# EVALUATION OF RESULTS OF FRACTURE NECK OF FEMUR IN CHILDREN

**A DISSERTATION**

submitted to

**UNIVERSITY OF SEYCHELLES**

for the degree of

**M.CH**

(Orthopaedics)

**2013**

**DR. DEVENDRA SINGH SOLANKI**

# CONTENTS

# INTRODUCTION

Dickson J.A. in 1953 aptly used the term “Unsolved Fracture” to describe fracture neck of femur. Fracture neck of femur in children is even more puzzling, because of the rarity of this fracture, the reaction of child’s tissue to this injury, their growth potentials, higher incidence of complications and absence of long and detailed follow up studies in literature so far.

We still do not know the prognostic factors of this fracture very conclusively. Literature is scanty regarding the management of this fracture and its complications.

Results are very unpredictable inspite of very judicious handling in very experienced hands. No one claims to be experienced enough to predict the outcome of this fracture.

In general, fracture in children have a good reputation for healing and being forgiving of minor variations in management. This is not true in case of fracture neck of femur in children are so rare that very few

orthopaedic surgeons have much experience with them (Blount, 1955). Hamilton (1961) predicted that an orthopaedic surgeon would see one in a life time! Hip fractures constitute approximately 1% of all fractures in children. Literature is scanty, therefore chances of solving the problem of this fracture seems to be for less than that in adults.

In some series the complication rate has approached 60%. These include non-union, aseptic necrosis, Coxa vara, premature epiphyseal fusion, limb length discrepancy, septic arthritis. Inspite of many of the complications aresimilar in the adults and children, the consequences which they produce and the prognostic factors are not the same. Therefore hip fractures in children must be looked at in a much different light.

Most obvious will be the several anatomic differences and biomechanical properties between the proximal femur of the child and the adult.

As is found in other bones of children, the periosteum of the femoral neck is thicker and stronger than in the adult.

The bones in children are dense and stronger. Thus unlike the 60 year old woman who may break her hip after a minor twist of the lower limb, it usually requires severe violence to fracture the child's hip. This accounts for a high frequency of associated injuries especially head, pelvic and visceral injuries which may leads to delay in handling of this fracture. Strong dense bone is hard to penetrate and a large fixation device may distract the fragment, however it may provide a good hold for the fixation device. The small diameter of the neck limits fixation device in size and number and very accurate fixation is required. Because the cancellous trabeculae in children are homogeneously oriented in femoral neck and not along stress lines as in adults the fracture surfaces are smooth with little impaction or interlocking.

The vascular anatomy of the child's hip changes with age and varies from that of the adult in at least one significant way that there is no vascular anastomosis within the bone between the femoral neck and head. While this may in part account for the higher incidence of avascular necrosis in the child, it must certainly

account for the different patterns of avascular necrosis seen in the child (Ratliff 1962).

In addition to many anatomic differences there are physiological differences perhaps the most important of these is the child's tolerance to cast immobilization without complications. Thus we have a means to help balance those problems of fixation.

It would probably be a mistake to transfer our knowledge gained from adults directly to children.

Little attention has been paid to the problems of squatting and sitting crossed legged are so essential for activities of daily living that even a slight limitation will greatly jeopardize the functional activity of an individual.

Keeping in view the above mentioned factors it would be worthwhile to review these challenging cases in the hope of achieving a better understanding of this unsolved problem.

# AIMS AND OBJECTIVE

1. To describe the natural history and sequelae of fracture neck of femur in children.
2. An attempt will be made to know the effect of following factors on complication rate :

– Age at the time of fracture.
– Type of fracture (Delbet's).
– Delay in treatment.
– Operative v/s conservative.
– Closed reduction v/s open reduction.

# REVIEW OF LITERATURE

## SURGICAL ANATOMY OF PROXIMAL FEMUR

The head of femur, capped with hyaline cartilage is more than half of a sphere. Anteriorly articular cartilage extends on the neck for weight bearing in the flexed hip.

The neck of the femur is an upward extension of the shaft , inclined upwards and forwards. This slope of neck of the femur is in line with the forward and upward propulsive thrust of normal progression e.g., walking, leaping etc. Angle of anteversion varies from an average of 40 degree in the new born to an average of 20 degree in adult. Neck shaft angle or angle of inclination is more in male as compared to female and child. Average angle of inclination in adult male is 140 degree, in adult female it is 127 degree and in new born it is 160 degree.

The angle is strengthened by the “Calcar femorale”, a flange of compact bone projecting like a spur into the cancellous bone of the neck, well in front of lessor

trochanter. Anteriorly the neck is wholly intracapsular, the lower part of neck along wise the crest is a bare bone, over which the tendon of obturator externus plays. The trochanters are for muscle attachments, each has an apophysis that ossifies separately from the shaft.

Ossification of the femur occurs in the seventh fetal week. At birth, only a single proximal physis is present. The medial portion becomes the subcapital physis and the lateral portion becomes the physis of the greater trochanter. Growth at the medial portion produces an elongated femoral neck by the age of approximately one year. A discrete capital femoral physis is established, and it ossifies at the age of approximately four months in girls and five to six months in boys (Canale, S.T. and King R.E.; 1991, Herring, J.A. and McCarthy, R.E.; 1986; Ogden, J.A., 1990). The ossific nucleus of the greater trochanter appears by the age of approximately four years in both boys and girls. Tetracycline and radioisotope studies have indicated that the capital physis contributes more to metaphyseal growth of the neck of the femur and less

to primary appositional growth of the femoral head (Canale, S.T. and King R.E.; 1991). Conversely, the trochanteric apophysis contributes more to appositional growth of the greater trochanter and less to metaphyseal growth of the femur (Langenskiold, A., and Salenius, P., 1967). The proximal femoral and trochanteric physes fuse in boys at the age of approximately sixteen years and in girls at approximately fourteen years (Hansman, C.F., 1962). Because of the persistent cartilaginous bridge and the tenous blood supply to the postero-superior aspect of the femoral neck, the proximal aspect of the femur is highly susceptible to physeal damage, growth arrest, and subsequent deformity after a fracture of the hip (Ogden, J.A., 1981).

**VASCULAR SUPPLY TO PROXIMAL FEMUR**

[Trueta (1957), Chung (1976) & Ogden (1981)]

The predominant blood supply of the proximal femur, regardless of the stage of postnatal development is derived from profunda femoral artery, which is the origin of two major branches.

- the lateral circumflex femoral artery
- the medial circumflex femoral artery

The medial circumflex femoral artery usually arises from profunda artery but can arise as an independent vessel from femoral artery. Both circumflex arteries originate at the level of the tendinous portion of iliopsoas muscle from which the vessel are separated by fibrous sheath.

The arteries of ligamentum teres usually arise from the acetabular branch of the obturator artery or directly from medial circumflex femoral artery.

The vulnerability of the blood supply to the proximal femoral epiphysis has been documented by Trueta, Chung and Ogden. They found that the primary blood supply to the femoral  head from birth until the age of approximately four years is from the medial and lateral circumflex arteries that traverse the femoral neck. The lateral circumflex artery supplies the greater trochanter, a small portion of the proximal femoral physis, and a small anteromedial area of the metaphysis. The medial femoral circumflex artery supplies the anterior and medial parts of the proximal

femoral physis, the posteromedial part chondroepiphysis, the posterior part of the physis, and the posterior part of the greater trochanter. Both arteries supply the capital femoral epiphysis. By the age of four years, the metaphyseal blood supply becomes neglegible. The two (posterosuperior and posteroinferior) retinacular systems of the medial femoral circumflex artery become the primary blood supplyto the epiphysis. The posteroinferior branches enter the epiphysis to supply the inferomedial portion of the chondroepiphysis and the medial segment of the proximal part of the growth plate. The posterosuperior branches course along the femoral neck to enter the chondroepiphysis, supplying the lateral and anterior portions of the femoral head. There is no clinically important anastomosis between the vessels that supply the capital femoral epiphysis. The blood supply from the lateral femoral circumflex system, from which much of the metaphyseal circulation is derived, and the artery of the ligamentum teres is minimum after the age of four years.

According to Trueta, after the age of eight or nine years, the vessels of the ligamentum teres make a more important contribution to the blood supply of the femoral head and at puberty the anastomosis between the epiphyseal, metaphyseal, and ligamentum blood supplies is re-established. The femoral head is most susceptible to vascular compromise as the multiple channels of blood supply in an immature individual change with age to a limited blood supply in a mature individual (Ogden, J.A., 1974).

Ogden (Ogden, J.A., 1974) noted that, as branches of the medial femoral circumflex artery traverse the capsule at the level of the insertion into the intertrochanteric notch, capsulotomy will not affect blood supply to femoral head if the capsular incision does not extend to the intertrochanteric notch. This finding supports the clinical observation by several authors that the risk of a vascular necrosis is directly affected by the degree of initial trauma and displacement rather than by the type of treatment. (Weiner, D.S. and O'Dell, H.W., 1969; Heiser, J.M., and Oppenheim, W.L., 1980; Ingram, A.J. and Bachyanski,

B., 1953; Pforringer, W., and Rosemeyer, B., 1980; Ratliff, A.H.C., 1962; Ratliff, A.H.C., 1970).

**Vascular Arrangement of Femoral Head at Birth and Variations with Advancing growth**

Variations of the vascular pattern with advancing growth may be summarized as follows (Trueta, 1957).

Phase 1: (At Birth):

Vessels comingfrom the lateral side of head course horizontally towards the medial side descending slightly towards the center of head.

Second group of vessels comes from the top of ossified shaft which course vertically through the cartilaginous head at right angles to the epiphyseal vessels.

Phase 2: Infantile (4 months to 3 years):

At four months epiphyseal ossification blood supply is through ascending cervical arteries. After 4 months of age, as the ossification center becomes prominent and the growth plate develops, the vertical metaphyseal vessels decrease in size and number. The lateral epiphyseal artery assumes major role.

Phase 3: Intermediate (4 to 7 years):

The epiphyseal plate is a firm barrier between the epiphysis and metaphysis. During these years, the only source of epiphyseal blood is from the lateral epiphyseal vessels.

Phase 4: Pre-adolescent (8 to 10 years):

After 7 years, ligamentum teres vessels, become more prominent, enter deeper into epiphysis and anastomose with lateral epiphyseal vessels. These are termed medial epiphyseal arteries.

Phase 5: Adolescent:

At adolescence, the trochanter is ossified and the growth plate extends across beneath trochanter and head epiphysis. By then, the growth plate corresponding to the head my begin to show thw first signs of its imminent disappearance. Barrier of the epiphyseal plate begins to break down and vascular anastomosis crosses over, bringing  into final or adult stage of circulation where the epiphyseal and round ligament vessels are joined again to those of

metaphysis , giving to the femoral head the vascular interwoven pattern.

**INCIDENCE**

Review of literature regarding incidence of fracture neck of femur goes back to late nineteenth century.

In first half of this century few cases were reported by Whitman (1900), Colonna (1928), Mithell (1936) and Wilson (1940) and Carrel and Carrel (1941).

**Allende and Legama (1951)** reported eight cases and stated that “fracture of neck of femur are rare among children when one considers the frequency with which they occur among adults.” They noticed a ratio of 2:602 with fracture neck of femur in adults.

**Ingram and Bachynski (1953)** reported 24 cases seen in last 25 years.

**Vyanghreswarudu (1956) and Grewal and Charnalia (1956)** reported 6 and 8 cases respectively.

**McDougall (1961)** again stressing the variety of this injury was of impression that only few surgeons have

the opportunity of treating more than one or two patients in the course of their carrier.

**Ratliff (1962)** observed a ratio of 1:130 neck of femur fracture in adults.

**Lam (1971)** indicated that up to 1971 there were total 652 known cases reported in World Literature. The incidence of this fracture in various published series of various authors is as follows:

Lam (1971) – 75 cases in 10 years; Kay & Hall (1971), 20 cases in 16 years; Miller (1973) – 6% of all children's fractures; Gupta and Chaturvedi (1973) – 74 cases in 12 years; Canale and Bourland (1977) – 69 fractures in 55 years; Heiser and Oppenheim (1980) – 50 cases in 27 years; Craig (1980) – 8 out of total 900 hip – fracture in adults.

## AGE INCIDENCE

Each report in literature has been reviewed to correlate the children's ages with the type of fracture. The study of these observations led to pathogenesis of the type of fracture seen in children with a possible correlation between the positioning or posture of the

child and muscular development, as it is found at the various age levels. (Walmsley 1932).

Utilizing all reported cases that one documented sufficiently for a graphing of types of fractures and the ages involved several observations can be made (Miller 1973).

a) The intertrochanteric fracture is not common and if it occurs, it appears to be more significant in the 2 to 4 year range or in the adolescent after 14 years of age.
b) The femoral neck fracture has approximately three peaks of incidence, first at 2 to 4 years of age, second at 8 to 9 years and third peak at 12 to 13 years of age.
c) Epiphyseal fractures are more prevalent in early life and again increased in incidence in the 12 to 13 years of age range, at least in its identifiable form with severe trauma.

Mean age in different series was as follows :

| | | | |
|---|---|---|---|
| Ingram and Bachynski | (1953) | - | 10.3 years. |
| Canale and Bourland | (1977) | - | 9.7 years. |

Heiser and Oppenheim (1980) - 8.9 years.

**SEX INCIDENCE**

Fracture neck of femur has higher incidence in boys in comparison to girls. Probably male child is more active than female child. Various authors encountered following sex incidence.

| Author | Year | Total No. of Cases Reported | Male | Female |
|---|---|---|---|---|
| Wilson | (1940) | 10 | 7 | 3 |
| Allende & Lexama | (1951) | 8 | 5 | 3 |
| Ingram & Bachynski | (1953) | 24 | 14 | 10 |
| McDougall | (1961) | 24 | 17 | 7 |
| Kay & Hall | (1971) | 20 | 9 | 11 |
| Lam | (1971) | 75 | 57 | 18 |
| Canale & Bourland | (1977) | 61 | 32 | 29 |
| Heiser & Oppenheim | (1980) | 39 | 23 | 16 |
| Sancheti et al | (1980) | 21 | 15 | 6 |
| Lam | (1986) | 41 | 23 | 18 |
| Pathi | (1986) | 45 | 30 | 15 |

**MODE OF INJURY AND PATHOGENESIS**

McDougall (1961) stated that “In a child the head and neck of the femur are dense and hard and considerable trauma is required to break them unless they are affected by pathological changes.” This accounts for the highfrequency of associated injuries especially head, pelvic and visceral injuries. In most of the reported series 80% cases are due to severe violence (Sancheti et al 1980). The usual cause of injury is either a fall from height or vehicular accident or fall from bicycle or being pushed over.

Of the 24 cases reported by McDougall (1961) 11 had fall from height. 7 patients fell from bicycle, 4 were involved in road accident, 1 case developed fracture due to severe titanic spasm and mode of injury was unknown in one.

20-30% of patients in most of the reported series had associated injuries, common being head injury and fracture pelvis. Miller (1971) tried to correlate the occurrence of specific type of fracture neck femur with particular age on the basis of deforming force of muscle mass around hip in children. He noted three peaks of incidence of this fracture, first in the 2 to 4

years age group, second to 8 to 9 years of age, third in the 12 to 13 years age group.

## DIAGNOSIS

In most cases, diagnosis is easily made, clinically as well as radiologically. History of violent trauma, pain and tenderness in groin and some possible swelling around hip, shortening, external rotation, some adduction of the injured limb as well as inability to raise the leg are usual clinical findings.

Delay in diagnosis occurs in undisplaced fractures and in severely in juried child where it may be over looked when other associated injuries direct the physician's attention.

Occasionally birth trauma will result in type I fracture which may be hard to recognize until fracture callus appears in roentgenograms.

Radioisotope bone scan done at least 48 hrs. after the onset of symptoms can be helpful in stress fractures and undisplaced fractures (Huges -1994).

## CLASSIFICATION

Delbet's classification, cited by Colonna (1928) is widely used. It is based on anatomical location:

Type I : Transepiphyseal
- fracture occurs at the level of epiphyseal line in a previously normal epiphysis.

Type II : Transcervical
- fracture occurs through mid portion of neck.

Type III : Cervicotrochanteric (Basal)
- fracture occurs at the base of femoral neck.

Type IV : Pertrochanteric (Intertrochanteric)
- fracture occurs between base of femoral neck and lesser trochanter.

This classification has been used by most of authors. However, the important factor of displacement was added by most of them.

**Allende & Lezama (1951)** categorized their patients on the basis of obliquity of fracture line i.e. Pauwel's angle.

**Miller (1973)** considered type III and type IV of Colonna classification as intertrochanteric fracture. He felt that basicervical fracture was of the same type as intertrochanteric, both from standpoint of planned treatment and prognosis.

**Ratliff (1974)** was of the opinion that description "transepiphyseal" for type I fractures was not anatomically correct. The fracture line occurs at the upper femoral epiphyseal plate but does not cross or penetrate the epiphysis of the head of femur.

The incidence of various subtypes of femoral neck fractures reported in literature is as follows :

Incidence of various types of fractures in various series are as follows:

| Author | Year | Total no. of cases reported | Type I | Type II | Type III | Type IV |
|---|---|---|---|---|---|---|
| Ingram & Bachynski | (1951) | 24 | 6 | 11 | 5 | 2 |
| Mcdougall | (1961) | 24 | 2 | 11 | 8 | 3 |
| Lam | (1971) | 75 | 2 | 37 | 23 | 13 |
| Gupta & Chaturvedi | (1973) | 74 | 3 | 41 | 19 | 11 |
| Ratliff | (1974) | 131 | 9 | 65 | 48 | 9 |
| Sancheti et al | (1980) | 21 | 1 | 8 | 9 | 3 |
| Maini et al | (1982) | 90 | 3 | 45 | 39 | 3 |

## TREATMENT

There is no unanimity in the literature regarding the management of this infrequent fracture of neck of femur in children.

**Whitman (1925)** stated that reduction could be obtained by manipulation and placing this fracture in abduction and marked internal rotation.

**Wilson (1940)** concluded that maintenance of reduction in Whitman method cast was difficult but questioned the advisability of internal fixation because of possible damage to the epiphyseal plate and secondary disturbance of growth. He further stated that oblique sub trochanteric osteotomy was useful as secondary salvage procedure in bringing a limited arc of motion into a useful plane.

**Carrel and Carrel (1941)** found that Whitman method was inadequate, that nailing was undesirable and the traction alone did not correct the deformity. They favored the combined method of traction and abduction.

**Colonna (1951)**in discussing these fractures felt that they were relatively simple to treat in the early stage and that the abduction method of Whitman was still a very satisfactory form of treatment.

**Allende and Lezama (1951)** Based their treatment on degree of obliquity of fracture line i.e. Pauwel's angle and concluded that –

i. In those cases where the angle of inclination was less than 50 degree reduction under anaesthesia and immobilization for two months in Whitman cast constituted the position of choice.
ii. In cases with femoral neck angle more than 50 degree a prompt osteotomy should be performed to compensate for this alteration in the femoral neck angle.

**Ingram & Bachynski (1953)** studied 24 patients treated by surgeons of the Campbell clinic since 1930.

They advocated treatment of these fractures by internal fixation of the fragments, more frequently than previously had been practiced. One of the greatest advantage of internal fixation was that it prevented coxa vara and non-union.

They opposed the use of Smith-Petersen nail as a fixation device for femoral neck fracture in children : as it was technically difficult due to hard, curved, and small diameter neck, secondly chances of distraction are always there with the use of S.P. nail. Stressing on the use of at least two or three Knowles's pins, parallel placement of pins was suggested. Placing the pins

crossed causes distraction. This recommendations have served as a guide until today and were supported by Canale & Bourland (1977).

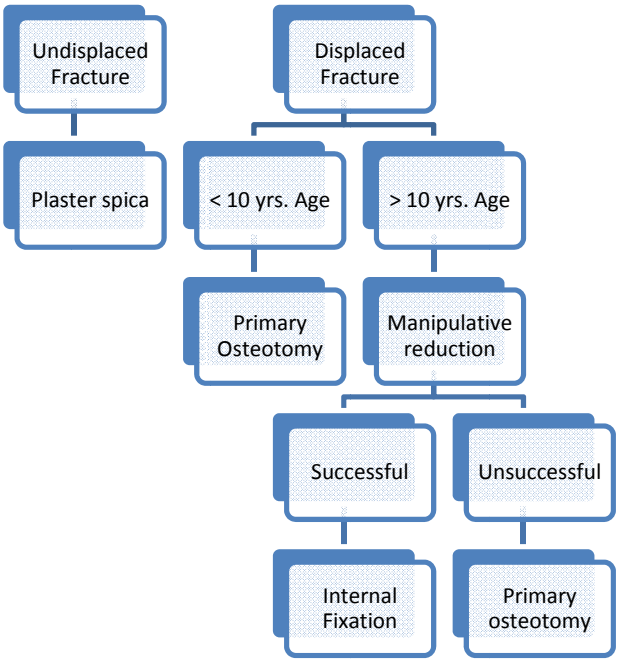
**Treatment Recommendations(Ingram & Bachynski)**

| | **Type of Fracture** | **Treatment** |
|---|---|---|
| Type I | Femoral head located | Closed reduction, Internal fixation |
| | Femoral head dislocated | Open reduction, Internal fixation |
| Type II | Undisplaced | Closed reduction |
| | Displaced | Internal fixation |
| Type III | Undislaced | Cast |
| | Displaced | Closed reduction, Internal fixation |
| Type IV | Undisplaced | Cast |
| | Displaced | Closed reduction, cast |

**McDougall (1961)** presented series of 24 patients. In his opinion equally good or bad results can be obtained by either means i.e. conservative or operative: recommended that internal fixation should be done only in older children that too with care.

Internal fixation may cause necrosis and damage to epiphysis. If operation is decided upon Knowles's pin should be used instead of Smith – Petersen nail. If conservative treatment is resorted then prolonged skeletal traction for at least a year in which no weight is borne on the affected leg are required. A mature youth can be treated on the same lines as that of adults.

**Ratliff (1962)** reported on 71 cases collected with the assistance of the members of the British Orthopaedic association over a period of 20 years and recommended following treatment:



Ratliff (1962) concended that his recommendations were "… based more on general principles than on statistical evidence", when he recommended primary subtrochanteric osteotomy for displaced fractures of femoral neck in children younger than ten years of age, or older than ten years of age in whom a good reduction could not be obtained. Although Ratliff stands alone in recommending this treatment, his approach emphasized, the difficulties with internal fixation in the smaller child or the child with poor reduction.

For displaced fractures he further advised that

- Only spica is not recommended.
- Smith – Patersen nail should not be used.
- Under 10 years of age primary internal fixation is difficult to perform.
- Lag screw of Charnley gives good results.
- Thomas splint shall not be used to maintain reduction.

**Bhansali(1965)** advocated reduction, internal fixation with Knowles or Moore's pins and primary

defunctioning osteotomy defunctions the detrimental effect of adductors at fracture site and allowed “Union to occur”.

**Marsh (1966)** reported 36 fractures in children, he recommended internal fixation with multiple pins for displaced fractures of groups II and group III and blade plate fixation was advised for displaced group IV. Further he was of opinion that these methods of treatment may prevent varus angulation, do not cause growth disturbance and if properly applied do not cause avascular necrosis by distraction of fragments.

**Lam (1971)** analysed 75 cases of fracture neck of femur in children from the age of 8 months to 17 years seen from 1961 to 1970 in Hongkong. He stated “My greatest difficulty is to make a plaster that will prevent union in a position of coxa vara.” He discouraged the use of Smith Petersen nail and advised following plan of treatment.

1. Displaced fractures
   - for displaced type II and type III fractures attempt close reduction.

- If close reduction successful then one and half spica or well leg traction spica for young patients and internal fixation with tw Moore's pins for older children.
- If close reduction is unsuccessful then resort to open reduction but in his opinion primary subtrochanteric osteotomy will be wiser decision.

2. Undisplaced type II and type III fractures – to treat them by one and half spica.

   No recommendation was made for transepiphyseal fracture.

**Lam (1986)** reviewed many of his patients seen in 1971 series and made following conclusions regarding treatment:

| **Epiphyseal** | | | **Cervical or Basal** | | **Trochanteric** | |
|---|---|---|---|---|---|---|
| Displacement | Partial | Dislocated | None | Displaced | None | Displaced |
| Reduction | Closed | Open | - | Closed/Open | - | Closed/Open |
| Immobilization | Moore's pin + Plaster spica | | Plaster spica Moore's pin + Plaster spica | | Plaster spica | |

**Kay & Hall (1971)** divided treatment modality into four types :

i. Reduction.
ii. Maintenance of reduction.
iii. Promotion of healing.
iv. Prevention of undesirable results.

Recommendations made by them are as follows :

Reduction : Reduction is obtained by counteracting the muscular forces that act upon the trochanteric area. Active manipulation must counteract the medial and proximal displacement of the distal fragment as well as its external rotation. In manipulating the fracture, one must pull the trochanteric area away from the pelvis, apply traction along the long axis of the extremity, and finally rotate the leg internally.

Maintenance of Reduction : This can be accomplished either by means of internal fixation (i.e. Smith – Petersen nail, multiple pins, modified Knowles's pins sliding nails, etc) or by non-surgical means such as traction. Hip spica in itself cannot fulfill the requirements for neutralization of the muscular forces

because the displacement of the fragments takes place along the axis of the spica and the direction of the forces comes through the proximal opening of the cast. Hip spica with abduction and internal rotation can maintain the obtained reduction but this position is not recommended because it includes many hazards for avascular necrosis.

Promotion of Healing: The healing process can be facilitated by 1) obtaining a good fracture-surface adaptation by anatomic reduction 2) allowing compression of fragments by internal fixation and 3) maintaining an adequate blood supply to the affected area. (Avoid unnecessary damage & tamponade effect upon retinacular vessels.

Considerations for Prevention of Undesirable Results. Undesirable results, except those from infection and other postoperative misfortunes, are 1) avascular necrosis of the proximal fragment 2) coxa vara, 3) non-union of the fracture, 4) growth disturbances of the capital femoral epiphysis.

**Gupta and Chaturvedi (1973)**discussed a study of 74 patients below the age of 16 from Kanpur. Gupta

stated that displacement osteotomy, both as a primary procedure for transcervical fractures, and as a salvage procedure when there are problems of union, gave gratifying results : he stressed the remodeling that can occur at the upper end of femur with growth. They opined that in displaced intracapsular fractures reduction and internal fixation was difficult and likely to damage further, the remaining blood supply, they therefore preferred intertrochanteric osteotomy a the treatment of choice.

**Miller (1973)** documented report of 39 cases of hip fracture in children compiled during a period from 1958 to 1972. Of these 8 were subtrochanteric, 8 intertrochanteric, 12 cases were of femoral neck fracture and 11 cases of epiphyseal. He proposed his guidelines for treatment of these fractures as follows :

| **Type** | | **Treatment advised** |
|---|---|---|
| Type I – Displaced and undisplaced | - | Internal fixation |
| Type II – Undisplaced | - | Spica, cast |

| | | |
|---|---|---|
| Type II – Displaced | - | CRIF/ORIF with smooth pins |
| Type III/IV | - | CR & spica |

**Talwalkar (1974)** after studying 100 cases from Bombay recommended anatomic reduction and complete immobilization as the treatment of choice for displaced fractures and recommended that open reduction should be attempted without hesitation when manipulation reduction is not possible.

**Kohli (1974)** analyzed 40 patients under 17 years of age seen from 1964 to 1971. Fresh fractures were treated by reduction and fixation with Knowles's pins, a defunctioning osteotomy and a double hip spica. Late cases were treated by same procedures with the addition of bone grafts after two or three weeks traction. Prolonged non-weight bearing and a defunctioning osteotomy were found useful in achieving a high rate of bony union and good function.

**Ratliff (1974)** based his treatment policy on the degree of displacement.

1. Undisplaced fractures – concluded that good results are to be expected with any should method of care. Displacement occurred in two patients during treatment which was described for the first time in literature for children.
2. Displaced fractures – he discussed the merits and demerits of various mode of treatment and made some important recommendations for treatment :
   i. Manipulative reduction and immobilization in a plaster spica for the treatment of displaced fractures of neck of femur in children are not recommended.
   ii. For internal fixation, Smith-Petersen nail is not to be used, smaller pins such as Moore's, Newman or Knowles are preferred.
   iii. There was no case to which premature epiphyseal fusion could be attributed to pins crossings growth plate. Premature epiphyseal fusion was always associated with avascular necrosis.
   iv. Non-union and coxa vara deformity were prevented by internal fixation, provided it was technically adequate.

v. Traction, as a mode of treatment should never be used for the adolescent child with a transcervical fracture that is displaced since it is essential that accurate reduction be achieved and maintained. However, traction can be used in young children with slight displacement.
vi. Open reduction is difficult, the blood supply of head of femur may be endangered and the results poor. However, an open reduction may have to be performed particularly when there is gross displacement.
vii. A primary subtrochanteric osteotomy is a useful procedure which may have to be performed when manipulative reduction has not been successful.
viii. Remarkable remodeling of the upper end of the femur with growth may occur after subtrochanteric osteotomy. This was noteworthy when the gap was left between the inferior part of proximal fragment and distal fragment. Remodeling cannot occur if distal fragment was placed close under the neck of femur, and in these cases shortening may result.

ix. The best results of primary subtrochanteric osteotomy was not employed when the displacement was slight and lower fragment was placed in slight abduction.

x. Late varus may develop at the site of osteotomy after union which occurred in two patients in his series. The tendency to varus should be anticipated when one is performing this operation and the distal fragment is deliberately placed in marked abduction.

However, in one case in his series non-union developed at osteotomy site.

**Canale and Bourland (1979)** described the results of treatment in 61 cases followed for a average of 17 years. Of these 55% had good results 20% were fair, 25% had poor results.

They favoured plan of treatment of Ingram and Bachynski (1951). Besides this they made some important observations and recommendations :

i. For transepiphyseal fracture attempt one close reduction, if it fails resort to open reduction.

Multiple attempts at close reduction are to be avoided.

ii. Pins placed should be parallel for compression. Effort should be made to avoid crossing growth plate as it may cause premature epiphyseal fusion because significant percentage of cases of premature epiphyseal fusion were from group in which pins crossed (78% of total cases of premature epiphyseal fusion).

iii. Their use of Knowles pins for fixation appeared to reduce the incidence of non-union and coxa vara.

iv. They do not believe that sub trochanteric osteotomy is indicated as primary procedure as recommended by Ratliff : and reserved it for late cases and those with delayed or non-union.

v. In undisplaced fractures results were good whatever method was chosen.

**Heiser and Oppenheim (1980)** Treated 50% of their cases in spica, 40% cases by internal fixation and 10% cases by prolonged bed rest. In their series

many of the principles previously established were reaffirmed :

i. For fractures which are undisplaced for these to collapse into coxa vara if treated non-operatively, they have no objection to treating these fractures by internal fixation. However, treating these fractures in traction followed by spica is an alternative if they are watched closely.
ii. All displaced fractures (except type IV) should be reduced and internally fixed.
iii. Open reduction to be done in those transepiphyseal and transcervical fractures for which close reduction has been unsuccessful.
iv. Smooth pins to be used for transepiphyseal fractures, threaded pins or lag screw are devices of choice. Blade plate will cause distraction and fixation device preferable should not cross epiphyseal plate, as in theory may cause epiphyseal arrest.
v. Type IV fractures should be treated by traction followed by spica.

**Boltzy (1980) & Quinlan et al (1980)** stated that such fracture must be regarded as an emergency and that prompt treatment is imperative. They advised that the intra articular haematoma should be evacuated as quickly as possible and that precise and accurate reduction should be followed by internal fixation.

**Sancheti et al (1980)** presented twenty one cases of fracture neck of femur in children. They opined that defunctioning osteotomy after internal fixation of fracture was not needed in all cases. They reserved primary subtrochanteric osteotomy for either late cases or delayed and non unions.

**Morrisy (1980)** stated that "there is a general lack of appreciation for newer fixation devices which may help greatly with complications such as coxa vara and non-union."

**Ratliff (1981)** added "suffice it to state that no new evidence has been obtained concerning the value of primary subtrochanteric osteotomy and I no longer believe this method of treatment is advisable."

**Maini et al (1982)** reported 90 cases, and McMurray osteotomy was done as primary procedure in 48 cases. In their series subcapital fractures were treated by spica. They advised spica cast treatment for type III fractures. However, no specific recommendations were made for type II fractures. But they discouraged the use of spica cast for the fractures as a mode of treatment.

**Canale Terry S. (1987)** After collection data on 92 fractures of hip in children since 1922, made treatment recommendations as follows :

---

**Type I (transcepiphyseal separation)**

| | |
|---|---|
| Without dislocation | Gentle closed reduction + internal fixation with smooth pins or cannulated screws <2 years of age gentle closed reduction + hip spica cast |

| | |
|---|---|
| With dislocation | Gentle closed reduction (one attempt), if not successful immediate ORIF with pins of screws |
| **Type II (transcervical)** | Closed or open reduction and internal fixation, regardless of amount of displacement. |
| **Type III (cervicotrochanteric)** | |
| Non-displaced | Immobilization in 1.5 spica cast; close follow-up required because of tendency to displace into varus. |
| Displaced | Gentle closed or open reduction + internal fixation; percutaneous screw fixation or, in older adolescent, |

dynamic hip screw and side plate.

**Type IV (intertrochanteric)** Skin or skeletal traction, abduction spica cast; internal fixation may be necessary if the fracture cannot be reduced and held in spica cast, or in older patients).

---

The occurrence of avascular necrosis was related to the degree of initial fracture displacement and also to the location of fracture. Type II fractures were at great risk (50%) than type III fractures. They concluded that immediate open reduction and internal fixation did not prevent avascular necrosis after displaced type II and type III fractures.

**Shane and Manelkar (1987)** In their opinion primary "displacement" osteotomy at the subtrochanteric level, have no place in children and should be

reserved for the treatment of delayed union and non-union.

Primary defunctioning subtrochanteric osteotomy with or without the use of Moore's pins is of dubious advantage for the following reasons :

i. Influence of defunctioning osteotomy on the abductor muscles lasts less than three weeks.
ii. The abductor pull is not affected.
iii. Good results are seen without the use of osteotomy.

**COMPLICATIONS AND THEIR TREATMENT**

A displaced fracture of the femoral neck is one of the most serious injuries. This fracture is well known for its sinister nature. Despite judicious handling significant morbidity often results. In some series complication rate has approached 60%. These include:

i. Avascular necrosis of proximal fragment.
ii. Delayed union and non-union.
iii. Coxa vara

iv. Premature epiphyseal fusion both at upper and lower end of the femur and the upper end of tibia.
v. Shortening of leg.

**Avascular Necrosis :**

In the adults avascular necrosis is usually associated with transcervical fractures, but in children it may also occur in intertrochanteric fractures (McDougall) (1961) and basal (Ratliff 1962) or undisplaced fracture (Ratliff 1981).

Incidence of avascular necrosis in different reported series is as follows :

| | | | |
|---|---|---|---|
| Carrel and Carrel | (1941) | - | 35% |
| Allende and Lezama | (1951) | - | 25% |
| Ingram and Bachynski | (1953) | - | 55% |
| Grewal & Charnalia | (1956) | - | 25% |
| McDougall | (1961) | - | 58% |
| Ratliff | (1962) | - | 43% |
| Kay and Hall | (1971) | - | 45% |

| | | | |
|---|---|---|---|
| Lam | (1971) | - | 17% |
| Ratliff | (1974) | - | 46% |
| Canale & Bourland | (1977) | - | 43% |
| Heiser & Oppenheim | (1980) | - | 17% |
| Sancheti et al | (1980) | - | 28.6% |
| Maini et al | (1982) | - | 40% |
| Lam | (1986) | - | 20% |
| Canale | (1987) | - | 46% |

**Causes of Avascular Necrosis :**

Avascular Necrosis has been reported as the primary cause of poor results in most series of fractures of the head and neck of the femur in children. The risk of avascular necrosis is directly proportional to the amount of initial displacement of the fracture fragments and to the compromise of the blood supply at the time of the fracture (Calandruccio and Anderson – 1980, Canale and Bourland – 1977, Gerber, Lehmann and Ganz – 1985, Heiser and Oppenheim – 1980, Ovesen, Arreskov and Bellstrom – 1980, Ratliff - 1970). In the report by Canale and

Bourland twenty five of the twenty six fractures after which avascular necrosis developed were displaced. Other authors have reported similar results. Other factors associated with an increased risk of avascular necrosis are a type I or II fracture and an age of more than ten years. The type of treatment of an acute fracture does not affect the rate of avascular necrosis (Canale and Bourland – 1977, Heiser and Oppenheim – 1980, Ratliff – 1962 and 1970). Immediate open reduction and internal fixation with evacuation of the intracapsular hematoma has been recommended (Bohler – 1981, Ovesen, Arreskov and Bellstrom – 1980, Swiontkowski - 1986), but the direct effect of this approach on the rate of avascular necrosis has not been proved.

**Symptoms :**

McDugall (1961) stated “while the bone is avascular, no pain is experienced and the patient may walk about quite freely, it is not until re-vascularization of the bone takes place and softening and collapse occur that pain and spasm become marked features.”

The first symptoms of avascular necrosis may be pain and limitation of motion as a result of synovitis. Radiographic signs may be seen as early as one and a half months after the fracture, and they include a lack of development or osteoporosis of the femoral head with widening of the cartilage space, followed by fragmentation and gross deformity of the femoral head. Radioisotope scanning with the use of a pinhole collimator may show decreased uptake in the involved femoral head compared with the contralateral hip before radiographic signs are evident (Herring and McCarthy - 1986) Ogden recommended bone scanning at three to four months after the fracture and again at one year to detect avascular necrosis, which usually develops within the first year after the injury. (Nielsen and Thaarup – 1984, Ratliff - 1962).

**Types of Avascular Necrosis of Proximal fragment :**

**Retliff (1962)** described three patterns of avascular necrosis which develop after fracture neck of femur in a child.

Type I avascular necrosis is the most severe and most common form and has the poorest prognosis Ratliff postulated that type I avascular necrosis results from damage to all of the lateral epiphyseal vessels; type II from localized damage to one or more of the lateral epiphyseal vessels near their insertion into the anterolateral aspect of the femoral head; and type III, which is rare but has a uniformly good prognosis, results from damage to the superior metaphyseal vessels. The high prevalence's of avascular necrosis after transepiphyseal fractures (which have range 52% to 100%) and after transcervical fractures (50% in the study by Canale and Bourland and fifty nine of 143 fractures in seven series), where the blood supply is the most vulnerable, seem to support this hypothesis.

**Lam (1986)** found difficult to classify avascular necrosis as after the head was seriously compressed, due to weight bearing after development of avascular necrosis, so he did not use Ratliff's grading of avascular necrosis.

**Diagnosis :**

Naerra (1937), Nielson (1938), Watson Jones (1940) and McDougall (1961) believed that changes following fracture neck femur and Legg-Calve-Perthe's disease were same, in femoral head.

**McDougall (1961)** was of impression that the radiological signs of avascular necrosis may not be obvious for two years after injury. Conversely, **Ratliff (1962)** later supported by many authors opined that in children, avascular necrosis always manifested within one year after injury and changes were not similar to LCP. A frequent early radiographic sign was loss of definition of the epiphyseal plate, indicating the commencement of premature fusion. This observation has repeatedly been found of value in predicting the onset of vascular necrosis. He opposed the idea of McDougall that changes of avascular necrosis resemble Legg-Calve-Perthe's disease. Avascular necrosis was diagnosed upon the characteristic radiographic evidence of increased density (Ratliff, 1962).

**Ogden (1981)** suggested a bone scan 3 to 4 months after the injury has healed, and another bone scan

one year after the injury to assess any possible vascular damage, a compromise. In his opinion the first roengenographic signs of ischemic necrosis are that the head does not become osteoporotic, that it does not grow compared to the opposite side, and that the cartilage space widens. These signs are present long before gross fragmentation and deformity appear.

**Prognosis :** Ratliff (1962)

Type I - Bad

Type II - Occasional revascularization did develop.

Type III - Revascularization always develops.

**Sancheti (1980)** stated that all cases of avascular necrosis remodeled satisfactorily and none developed arthritic changes.

**Maini et al (1982)** noticed revascularization of 75% heads who previously developed avascular necrosis.

**Shahne et al (1987)**noticed remarkable capacity for spontaneous remodeling after avascular necrosis in

children with restitution of the height of the capital epiphysis making accurate prognostication difficult.

The consequences of avascular necrosis can be devastating. In the series of Forlin et al, nine of 14 patients had disabling pain, a range of motion of less than 50 %, restricted activity, and severe deformity of the femoral neck and head. Devison and Weinstein reported that seven of their nine patients in whom avascular necrosis developed needed additional operations, which included three cup arthroplasties and one total hip replacement, to obtain acceptable function of the hip. In the series of Canale and Bourland, 62% who had avascular necrosis had a poor result at an average of seventeen years after the injury.

**Treatment of avascular necrosis :**

There is no documented effective treatment for avascular necrosis. Morrisy questioned whether any treatment can affect the natural history of avascular necrosis. Recommendations for treatment have included bed rest; non-weight-bearing; and operative procedures. including soft-tissue releases about the

hip for flexion and adduction contractures, osteotomy, arthrodesis, and arthroplasty of twenty six patients who had avascular necrosis in the study by Canale and Bourland, twenty two had avascular necrosis without associated non-union or coxa vara; twelve of these patients had some form of treatment for avascular necrosis and ten had not. The results were similar in both groups; poor results in approximately 60% (seven of twelve patients who had treatment and six of ten who had not) although older children (more than 10 years old) had a poor result more often. Some authors have recommended prolonged non-weight-bearing if avascular necrosis develops (Ovesan et al, Ratliff). Motion should be maintained during periods of synovitis, and containment bracing until reossification occurs may be considered for children who are less than six years old. Internal fixation that is in place when avascular necrosis develops should be removed after union of the fracture has been achieved. Remodeling may occur over a prolonged time (as many as five years) and is more likely to occur in younger children than in older ones.

**Denys Wainwright (1970)** thought that revascularization of a dead head could be accelerated by an osteotomy in slight varus.

**Burr H. Curtis (1976).** Management had to be tailored to suit the family and the circumstances aiming for containment of the femoral head by osteotomy or by abduction bracing.

**Canale (1987)** stated "In several children under the age of 10 years, with type I or type III avascular necrosis removal of the Knowles pin followed by an "abduction containment" orthosis has produced acceptable results. They have arbitrarily "contained" the femoral head for one year.

**Coxa vara :**

The neck shaft angle in a child is 160 degree and as the age advances it decreases (R.J.Last, 1984).

The prevalence of coxa vara has been reported to be approximately 20 to 30% (ninety five of 508 fractures in nine series) and was lower in series in which

internal fixation was almost always used for displaced fractures. Lam reported coxa vara in twenty three (31 %) of seventy five fractures, primarily in displaced type II and III fracture that had been treated with closed reduction and external immobilization. Canale and Bourland reported that patients in their series who had been treated with internal fixation had a milder form of coxa vara and a better over all result than did patients who had been treated with external immobilization. Other authors have reported similar results. Coxa vara deformity may be caused by malunion, avascular necrosis, premature physeal closure, or a combination of these complications severe coxa vara shortens the affected extremely, cause an abductor or gluteal lurch, and may result in degenerative changes about the hip. Progressive remodeling of the coxa vara can be expected in very young children and in those in whom the neck shaft

angle exceeds 110 degrees. If the neck shaft angle is 110 degrees or less or if the child is more than eight years old subtrochanteric valgus osteotomy may be considered (Ratliff 1974, Canale & Bourland 1977, Morrisy 1980, Heiser and Oppenheim 1980, Canale 1987). Isolated instances of progressive remodeling of both varus and valgus malunions in children have been reported (Katz 1983, Deluca & Keck 1976) and a two year period of observation before operative intervention is reasonable (Canale 1987). Subtrochanteric valgus osteotomy is recommended for persistent coxa vara deformity, with the closing wedge removed just distal to the greater trochanter and the osteotomy fixed with a pediatric hip screw.

**Delayed Union and Non-union :**

Non Union is an infrequent complication of fracture of the hip in children, it has been reported to occur in

6 to 10% of fractures. Most authors have agreed have agreed that the primary cause of non-union is failure to obtain and maintain an adequate anatomical reduction and that most non-unions occur in displaced fractures (Canale 1929, Canale & Bourland 1977, Heiser & Oppenheim 1980). In the early Campbell Clinic series of twenty four fractures (Ingram & Bachynski 1953), there were two non-unions one of a displaced type II fracture and one of a displaced type III fractures; the one non-union in a series of twenty five fractures in the later study (Canale & Bourland 1977) occurred in a displaced type-II fracture. Forlin et al reported non-union of seven of sixteen fractures; six non unions were transcervical fractures. Four of the fractures had been treated with open reduction and internal fixation, and one had been treated with traction and immobilization in a cast.

Unlike avascular necrosis and coxa vara, for which a period of observation is appropriate, non-union should be treated operatively as soon as possible. Subtrochanteric valgus osteotomy can be performed to make the non-union more horizontal and to allow compressive vertical forces to aid in union. Bone grafts can be used if necessary to argument the osteotomy, and internal fixation should be used across the site of the non-union; a spica cast is worn for twelve weeks after the osteotomy.

**Premature Epiphyseal Fusion, Shortening and Growth Disturbances :**

Premature physeal closure has been reported in 65% of children who had a proximal femoral fracture [sixty-nne [28%] of 244 fracture in four series (Hughes and Beaty, 1994)]. The prevalence increases when internal fixation crosses the physis or when avascular

necrosis is present (Canale 1928; Heiser & Oppenheim 1980; Lam 1971; Pforringer & Rosemeyer 1980). Forlin et al reported premature physeal closure in fifteen fractures , eleven of which had pins that crossed the capital physis. In the study by Canale and Bourland, eighteen (64%) of twenty eight patients in whom pins penetrated or crossed the physis had premature physeal closure; however, eight patients in whom pins did not penetrate the physis also had premature physeal closure. Pforringer and Rosemeyer found no correlation in their patients between premature closure and the type of treatment Premature physeal closure is frequent in patients who have type II and III avascular necrosis (Ratliff 1970).

Because the capital femoral physis contributes only thirteen percent of the growth of the entire extremity and usually closes earlier than most of the other

physes of the lower extremity, there usually is less than two centimeters of shortening, except in very young children (Swiontkowski 1989). Here severe shortening generally is associated with avascular necrosis, especially in younger children, and when avascular necrosis develops with coxa vara. Regardless of the amount of shortening, children who have premature physeal closure should be observed closely and sequential limb-length scanograms and radiographs of the wrist to determine bone age. Epiphyseodesis of the contralateral extremity may be performed if necessary to equalize limb lengths when the discrepancy is expected to be 2.5 centimeters or more (Canale 1987).

**Other Complications :**

Infection is uncommon after fractures of the hip in children. Of the eighty six patients in the two

Campbell Clinic series, only one (1%) in the early group had an infection (Canale & Bourland 1979), which developed after an open reduction that had been performed two months after a fracture-dislocation. Lam and Ratliff reported similar low prevalences of infection. Davison and Weinstein reported infectious arthritis in two of their nineteen patients, both of whom also had avascular necrosis.

Chondrolysis after a fracture of the hip was reported by Forlin et al. in seven of sixteen patients. All seven of the patients who had chondrolysis also had avascular necrosis and a poor result.

# MATERIAL & METHODS

The present study comprised of prospective evaluation of the results of randomly selected cases of fracture neck of femur in children males upto 16

years & females upto 14 yrs. (i.e. upto fusion of epiphysis), presenting in the Deptt. of Orthopedics, SMS Medical College from 1998 to2001 and there after in private hospitals in Gurgaon till 2012 were included in the study.

Immediately after admission of the patient a preliminary clinical and radiological examination was done. A brief history regarding mode and date of injury was taken and a clinical examination to assess other associated injuries was done. Depending on the priority of the treatment of injuries the patient was shifted to the concerned ward (i.e. neurosurgery, urology, general surgery or orthopedics) so that serious accidental injuries were dealt with suitably. A below knee skin traction was applied immediately in the ward.

Taking into consideration the general condition of the patient, local condition and type of fracture, the treatment modality for the patient was chosen.

For the purpose of this study, Delbert's classification cited by Colonna (1929) was used.

Broadly the treatment plan advised by Lam (1971) was followed with slight modifications taking into account the associated injuries, hospital resources and individual surgeons preferences.

Treatment plan followed:

| **Epiphyseal** | | | **Cervical or Basal** | | **Trochanteric** | |
|---|---|---|---|---|---|---|
| Displacement | Patial | Dislocated | None | Displaced | None | Displaced |
| Reduction | Closed | Open | | Closed/open | Closed/open | |
| Immobilisation | Moore's pin + Plaster spica | | Plaster spica | Moore's pin + Plaster spica | Plaster spica | |

## CONSERVATIVE TREATMENT :

All cases treated conservatively were undisplaced fractures except in few cases where a few displaced fractures were treated conservatively because of associated injuries or refusal for surgery. A spica cast was applied in 10-15 degrees abduction & 10 degree internal rotation under general anaesthesia. The patient was watched for 24 hours in the hospital for any discomfort. Check X-rays were taken and if found satisfactory the patient was discharged after teaching static quadriceps exercises and care of spica.

The patient was reviewed at two weeks to see any loss of reduction in spica cast. Subsequently the patient was reviewed at 8 weeks and the spica was removed to assess the progress of fracture healing. Taking into consideration the union at fracture, age of the patient, type of fracture, non weight bearing mobilization of hip joint was allowed. Patient was then reviewed at 3 months and partial weight bearing with crutches was allowed.

## OPERATIVE TREATMENT:

All type-II displaced fractures were treated by operative procedure. In all cases prophylactic injectable antibiotic (Inj. Cefazoline) was given during induction of anaesthesia. Patients were operated in general anaesthesia under Image Intensifier Television control. Closed reduction was done on fracture table with patient supine by minimal manipulation (either by Whitman or Leadbetter technique). In cases where closed reduction was not achieved in two attempts, open reduction and internal fixation through Watson Jones approach was done.

The local part was scrubbed with savlon for 5 min. and then painted with 5% providone iodine solution and draped with sterile sheets.

Internal fixation was carried out through the lateral approach. A vertical incision was made parallel with the femur approx. 1.5 cms. below the base of greater trochanter. This dissection was deepened in the line of incision down to bone. Fracture was fixed with suitable implant under IITV control. (Various implants used were Moore's pin, partially threaded cancellous screws & adolescent dynamic hip screw).

Once the fracture was fixed internally, irrigation with normal saline was done and the wound was closed in layers & dressed.

Post operatively a close watch was kept on the vital parameters, circulation of limb and for any signs of infection. Check X-rays were taken & a hip spica cast (POP) was applied to all cases below 12 years of age after 24-48 hours of surgery. The patient was discharged if the condition was satisfactory. Post operative antibiotics were routinely given to all patients till removal of sutures. Sutures were removed through a window in the spica cast on the $12^{th}$ day.

After 2 months the spica cast was removed and clinicoradiological evaluation for union at the fracture site was done. Non weight bearing mobilization or reapplication of spica cast was done after taking into account the status of union, age of patient, and presence or absence of any complications. Partial weight bearing with crutches at 12 weeks and later full weight bearing at 16 weeks was allowed according to the progress of union and presence or absence of any

complications. The above mentioned line of treatment was occasionally modified due to associated injuries.

The patient was reviewed at 6 months & then at 1 year and subsequently yearly. The patients was examined for the following points:

**Clinical assessment**

- Pain
- Gait
- Ability to squat and sit crossed legged
- Tenderness
- Limb length discrepancy
- Movements at hip

**Radiologic assessment** two views were taken – anteroposterior view with both hips in 20 degree internal rotation and frog lateral position. The following points were recorded:

- Union at fracture site
- Neck shaft angle
- Status of head, neck & physis
- Avascular necrosis

**RESULTS:**

Final results were evaluated according to modified Retliff's Criteria (1962).

| | **Good** | **Fair** | **Poor** |
|---|---|---|---|
| Pain | None or ignores | Occasional | Disabling |
| Movement | Full or terminal restriction | Greater than 50% | Less than 50% |
| Activity | Normal or avoids games | Normal or avoids games | Restricted |
| Roentgenographic indications | Normal or some deformity of the femoral neck | Severe deformity of the femoral neck<br>Mild avascular necrosis | Severe avascular necrosis<br>Degenerative arthritis<br>Arthrodesis |

# PROFORMA

Case No.

Name Age Sex

Address Caste

Date of injury Date of admission

Mode of injury Date of operation

Date of discharge

Type of fracture (Delbet's): Side of fracture L/R

Associated injuries

Examination

Management

General

Associated injuries

| | |
|---|---|
| Fracture neck of femur: | Closed reduction / open reduction |
| | Fixation device |
| | Reduction / stability achieved |

Delay in Treatment

Follow up

1. Immediate postoperative : Sign and symptom of infection
2. At 8 weeks : Radiologic progress of union
3. At 12 weeks : Range of motion – Flexion/Extension
   Abduction/
   Adduction
   Rotations
   Limb length discrepancy
   Radiologic- Progress of union at fracture site
4. At 6 months
   - Pain in the affected hip
   - Gait
   - Ability to squat and sit cross legged
   - Tenderness
   - Limb length discrepancy
   - Range of motion at hip : Flexion/Extension
     Adduction/
     Abduction
     Rotations

Radiological assessment: Union at fracture / osteostomy site

Neck shaft angle

Status of physis

Avascular necrosis (Ratliff)

Any other finding

At 1 year:-

- Pain in the affected hip.
- Gait
- Ability to squat and sit cross legged
- Tenderness
- Limb length discrepancy
- Range of motion at hip: Flexion/Extension
  Adduction/Abduction
  Rotations

Radiological assessment: Union at fracture/ osteotomy site

Neck shaft angle

Status of physis

Avascular necrosis (Ratliff)

Any other finding

# OBSERVATIONS

The present study of consists of follow up of 61 cases of femoral neck fractures in children (Males < 16 yrs. & females < 14 yrs.). There were 99 cases treated by different methods in the Deptt. Of Orthopedics, S.M.S. Medical College & Hospital, Jaipur during period of 10 years from 1991 to 2001.

However, out of these 99 cases only 61 had a follow-up of more than 1 year and are included in the present study for evaluation of the results.

## TABLE – I: AGE DISTRIBUTION

| **Age at the time of Injury** | **No. of Cases** | **Percentage of total cases** |
|---|---|---|
| 1 – 4 years | 9 | 9% |
| 4 – 8 years | 31 | 31% |
| 8 – 12 years | 37 | 38% |
| 12 – 16 years | 22 | 22% |
| **Total** | **99** | **100%** |

Almost 69% of fractures occurred in 4 – 12 years age group.

## TABLE – II: SEX DISTRIBUTION

| Total Number of cases | No. of Male | No. of Female |
|---|---|---|
| 99 | 52 | 47 |
| Percentage | 52.5% | 47.5% |

Males and Females were nearly equally involved.

## TABLE – III: DISTRIBUTION OF SIDE INVOLVED

| Side involved | No. of Cases | Percent of cases involved |
|---|---|---|
| Left | 62 | 63% |
| Right | 37 | 37% |
| Total | 99 | 100% |

Left side was more commonly involved.

## TABLE – IV: DISTRIBUTION OF MODE OF INJURY

| **Mode of Injury** | **No. of Cases** | **Percentage** |
|---|---|---|
| Fall from height | 77 | 78% |
| Vehicular Accident | 16 | 16% |
| Miscellaneous Slipped in stairs fall of heavy object in limb | 4 | 4% |
| Fall from bicycle | 2 | 2% |
| **Total** | **99** | **100%** |

Majority of cases suffered trauma due to fall from heights (78%) either from tree tops in rural areas or from roof tops or balcony in urban areas. Vehicular accidents were either road traffic accidents or injury by fall from tractors in the fields.

## TABLE – V: ASSOCIATED INJURIES

| **Associated Injuries** | **No. of Patients** | **Percentage of total cases** |
|---|---|---|
| Head Injury | 5 | 5% |
| Pelvic Fracture with or without visceral injuries | 8 | 8% |
| Fracture of other long bones (femur, leg bones, humerus) | 5 | 5% |
| Others (fracture radius, metacarpal) | 6 | 6% |
| Compression fracture $D_{12}$ | 1 | 1% |
| Fracture of fibula with paroneal injury | 1 | 1% |
| **Total** | **26 out of 99 cases** | **26%** |

Out of the total 99 cases, 26% had one or the other associated injury, commonest being pelvic fractures.

**TABLE – VI (a) : FRACTURE TYPE (DELBETS)**

| **Delbet's type** | **No. of cases** | **Percentage of total cases** |
|---|---|---|
| Type I : Displaced<br>Undisplaced | 1<br>0 | 1%<br>0% |
| Type II<br>:Displaced<br>Undisplaced | 42<br>15 | 43%<br>15% |
| Type III :<br>Displaced<br>Undisplaced | 31<br>8 | 31%<br>8% |
| Type IV :<br>Displaced<br>Undisplaced | 2<br>0 | 2%<br>0% |
| **Total** | **99** | **100%** |

Type II fracture was commonest (58%) and most of them (43 out of 58) were displaced fractures. Out of the 99 fractures 76% were displaced.

Out of total 99 cases, we had successfully followed up 61 cases for more than a year. 18 cases were lost and 20 cases the injury was less than a year old and were excluded from the present study because of inadequate follow-up.

**TABLE – VI (b) : FRACTURE TYPE (DELEBET'S) IN CASES WITH FOLLOWUP OF MORE THAN ONE YEAR**

| **Delbet's type** | **No. of Cases** | **percentage of total cases** |
|---|---|---|
| Type I : Displaced<br>Undisplaced | 0<br>0 | 0%<br>0% |
| Type II :<br>Displaced<br>Undisplaced | 22<br>10 | 36.5%<br>15% |
| Type III :<br>Displaced<br>Undisplaced | 22<br>6 | 36.5%<br>10% |
| Type IV :<br>Displaced<br>Undisplaced | 1<br>0 | 2%<br>0% |
| **Total** | **61** | **100%** |

There was no type I fracture in the present study. Type II & III displaced fracture were of equal number (36.5%).

## TABLE – VII : DURATION OF FOLLOW-UP AFTER INJURY

| Period of follow-up after injury | No. of Cases studied | % of total cases |
|---|---|---|
| 1-2 years | 33 | 54% |
| 2-3 years | 12 | 20% |
| 3-4 years | 10 | 16.5% |
| 4-5 years | 0 | 0% |
| 5-6 years | 4 | 6.5% |
| 6-7 years | 1 | 1.5% |
| 7-8 years | 1 | 1.5% |
| **Total** | **61** | **100%** |

Out of the total 61 cases included in the study, 46% of the cases were followed for more than 2 years after the injury.

## TABLE – VIII : DELAY IN TREATMENT

| **Delay in treatment after injury** | **No. of Cases** | **Percentage of Cases** |
|---|---|---|
| Less than 2 days | 16 | 26% |
| 3 days to one week | 22 | 36.5% |
| 8 days to two weeks | 10 | 15% |
| 15 days to four weeks | 6 | 10% |
| Neglected cases | 7* | 12.5% |
| **Total** | **61** | **100%** |

**Case No. 46 refused operation and she was discharged on below knee skin traction. She did not follow the treatment properly and reported again after 6 weeks with coxa vara. This case is counted herein neglected cases.*

Only 26% of cases out of the total 61 cases were treated within 2 days. Most of the cases (36.5%) were treated with delay of 3 days to one week.

## TABLE – IX : DISTRIBUTION OF CONSERVATIVELY TREATED CASES AND OPERATIVELY TREATED CASES

| Fracture Type | Total No. of Cases | No. of Neglected cases (%) | No. of Conservative cases (%) | No. of Operatively treated cases (%) | | |
|---|---|---|---|---|---|---|
| Type I: | | | | ORIF (%) | CRIF (%) | In situfixation(%) |
| Displaced | 0 | 0 | 0 | 0 | 0 | 0 |
| Undisplaced | 0 | 0 | 0 | 0 | 0 | 0 |
| Type II: | | | | | | |
| Displaced | 22 (100%) | 3 (13%) | 0 | 5 (23%) | 14 (64%) | 0 |
| Undisplaced | 10 (100%) | 1 (10%) | 6 (60%) | 0 | 0 | 3 (30%) |
| Type III: | | | | | | |
| Displaced | 22 (100%) | 3 (13%) | 1 (4.5%) | 5 (23%) | 13 (59%) | 0 |
| Undisplaced | 6 | 0 | 3 (50%) | 0 | 0 | 3 (50%) |
| Type IV: | | | | | | |
| Displaced | 1 | 0 | 0 | 0 | 1 (100%) | 0 |
| Undisplaced | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Total** | **61** | **7** | **10** | **10** | **28** | **6** |

ORIF: Open reduction and internal fixation
CRIF: Closed reduction and internal fixation.

All type-II displaced fractures underwent operative treatment (87%). Only 1 displaced type-III fracture was treated conservatively. All neglected cases underwent secondary reconstructive operations and were included in the evaluation of results.

**TABLE – X: VARIOUS IMPLANTS USED IN RELATION TO AGE GROUP**

| **Age Group** | **Total No. of Cases treated** | **Moore's pin** | **Cancellous screw** | **Adolescent DHS** |
|---|---|---|---|---|
| 1 – 4 years | 5 | 1 | 1 | 0 |
| 5 – 8 years | 24 | 4 | 1 | 0 |
| 9 – 12 years | 20 | 2 | 17 | 0 |
| 13 – 16 years | 12 | 1 | 7 | 2 |
| **Total** | **61** | **8** | **26** | **2** |

In younger age group Moore's pin were more commonly used. In majority of cases cancellous screw was the implant of choice.

**TABLE – XI: COMPLICATION RATE IN RELATION WITH AGE**

| Age in years | Total No. of cases | AVN | Non Union | PEF | Coxa Vara (<110) | LLD (In cm.) Short 1-2.5 | Short >2.5 | Long >1 | Total No. of Complications |
|---|---|---|---|---|---|---|---|---|---|
| **1 – 4** | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **5 – 8** | 24 (100%) | 0 | 1 (4%) | 1 (4%) | 3 (12%) | 1 (4%) | 3 (12%) | 4 (16%) | 8 cases (33%) |
| **9 – 12** | 20 (100%) | 3 (15%) | 1 (5%) | 4 (20%) | 1 (5%) | 3 (15%) | 0 | 1 (5%) | 8 cases (40%) |
| **13 - 16** | 12 (100%) | 5 (42%) | 1 (8%) | 5 (42%) | 2 (16%) | 2 (16%) | 3 (24%) | 0 | 7 cases (58%) |
| **Total** | **61 (100%)** | **8 (13%)** | **3 (5%)** | **10 (16%)** | **6 (10%)** | **6 (10%)** | **6 (10%)** | **5 (8%)** | **23case (38%)** |

AVN: Avascular Necrosis PEF: Premature Epiphyseal fusion

LLD: Limb length discrepancy

Out of 61 cases – 23 cases (38%) showed complications. Complication rates increased with the age of patients i.e. in 5-

8 age group it was 33% and in 13-16 age group it was 58%.
The most common complication encountered was PEF (16%).
AVN was more common in 13-16 age group (5 out of 8).

**TABLE – XII: COMPLICATIONS IN RELATION WITH TYPE OF FRACTURES**

| Fracture Type | Total No. of cases | AVN | Non Union | PEF | Coxa Vara (<110) | LLD (In cm.) Short 1-2.5 | Short >2.5 | Long >1 | Total No. of Complications |
|---|---|---|---|---|---|---|---|---|---|
| Type I D | 0 | - | - | - | - | - | - | - | - |
| U | 0 | - | - | - | - | - | - | - | - |
| Type II D | 22 (100%) | 7 (32%) | 2 (9%) | 9 (41%) | 4 (18%) | 4 (18%) | 3 (13%) | 4 (18%) | 16case (72%) |
| U | 10 (100%) | 0 | 1 (10%) | 0 | 0 | 0 | 0 | 0 | 1 case (10%) |
| Type III D | 22 (100%) | 1 (4.5%) | 0 | 1 (4.5%) | 2 (9%) | 1 (4.5%) | 3 (12%) | 1 (4.5%) | 5 cases (22%) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **ype /** | 1 (100%) 0 | 0 - | 0 - | 0 - | 0 - | 1 (100%) - | 0 - | 0 - | 1 case (100%) 0 |
| **otal** | **61 (100%)** | **8 (13%)** | **3 (5%)** | **10 (16%)** | **6 (10%)** | **6 (10%)** | **6 (10%)** | **5 (8%)** | **23case (38%)** |

AVN: Avascular Necrosis PEF: Premature Epiphyseal fusion

LLD: Limb length discrepancy D: displaced U: Undisplaced

72% Complications rate was reported in (highest in) Type-II displaced fractures. Out of 45 displaced fractures 22 cases showed complications (50%). Serious complications such as AVN & non union were found largely in Type-II displaced fractures. Over all complications rate was 23 cases out of 61 (38%).

## TABLE – XIII: COMPLICATION IN CONVERSATIVELY TREATED GROUP

| Fracture type | Total no of cases | No. of cases treated conservatively | AVN | Non Union | PEF | Coxa Vara (<110) | LLD (In cm.) Short 1-2.5 | Short >2.5 | Long >1 |
|---|---|---|---|---|---|---|---|---|---|
| Type I | | | | | | | | | |
| D | 0 | - | - | - | - | - | - | - | - |
| U | 0 | - | - | - | - | - | - | - | - |
| Type II | | | | | | | | | |
| D | 22 | 0 | - | - | - | - | - - | - | |
| U | 10 (100%) | 6 (60%) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Type III | | | | | | | | | |
| D | 22 (100%) | 1 (4.5%) | 0 | 0 | 0 | 1 (4.5%) | 01 | 0 (4.5%) | |
| U | 6 (100%) | 3 (50%) | 0 | 0 | 0 | 0 | 0 | | 0 |
| Type IV | | | | | | | | | |
| D | 1 | 0 | - | - | - | - | - | - | - |
| U | 0 | 0 | - | - | - | - | - | - | - |
| **Total** | 61 | 10 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |

AVN: Avascular Necrosis PEF: Premature Epiphyseal Fracture
LLD: Limb length discrepancy D: displaced U:Undisplaced

Approx. 50% of undisplaced fractures were treated conservatively & no complication was encountered in them. Complications were seen only in displaced fractures treated conservatively.

## TABLE – XIV: COMPLICATIONS IN OPERATED CASES

| Fracture type | Total no. of cases | No. of cases treated conservatively | AVN | Non Union | PEF | Coxa Vara (<110) | LLD (In cm.) Short Short Long | Total no. of complicati-ons |
|---|---|---|---|---|---|---|---|---|
| Type I | | | | | | | | |
| D | 0 | - | - | - | - | - | - - - | - |
| U | 0 | - | - | - | - | - | - - - | - |
| Type II | | | | | | | | |
| D | 22 | 19 (100%) | 6 (31%) | 1 (5%) | 7 (37%) | 2 (10%) | 31 4 (15%) (5%)(21%) | 13 (68%) |
| U | 10 | 3 (100%) | - | - | - | | - - - | |
| Type III | | | | | | | | |
| D | 22 | 18 (100%) | 1 (5%) | - | 1 (5%) | - | 1- 1 (5%) | 2 (10%) |
| U | 6 | 3 (50%) | - | - | - | - | - -- | - |
| Type IV | | | | | | | | |
| D | 1 | 1 | - | - | - | - | - 1 - | 1 |
| U | 0 | - | - | - | - | - | - - - | - |
| **Total** | 61 | 44 | 7 | 1 | 8 | 2 | 4 25 | 16 |

AVN: Avascular Necrosis PEF: Premature Epiphyseal Fracture

LLD: Limb length discrepancy D: displaced U:Undisplaced

3 out of 22 type-II displaced fractures were neglected. Out of 19 (type-II displaced), operated cases 13 were complicated. 68% of type-II displaced fractures were complicated and only 10% of type-III displaced fractures.

**TABLE – XV: COMPLICATIONS RATE IN OPERATED, CONSERVATIVELY TREATED & NEGLECTED CASES**

| Type | Total Cases | Conservatively treated cases | | Operatively treated cases | | Neglected Cases | |
|---|---|---|---|---|---|---|---|
| | | No. | Complicated (%) | No. | Complicated (%) | No. | Complicated (%) |
| Type-I | | | | | | | |
| D | 0 | - | - | - | - | - | - |
| U | 0 | - | - | - | - | - | - |
| Type-II | | | | | | | |
| D | 22 | 0 | 0 | 19 | 13(68%) | 3 | 3(100%) |
| U | 10 | 6 | 0 | 3 | 0 | 1 | 1(100%) |
| Type-III | | | | | | | |
| D | 22 | 1 | 1(100%) | 18 | 1(6%) | 3 | 3(100%) |
| U | 6 | 3 | 0 | 3 | 0 | 0 | 0 |
| Type-IV | | | | | | | |
| D | 1 | - | - | 1 | 1(100%) | - | - |
| U | 0 | - | - | - | - | - | - |
| **Total** | **61** | **10** | **1(10%)** | **44** | **15(34%)** | **7** | **7(100%)** |

We had not treated any displaced type-II fracture conservatively. Out of 19 type-II displaced fractures treated operatively, 13 developed complications (68%).

Out of 19 type-III displaced fractures, 2 developed complications (11%). Undisplaced fractures treated conservatively not developed complications (9 out of 16).

**TABLE – XVI: COMPLICATIONS RATE IN RELATION WITH DELAY IN TREATMENT**

| **Delay in treatment** | **No. of cases** | **Total no. of complications** |
|---|---|---|
| Less than 2 days | 16 (100%) | 4 cases (25%) |
| 3 days – 1 week | 22 (100%) | 6 cases (28%) |
| 1 – 2 weeks | 10 (100%) | 5 cases (50%) |
| 2 – 4 weeks | 6 (100%) | 1 case (16%) |
| Neglected Cases (> 4 weeks) | 7 (100%) | 7 Cases (100%) |
| **Total** | **61** | **23(38%)** |

AVN: Avascular Necrosis PEF: Premature Epiphyseal Fusion LLD: Limb length discrepancy

In cases treated with in two days only 25% developed complications. 7 out of these (100%) treated with a delay of more than a month were complicated. Complication rate increased with increase in delay in treatment.

## TABLE – XVII: COMPLICATION RATE IN OPEN REDUCTION AND INTERNAL FIXATION Vs. CLOSE REDUCTION AND INTERNAL FIXATION

| Fracture Type (Delbet's) | No. of Cases Operated | ORIF No. of Cases | Complications Occurred (%) | CRIF No. of Cases | Complications Occurred (%) |
|---|---|---|---|---|---|
| **Type – I** | | | | | |
| **D** | 0 | - | - | - | - |
| **U** | 0 | - | - | - | - |
| **Type – II** | | | | | |
| **D** | 19 | 5 | 5 (100%) | 14 | 7 (50%) |
| **U** | 3 | 0 | - | 0 | - |
| **Type – III** | | | | | |
| **D** | 18 | 5 | - | 13 | 2(14%) |
| **U** | 3 | 0 | - | 0 | - |
| **Type – IV** | | | | | |
| **D** | 1 | 0 | - | 1 | 1*(100%) |
| **U** | 0 | 0 | - | 0 | - |

*Limb length discrepancy only.

ORIF: Open Reduction and Internal Fixation D: Displaced

CRIF: Close Reduction and Internal Fixation U: Undisplaced

50% of cases operated by open reduction were complicated and only 34% of cases treated by closed reduction were complicated.

## TABLE – XVIII: PREMATURE EPIPHYSEAL FUSION CAUSED BY PENETRATION OF IMPLANTS

| Fracture Type (Delbet's) | Total No. of PEF | No. of cases in whi physis damaged by implants | Occurred with AVN |
|---|---|---|---|
| **Type-I** | | | |
| **D** | 0 | - | - |
| **U** | 0 | - | - |
| **Type-II** | | | |
| **D** | 9 | 1 | 8 |
| **U** | 0 | - | - |
| **Type-III** | | | |
| **D** | 1 | - | 1 |
| **U** | 0 | - | - |
| **Type-IV** | | | |
| **D** | 0 | - | - |
| **U** | 0 | - | - |

PEF: Premature epiphyseal fusion  AVN: Avascular Necrosis

Out of 10 PEF only in one case crossing by implants may be the cause of it.

## TABLE – XIX: FINAL RESULTS

| Fracture Type (Delbet's) | Total No. of Cases | Good(%) | Fair(%) | Poor(%) |
|---|---|---|---|---|
| **Type – I** | | | | |
| **D** | 0 | - | - | - |
| **U** | 0 | - | - | - |
| **Type – II** | | | | |
| **D** | 22 | 11 (50%) | 4 (18%) | 7 (32%) |
| **U** | 10 | 10 (100%) | 0 | 0 |
| **Type – III** | | | | |
| **D** | 22 | 18 (81%) | 3 (14%) | 1 (5%) |
| **U** | 6 | 6 (100%) | 0 | 0 |
| **Type – IV** | | | | |
| **D** | 1 | 1 (100%) | - | - |
| **U** | 0 | 0 | - | - |
| **Total** | **61** | **46 (75%)** | **7 (11%)** | **8 (13%)** |

D: Displaced U: Undisplaced

**Those cases which were good clinically & poor radiologically were considered in poor category.*

In type-II displaced fractures, 50% showed good result & 32% showed poor result. In type-III displaced fractures, 81% showed good result & 5% showed poor result. Out of 8 poor results 7 were due to type-II displaced fractures.

# DISCUSSION

For more than a century the treatment and the results of fracture neck of femur have been a matter of controversy amongst surgeons. In reality the problem in children may be even more elusive to solution since the occurrence of this injury is rare, and thus there is insufficient opportunity to study the results.

The present study is a critical analysis of 61 fractures of neck of femur in children, out of 99 cases treatedatDeptt. of Orthopedics, SMS Medical College from 1998 to2001 and there after in private hospitals in Gurgaon till 2012

**AGE INCIDENCE (Table - I)**

Maximum number of cases (38%) in this series belonged to 8-12 yrs. of age group. These observations closely resemble to that of Allende & Lezama (1951), Miller (1973) and Pathi (1986). However, Wilson (1940), McDougall (1961), Kay and Hall (1971), Ratliff (1974) and Sancheti et al (1980) noticed higher incidence in second decade of life.

This pattern of age related occurrence can possibly be explained by the fact that children in this group are more physically active and are dare devils. Smaller children are usually not involved in activities which lead to this fracture e.g. climbing trees, kite flying etc. Older children are usually sedate and careful.

In this series the youngest patient was 4 years old while the oldest one was 16 years of age.

**COMPLICATIONS WITH RELATION TO AGE (Table-XI)**

As shown in Table-XI the incidence of complications were higher in older age group patients. In 5-8 age group it was 33%, 9-12 years age group it was 40% & in 13-16 it was 58% complicated. Also the incidence of serious complication i.e. avascular necrosis was high in older age group.

These observations were also made by Canale and Bourland (1977); increased risk of avascular necrosis in patients more than 10 years old and Heiser & Oppenheim (1980); average age for “avascular necrosis” group was 13.5 years where as the average age for uncomplicated fracture neck of femur group was 6.5

years. This can be explained by the fact that the vessels supplying the proximal fragment are directly injured at the time the fracture and since the foveolar artery in children under the age of 10 to 13 does not anastomose with the branches of the retinacular vessels, avascular necrosis develops.

**SEX INCIDENCE (Table – II)**

Out of 99 cases males (52.5%) and females (47.5%) are nearly equally involved.

However, most other series observed a somewhat higher incidence in males [Canale & Bourland (1971), Heiser & Oppenheim (1980), Lam (1986), Sancheti et al (1980)].

The equal occurrence of this fracture in this series may be due to similar outdoor activities of children in our country.

**SIDE INVOLVED (Table-III)**

In the present series the left side was more commonly (63%) involved. This predominance could not be related to any factor.

**MECHANISM OF INJURY (Table – IV, V)**

McDougall (1961) stated that " In a child the head and neck of the femur are dense and hard and considerable trauma is required to break them unless they are affected by pathological changes."

Significant amount of trauma is required to fracture a child's hip. In most of the reported series 80% cases are due to severe violence (Sancheti et al, 1980). In the present series 78% fractures occurred after fall from height, usually more than 10 feet. In rural areas fall is usually from a tree top or from a balcony. the next most common cause is vehicular accidents (16%). This amounts to a total of 94% of fractures being caused by severe violence.

The severe violence required to fracture a child's hip also accounts for the high frequency of associated injuries. In the present series, 26% of cases had some associated injuries, the most common being pelvic features (8 out of 99). The incidence of associated injuries is somewhat higher in road traffic accidents (9 out of 16 vehicular accidents).

**DURATION FOLLOW-UP (Table-VII)**

In the present series we studied 99 cases of which only 61 had a follow up of more than 1 yr. This is the minimum follow-up that is required to arrive at any conclusion.

Nielsen & Thaarup – 1984 and Ratliff 1962 stated that avascular necrosis usually develops with in the first year after the injury.

So, in this study cases who were followed up for more than 1 year were included but, we certainly expect an increase of follow-up. This was proved in the case no. 29. Where clinical & radiological sings & symptoms of avascular necrosis occurred even after 1.5 years. Upto 1 year after injury this patient's result was classified as good.

This point was very correctly high lightened by Leung and Lam (1986). They reviewed a personnel series of Lam (1976) again after a period of 17 to 23 years after injury and concluded that the earlier clinical results had been excellent, despite a high incidence of complications; but the new, later review shows an 83% incidence of radiographic abnormality while 24% of the patients have pain a limp or leg shortening.

## TYPE OF FRACTURE [Table VI (a), VI(b)]

Transcervical fractures constituted 58% (57 of 99) of the present series, which is similar to reported series of most of the authors viz.

- Ingram and Bachynski (1957) - 46%
- McDougall (1961) - 46%
- Lam (1971) - 49%
- Gupta & Chaturvedi (1973) - 55%
- Ratliff (1974) - 50%

Curiously out of 99 cases we encountered only 2 cases of Type-IV. This incidence is very low when compared with publications from the west. The minimum percentage reported in the literature available is 7%. Maini et al (1982) reported 3% at Rohtak, India.

## DISPLACEMENT OF FRACTURE [Table-VI (a), VI (b)]

Displaced fractures were more common (76%) than undisplaced ones. Though the periosteum of child is thick & strong, the violent force needed to break a child's hip, usually displaces the fracture fragments also. As all authors agree that in about 80% cases history of violent

trauma is obtained, this can explain the incidence of displaced fractures (76%) in the present series.

Morrisy (1980) pointed out that, the periosteum of the femoral neck in children is thicker and stronger than in adults, explaining why approx. 50% of all hip fracture in his series remain undisplaced. This also explains why in the present study, 24% of fractures remained undisplaced, despite the fact that 94% were caused by violent trauma.

**RELATION OF TYPE OF FRACTURE WITH COMPLICATIONS (Table-XII)**

The risk of avascular necrosis is directly proportional to the amount of initial displacement of the fracture fragments and to the compromise of the blood supply at the time of fracture (Ratliff – 1970; Canale & Bourland – 1977; Calandruccio and Anderson – 1980; Ovesen, Arreskov and Bellstrom – 1989, Gerber, Lehmann and Ganz - 1985). Type-I & II fracture are associated with an increased risk of avascular necrosis (Ratliff 1962 and 1970; Canale & Bourland – 1977 and Heiser and Oppenheim - 1980).

As shown in Table-XII, complication rate was highest in Type-II fracture (82%). Out of 45 displaced fractures 22 cases (50%) showed complications.

Serious complications such as avascular necrosis and non union were found largely in Type-II displaced fractures.

**DELAY IN TREATMENT (Table-VIII)**

In the present series almost 75% of cases were treatedafter a delay of 2 days. Most of the cases (36.5%) were treated within a period of 3 to 7 days after injury.

Those cases who reported after a delay of 1 month were considered as neglected cases (12.5%) and treated by secondary procedures. In publications from the western countries most of the cases were treated within 2 days.

This delay in our cases can be attributed to late reporting of cases, overcrowded hospitals and because of associated injuries.

Whether initial delay in starting the treatment has any role in the causation of the complications, is difficult to say. Theoretically all these fractures should be reduced immediately and the hip joint should be drained to release the tamponade effect of haematoma on the

retinacular vessels. The ideal time would be within 6-8 hours before ischaemic necrosis of cells occurs.

Bohler – 1981, Ovesen, Arriskov and Bellstrom – 1989, Swiontkowski – 1986 had advocated immediate open reduction or closed reduction with evacuation of capsular haematoma.

Gerber and Lehman & Ganz (1985) after reviewing 28 cases from 7 Swiss AO Hospitals, which were treated by evacuation of intracapsular haematoma early by either aspiration or capsular release, as advocated by Reitzy (1980) found that this method still resulted in avascular necrosis in 30% cases.

Effect of early hip decompression on the frequency of aseptic necrosis in children with fracture of neck of femur was also studied by Ng GP, Cole WG in 1996. He reported only 8% (3 out of 39 Type-II & III fractures) rate of avascular necrosis in cases treated by early hip decompression as compared to 41% (22 out of 54 in Type-II & III fractures) in cases treated late. In the present series haematoma aspiration or evacuations could not be done in any case because of delayed reporting of patients in our set-up but curiosity the

complication rates in our cases were not significantly higher than those quoted in literature.

As shown in Table-XVI the complication rate increased with the delay in treatment. Only 25% cases who were treated in less than two days were complicated. All neglected cases were complicated.

The table clearly shows a rising trend in complications with delay in treatment.

**TREATMENT (Table-IX, X, XIII, XIV, XV)**

72% of our cases were treated by operative means and 16% were treated conservatively.

All **displaced fractures** except two cases were operated. We were forced to treat two displaced fractures conservatively, one because of an associated ipsilateral compound fracture shaft femur and the second because of refusal for surgery.

50% of all **undisplaced fractures** (8 out of 16) were treated conservatively. No complications were encountered in this group. 50% of these undisplaced fractures were operated because of the surgeon's prefence.

There is no unanimity in literature regarding management of undisplaced fractures. In first half of this century, most of the authors viz. Wilson (1940), Carrel and Carrel (1941), Colonna (1951), Allende & Lezama (1951) advocated conservative treatment of the undisplaced fractures. McDougall (1961) opined that equally good or bad results can be obtained by either means. Lam (1971) encountered great difficulty in preventing coxa vara in plasters. Ratliff reported displacement of fracture in two cases “during” conservative treatment. Ingram & Bachynski (1977), Heiser & Oppenheim (1980) strongly favoured internal fixation in children.

The results of our series indicate that undisplaced Type-II & III fractures can be treated by cast immobilization. However, the number in our series, is too small to be a basis for sound conclusion.

Table-XIV indicates that most of the cases in Type-II displaced fractures were complicated (68%) as compared to Type-III displaced fractures (only 10%). This observation bears no relation with the type of treatment given, prognosis depends more on the type of fracture

than on the type of treatment. This was also observed earlier by many authors. (Ratliff – 1962 and 1970, Canale and Bourland – 1977, Heiser and Oppenheim – 1980). They stated that the type of treatment of the acute fractures does not effect the rate of avascular necrosis.

We can see in Table – XVII that in the operatively treated group, complication rate was high in those who were treated by open reduction. The probable causative fracture may be that:

- these are the cases which could not be reduced closed and significant amount of additional trauma was inflicted during reduction, further compromising the meagre blood supply.
- by doing open reduction we tend to inflict some additional insult to the remaining blood supply.

**COMPLICATIONS (Table-XI to XVII)**

In the present series, despite the fact that many cases were treated late, most of the cases were displaced fractures (73%), most common fracture was Type-II (51%), the overall complication rate was only of 38% (23 out of 61 cases).

- Avascular necrosis in 8 out of 61 cases. (13%).
- Most common complication was premature epiphyseal fusion 10 out 61 cases (16%).
- Coxa vara was reported in 6 cases (10%).
- Significant (>2.5 cms.) limb length discrepancy occurred in 6 cases (10%).

Coxa vara, limb length discrepancy and isolated premature epiphyseal fusion does not always lead to poor results (Lam 1971). Avascular necrosis has been reported as the primary cause of poor results in most series.

**Avascular necrosis:**

Incidence of avascular necrosis in the present series was 13%, 8 out of 61 fractures. The rate of avascular necrosis varied from 17% to 47%as summarized by Hughes and Beaty (1994). Our results are encouraging but this may not be the true picture because –

- there was no Type-I fracture in this series.
- duration of follow-up was only 1 year in 54% cases – as highlighted by Lueng & Lam (1986) these figures will probably be revised after a longer follow-up.

We observed that the risk of avascular necrosis is definitely related to the following factors-

- displacement of fractures; all 8 cases of avascular necrosis occurred in displaced fractures.
- type of fracture; avascular necrosis was more common in Type-II fracture (7 cases occurred in Type-II and one case occurred in Type-III).
- age at the time of injury; all avascular necrosis occurred in older age groups (3 avascular necrosis in 9-12 years age group & 5 in 12-16 years age group)

The risk of avascular necrosis is directly proportional to the amount of initial displacement of the fracture fragments and to the compromise of the blood supply at the time of the fracture (Calandruccio and Anderson – 1980, Canale and Bourland – 1977, Gerber, Lehmann and Ganz – 1985, Heiser and Oppenheim –1980, Ovesen, Arreskov and Bellstrom – 1989, Ratliff - 1970). In the report by Canale and Bourland twenty five of the twenty six fractures after which avascular necrosis developed were displaced. Other authors have reported similar results. Other factors associated with an increased risk of avascular necrosis are a type-I or II fracture and an age of

more than ten years. The type of treatment of an acute fracture does not affect the rate of avascular necrosis (Canale and Bourland – 1977, Heiser and Oppenheim – 1980, Ratliff – 1962 and 1970).

An interesting observation in the present series was that in 4 cases of avascular necrosis out of total of 8 cases there was only occasional pain and only terminal restriction of movements with no disability. Radiologically these cases showed advanced changes.

McDuagall (1961) stated “while the bone is avascular, no pain is experienced and the patient may walk about quite freely, it is not until revascularization of the bones takes place and softening and collapse occur that pain and spasm become marked fractures.”

**Non-union:**

Non union was present in only 5% cases (3 out of 61), (Case No. 45, 47 and 80) in this series.

Case No. 45: In this type-II displaced fracture, screws were broken because of early weight bearing and a repeated fall. Removal of screws and Mac Murrey’s osteotomy resulted in firm union at the fracture site.

Other two cases were neglected cases, which were treated by valgus osteotomy and the fracture site united promptly.

Other series also reported similar incidence:

- Canale & Bourland (1977) - 6.5%
- Sancheti et al (1982) - 0%
- Heiser & Oppenheim (1986) -7.5%

Therefore, union is not a major problem in fracture neck of femur in children. These fractures united readily even where fixation was in adequate or there was a distraction of 3-4 mm at the fracture site.

**Premature epiphyseal fusion and growth disturbance:**

The cases were observed for a minimum period of 1 year after injury and physis was compared with the normal side.

Premature epiphyseal fusion occurred in (16%) cases. Shortening associated with premature epiphyseal fusion is usually less than 2 cm., because the capital femoral physis contributes only thirteen percent of the growth of the entire extremity, except in very young children

(Swiontkowski, 1989). Here severe shortening generally is associated with avascular necrosis, especially in younger children, and when avascular necrosis develops with coxa vara. Regardless of the amount of shortening, children who have premature physeal closure should be observed closely and sequential limb-length scanograms and radiographs of the wrist to determine bone age. Epiphyseodesis of the contralateral extremity may be performed if necessary to equalize limb lengths when the discrepancy is expected to be 2.5 centimeters or more (Canale 1987). So, premature epiphyseal fusion in itself does not lead to poor results.

The incidence of epiphyseal closure varies with different authors ranging from 0% (Maini et al 1982) to 62% (Canale and Bourland, 1977). Several interrelated factors are associated with the occurrence of premature epiphyseal fusion in itself does not lead to poor results.

The incidence of epiphyseal closure varies with different authors ranging from 0% (Maini et al 1982) to 62% (Canale and Bourland, 1977). Several interrelated factors are associated with the occurrence of premature epiphyseal closure.

Canale & Bourland (1977) have clearly shown that premature fusion is likely to occur if pins had crossed the epiphysis (75% in his series) in our series out of 10 cases of premature epiphyseal fusion only one could be due to damage caused by pins. The remaining cases showing premature epiphyseal fusion were due to avascular necrosis.

Ratliff (1962) also reported closure of the distal femoral epiphysis after prolonged cast immobilization. We did not encounter such a case.

We also encountered 5 cases of limb engineering. These may be attribute to –

- ipsilateral fracture femur & leg bones.
- fracture in the opposite limb.
- coxa magna with long neck.
- in one case no justifiable reason could be given, possibly it could be because of irritation of the physis by cancellous screw tip.

**Coxa Vara:**

Cases resulting with a neck shaft angle of 110 or less were labelled as coxa vara. We encountered 6 cases out

of 61 (10%) in this series of which 5 of them were neglected cases. None of the conservatively treated type II or III undisplaced fractures resulted in coxa vara as was feared by Ingram & Bachynski (1953), Lam (1971) and Canale and Bourland (1977).

**Other Complications:**

Lueng & Lam (1986) described 12% cases of coxa magna in their series. They described it as flattened femoral head with a short neck. We encountered 3 cases of coxa magna. None of them showed a short neck. They all showed an increased transverse diameter of head but no flattening. They had a follow up of more than 2 years.

Trochanteric apophysis fused in three cases. In one case it could be because of damage to growth plate by implants.

Superficial infection was encountered in one case which settled with antibiotics & dressings.

**RESULTS**

Ratliff's (1962) criteria was used to assess the final results at the end of 1 year or more. However, we found some difficulty in classifying the cases. Because in some cases

patients were clinically very good but radiologically very poor e.g. case no. 23 shown in slides had absolutely no complaints on clinical examination, but a full blown picture of avascular necrosis radiologically. This case was classified in the poor category.

However, results are comparable to other series –

| | **Good** | **Fair** | **Poor** |
|---|---|---|---|
| Kay & Hall (1971) | 56% | 23% | 21% |
| Canale & Bourland (1977 | 55% | 20% | 10% |
| **Present Series** | **75%** | **11%** | **13%** |

The results of the present series are likely to change in forthcoming years as it can be predicted that lot many cases will further deteriorate due to development of avascular necrosis & degenerative arthritis (Lueng and Lam - 1986). On the contrary, a few hips will definitely show remodeling and revascularization. (Sancheti et al (1980), Maini et al (1982)).

Sancheti et al (1980) stated that all cases of avascular necrosis remodeled satisfactorily and none developed arthritic changes.

Maini et al (1982) noticed revascularization of 75% heads who previously developed avascular necrosis.

The need for ongoing study and long follow up of these fractures need not be stressed.

# SUMMARY AND CONCLUSION

1. A detailed study of 61 femoral neck fractures out of 99 cases in children observed for more than 1 year is presented.
2. This fracture was more common in 8-12 years of age group (38%).
3. Males and female were equally involved (Male – 52.5% & Female – 47.5%) due to similar outdoor activities.
4. 94% fractures resulted from violent trauma (Fall 78% + Vehicular accidents 16%).
5. Associated injuries were common (26%) because of high velocity trauma.
6. Occurrence of Delbet's type-II fracture was commonest (52%) and displaced fractures were more common than undisplaced fractures(3:1).
7. Most of the fractures (74%) were treated after a delay of more than 2 days. A definite relation between the delay in treatment and complication rate was found.
8. All neglected cases (delay of more than 4 weeks of treatment) were complicated.

9. Most of the fractures were treated operatively (72% fresh + 11% neglected = 83%).
10. Open reduction was done in 10 out of 30 displaced fractures treated operatively.
11. Results of undisplaced fractures treated conservatively were encouraging. All undisplaced fractures which were treated conservatively showed no complications.
12. We found following factors as poor prognostic indicators:
    - older child
    - type II displaced fracture
    - displaced fractures
    - delay in treatment
    - open reduction
13. Aseptic necrosis was observed in 13% of cases. This was the main cause of poor result.
14. Clinical findings of avascular necrosis may not correlate with the actual status of the head. It is mandatory to do a radiologic examination in each case.
15. Non-union occurred in 5% cases.

16. Coxa vara was common in neglected and conservatively treated displaced type-III fractures. In this series there were 6 cases of coxa vara (> 110).
17. No significant shortening was found in cases with isolated premature epiphyseal fusion.
18. All cases of avascular necrosis showed premature epiphyseal fusion.
19. Trochanteric apophysis fused earlier only in type III & IV cases.
20. Coxa magna was observed in 3 cases.
21. One case of unexplained limb lengthening (2 cm.) was reported.
22. According to Ratliff's criteria 75% were good, 11% were fair and 13% were poor results.
23. Longer follow-up and ongoing study is needed to assess the final outcome of these injuries in our population.