COMPLICATIONS AND OUTCOME OF SUPRACONDYLAR FRACTURES OF THE HUMERUS IN CHILDREN AT THE KENYATTA NATIONAL HOSPITAL

BY

DR. WILSON M. KIRAITU

M.B.CH.B (NAIROBI)

A DISSERTATION SUBMITTED IN PART FULFILLMENT FOR THE DEGREE OF MASTER OF MEDICINE (SURGERY) AT THE UNIVERSITY OF NAIROBI

2003

DECLARATION

This dissertation is my original work and has not been presented for a degree in any other university

Signed.....

Dr. Wilson M. Kiraitu

Date.....5.2.003.....

Supervisor

This dissertation has been submitted for examination with my approval as university supervisor

Signed.....

Mr. Mutiso V.M

M Med (surgery) NBI

Lecturer Dept. Orthopaedic Surgery

2003

DEDICATION

This book is dedicated to my family, for their unswerving support, inspiration, great optimism and patience.

ACKNOWLEDGEMENT:

Thanks are due:

To Mr. Mutiso V.M, lecturer, department of orthopaedic surgery, for his guidance, advice and support during the conduct of this study.

To Mr. J.C Mwangi, lecturer, department of orthopaedic surgery, for his stimulating critique and valuable discussion of humeral supra-condylar fractures.

To Prof. J.E Ating'a, Associate professor of orthopaedic surgery, for reading through this dissertation and offering most insightful counsel.

To the staff of KNH medical records and radiology department for retrieving patients records and radiographs.

To Kenyatta National Hospital Ethical and Research Committee for studying the proposal and allowing this study to proceed.

To Dr. L. Miriti, for assisting in data collection.

To Antony and Jackim, for analyzing the data.

To Stella, for her excellent secretarial services.

To many others who contributed in one way or the other I remain highly indebted.

Contents page

LIST OF TABLES

LIST OF FIGURES

ACRONYN AND ABBREVIATIONS

K.N.H – Kenyatta National Hospital

CRPP – Closed reduction and percutaneous pinning

ORIF – Open reduction and internal fixation

MUA – Manipulation under anaesthesia

% - Percentage

Fig – figure

DOA – date of Admission

DOO – Date of Operation

DOD – Date of Discharge

POP- Plaster of Paris

Summary

Supracondylar fracture of the humerus is a common elbow injury in children.

The main objective of this retrospective study was to determine the epidemiological characteristics, complications and outcome of supracondylar fractures of the humerus in children as seen at Kenyatta National Hospital.

The study found out that supracondylar humeral fractures, had a peak incidence of between four and seven years. Most patients were boys. Fall from height was the commonest cause of injury. Displaced fractures (Gartland IIIa + IIIb) accounted for the majority of these fractures (58.4%). Eighty four point four percent (84.4%) of patients, with undisplaced fractures (Gartland I and II) treated conservatively had good results, while 67.5 % of patients, with displaced fractures treated by open reduction and internal fixation had good results.

Seven (7 of 255) patients, sustained vascular injuries. These were noted to occur in patients with high-energy fracture type (Gartland type IIIa). Compartment syndrome occured in 1.2% (3 of 255) of the patients. All the three patients underwent emergency fasciotomies and at follow-up, they were found to have good limb function.

Twelve patients had neurological lesions. Ten of these recovered fully, without operative intervention.

Long term complications included: - cubitus varus, cubitus valgus, elbow stiffness and myositis ossificans. The incidence of cubitus varus, a common angular deformity, was found to be 12.6 %.

Key conclusions and recommendations were: - back slab-cast, collar and cuff is adequate treatment for undisplaced fractures (Gartland I and II).

Closed reduction and percutaneous pininng method, is underutilized at Kenyatta National Hospital and needs to be actively promoted.

1.0 INTRODUCTION

Supracondylar fracture of the humerus is a common fracture of childhood. This fracture is attended by immediate and late complications that contribute significantly to morbidity. Most of these complications can be prevented by early diagnosis and appropriate treatment.

Aims and objective

Main objective: To determine the epidemiological characteristics, complications and the outcome of supracondylar fracture of the humerus in children managed by various methods at KNH.

Specific objectives

1. To determine the epidemiological characteristics of the humeral supracondylar fracture as seen at KNH.
2. To determine the distribution of the various supracondylar fracture types.
3. To determine the treatment options for supracondylar fracture of the humerus in children available at KNH.
4. To determine the complications of various fracture types treated by various methods.
5. To determine the outcome of humeral supracondylar fractures treated by various methods.

2.0 LITERATURE REVIEW

2.1 Epidemiology

Paediatric elbow fractures are extremely common. It has been estimated that they account for approximately 65% of all fractures and dislocations in children. [1,2,3,4,5].

Supracondylar fracture accounts for 60% of the peadiatric elbow fractures [2,3]. These fractures frequently occur between three and eleven years of age with the highest incidence between five and eight years. The fracture is uncommon after twenty years. The male to female ratio is 3:1 [1,2,5].

Gaudeuille A et al [1] studied 199 children with supracondylar fractures between the ages of zero and 15 years. Most patients were boys 62%. Fracture occurred during play in 74% of cases and left arm was injured in 92% more often than the right hand.

In his study at KNH, Odongo [6] found out that 65% of cases resulted from fall from a height. Fansworth CL et al [2] found that girls tended to sustain these fractures more than boys and the non- dominant arm was more often injured. Children less than three years tended to fall from household objects (beds, stairs, chairs, etc) three to six feet high. Older children, more than four years old tended to fall from playground equipment such as monkey bars, slides, skating boards and swings.

2.2 Mechanism of injury

Supracondylar fracture takes place through a relatively weak portion of the lower end of the humerus between the condyles distally and the strong shaft of the humerus proximally [7,8] .Wilkins [9] reviewed 4,500 fractures in 31 major series and observed that 97.7% were of extension type and 2.2% were of flexion type. For the extension type the mechanism of injury is commonly a fall on the outstretched hand with the elbow extended. The force is applied indirectly to the distal humerus displacing it posteriorly. Posteriorly displaced fractures may be displaced medially or laterally [10,11].

The flexion type results from a fall on a flexed elbow. Direct force is applied to the flexed elbow and may displace the distal fragment anteriorly [4,10,12].

Gaudeuille A et al (1) found that the mechanism of fracture was extension in 96.6% (115 of 119). Most fractures(68.1%) were severe grades (Gartland IIIa + IIIb).

2.3 Clinical presentation

Following supracondylar fracture, the child is in pain and the elbow is swollen. Children who present with non- displaced fracture may initially have minimal swelling [13]. With posterior displacement the S-deformity of the elbow is usually obvious and the bony landmarks are abnormal. The olecranon process is prominent and the distal humeral fragment is displaced posteriorly and proximally due to the triceps pull [13,14,15].

2.4 Radiological evaluation

A careful study of radiological signs both in antero-posterior and lateral views enables one to determine the fracture pattern and to check for adequacy and accuracy of reduction [16,17]. Sub-optimal fracture reduction results in malunion later. The fracture is seen more clearly in the lateral view. Gartland [18] classified extension fracture into three types.

Gartland type 1:Fractures are non-displaced.

Fig 1

Gartland type II:

Fractures are angulated but not translated in the sagittal plane with hinging of the posterior cortex of the humerus.

Fig 2

Gartland type III: Fractures are posterially displaced with:

Gartland IIIa- being displaced postero –medial.

Fig 3

Gartland IIIb – being displaced postero – lateral.

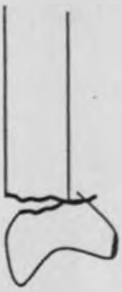

Fig 4

2.5 Management

Careful and continuous examination of the forearm and hand is required. The fingers may be warm and show good capillary refill even when the brachial artery is disrupted

[3,19].

Prompt recognition of vascular injury should prevent Volkmann's ischaemic contracture [20]. Vascular injuries accompanying supracondylar fractures should be repaired immediately [21,22]. Examination of the hand and forearm for signs of compartment syndrome should be repeated severally for at least 48hrs from the time of admission and treatment.

Nerve injuries present at the time of presentation should be documented: Recovery is the norm in children [23,24,25,26]. Surgical exploration and repair is recommended if nerve function has not returned to normal within six and eight months post-injury

[4,23,26].

Closed reduction and immobilization

Criteria for closed reduction and immobilization are: [16,27,28,29].

i. Easy reduction.

ii. Minimal swelling.

iii. Stable fracture.

iv. No vascular compromise.

Gartland type I fractures can be satisfactorily treated with immobilization with backslab-plaster cast and collar [4,10,21]. Previously closed reduction and maintenance of reduction with splint or cast immobilization was recommended for displaced supracondylar fractures [29,30,31]. Loss of reduction and repeated manipulation frequently resulted in elbow stiffness and epiphysed damage [32]. Closed reduction and casting for displaced fractures (supracondylar fracture) resulted in higher percentages of early and late complications [14,30,33,34].

Closed reduction is difficult to achieve and maintain because of the thinness of bone of the distal humerus between the coronoid and olecranon, where most supracondylar fractures occur. For this reason many authors do not advocate closed reduction and casting for displaced supracondylar fractures.

Traction

Dunlop [33], disappointed by the results of closed reduction and casting described lateral traction in full extension. Ippolito, Caterini and Scola [28] reported good results at long term follow up in 81% of non-displaced and 78% of displaced fractures, treated conservatively with overhead skeletal traction, plaster cast and traction bow.

Worlock and Colton [35] reported the use of overhead olecranon traction through an olecranon screw and traction clip in 27 severely displaced supracondylar fractures. Eighty one percent had excellent results, five percent had good results and two percent had poor results.

The major disadvantage of traction was the long hospital stay and elbow stiffness.

Closed reduction and percutaneous pinning

Cheng et al [36] analyzed in detail 403 patients with supracondylar fractures. One hundred and eighty (180) patients with Gartland II and III extension fractures, were treated by primary closed reduction and percutaneous pinning using smooth kirschner wire. Eighty two patients were followed up for an average of three and a half years and were studied in detail clinically and radiologically.

The study showed that crossed or lateral percutaneous pinning is effective in treatment of Gartland type II and type III extension fractures with high success rates and minimal complications. Betty and Braveus [16] reported good results in 95% (61 of 64)type III supracondylar fractures treated with closed reduction and percutaneous pinning. Peters et al [37] reported 97.5% (38 of 39) achieved good or excellent results based on Flynn grading scale.

Abnebneth et al [34] in their long term results of treatment of 135 children with displaced extension type supracondylar fracture of the humerus found that closed reduction and percutaneous pinning was superior with excellent and good results in 87% and the lowest incidence of poor results, 8%. Open reduction and wire fixation and closed reduction with plaster cast gave excellent and good results in 74% and 64% respectively. They recommended closed reduction and pinning as the method of choice of treatment for Gartland II and III type fractures.

Danielson and Petterson [14] noted loss of reduction when one pin was used. Fylnn et al [39] use two crossed pins. Iyengar [38] found no difference in the final outcome between early and delayed closed reduction and percutaneous pinning. Peters et al [37] reviewed 43 displaced extension type supracondylar fractures in children. Ninety one percent (39 of 43) of the fractures were managed by immediate closed reduction and percutaneous pinning, at mean follow up of 35 months, 97% achieved good or excellent results based on the Flynn grading scale.

Open reduction and internal fixation

The indications for open reduction and internal fixations are:

[3,32,14,15,40,41, 42,43].

(i) Unsatisfactory closed reduction.

(ii) If the elbow is so severely swollen that a closed reduction cannot be maintained.

(iii) Gartland type IIIb displaced fracture with no cortical contact and completely detached periosteum.

(iv) Compound fracture that require irrigation and debridement.

(v) Vascular injury.

(vi) Multiple fragments.

When open reduction and internal fixation are to be carried out it should be performed after the swelling has decreased, but not later than five days after injury because of the risk of development of myositis ossificans [40, 41]

Fleurian-Chateau [42] in their analysis of open reduction of irreducible supracondylar fractures in children found, 62.5% (25 of 41) of children the humerus was button holed through the brachialis muscle; one had entrapment of common flexor tendon at its origin and one had entrapment of the triceps. In 15 children there was entrapment

or tethering of the median nerve and radial nerve or the brachial artery or all. This was not predictive of pre-operative neuro-vascular deficit that was recorded in 21 of the patients. At follow –up the range of motion was satisfactory in 94% of patients and there was no significant cubitius varus.

They concluded that open reduction and fixation of supracondylar fracture is safe and effective procedure for which orthopaedic surgeons should lower their threshold given certain appropriate indicators.

2.6 COMPLICATIONS

Early complications.

Vascular injury:

Vascular injury has been reported to range from 8% to 12 % [19, 22, 28, 43]. Injury to brachial artery occurs in about 10% of patients with supracondylar fractures [19,21,44]. In many cases circulation is restored once the fracture is reduced.

Close observation of vascular status by capillary refilling, radial pulse oximeter monitoring and dopler waveform analysis are recommended. Cheng et al [36] in their prospective study found 5% of patients with absent radial pulse and only one patient required exploration.

One should always have a high index of suspicion for compartment syndrome because Volkmann's ischaemic contracture is the most devastating complication of this injury [45]

Mosely and Wilkins [16] recommend fasciotomy in the presence of clinical signs of compartment syndrome such as paraesthesia, pain on passive motion, pallor, pulseless and palpable firmness in the forearm.

Indications for fasciotomy are:

(i) Clinical signs such as; demonstable motor and sensory loss.

(ii) Compartment pressures above 35 mmHg.

(iii) Interrupted arterial circulation to the extremity for more than four hours.

Nerve injury

The incidence of neurologic injury ranges from 5% to 19% [23,24,44]. Any of the peripheral nerves, median, anterior interosseous, radial and ulna may be damaged. Wilkins [16] reviewing 4500 fractures found radial, median and ulna nerves were involved in that order of frequency. All recovered completely from 4 to 40 weeks post-injury.

In closed fractures, documentation, observation and supportive therapy is the preferred treatment in children with neurologic deficit [23,44].

Exploration and neurolysis has been recommended at five months after injury if there is no clinical or electromyographic evidence of return of normal nerve function [23].

Late complications

Cubitus varus and valgus are the most common late complications after displaced supracondylar fractures, occurring in up to 40% of cases [46,47]. Smith [48] showed that medial tilting of distal fragment was the most important cause of change in the carrying angle. Labelle et al [49] found medial tilting of the distal fragment to be the cause of deformity in all the patients with cubitus varus after supracondylar fracture.

Elbow stiffness

Elbow stiffness is common after this injury and immobilization. It takes at least three months for full return of movement [28]. Full extension may take even longer.

Malunion

This may result from failure to reduce the fracture accurately resulting in the so-called gun stock deformity, which consists of a combination of residual varus, internal rotation and extension. The later two will usually correct by remodeling but residual varus angulation will not [50,51].

Myositis ossificans

Blood collects under the stripped soft tissue forming haematoma instead of being absorbed the haematoma is invaded by osteoblasts and becomes ossified.

Tardy ulna nerve palsy

Tardy ulna nerve palsy may occur due to stretching of the ulna nerve in association with valgus deformity of the elbow. This requires surgical correction [23,25].

Sudeck's post traumatic osteodystrophy

This is a rare complication.

Non-union

Non-union is rare. It may occur if fracture is not accurately reduced or due to inter position of soft tissue between fracture ends.

3.0 MATERIALS AND METHODS

Setting:

The study was carried out at KNH, a national referral and teaching hospital.

Criteria

Inclusion criteria.

(i) Age - only records of children under 15 years were studied.

(ii) Type of fracture - only closed fractures were studied.

(iii) Period - only records of patient admitted and treated between 1996-2000 were included.

(iv) Records of patients who first presented and were treated and followed up at KNH.

(v) Record of patients referred to KNH within 48 hours from other health facilities.

Exclusion criteria

(i) Records of patients over 15 years of age.

(ii) Records with grossly insufficient information.

(iii) Open fractures.

(iv) Records of patients treated before 1996.

(v) Record of patients referred to KNH beyond 48 hrs.

Study design:

This was a retrospective study of paediatric humeral supracondylar fractures at K.N.H.

Procedure

The proposal for the study was approved by the KNH Ethical committee. A research assistant (Medical Doctor) was appointed and appraised on the purpose of study and the method of data collection. The staff of the medical records and radiology departments were informed of the study and assisted in retrieving patients case notes and radiographs.

The questionnaire [appendix II] was pre-tested by picking the patients' case notes and radiographs randomly, reviewing the data and then making entries. It was found to be adequate and appropriate for the purpose of the study. We then carried-out, a detailed review of case note, and radiographs of the patients who had sustained supracondylar fractures of the humerous during the period of 1996 to 2000.

Case notes were deemed to be adequate if they contained information regarding the patient's sex, age, date of injury, date of hospital admission, cause of injury, arm injured, associated injuries, method of treatment, duration between injury and operation, date of discharge and follow-up period. The information was entered separately in the data sheet for each patient. Inadequate case notes were those containing inadequate information, as listed above. They were noted and excluded from the study.

Radiographs were regarded as adequate if both antero-posterior and lateral views were present and of good quality. Poor quality radiographs were defined as over penetrated, under penetrated and oblique views. Only adequate radiographs were used to determine fracture characteristics. Fractures were grouped as either extension or flexion type.

We classified extension type fracture as Gartland type I, II, IIIa and IIIb (fig 1,2,3 and 4). For each fracture type the initial and definitive treated method were reviewed and recorded in the data collection sheet.

The method of treatment was identified as;

(1) MUA, backslab- plasters cast, collar and cuff.

(2) Traction whether vertical or straight lateral traction.

(3) CRPP - closed reduction and percutaneous pinning.

(4) ORIF - open reduction and internal fixation.

Records of the patients were studied for the duration of follow-up, complications and outcome. Complications were classified as early, if they occurred at the time of injury or during the early post-injury period. Late complications were those observed during the follow-up period. A minimum follow-up of six months from the date of injury was chosen as a baseline for a complication to be regarded as a long-term complication arising from the injury. Case notes with inadequate information were excluded from analysis of complications and outcome (table 12,13,14,15,and 16). The results of patients who had detailed clinical information were assessed by Flynn's grade for elbow function. The Flynn's grading scale is shown in Table [1].

In this study excellent and good results were grouped together as good results.

Table 1

	RESULTS	FUNCTIONAL LOSS OF EXTENSION – FLEXION (degrees)	CHANGE IN CARRYING ANGLE (degrees)
Satisfactory	Excellent	0 to 5	0 to 5
	Good	6 to 10	6 to 10
	Fair	11 to 15	11 to 15
Unsatisfactory	Poor	Over 15	Over 15

Study Limitations

The following limitations and difficulties were encountered during the course of the study.

(1) Slow and lengthy process of retrieving patients records. Although the staff of the medical records and x-ray department were very helpful and co-operative, the retrieving of the records and radiographs proved to be tedious owing to the haphazard manner of filling radiographs and to a lesser extent, patients case notes. This unnecessarily prolonged the period of data collection.

(2) Missing radiographs. In some instances we obtained case notes but could not trace the corresponding radiographs. These were excluded from the study.

(3). Poor quality radiographs. Over penetrated and oblique views were few.

(4) Incomplete and inadequate clinical notes. This was particularly a problem during follow-up. For example complications noted earlier received no mention at subsequent follow-up. Such cases were not included in the analysis of outcome.

(5) Patient's failure to attend follow-up clinics. Review of case notes showed a number of patients dropped from follow-up for reasons not indicated or elected to be referred to the nearest hospitals for continued follow-up. Such patients (case notes) were excluded from analysis of long-term complications and outcome.

Some of these limitations had been anticipated and addressed by inclusion and exclusion criteria. Others arose in the course of study and appropriate recommendations have been proposed.

Data management

After completing and checking the questionnaires, the data was entered into the computer using Statistical Package for Social Scientists (SPSS) version 9.0. Chi-square was used to analyze categorical variables, and where conditions for use of Chi-square were not met, Fisher exact probability test was used. Results were presented in tables, bar charts, histograms, pie charts and frequency polygons.

4.0 Results:

A review of 471 patient case notes below 15 years admitted with humeral supracondylar fracture was conducted. Two hundred and fifty five (255) records had adequate information regarding age, sex, arm injured, mechanism of injury, type of fracture, initial method of treatment, definitive method of treatment and hospital stay duration. A subgroup of 183 patients had detailed information to allow assessment of results by Flynn's grading scale for elbow function. The results are presented below.

Table 2: Frequency distribution of gender of patient with supracondylar fracture

GENDER	FREQUENCY(f)	PERCENTAGE (%)
Male (M)	185	72.5
Female(F)	70	27.5
	n=255	100

Male to female ratio was 2.6:1

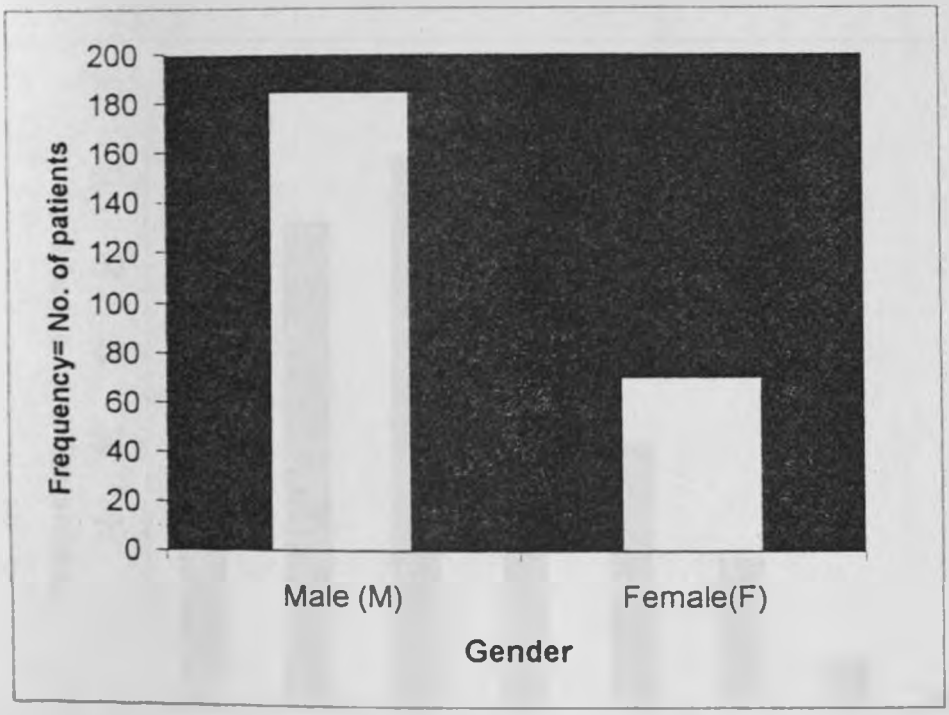

Fig 2: Bar chart showing frequency distribution of gender of patient with Supracondylar fracture

Table 3: Grouped frequency and % distribution of children with Supracondylar fracture

Age in yrs	Frequency (f)	Percentage (%)
0-1	19	7.1
2-3	55	21.6
4-5	62	24.3
6-7	64	25.1
8-9	30	11.8
10-11	17	6.7
12-13	6	2.4
14-15	2	0.8
	255	100%

Peak incidence was 4-7 years.

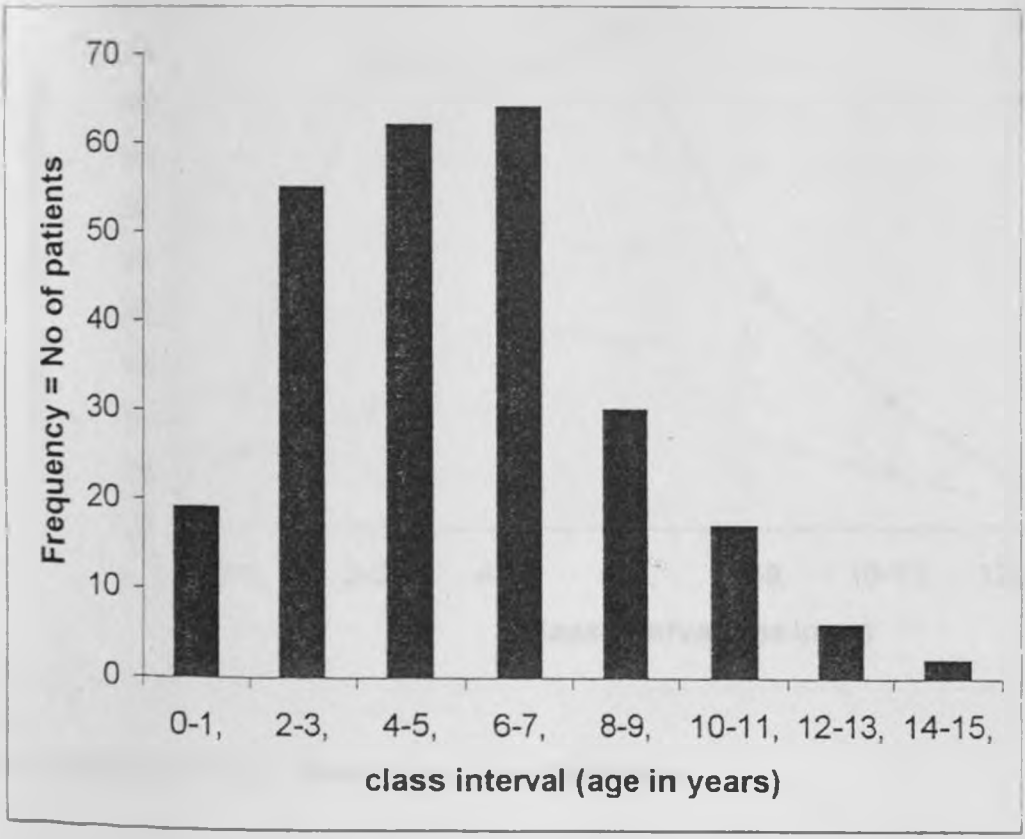

Fig 4: Histogram showing grouped frequency % distribution of children with Supracondylar fractures.

Table 4: Grouped frequencies for age-sex distribution

Class interval Age in years	Gender of patients		Total
	Male	*Female*	
0-1	12	7	19
2-3	44	11	55
4-5	42	20	62
6-7	47	17	64
8-9	22	8	30
10-11	12	5	17
12-13	4	2	6
14-15	2	0	2
	185	70	255

Highest incidence in males, occurred in the age group 6-7 years
Highest incidence in females, occurred in the age group 4-5 years.

Fig 6: Frequency polygon showing age – sex distribution.

Table 5: Cause of injury and their percentage (%) distribution

Fall from:	Female	%	Male	%	Total	%
Bicycle	13	5.1	33	12.9	46	18
Tree	16	6.3	42	16.5	58	22.8
Table/desk/chair	5	2	7	2.7	12	4.7
Staircase	8	3.1	15	5.9	23	9
bed	2	0.8	3	1.2	5	2
Fall on level ground	20	7.8	68	26.7	88	34.5
Assaults	2	0.8	3	1.2	5	2
RTA	1	0.4	9	3.5	10	3.9
Others	3	1.2	5	2	8	3.2
	70		185		n=255	100

Fall from a height, was the leading cause of injury (56.5%).

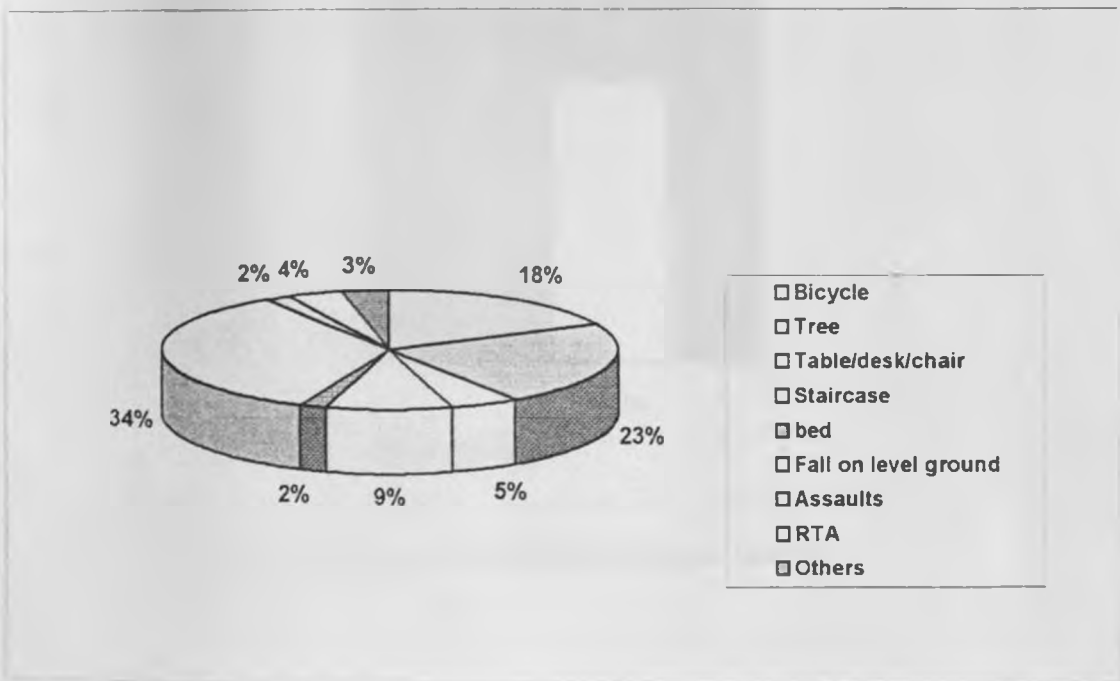

Fig 7: Pie chart showing cause of injury& their percentage (%) distribution.

Table 6: Arm injured

Arm injured	Frequency (f)	Percentage (%)
Left	174	68.2
Right	81	31.8
	n=255	100

The left arm was mostly injured (68.2%).

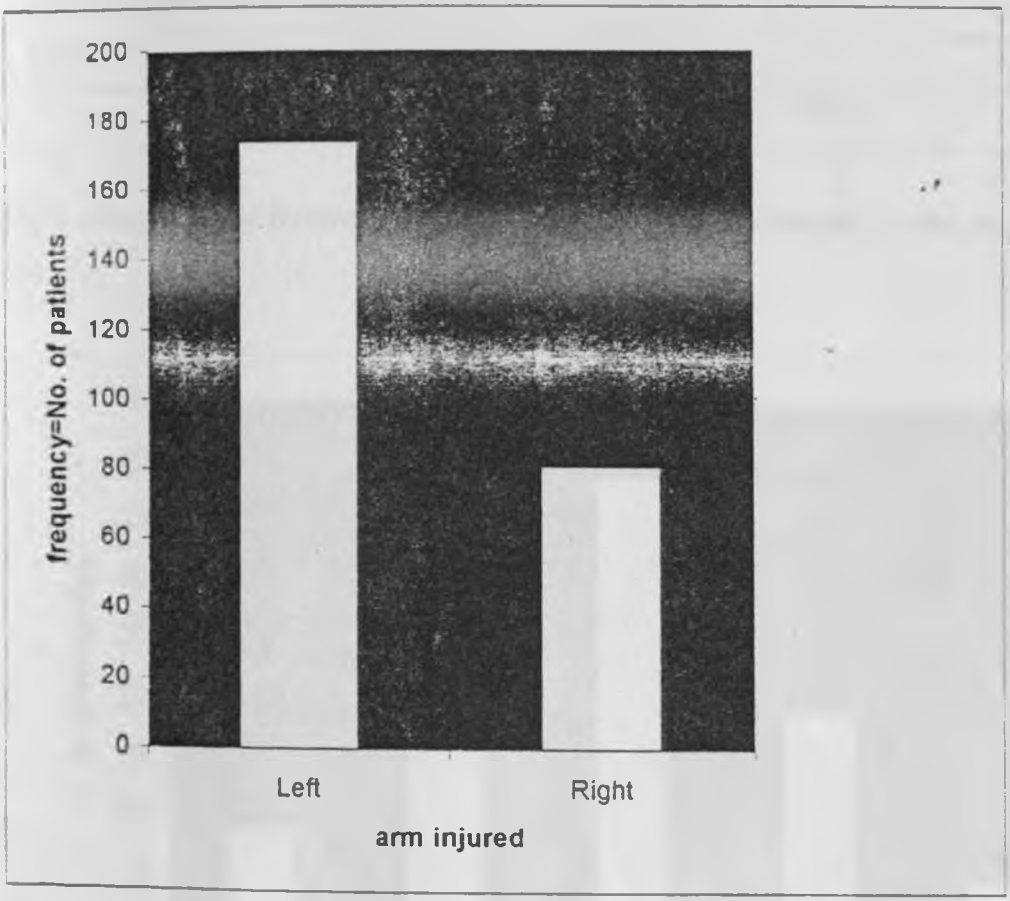

Fig 8: Bar chart showing frequency distribution of arm injured.

Table 7: Fracture type and their percentage distribution

Fracture grade	Frequency=No. of fractures	Percentage (%)
Gartland Type I	24	9.4
Gartland Type II	68	26.7
Gartland Type IIIa	99	38.8
Gartland Type IIIb	50	19.6
Flexion	14	5.5
	n=255	100%

High energy type of fratures (Gartland IIIa and IIIb) accounted for the majority (58.4%).

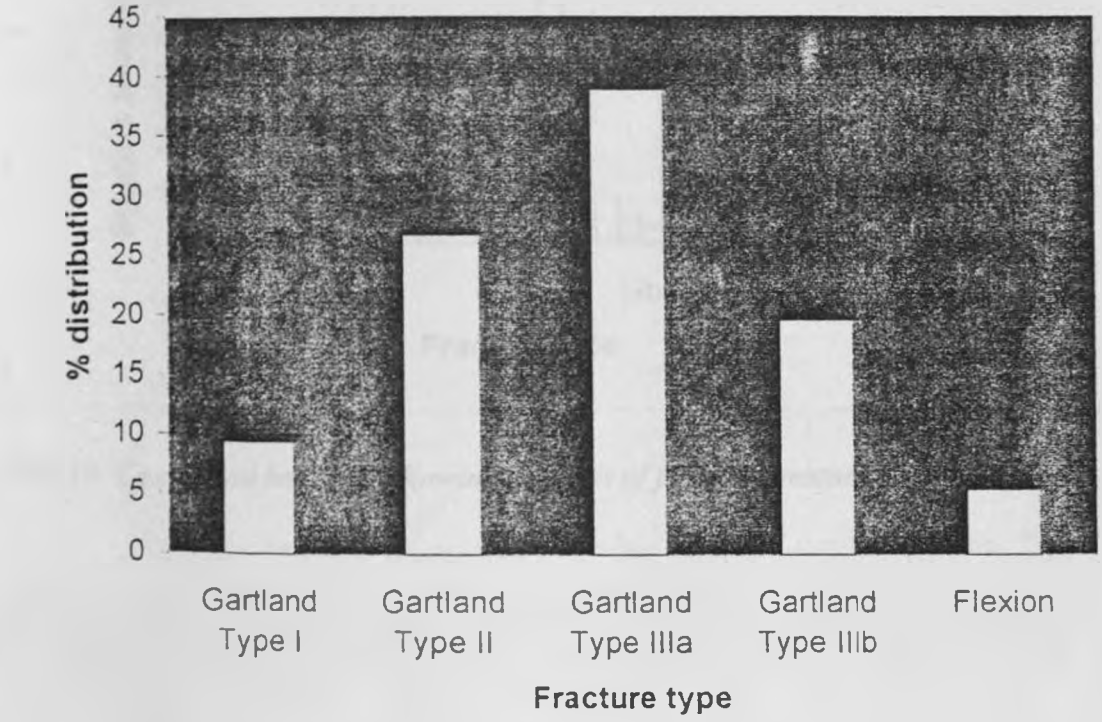

Fig 9: Bar chart showing Percentage distribution of various fracture types.

Table 8: Method of fracture treatment

Type	± MUA+POP Collar+CUFF	Traction	CRPP	ORIF	Total
I	24	0	0	0	24
II	51	3	8	11	73
IIIa	23	7	5	72	107
IIIb	9	5	3	35	52
Flexion	7	1	0	6	14
Total	114	16	16	124	

Undisplaced fractures (Gartland I and II) were mainly (80.6%) treated conservatively. Displaced fractures (Gartland IIIa and IIIb), 68.5%, were treated by ORIF.

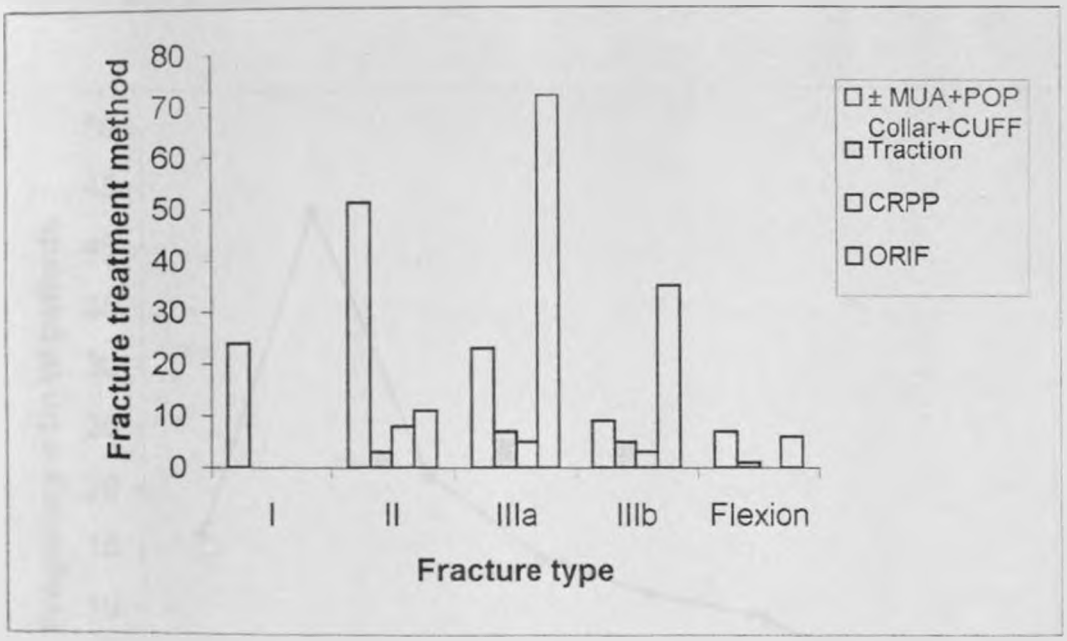

Fig 10: Compound bar chart showing methods of fracture treatment

Table 9: Interval between injury and operation.

Duration (days)	No. of patients	Percentages %
0-2	16	12.9
3-5	43	34.7
6-8	21	16.9
9-11	14	13.3
12-14	11	8.9
15-17	9	7.3
18-20	4	3.2
>21	6	4.8
	124	100

Forty seven point six percent (47.6%) of patients were operated within the first five days. The risk of developing myositis ossificans, is increased when operations are performed after five days.

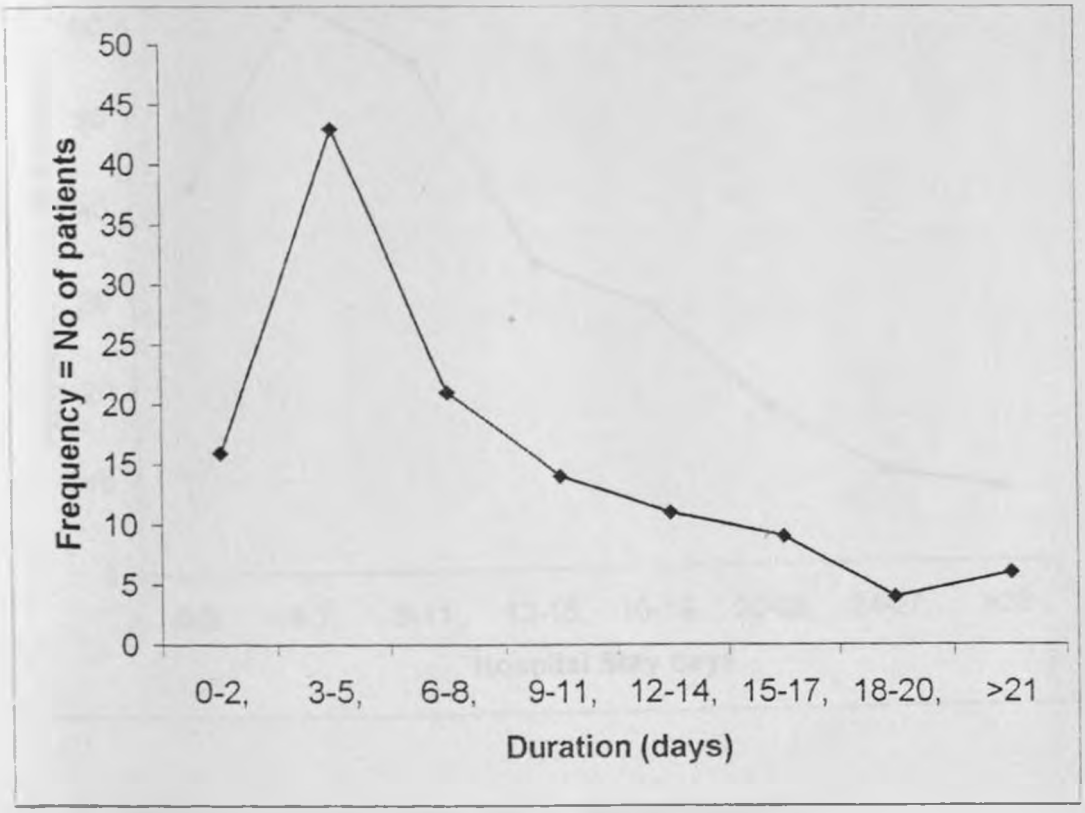

Fig 11: Frequency polygon showing the interval between injury and operation.

Table 10: Grouped frequency and % distribution of the numbers of Hospital stay days

Days	Frequency (f) = No. Patients	Percentage %
0-3	42	16.5
4-7	62	24.3
8-11	55	21.6
12-15	33	12.9
16-19	28	11.0
20-23	17	6.7
24-27	10	3.9
>28	8	3.1
	n=255	100

Many of the patients (62.4 %), were discharged from the hospital within eleven days.

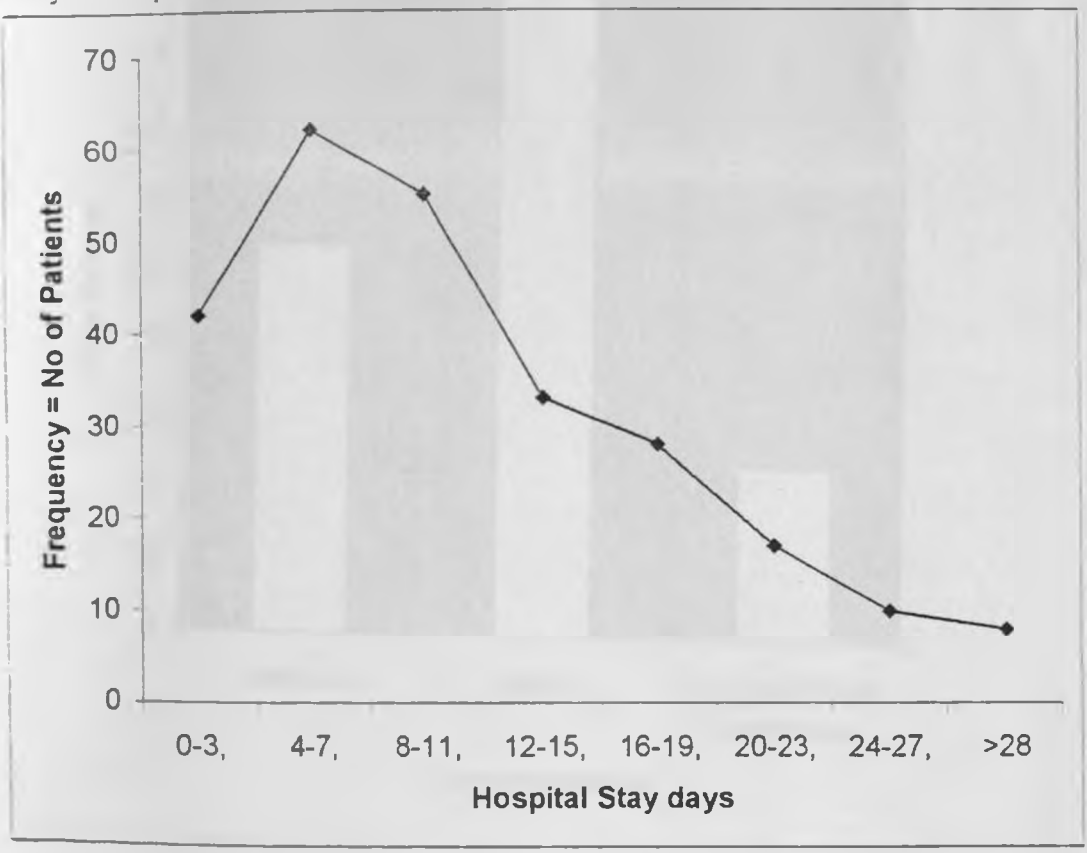

Fig 12: Frequency polygon showing No. of Hospital stay days.

Table 11: Early complications

Complication	Fracture Type					Total %
	I	II	IIIa	IIIb	Flexion	
Vascular			6	1		2.7
Nerve	1		9	2		4.7
Compartment Syndrome			3			1.2

Almost all (21 of 22) of the early complications occurred in high-energy fracture types (Gartland IIIa and IIIb).

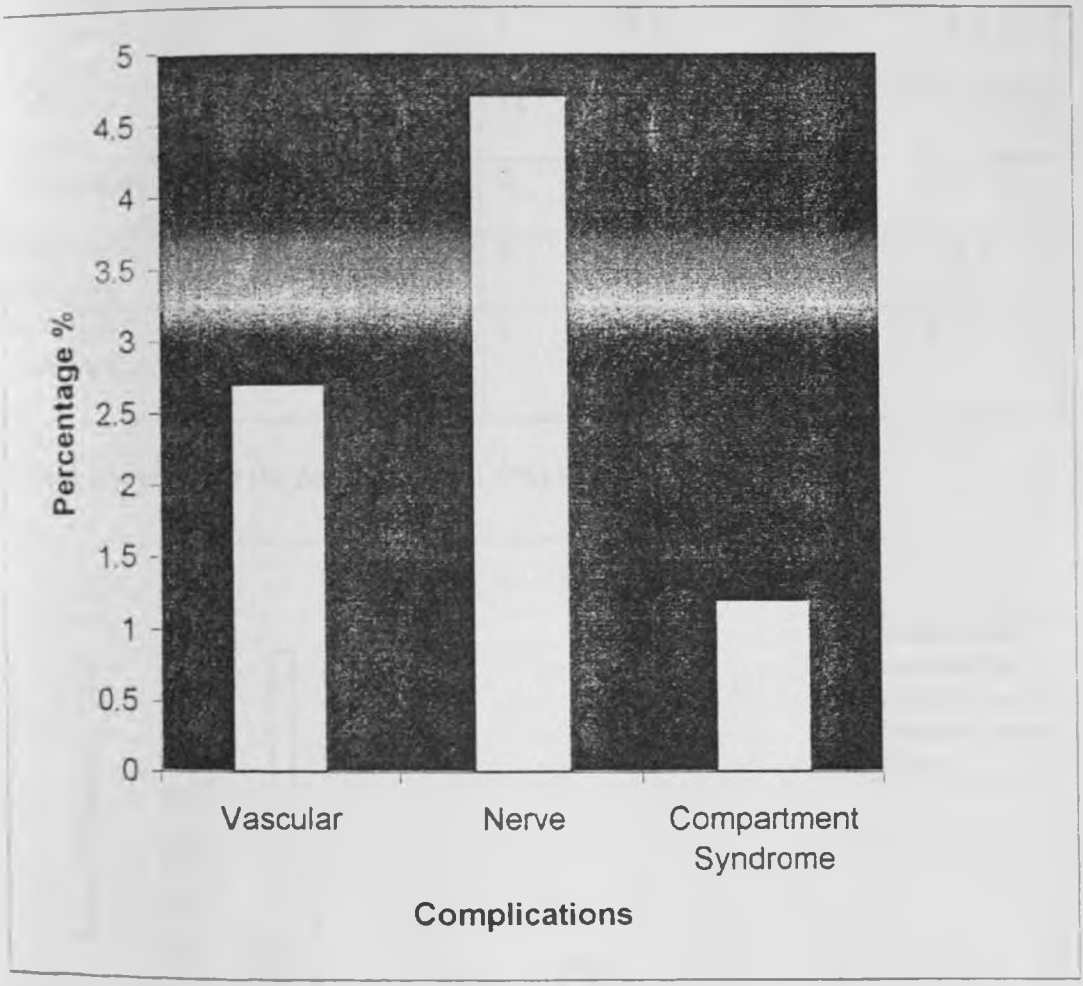

Fig 13: Bar chart showing % distribution of early complications

Table 12: Long term complication of various Fracture Types

Complication	Fracture Type I	Fracture Type II	Fracture Type IIIa	Fracture Type IIIb	Flexion	Total %
Elbow stiffness	3	17	45	26	4	51.9
Cubitus Valgus	0	0	5	4	0	4.9
Cubitus Varus	0	2	14	6	1	12.6
Volkmanns I.C	0	0	2	0	0	1.1
Pin tract Infection			3	2	0	2.7
Myositis Ossifications			2	1		1.6

Elbow stiffness was the commonest (51.9%) long-term complication

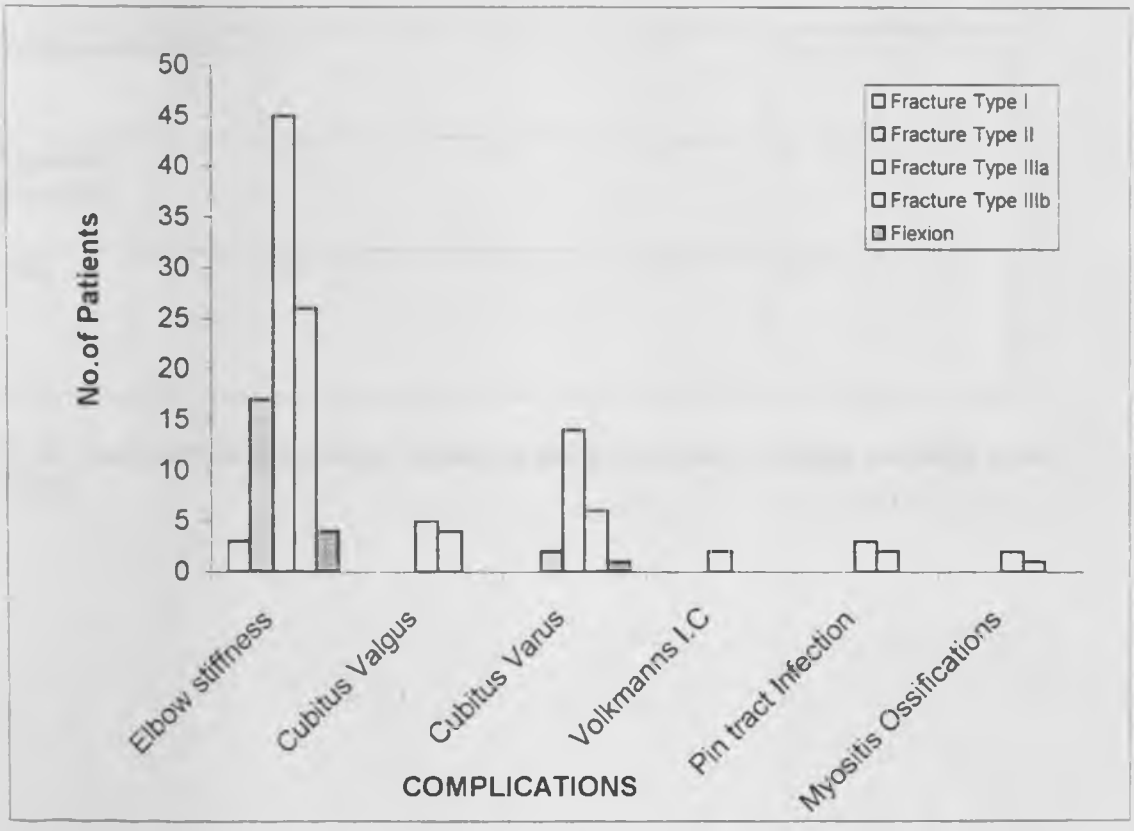

Fig 14: compound bar chart showing long term complication of various fracture Types

Table 13: Results of undisplaced and displaced fracture treated by traction

	Good	Fair	Poor	Total
Undisplaced (I+II)	3	0	0	3
Displaced (IIIa+IIIb)	7	1	1	9
Total	10	1	1	12

All the undisplaced fractures treated with traction achieved good results.

Table 14: Results of undisplaced and displaced treated by CRPP

	Good	Fair	Poor	Total
Undisplaced (I+II)	6	0	0	6
Displaced (IIIa+IIIb)	7	0	0	7
Total	13	0	0	13

All the patients treated by closed reduction and percutaneous pinning, achieved good results.

Table 15: Results of undisplaced fracture and displaced fracture treated by pop

	Good	Fair	Poor	Total
Undisplaced (I+II)	38	6	1	45
Displaced (IIIa+IIIb)	2	7	15	24
Total	40	13	16	69

Eighty-four point four (84.4%) of patients with undisplaced fractures treated with pop, had good results.
Poor results were noted in 62.5% of patients with displaced fractures treated by this method.

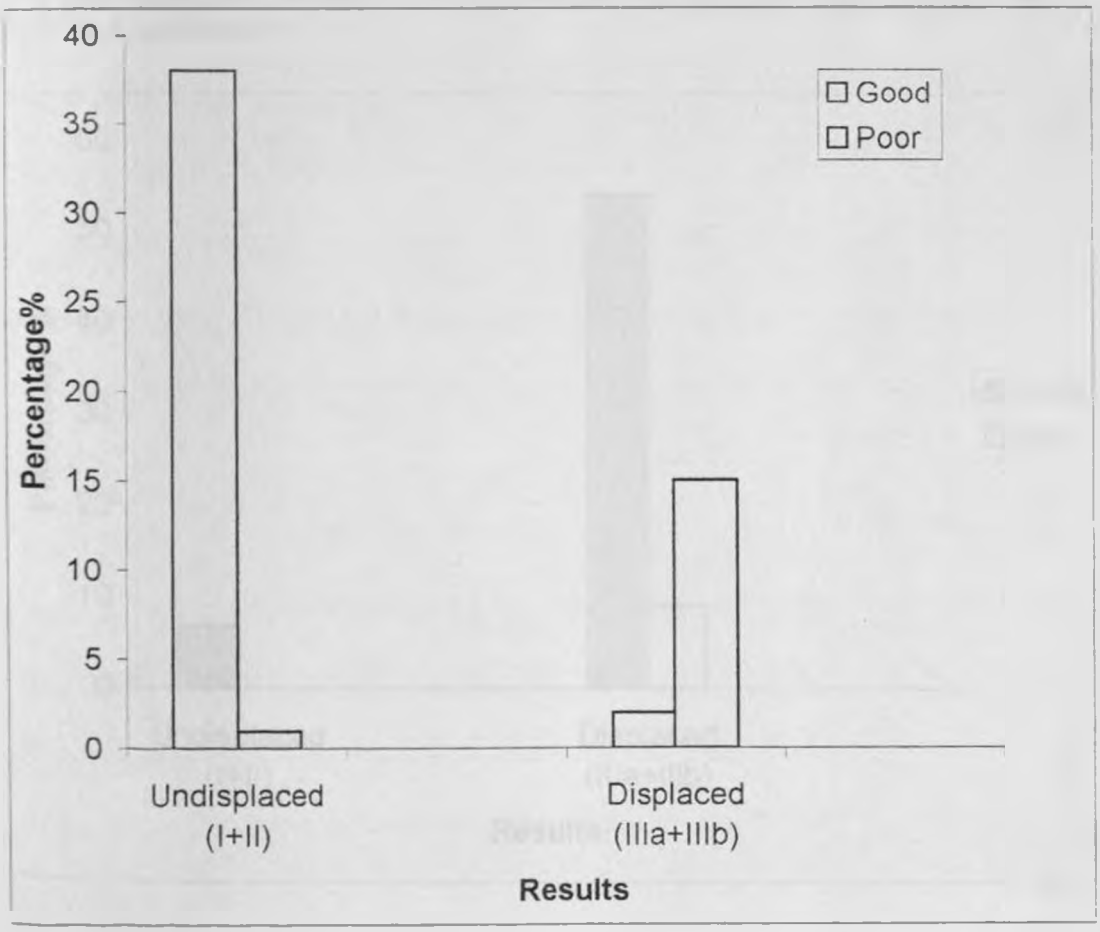

Fig 15:Bar charts results of undisplaced fracture and displaced fracture treated by POP.

Table 16: Results of undisplaced and displaced #s Treated by ORIF

	Good	Fair	Poor	Total
Undisplaced (I+II)	7	2	0	9
Displaced (IIIa+IIIb)	54	17	9	80
	61	19	9	89
67.5% (54 of 80)	***Had good results***			
11.3% (9of 80)	***Had poor results***			

Sixty seven point five percent (67.5%) of patients with displaced fractures treated by ORIF, had good results.

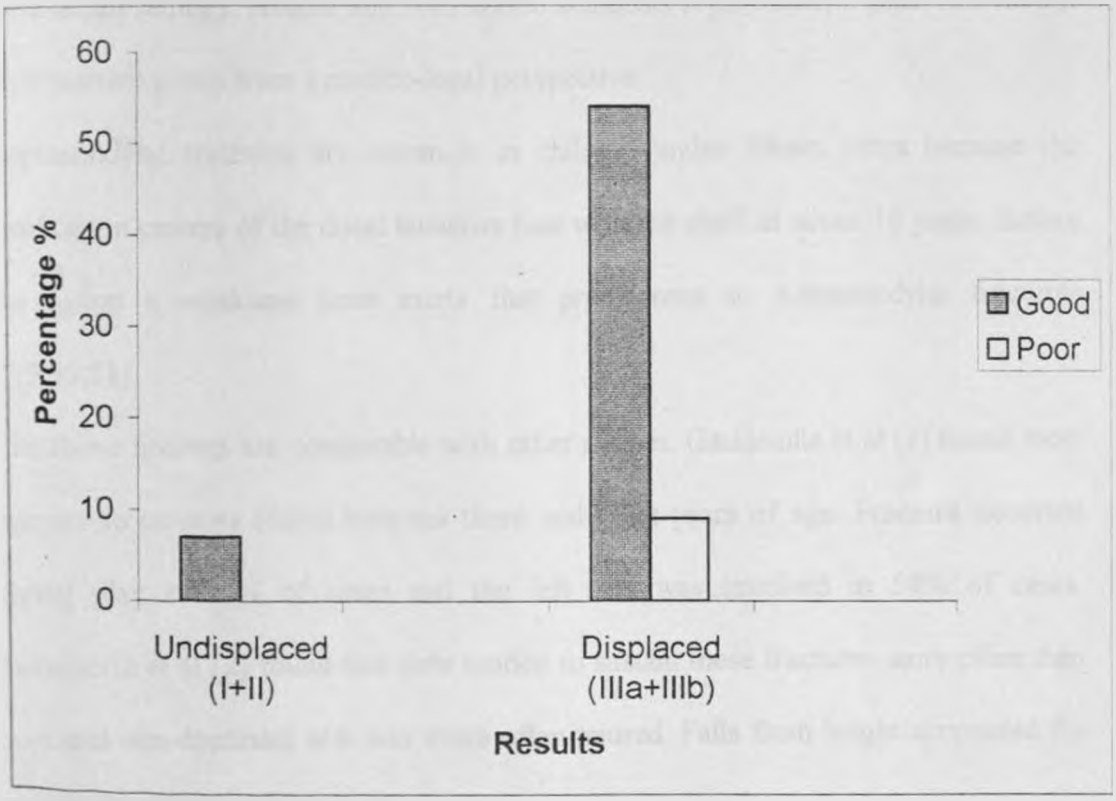

Fig 16:Bar chart results of undisplaced and displaced #s treated by ORIF.

5.0 DISCUSSION

The purpose of this study was to determine epidemiological characteristics, complications and outcome of humeral supracondylar fracture as seen at K.N.H.

5.1 Epidemiological characteristics of humeral Supracondylar fracture:

In this study supracondylar fractures occurred frequently between two (2) and nine (9) years with a peak incidence of between four and seven years. In 57.5%, fall from a height (tree, bicycle, table, desk, staircase, bed) was the commonest cause of injury. KNH serves both urban and rural populations and this explains the varied causes of injuries i.e. fall from trees (mostly from rural setting) bicycles and staircases (mostly from urban setting). Assault and road traffic accidents represented a small (5.9%) but an important group from a medico-legal perspective.

Supracondylar fractures are common in children under fifteen years because the ossification centers of the distal humerus fuse with the shaft at about 16 years. Before the fusion a weakness zone exists that predisposes to supracondylar fractures [7,9,50,51].

The above findings are comparable with other studies. Gaudeuille et al [1] found most patients to be boys (62%) between three and eight years of age. Fracture occurred during play in 74% of cases and the left arm was involved in 54% of cases. Farnsworth et al [2] found that girls tended to sustain these fractures more often than boys and non-dominant arm was more often injured. Falls from height accounted for 70% of the fractures in his study.

Other studies by Atinga [27], Ippolito et al [28], Piggot et al [56], Danielson [14], had comparable results.

Fracture type

The study found the majority of the fractures were of extension type (94.6%). Flexion type accounted for only 5.5%. For the extension type the mechanism of injury is a fall on the outstretched arm with the elbow extended and the force applied indirectly to the distal humerus, displacing it posteriorly [10,11]. The fracture type were high grade (Gartland IIIa and IIIb) in 58.4%.

KNH is a national referral hospital, and this may explain the high incidence of of displaced fractures observed in this study.

High-grade fractures are caused by high kinetic energy as occurs during a fall from height.

High incidence of high grade humeral supracondylar fractures were reported in other series [3, 11,18, 32, 36, 56].

5.2 Management

MUA, backslab-cast, collar and cuff

A total of 114 patients (42.7%) were treated by this method. These were seven patients with flexion type fractures and107 patients with extension type fractures. On check radiographs 31.3% {10 of 32} of patients with high grade fractures [Gartland type IIIa and IIIb] were found to have lost alignment and under went open reduction with internal fixation.

Treatment of supracondylar fractures of the humerus in flexion with a collar and cuff was recommended and taught by such authorities: Watson – Jones 1952 and Charnley 1961 [55]. It is widely accepted as the ideal outpatient treatment for undisplaced or minimally displaced fractures [16, 27,28,29].

Blount et al 1951 noted that in the presence of severe swelling or a neurovascular deficit the method had 'nothing to commend'. D' Ambrosia 1952 described the 'Supracondylar dilemma-' when the reduction is achieved, the elbow often has to be extended beyond 90^0 because of loss of radial pulse in such a position, the stabilizing effect of triceps and posterior periosteum is lost: redisplacement and cubitus varus may then occur.

Sub-optimal results were also noted by others when collar and cuff was used in the treatment of displaced fractures [14, 30, 31, 33]

Traction

Few patients 6.35% (16/255) were treated with this method. Ten had good results. Worlock and Colton [35] reported the use of olecranon traction through an olecranon screw and traction clip in 27 severely displaced supracondylar fractures. Eighty one percent had excellent results, five percent had good results and two percent had poor results. Ippolito, Caterin and Scola [28] reported good results in 81% of non-displaced and 78% of displaced fractures treated conservatively with overhead skeletal traction. Piggot et al 1986 [56] reported 90% satisfactory and only eight unsatisfactory results. They pointed to long hospital stay duration as the main disadvantage of treatment by traction. They also noted that treatment of impacted fractures by traction alone is not recommended because the distal fragment is not free to realign. Due to long hospital stay duration and limited bed availability at KNH, traction method is not popular.

CRPP - closed reduction and percutaneous pinning

Sixteen patients (6.3%) were treated with closed reduction and percutaneous pinning (CRPP). At follow –up, 13 patients had good results and three patients were lost to follow – up. Closed reduction is difficult to achieve and maintain by collar and cuff because of thinness of bone of the distal humerus between the coronoid and olecranon, where most supracondylar fractures occur. For this reason, many authors have described percutaneous pinning techniques, which have become the treatment of choice for most supracondylar fractures [16,34,36,37,38].

Ababneth et al [34] found that closed reduction and percutaneous pinning achieved excellent and good results in 87% and poor results in 8%.

Peters et al 1995, Cheng JC 1995, achieved good results in over 90% of patients treated with CRPP. Danielson and Petterson (1980) noted loss of reduction when only one pin was used. Flynn et al [39] used two pins. Arino et al [52] recommended two lateral pins. Iyengar et al [38] found no difference in the final outcome between early and delayed reduction and pinning of Gartland type III fractures. Closed reduction and percutaneous pinning is not widely practiced at KNH probably due to:

(i) Lack of adequately trained personnel in closed reduction and percutaneous pinning method.

(ii) Learning curve that is required to master the technique.

(iii) Fluoroscopy not available at odd times.

(iv) Inefficient and under utilization of hospital resources i.e. theatre and personnel.

J.C Flynn et al [39] noted the merit of closed reduction and percutaneous pinning

(i) Maintenance of fracture stability.

(ii) Vascular safety.

(iii) Simplified management.

(iv) Reduced Hospital stay.

(v) Satisfactory appearance and function of the elbow.

Open reduction and internal fixation

Forty eight point six percent (124 of 255) patients were treated with open reduction and internal fixation primarily. Majority of these were Gartland IIIa and

IIIb, 86.3% (107 of 124) patients. At follow-up 67.5% of patients with displaced fractures had good results and 11.3% had poor results.

Abnebneth et al [34] reported excellent and good results in 74% of displaced fractures managed with open reduction and internal fixation. Weiland et al 1978 . Danielson et al 1980, Ramsey 1973, Shifrim et al 1984, Thompson et al 1984, Gruber et 1964, advocated for open reduction and internal fixation for severely displaced supracondylar fractures.

Piggot et al [56], noted surgical treatment of the severely displaced supracondylar fracture was not in favor because- 'permanent limitation of motion is all too frequent.' Gruber M.A [16], observed that most series demonstrating significant loss of motion were reported by surgeons who utilized the posterior approach or resorted to surgery after repeated closed manipulations failed to achieve satisfactory reduction.

Fleuriau – Chateau et al [42] in their analysis of open reduction of irreducible supracondylar fractures in children concluded that open reduction is safe and effective procedure for which orthopaedic surgeons should lower their threshold given certain appropriate indicators.

In this study 1.2% (15 of 114) patients who had been managed with MUA, backslab-plaster cast, collar and cuff redisplaced and had to be operated.

5.3 complication

Early Complications

Vascular Injury

Two point seven percent (7 of 255) of patients sustained vascular injuries. Six of these patients had Gartland type IIIa fractures. Vascular compromise is reported to occur in as many as 12% of patients with supracondylar humeral fractures [19, 21, 22, 43].

The mechanisms of vascular injury are: disruption of vascular wall, compression and vascular spasm. Complete disruption usually present with initial haemorrhage, which decreases as the vessel goes into spasm and clot develops. Partial disruptions may not present with ischaemia, as a channel for blood flow is maintained. In many patients distal circulation is restored, once the fracture is reduced and stabilized [57,58]. In this study five (5 of 7) patients with vascular compromise, had their distal circulation restored upon reduction and stabilization of the fractures.

Irreversible muscle necrosis occurs after six hours of ischaemia. and therefore close observation of vascular status is necessary. Surgical exploration of the brachial artery is recommended, if circulation does not return to normal, with the elbow flexed to less than 45 degrees. Timing of vascular exploration is individualized, with priority given to restoration of perfusion to ischaemic muscles and nerves [43, 58]. In this study two patients underwent brachial artery exploration due to persistent poor distal circulation. This is comparable to other studies. Shaw BA et [19], reported 14 patients (14 of 17), had their circulation restored after fracture reduction and stabilization with Kirschner wires. In his study, two patients (2 of 7) brachial artery was explored because of unsatisfactory blood supply to the hand.

Compartment syndrome

Compartment syndrome occurred in 1.2% (3 of 255) of the patients. All these patients had Gartland IIIa type fractures.

Bleeding, oedema and inflammation cause increased intra compartmental pressure. These events trigger off the vicious cycle of Volkman's ischaemia, with increasing capillary leakage and increasing pressure. Loss of capillary bed perfusion results in local muscle and nerve ischaemia, even though arterial trunk flow may be patent [44 45]

Compartment syndrome is rare but a serious complication of supracondylar humeral fractures [44]. It requires immediate fasciotomy. Wilkins [16] pointed out that the morbidity caused by fasciotomy is minimal, while that caused by untreated compartment syndrome is much greater. Facilities for measuring and monitoring intra compartment pressures are not available at K.N.H and therefore the diagnosis is clinical. A high index of suspicion aids in prompt diagnosis and intervention.

In this study, all the three patients with compartment syndrome underwent emergency fasciotomies. At follow-up, all the patients had good limb function.

Nerve Injury

In this study, 4.7% (12 of 255) of patients had nerve injuries. Neurological injuries are reported to occur in up to 19% of patients with supracondylar humeral fractures [23,24].

Seddon [59] classified nerve lesion as; neurapraxia, axonotmesis and neurotmesis, depending on the severity of injury. Low energy injury is likely to cause a neurapraxia, the patient should be observed and recovery anticipated. This study found out that ten patients (10 of 12) with nerve injuries recovered fully, without operative intervention. A high-energy injury is more likely to cause axonal and endoneural disruption, making recovery less predictable. A very high energy closed injury or an open injury, is likely to divide the nerve and early exploration is

recommended [23, 24, 60]. In this study, exploration was performed for two patients, with persistent neurological deficit.

High-energy fracture types, Garland IIIa and IIIb were associated with neurological injuries. This is similar to other studies: Culp R W et al 1990 and Severijnen R S et all 1999.

Long Term Complication

Cubitus varus

Cubitus varus is the most common angular deformity that results from supracondylar fractures in children [46,47,48]. In this study the incidence was found to be 12.6% [23 of 183] of patients. The deformity is due to medial angulation of the distal fragment. Smith [48] proved that varus tilting of the distal fragment was responsible for cubitus varus.

Re-modeling of the bone does not correct the varus deformity [53, 51 49]. Therefore, adequate reduction of the fracture is necessary to prevent this cosmetically disfiguring deformity [53,47].

Cubitus valgus

This occurred in 4.9% of patients. Beals [16] noted that the normal carrying angle from birth to age four years is 15 degrees and increases to 17.8 degrees in adults. For this reason an increase in valgus is not cosmetically noticeable as a varus deformity [16,49].

The importance of cubitus valgus is the liability to cause tardy ulnar nerve palsy. [23, 24, 61]. This may require surgical transposition of the ulnar nerve anterior to the elbow joint

Elbow stiffness

Ninety-five patients (51.9%) had elbow stiffness at follow-up. Majority of these patients (71 of 95) had Gartland type IIIa and IIIb fracture. Many had been managed by ORIF.

Attenborough [50], Dogde [30], and Piggot [56] had noted the frequency and significance the of this complication.

Factors responsible for joint stiffness include; soft tissue contracture, heterotopic bone formation, intraarticular adhesions, articular incongruity or a combination [28, 61].

Myositis ossificans

This was a rare complication affecting 1.1% of the patients. Heterotopic ossification occurs in damaged soft tissues. It is usually associated with forceful reduction and over-enthusiastic passive movement of the elbow.

Smith [54], Blount [7] Danielsson and Petterson [14], discouraged repeated manipulations. Failed closed manipulation after three attempts is considered an indication for ORIF [16, 39, 41].

5.4 Conclusions

1. Fall from a height (tree, bicycle, staircase, chair, bed) is the commonest cause of supracondylar fractures of the humerus in children.
2. Majority of these fractures are displaced high-grade type (Gartland IIIa and IIIb).[Related to the referral practices].
3. Elbow stiffness is a common complication, following supracondylar fracture of the humerus.
4. Patients with undisplaced fractures (Gartland I and II), and managed conservatively had a high rate of good results.

Recommendations

1. Conservative treatment with backslab-cast, collar and cuff is adequate treatment for undisplaced, low grade fractures (Gartland I and II).
2. Conservative treatment with backslab-cast, collar and cuff is inadequate method of treatment for displaced high grade fractures Gartland (IIIa and IIIb).
3. Closed reduction and percutaneous pinning (CRPP) under fluoroscopy is underutilized at Kenyatta National Hospital and should be actively promoted for the advantages already mentioned.

REFERENCES

1. Gaudeuille A, Douzima PM, Makolati Sanze B, Mandaba JL: Epidemiology of supracondylar fractures of the humerus in children in Bangui, Central African Republic. Med Trop (Mars). 57(1): 68-70, 1997.
2. Fansworth CL, Silva PD, Mubarak SJ: Etiology of supracondylar humerous fractures. J Pediatr Orthop. 18(1): 38-42, Jan-Feb 1998.
3. Millis MB, Singer IJ, Hall JE: Supracondylar fracture of the humerous in children: further experience with a study in orthopaedic decision-making. Clin Orthop 188:90-97, 1984.
4. Vahvanen V, Alto K: Supracondylar fracture of the humerus in children. A long-term follow –up study of 107 cases. Acta Orthop Scand 49: 225-33, 1978.
5. Palmer EE, Niemann KMW, Vesley D,Armstrong JH. Supracondylar fractures of the humerus in children. J Bone Joint Surg [Am]. 60A: 653-6, 1978.
6. Odongo C: Dissertation, Supracondylar fractures of the humerous at Kenyatta National Hospital1987 (M.Med. Surgery)
7. Blount WP, Schults L, Cassidy RH: Fractures of the elbow in children. JAMA. 146: 699-704,1951.
8. Blount WP: Fractures in children in Baltimore, Williams & Wilkins. 1982 pp 129.
9. Rockwood, CA, Jr, Wilkins KE (eds): Fractures in children, vol. 3, Philadelphia, JB Lippinott, 1984, pp.1-86. Second edition.
10. Landin LA, Danielson LG: Elbow fractures in children: An epidemiological analysis of 589 cases. Acta Orthop Scand. 57:309-312,1986.
11. Otsuka NY, Kasser JR: Supracondylar fractures of the humerus in children. J. Am Acad Orthop Surg5:19-26,1997.

12. Milch H: Fracture dislocations of the distal humeral condyls. J Trauma 4: 529-607,1994.

13. Dee R, Hurst Lc, Gruber MA, et al: Principles of Orthopaedic practice. New York: MCGraw-Hill; 1997:Chapter 32. Second edition.

14. Danielson L, Petterson H: Open reduction and pin fixation of severely displaced supracondylar fractures of the humerus in children. Acta Orthop Scap. 51:249-55,1980.

15. Ramsey RH and Gritz J: Immediate open reduction and internal fixation of severely displaced supracondylar fractures of the humerus in children. Clin. Orthop. 90:130,1973.

16. A.H Crenshaw, M.D. (ed.) (1992) Campbell's Operative Orthopaedics, 8th edition, Mosby, London. pp 1000-1015.

17. Mohammed S, Rymaszeewski LA, Runciman J: The Baumann angle in supracondylar fractures of the distal humerus in children. Jpediatr Orthop. 19(1): 65-9, Jan-Feb 1999.

18. Gartland JJ: Management of supracondylar fractures of the humerus in children. Surg Gynecol Obste 109:145-154, 1959.

19. Shaw BA, Kasser JR, Emans JB, et al: Management of vascular injuries in displaced supracondylar humerus fractures without arteriography. J Orthop Trauma 4:25-29,1990.

20. Blount WP: Editorial. Volkmann's ischaemic contracture. Surgery Gynaecol Obstet. 90:244-6,1950.

21. Kelsch G, Savvidis E, Jenal G, Parsch K: Concomitant vascular complications in supracondylar humeral fractures in children. Unfallchirug. 102 (9): 708-15, Sep 1999.

22. Sabharwar S, Tredwell SJ, Beauchamp RD, Mackenzie WG, Cains R, LeBlanc JG: Management of pulseless pink hand in pediatric supracondylar fractures of humerus. J Paediatric orthop. 17 (3):303-10, May-Jun 1997.

23. Culp RW, Osterman AL, Davidson RS et al: Neural injuries associated with supracondylar fractures of the humerus in children. J. Bone and Joint Surg 72-A:1211-1215, 1990.

24. Severijnen RS: Neurological complications in children with supracondylar fractures of the humerus. Eur J Surg. 165 (3): 180-2, Mar 1999.

25. Joist A, Scherf FG, Joosten U, Neuber M: Post-traumatic anterior interosseous nerve syndrome after supracondylar humerus fracture in a child. Chirug. 68(7): 738-41, Jul 1997.

26. Sairyo K, Henmi T, Kanemastu Y, Nakano S, Kajikawa T: Radial nerve palsy associated with slightly angulated pediatric supracondylar humerus fracture. J.Orthop Trauma. 11 (3): 227-9,Apr 1997.

27. Atinga JEO: Conservative management of supracondylar fractures of the humerus in Eastern Provincial General Hospital, Machakos. East. Afr. Med. J. 55(1) 551-560, 1984.

28. Ippolito E, Caterini R, Scola E: Supracondylar fractures of the humerus in children: Analysis at maturity of fifty-three patients treated conservatively. J Bone Joint Surg [AM]. 68A(3) 333-334,1986.

29. Jeshrani MK: Elbow injuries seen at Kenyatta National Hospital in 1974: Incidence and observations concerning their management. E Afr Med J. 55(7) 303-5, 1978.

30. Dodge HS: Displaced supracondylar fractures of the humerus in children: Treatment by Dunlop's traction. Bone Joint Surg [AM]. 54A: 1408-18,1972.

31. El-Sharkawi AH, Fattah HA: Treatment of displaced supracondylar fractures of the humerus in children in full extension and supination. J Bone Joint Surg [Br]. 47B: 273-9,1965.

32. Weiland AJ, Meyer SS, Tolo VT, et al: Surgical treatment of displaced supracondylar fractures of the humerus in children. Analysis of fifty-two cases followed for five to fifteen years. J Bone Joint Surg 60A: 657-61, 1978.

33. Dunlop J: Transcondylar fracture of the humerus in childhood. Bone Joint Surg. 21:59 73, 1939.

34. Abnebneth M,Shannak A, Agabi S, Hadidi S: The treatment of displaced supracondylar fractures of the humerus in children: A comparison of three methods. Int Orthop. 22(4)268-5,1998.

35. Worlock PH, Colton CL: Displaced supracondylar fractures of the humerus in children treated by overhead olecranon traction. Injury. 15:316-21,1984.

36. Cheng JC, Lam TP, Shen WY: Closed reduction and percutaneous pinning for type III displaced supracondylar fractures of the humerus in children. J Orthop Trauma 9 (6): 511-5,1995.

37. Peters CL. Scott SM, Stevens PM: Closed reduction and percutaneous pinning of displaced supracondylar humerus fractures in children: Description of new closed reduction technique for fractures with brachialis muscle entrapment. J Orthop Trauma 9(5): 430-4, 1995.

38. Iyengar SR, Hiffinger SA, Townsend DR: Early versus delayed reduction and pinning of type III displaced supracondylar fractures of the humerus in children: A comparative study. J Orthop Trauma. 13 (1): 51-5, Jan 1999.

39. Flyn JC, Mathews JG and Benoit RL: Blind pinning of displaced supracondylar fractures of the humerus in children. J Bone Joint Surg. 56A: 263,1974.

40. Shifrin PG, Gehring HW and Iglesiosis LJ: Open reduction and internal fixation of the displaced supracondylar fractures in children. Orthop. 188:58, 1984.

41. Thomson GH, Wilber JH and Marcus RE: Internal fixation of fractures in children and adolescents: A comparative analysis. Clin. Orthop. 188:10, 1984.

42. Fleuriau – Chateau P, McIntyre W, Letts M: An analysis of open reduction of irreducible supracondylar fractures of the humerus in children. Can J Surg. 41(2): 112-8, Apr 1998.

43. Vasli LR: Diagnosis of vascular injury in children with supracondylar fracture of the humerus. Injury 9:11, 1988.

44. Tschopp O, Rombouuts JJ, et al: Complications for supracondylar fractures of the humerus in children. Acta orthop Belg. 62 Suppl 1:51-7.

45. Krezien J, Richter H, Gussmann A, Schildnecht A: Compartment syndrome and volkmann contracture- can they be prevented in supracondylar humerus fracture. Chirug, 69(11):1252-6,Nov 1998.

46. Devnani AS: Lateral closing wedge supracondylar osteotomy of humerus for post-traumatic cubitus in children. Injury. 28(9-10): 643-7, Nov-Dec 1997.

47. Hindman BW, Schreiber RR, Wiss DA,. Ghilarducci MJ and Avolio RE: Supracondylar fractures of the humerus: Prediction of the cubitus varus deformity with CT. Radiology 165:513. 1998.

48. Smith FM: Surgery of the elbow second edition, pp. 60-136, 1972. WB Saunders Company, Philadelphia – Toronto.

49. Labelle H, Bunnell WP, Duhaime M and Poitras B: Cubitus varus deformity following supracondylar fractures of the humerus in children. J Paediatr Orthop 2:539,1982.

50. Attemborough CG: Remodelling of the humerus after supracondylar fractures of the humerus in childhood. J Bone Joint Surg [AM]. 35B: 386-95,1953.

51. Ogden JA: The uniqueness of growing bones. In Rockwood CA Jr, Wilkins KE and King Re (eds): Fractures in children, Vol 3. Philadelphia. JB Lippincott, pp 1 –86, 1984.

52. Arino VC, Lluch EE, Ramirez AM et al: Percutaneous fixation of supracondylar fractures of the humerus in children. Analysis of fifty-two cases followed for five to fifteen years. J Bone Joint Surg 60A: 657-61,1978.

53. D'Ambrosia RD: Supracondylar fractures of the humerus: prevention of cubitus varus. J Bone joint Surg [Am]. 54A: 60-6,1972.

54. Smith L. Deformity following supracondylar fractures of the humerus. J Bone Joint Surg [Am]. 42A235-52, 1960.

55 Charnley J. The closed treatment of common fractures. Third edition Baltimore, Williams and Wilkins 1972.

56 Piggot J. Graham H.K Mccoy G.F, Supracondylar fractures of the humerus in children: treatment by straight lateral traction. J.Bone Joint Surg. 68 – B(4)577-583. 1986:

57. Frykberg ER, Advances in the diagnosis and treatment of extremity vascular trauma. Surg Clin N Am 1995; **75(2):**207-23.

58. Weaver FA, Papanicolaou G, Yellin AE. Difficult peripheral vascular injuries. Surg Clin N Am 1996; **76(4):** 843-59.

59. Seddon HJ (1942) A classification of Nerve Injuries. *British Medical Journal 2*, 237-239.

60 Seddon HJ (1972) *Surgical Disorders of the Peripheral Nerves*. Churchill Livingstone, Edinburgh.

61 Apley's system of Orthopaedic and Fractures. Eighth edition, pp 308-309 , 571 &599

726300 - 19
726550 - 9
726562 - 6
726450 - 9
726581 - 2
725272

KENYATTA NATIONAL HOSPITAL
P.O. Box 20723.
NAIROBI.

Email: *knh@healthnet.or.ke*

Ref: KNH-ERC/01/992

11 April 2001

Dr. Wilson M. Kiraitu
Dept. of Surgery
Faculty of Medicine
University of Nairobi

Dear Dr. Kiraitu,

RE: RESEARCH PROPOSAL "OUTCOME AND COMPLICATIONS OF SUPRACONDYLAR FRACTURE OF THE HUMERUS IN CHILDREN AS SEEN AT KENYATTA NATIONAL HOSPITAL" (P934/11/2000)

This is to inform you that the Kenyatta National Hospital Ethical and Research Committee has reviewed and **approved** the revised version of your above cited research proposal.

On behalf of the Committee I wish you fruitful research and look forward to receiving a summary of the research findings upon completion of the study.

This information will form part of data base that will be consulted in future when processing related research study so as to minimize chances of study duplication.

Thank you.

Yours faithfully,

PROF. A.N. GUANTAI
SECRETARY, KNH-ERC

c.c. Prof. K.M. Bhatt,
Chairman, KNH-ERC,
Dept. of Medicine, UON.

Deputy Director (CS),
Kenyatta N. Hospital.

Supervisor: Dr. Vincent Mutiso, Dept. of Orthopaedic Surgery, UON

The Chairman, Dept. of Surgery, UON

The Dean, Faculty of Medicine, UON

APPENDIX II

DATA COLLECTION SHEET

1. Code _____ Gender _____ Age _____

Date of Injury _____ DOA _____ DOO _____ DOD _____

Last review _____ Follow –up period _____

2. Cause of injury: Tick where appropriate.

(i) Fall from: (a) Bicycle (b) Tree (c) Table/Chair/desk (d) Staircase (e) Bed

(ii) Fall on level ground ☐

(iii) Assault ☐

(iv) RTA ☐

(v) Others ☐ (Specify)

3 (a) Arm left:

Left ☐ Right ☐ Both ☐

(b) Vascular assessment

Method	Present	Absent
Capillary		
Radial pulse		
Pulse Oximeter		
Gangrene		
Others (specify)		

(c) Neurological assessment

Nerve	Motor		Sensory	
	Present	Absent	Present	Absent
Median				
Radial				
Ulna				

(d) Associated injuries

Head ☐ Chest ☐ Abdomen ☐

Upper Limbs ☐ Lower Limbs ☐

4. Radiological Assessment

(a) Pre-reduction fracture type

Extension ☐ Flexion ☐

(b) Extension type:

Gartland: I ☐ II ☐ IIIa ☐ IIIb ☐

5. Method of management

Method	I	II	IIIa	IIIb	Flexion
MUA, POP-Backslab/Collar					
Traction					
CRPP					
ORIF					
Others (Specify)					

6. Fracture type and complications

	FRACTURE TYPE				
Complication	I	II	IIIa	IIIb	Flexion
Vascular Injury (Compression. Spasm. Severed vessel)					
Compartment Syndrome					
Nerve Injury (neurapraxia, axotnemesis, neurotnemesis)					
Volkmann's Contracture					
Cubitus Valgus					
Cubitus varus					
Elbow Stiffness					
Pin Tract Infection					
Myositis Ossificans					

7. Grading of results (Flynn's) (tick where appropriate)

	RESULTS	FUNCTIONAL LOSS OF EXTENSION-FLEXION (degrees)	CHANGE IN CARRYING ANGLE (degrees)
Satisfactory	Good	0-10	0-10
	Fair	11-15	11-15
Unsatisfactory	Poor	Over 15	Over 15