna. In this study, we followed the technique given by Rabinovich et al.[28] All patients underwent closed reduction under image intensifier under laryngeal mask anaesthesia. After achieving satisfactory reduction, ulna was fixed by antegrade nailing with smooth RUSH pins through the lateral

surface of olecranon about 1.5 to 2 cm distal to physis (olecranon apophysis).[28] Then, long arm pop cast was applied.

Most studies[26-28] suggested early operative stabilization within 2 days of injury. In this study, the average duration of time from injury to operation was 2.60 days (approx. 3 days). Most of the patients (n=16) were operated after 3 days of injury. This delay of time is because of geographical location and transportation problems. The average duration of surgery was 62.42 minutes. This correlates with average duration of surgery (approx. 50min) reported in many studies.[27,30]

Closed forearm fractures in children have very less chance of non- union.[31-36] Long arm circular cast was removed after adequate evidence of fracture union.[31,32] In this study, all fractures united within 8 weeks (i.e. 2 months). There were no non-uniuon or delayed union. Most of the patients (51.51%) obtained fracture union in 4th week. The mean duration of fracture healing or union was 5.39 weeks (approx. 6 weeks). This outcome was better than some studies,[33-35] where average union time was reported to be 10 weeks (i.e. 2.5 months).

UmileGossipe Longo et al.[37] in their review article have reported many scoring system used for elbow disorders. Among those scoring systems, we preferred jupiter's criteria.[38] Jupiter criteria evaluate pain, disability and range of movement. Symptoms are recorded at clinical interview, and the patients are examined clinically and radiographically. Elbow and forearm movementsare measured using a standard large goniometer, recording the extensionof the elbow with the forearm in maximal supination. Double-exposure photographs show the range of elbow movement, andloss of flexion/extension is expressed by comparison with the normalarm. Ulnar nerve function is also assessed.

In this study, functional status of elbow was evaluated immediately after cast removal and at final follow-up visit. At cast removal (i.e. time of adequate bony healing), out of 33 patients, 6 (18.18%) had excellent, 10 (30.30%) had good, 13 (39.39%) had fair, and 4 (12.13%) had poor functional recovery, according to jupiter's criteria. The reason being their low arc of movement, moderate disability and pain activity secondary to longer immobilization, PIN injury and poor patient compliance to physiotherapy. This suggests that monteggia fracture with PIN injury may cause severe disability and vigorous physiotherapy is needed to improve arc of motion. The average arc of movement was 93.48 degrees. This is considered as a satisfactory arc of movement immediately after cast removal.39 various studies[40,41] have advocated early and vigorous physiotherapy immediately after cast removal in pediatric forearm fractures. Therefore, in this study all patients were sent to physiotherapy department for vigorous physiotherapy. After adequate physiotherapy, at the time of final follow-up visit, jupiter's criteria is used to evaluate functional status of elbow.

In this study, average duration of follow-up was 9.69 weeks. This follow-up duration is very short according to many studies in the literature.[32,33,42] However, with limited time of cross-sectional study, patients were followed up until satisfactory results obtained or within 12 weeks maximum. At the time of final follow-up visit, out of 33 patients, 18 (54.54%) had excellent, 10 (30.30%) had good, 3 (9.09%) had fair and 2 (6.07%) had poor functional recovery. The average arc of movement was 126.66 degrees. This outcome is better compared to that reported by Rabinovich et al.28 and Luo DD et al.[42] In those two studies, they reported satisfactory functional recovery in 50 to 60 % of the patients and average arc of movement was 115 degrees.

Many studies[28-32] reported higher prevalence of complications associated with internal fixationoffractureofulnausingintramedullary nails, such as pin site infection (8 to 10%) and joint stiffness (10 to 12%). However, in this study, pin site infection was quite low (6.06%). There are no enough reports of pin insertion site swelling or granuloma

formation in the literature,[42] but in this study we obtained very high prevalence (30.30%) of this complication. The reason behind that is irritation due to the head of RUSH nails. These swellings subsided immediately after implant exit in all cases. Therefore, with continuous evolution in surgical techniques and characteristics of implants, we strongly believe that these complications will be minimized. The limitations of our study are:

1. Shorter duration of study
2. Single center study
3. Study without comparative analysis and tests of significance
4. Small sample size and non-randomized design
5. Examiner's bias

CONCLUSIONS

This study concludes that most of the pediatric Monteggia fractures (class B and C) can be treated with closed reduction and percutaneous intramedullary nailing using RUSH pins. This technique has very good functional and neurological outcomes with fewer complications..

This study should be conducted in a larger population with longer follow up. Sampling should be randomized and this treatment method should be compared with other treatment method with tests of significance. A large scale multi-center study will also be helpful in determining prevalence of complications.

CONFLICT OF INTEREST: None.

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