A CRITICAL ANALYSIS OF OPERATIVE MANAGEMENT OF FRACTURE NECK OF FEMUR AT THE KENYATTA NATIONAL HOSPITAL ORTHOPAEDIC UNIT OVER A FIVE-YEAR PERIOD

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BY

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DECLARATION

CANDIDATE

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

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"It is not the European in Europe who spends most of his time in the office and travels by car that needs normal legs but the Masai, who spends half his life time on his two feet".

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A total of 122 patients were operated for femoral neck fracture at the orthopaedic unit of Kenyatta National Hospital in the period January 1976 to December 1980. Available records of 71 patients were reviewed. Only 42 of these were followed up for periods ranging between one and six years.

Sixty (84.5%) of the patients sustained fractures following road traffic accidents. The rest of the patients developed fractures either as a result of attacks by animals (7.0%), or following a fall (5.6%). Two patients (2.8%) had pathological fractures. All the patients presented themselves to hospital within 24 hours of injury but definitive and appropriate management was long delayed sometimes even up to 20 weeks for those referred from District and Provincial hospitals. Surprisingly two thirds of the patients were below the age of sixty.

Four types of operative management were noted.

1. Traditional method of reducing the fracture on an orthopaedic table, temporary fixation by guide wires under x-ray control and fixation with Smith Patterson nail or McLaughlin's pin and plate.
2. Open reduction of the fracture and fixation
   with $130^\circ$ fixed angle plate according to AO group.
3. Primary prosthetic replacement.
4. Excision arthroplasty.

The results of these different treatments are critically
analysed and conclusions drawn. Some suggestions are
made as to the future planning of the treatment of
femoral neck fractures in the Country.
CHAPTER II

INTRODUCTION

The usual presentation of a patient with femoral neck fracture is one of an elderly patient who gives history of trivial trauma to the lower limb, developing sudden hip pain, and inability to walk. Radiology shows osteoporotic bones with a fracture in the neck of the femur (Bentley, Nieminen, Osborne, Peltier). This diagnosis is often not difficult to make but most challenging is the optimum management of such patients who often are poor operative risks and poorly tolerate prolonged immobilisation in bed (Laros). However age is not the only factor which influences the various modalities of management but peculiarities like vascular anatomy and biomechanics inherent in the femoral neck render fractures vulnerable to various complications.

Precisely, the neck of femur is that part of the upper end of femur lying between a line drawn along the inferior margin of the head of femur and one drawn across the inter-trochanteric ridge anteriorly and the inter-trochanteric crest posteriorly. It does not include fractures involving the trochanter (Kyle, Delee and Harris).
Femoral neck fractures have been classified in many ways using various criteria. Anatomy, vascularity and displacement are some of the factors used in the past to classify this fracture. Using displacement Garden classified these fractures into Type I, II, III and IV with type I having no displacement and type IV being grossly displaced. Pauwels utilising the biomechanics of the hip has devised a classification that correlates the fracture line to the line of action of the compressive force of the body. Pauwels classifies femoral neck fractures into three groups. In Type I the line of fracture inclines at an angle less than 30° from the horizontal plane. Type II include those fractures with inclination between 30° and 50°. The last group have an angle of inclination of 50° or more. This classification that is fairly easy to apply is accurately reproducible and if used for management, uniform results are achieved. Due to its ease of adaption and applicability, Pauwels classification has been used throughout this study.

Hageberg and Freeman working with European studies have demonstrated the role of fatigue in the causation of these fracture. They have also documented a female preponderance. There are, however, no corresponding studies in African populations but judging from the age distribution pattern of Kenyans (Central Bureau of Statistics), the role of fatigue in the causation of
femoral neck fractures would be only minimal.

Management of the femoral neck fractures varies from one centre to another, with varying degrees of success (Nieminen, Garden, Graham, Meyers, McMurray)

Better and modern techniques are being developed in order to improve the surgical management of this elusive fracture. These techniques are increasingly being geared towards the utilization of the biomechanics and surgical anatomy of the femoral neck, and hip in general (Osborne, Nieminen, Garden, Crawford, Frandson, Lahdenrata, Meyers, Laros, and Pankovich). These factors dictate the surgical management and to a great extent influence the expected prognosis. Many writers including the ones named above, have documented excellent prognosis in this fracture and improved results with early weight bearing. Garden, Osborne and Graham have reported rates of union above 80% with little or no requirement for a second intervention.

At the orthopaedic unit of Kenyatta National Hospital the nature of this problem is ill defined. Also lacking is a standardised protocol of management. However efforts to perfect the techniques used in the management are well underway; so are attempts to standardise the surgical
management at the unit. Both these attempts require a critical evaluation of the problem and the outcome of the various modalities of management currently in practice at the hospital.

It is with the latter in mind that this study was undertaken.

The aim of this study was therefore to:-

1. Collect data on the nature of the femoral neck fracture at the orthopaedic unit of Kenyatta National Hospital in relation to:-
   a) Aetiology.
   b) Age and sex patterns.
   c) Classification.
   d) Modalities of management of this fracture and the outcome.

2. Demonstrate the utilisation (if any) of the basic principles of biomechanics and surgical anatomy in the management of the fracture femoral neck.

3. Analyse the data with statistical comparison of the various modalities of operative management.

4. Use the results so gained and the conclusions so drawn to make practical recommendations to the Department.
CHAPTER III
MATERIALS AND METHODS

Records of all patients admitted with femoral neck fractures to the orthopaedic unit of Kenyatta National Hospital between January 1976 and December 1980 were reviewed. Those patients still attending the orthopaedic clinic were reviewed and assessment made at the time of the review.

The results of the follow up were classified in three categories - excellent, good and poor according to the set criteria. This assessment was done for patients seen one year or more after surgery. The set criteria was as follows:-

**Excellent**

Presence of the following:-

1. No intervention necessary one year or more after surgery.
2. No pain in the affected hip.
3. No limp.
4. No limitation in movements.
5. Full weight bearing possible (or patient back to normal life).
6. Radiological evidence of union.
GOOD

Presence of the following:-

1. No further intervention one year or more after surgery.
3. Minimal limp (or shortening of \( \frac{1}{2} \) inch or less).
4. Slight limitation of movements.
5. Partial weight bearing (or use of one clutch) one year following surgery.
6. Radiological evidence of union.

POOR

Presence of one or more of the following:-

1. Further intervention necessary or undertaken within the period of follow up.
2. Severe pain in the affected hip.
3. Severe limp (or shortening of more than \( \frac{1}{2} \) inch).
4. Severe limitation of movements.
5. Partial weight bearing not possible one year or more after surgery.
6. Radiological evidence of non-union or avascular necrosis.

These results were statistically computed and comparison made between the various modalities of management.
The characterisation of the patients investigations done and methods of management applied were also reviewed. Where possible the indication of the method used was also extracted and computed. The nature of complication and management were recorded and analysed as were prophylactic measures taken against infection and thrombo-embolism and their efficacy.

All the above data together with the duration of stay in hospital were analysed and statistical computation made and where applicable statistical correlation done.

This study also categorised patients according to the mode of admission to the orthopaedic unit of Kenyatta National Hospital. Similar computations were done for referred patients and those directly admitted.

The results of subsequent follow up were also reviewed. The patients were reassessed at the orthopaedic consultant clinic by an orthopaedic specialist or in his absence by a registrar in the department.
CHAPTER IV

RESULTS

AGE DISTRIBUTION

The youngest patient was a four year old boy who sustained femoral neck fracture following a fall from a bicycle. The oldest patient was a 79 years old male patient who slipped and fell sustaining a Pauwel III fracture. The age distribution is shown in table 1 below.

TABLE 1

AGE DISTRIBUTION OF PATIENTS ADMITTED TO KENYATTA NATIONAL HOSPITAL WITH FEMORAL NECK FRACTURE 1976 - 1980

<table>
<thead>
<tr>
<th>AGE GROUP</th>
<th>MALE</th>
<th>FEMALE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 9</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>10 - 19</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>20 - 29</td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>30 - 39</td>
<td>7</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>40 - 49</td>
<td>13</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>50 - 59</td>
<td>8</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>60 - 69</td>
<td>6</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>70 - 79</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Over 80 years</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Adults</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>54</td>
<td>17</td>
<td>71</td>
</tr>
</tbody>
</table>

X (mean) 45.11 43.88 44.81
The mean age was 45 years (44.81 ± SD = 18.64 years). There was no significant difference (t = 0.23 p 0.01) between the mean age for males (45.11 years) and that of females (43.88 years). Figure 1 summarises these results.

**FIGURE 1**
AETIOLOGY

A majority of patients 60 (84.5%) sustained injuries through road traffic accidents. The rest of the patients sustained femoral neck fractures due to various factors shown in table 2 below.

Table 2

AETIOLOGICAL FACTORS IN FEMORAL NECK FRACTURES

<table>
<thead>
<tr>
<th>TYPE</th>
<th>NO. OF PTS.</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAFFIC ACCIDENTS</td>
<td>60</td>
<td>84.5%</td>
</tr>
<tr>
<td>ANIMAL ASSAULT</td>
<td>5</td>
<td>7.1%</td>
</tr>
<tr>
<td>FALL</td>
<td>4</td>
<td>5.6%</td>
</tr>
<tr>
<td>PATHOLOGICAL FRACTURES</td>
<td>2</td>
<td>2.8%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>71</td>
<td>100%</td>
</tr>
</tbody>
</table>
DURATION OF STY IN HOSPITAL

The average stay in hospital was 19 weeks for referred patients and 5 weeks for direct admissions to Kenyatta National Hospital. After surgery, however, the average stay was only 10 - 14 days. - (Figure 2).

FIGURE 2
RADIOLOGICAL FINDINGS

These were classified according to Pauwel's classification. The results shown in table 3 indicate that most patients were either Pauwels II or III-28 (39.4%) and 26 (36.6%) respectively. A small fraction 12 (16.9) was not classified.

TABLE 3
Radiological Findings of 71 patients with fracture neck of femur

<table>
<thead>
<tr>
<th>PAUWEL CLASS</th>
<th>NUMBER OF PATIENTS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>5</td>
<td>7.1</td>
</tr>
<tr>
<td>II</td>
<td>28</td>
<td>39.4</td>
</tr>
<tr>
<td>III</td>
<td>26</td>
<td>36.6</td>
</tr>
<tr>
<td>NOT CLASSIFIED</td>
<td>12</td>
<td>16.9</td>
</tr>
<tr>
<td>TOTAL</td>
<td>71</td>
<td>100</td>
</tr>
</tbody>
</table>
HISTOLOGICAL FINDINGS OF PATHOLOGICAL FRACTURES.

There were two patients with pathological fractures both of them were due to secondaries in the neck femur. One patient had a secondary from carcinoma prostate with no urinary symptoms. The second patient had a primary in the breast. She had had mastectomy done and was undergoing radiotherapy. There was no primary neoplasm of the neck of femur.

MANAGEMENT

69 (97.2%) of the 71 patients were treated primarily with operation. Two patients were originally treated with analgesics for pain but had to undergo replacement arthroplasty later. One of the latter had total hip replacement for severe arthritis. Table 4 shows the breakdown according to the management and table 5 the management in relation to Pauwel's classification.
## TABLE 4
MODALITIES OF PRIMARY MANAGEMENT OF FEMORAL NECK FRACTURES

<table>
<thead>
<tr>
<th>MODALITY</th>
<th>NUMBER OF PATIENTS</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal fixation by traditional methods</td>
<td>31</td>
<td>43.7</td>
</tr>
<tr>
<td>Internal fixation according to AO group</td>
<td>20</td>
<td>28.2</td>
</tr>
<tr>
<td>Replacement Arthroplasty</td>
<td>19</td>
<td>26.8</td>
</tr>
<tr>
<td>Excision Arthroplasty</td>
<td>1</td>
<td>1.4</td>
</tr>
</tbody>
</table>
**TABLE 5**

**MANAGEMENT ACCORDING TO PAUWEL'S CLASSIFICATION**

<table>
<thead>
<tr>
<th>PAUWEL'S CLASSIFICATION MANAGEMENT</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>NOT CLASSIFIED</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal fixation by traditional methods</td>
<td>3</td>
<td>12</td>
<td>11</td>
<td>5</td>
<td>31</td>
</tr>
<tr>
<td>Internal fixation according to AO group</td>
<td>0</td>
<td>12</td>
<td>4</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Replacement Arthroplasty</td>
<td>2</td>
<td>4</td>
<td>11</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Excision Arthroplasty</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>5</td>
<td>28</td>
<td>26</td>
<td>12</td>
<td>71</td>
</tr>
</tbody>
</table>
Further intervention was necessary in 11 (15.5%) patients as given in table 6.

<table>
<thead>
<tr>
<th></th>
<th>Fixation by Traditional methods</th>
<th>AO Fixation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Replacement of Device</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2. Excision Arthroplasty</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3. Replacement Arthroplasty</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>4. Arthrodesis</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

7 patients who required further intervention were Pauwel's III type who had been initially managed by traditional methods without osteotomy. There was one patient with Pauwel II who had improper fixation with a cracked upper femur, a loose device and subsequent destruction of the hip joint. He required excision arthroplasty as the salvage procedure.
One patient with Pauwel III fracture treated by internal fixation using traditional pin and plate had replacement arthroplasty (Austin Moore prosthesis) in 1977 and required excision arthroplasty one year later.

The patient who was treated by AO method initially and required arthrodesis had a Pauwel II fracture with subsequent avascular necrosis and destruction of the hip joint. He was pain free after the arthrodesis.

**COMPLICATIONS**

The commonest complication recorded in the study was wound infection 6 (8.5%). 5 (7.1%) patients developed avascular necrosis with collapse of the head radiologically. Improper fixation occurred in 3 patients intra-operatively. The rest of the complications were as shown in table 7.

**TABLE 7**

**COMPLICATION OF FEMORAL NECK FRACTURES AFTER OPERATION**

<table>
<thead>
<tr>
<th>COMPLICATION</th>
<th>NUMBER OF PATIENTS</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound infection</td>
<td>6</td>
<td>8.5</td>
</tr>
<tr>
<td>Avascular necrosis</td>
<td>5</td>
<td>7.1</td>
</tr>
<tr>
<td>Improper fixation</td>
<td>3</td>
<td>4.2</td>
</tr>
<tr>
<td>Pulmonary Embolism</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>Sciatic nerve injury</td>
<td>1</td>
<td>1.4</td>
</tr>
</tbody>
</table>
ASSESSMENT OF OUTCOME

Of the 71 patients whose records were available, 29 were lost during the follow up. In all 42 patients were seen for periods of more than one year after surgery. 22 of these had been managed by traditional methods of internal fixation and 20 patients according to AO technique. All patients with replacement arthroplasty were lost in the follow up. The results of the outcome according to the set criteria are given in table 8.

| TABLE 8 |
| OUTCOME ACCORDING TO MODALITY OF MANAGEMENT |

<table>
<thead>
<tr>
<th></th>
<th>EXCELLENT</th>
<th>GOOD</th>
<th>POOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional method of Fixation</td>
<td>12</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>AO Fixation</td>
<td>15</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Replacement Arthroplasty</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Excision Arthroplasty</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
There was a significant difference ($X^2 = 6.92, p < 0.05$) between management by internal fixation using traditional methods and according to AO group. The latter method yielded better results with 95% of the patients rating as either excellent or good. 8 patients (11.3%) of patients managed by traditional methods had poor results all of whom had further intervention in the form of replacement arthroplasty.
THE PHYSIOLOGY OF THE HIP

The neck of femur has important anatomical and physiological peculiarities that influence the causation, healing and long term behaviour of fractures in this area of the femur (Pauwels, Trueta).

These inherent characteristics are also known to be responsible for the complications that follow surgical management of fractures of neck of femur. Of importance are, vascular anatomy of the head of femur, biomechanics of the hip joint and the general physiological factors known to influence bone healing. As there can be no complete scientific discourse on this fracture or successful regimen of management that ignores these fundamental qualities of the neck, a brief outline of their salient and relevant features is given below.

A) The Vascular Anatomy of the Head of Femur

Trueta has described the vascular anatomy of the head of femur during growth and adulthood. He described five main phases of vasculature of the femoral head during growth.

a) At birth

Vessels coming from the lateral side of the head
proceed horizontally towards its medial side while other vessels emerge almost vertically from the top of the ossified shaft. Vessels are also seen to be coming from the ligamentum teres but they are not constant and do not always contribute to the nourishment of the head.

b) **Infantile phase: 4 months - 4 years**
The predominant blood flow arises from the metaphyseal vessels crossing the area later to be occupied by the growth plate. The lateral epiphyseal vessels are also important but there are no penetrating vessels from the ligamentum teres even if in the early days some large vessels were seen to enter the head from this source. They soon disappear.

c) **Intermediate Phase 4 - 7 years**
The epiphyseal plate has established a firm barrier between the epiphysis and the metaphysis. The metaphyseal blood flow decreases to become negligible or nearly so, while the ligamentum teres has not yet provided vessels penetrating the epiphysis. During these two to three years, the only blood supply to the epiphysis comes from the lateral epiphyseal vessels, all of them tightly grouped on the lateral aspect of the head. These vessels are branches of the medial femoral circumflex artery.
Foveolar artery very small - reaching only as far as the Fovea - not anastomosing. 20% of cases.

Diagram showing Foveolar artery anastomosing with retinacular arteries. 80% of cases.

FIGURE 3: DIAGRAMMATIC REPRESENTATION OF THE BLOOD SUPPLY TO THE HEAD AND NECK OF FEMUR IN CHILDHOOD.
d) **Pre-adolescent phase (8 - 10 years)**

Here, while the growth plate acts as a barrier to the vessels, the arteries from ligamentum teres firmly reach the depths of the epiphysis and become anastomosed to the vessels all of which are branches of the later epiphyseal arteries. Thus at this stage, the epiphysis receives blood from two sources situated at the greatest possible distance from each other. No metaphyseal vessels are present. However, 20% of children never develop this anastomosis (McDougall).

![Figure 3](image)

e) **Adolescent phase (and adult)**

In this phase the barrier of the epiphyseal plate begins to breakdown, and vascular anastomosis crosses over bringing into being the final or adult stage of circulation where the epiphyseal and ligamentum teres vessels are joined again to those of the metaphysis giving to the femoral head an interwoven vasculature. Throughout adulthood, the vasculature remains virtually the same as in the adolescent (Trueta).

Epiphyseal vessels (those in the secondary centre of ossification) are classified into either medial or lateral according to their point of entry into the bone. The metaphyseal vessels are either inferior or superior.
FIGURE 4: VASCULATURE FOR AT 20 YEARS ADAPTED FROM TRUETA.⁴⁵
Metaphyseal vessels and lateral epiphyseal vessels are branches of the medial femoral circumflex artery (Trueta). The medial epiphyseal vessels come from the ligamentum teres artery an acetabular branch of obturator artery. The lateral epiphyseal vessels supply up to four fifths of the epiphysis. On the other hand the inferior metaphyseal vessels supply over two thirds of the metaphysis (Figure 4). These vascular pattern is however subject to many variations, with some cases having no ligamentum teres artery at all.

**Epiphyseal Arterial Pattern**

a) **Lateral epiphyseal arteries**

These enter the head posterosuperiorly lying in a thick fibrosis sheath. They spiral along the area originally occupied by the epiphyseal plate in a downward, medial and anterior direction.

b) **Medial epiphyseal arteries**

These enter the fovea capitis and run laterally to anastomose with the lateral epiphyseal vessels. These two systems have a tendency towards the epiphyseal side and little or none to the metaphysis. They are arranged in arcades and tiers.

**Metaphyseal group**

a) **The Superior metaphyseal vessels**

According to Trueta, two to four arteries arise from
the origin of the lateral epiphyseal vessels. They enter the superior aspects of the femoral neck (away from the articular margin). They run vertically downward but turn superomedially, quarterway down the neck.

b) **Inferior metaphyseal group**

The lateral femoral circumflex gives a variable number of vessels that contribute to the inferior metaphyseal group. They enter the bone just next to the inferior articular margin without any arches, penetrating deep into the metaphysis.

The pattern of metaphyseal vessels unlike the epiphyseal group is one of interconnecting anastomoses within the synovial tissue in the form of a circular ring - "circulus arteculi vasculosus" (Tueta\textsuperscript{44}). This circle is deficient anteriorly in the neck.

The two systems freely anastomose within themselves and across the old epiphyseal plate (Trueta\textsuperscript{45}). Their fine arrangement in the marrow is that of capillaries and sinusoids arising from arterioles. These soon unite into venules that run as veins together with arteries in the subsynovial tissue. Nutrition of the articular cartilage is from its deep attachment and along its
POSTERIOR

a. Foveolar A.
   (Artery of head lig.)

b. Posterior superior retinacular arteries.

c. Posterior inferior retinacular arteries.

d. Medial femoral circumflex artery.

FIGURE 5: BLOOD SUPPLY TO THE HEAD AND NECK OF FEMUR
(AFTER McDOUGALL 28)
margin except for this source, the cartilage is avascular.

It is imperative to state that the retinacular firmly fixes these vessels to the bone in/neck of femur. This renders them vulnerable to rupture in fracture of the femoral neck. Of particular mention is the lateral epiphyseal group that is often damaged in abduction fractures and as it predominates in the femoral head blood supply leads to avascular necrosis. Equally important is the fact that nutrient arteries play no part in the nutrition of the neck of femur. The lateral epiphyseal vessels disperse from the retinacula and penetrate foramina in the neck to supply it with blood.

Trueta⁴⁴ has summarised the blood supply to the femoral head as follows:

The blood supply to the femoral neck and head is derived from an extracapular arterial ring at the base of the neck. The anterior portion of the arterial ring is mainly from the lateral femoral circumflex figures. The posterior portion is supplied by the medial femoral circumflex artery (figure ⁵). Ascending cervical arteries from the arterial ring perfolate the capsule and become retinacular arteries. Postero-superiorly, are (lateral epiphyseal arteries) numerous vessels (three to eight in number) while antero-inferiorly there are only one two three vessels. (Figure ⁶).
ANTERIOR

a. Foveolar artery (artery of the head lig.)
b. Anterior retinacular arteries.
c. Lateral femoral circumflex artery.

FIGURE 6: BLOOD SUPPLY TO THE HEAD AND NECK OF FEMUR. (AFTER McDOUGALL 28).
Trueta further states that there are two separate systems of vessels in childhood (epiphyseal and metaphyseal) that in adulthood freely anastomose. Most investigators now agree that the femoral head is supplied primarily by the lateral epiphyseal vessels. The metaphyseal vessels supply mainly the metaphyseal portion of the neck. The contribution of the ligamentum teres artery that is usually derived from the obturator artery is not clear. It however seems that it supplies primarily the area of the head around the fovea capitis where the ligamentum teres is attached. There is evidence that avascular necrosis developed if all retinacular vessels were damaged regardless of the state of ligamentum teres supply. On the other hand the extracapsular location of the femoral neck posteriorly explains the low incidence of femoral head necrosis following basal neck fractures.

Venous drainage of the hip is into the obturator and common femoral veins. Also there is flow towards plexuses in the sciatic notch and the ischial tuberosity. There have been attempts elsewhere to improve the vascularity of the femoral head when the lateral epiphyseal arteries are feared to be damaged. Methods like the muscle pedicle grafts have been used with limited success (Meyers). Such attempts have so far not been noted in this study.
However noted was possible disimpaction of an abduction fracture that had not been diagnosed early and the patient continued putting full weight on it. He later developed avascular necrosis and required replacement arthroplasty. Disimpaction of abduction fracture and vascular damage is reported in many series. Bentley\textsuperscript{4}, Crawford\textsuperscript{12}, Garden\textsuperscript{17} have reported avascular necrosis following impacted abduction fractures. Vascularity plays an important role in the causation of complications observed in childhood (Rafliff\textsuperscript{41}).
B is the point of action of muscle pull M, in the direction of the arrow.

O is the centre of the femoral head through which resultant force R acts (R = Resultant of partial body weight and muscle pull).

S is the centre of gravity (sacral 5) through which body weight K acts.

C is the point of action of body weight on same horizontal plane as B and O. (Projection of S).

Applying mechanical laws of physics, moments about O are given by:

Lever arm OB \times \text{muscle force } M = \text{lever arm } OC \times \text{body weight } K.

When this equation is balanced, the body rests at equilibrium.

The resultant force R is proportional to the sum of the products in both sides of the equation.

\[ R' = (OB \times M) + (OC \times K). \]

**FIGURE 7: FORCES ACTING AT THE HIP JOINT UNDER PHYSIOLOGICAL CONDITIONS.**
The biomechanics of the hip joint

The biomechanics of the hip joint has significant effect and influence on the healing of the femoral neck fractures. It is imperative that the biomechanics of the hip joint be understood in order to utilise them to enhance bone healing and reduce the magnitude of morbidity associated with these fractures.

In his monologue, Pauwel has clearly demonstrated the forces in operation at the upper extremity of the femur (neck and head of femur). Blount has also given evidence to the importance of the biomechanics at the hip and shown the significant role played by an external support.

Under physiological states, the upper extremity of the femur is subjected to a load which is a resultant of the forces acting at this extremity. In figure 7, the load $R$ is a resultant of the muscular force $M$ and the body weight $K$. $K$ (and therefore $R$) is minimal when the body weight is evenly distributed as in standing still on both feet and maximum when one stands on one leg without external support e.g. cane (Blount). Resultant force $R$ has the following effects on the upper femoral extremity.
FIGURE 8: PHYSIOLOGICAL LOADING ON THE UPPER END OF FEMUR.
Head of femur

Under physiological states, $R$ is purely compressive on the femoral head, and at the hip joint in general since the line of action of $R$ crosses the centre of rotation of the head and is perpendicular to it: Figure 8.

Neck of Femur

The line of action of force $R$ is not perpendicular to the long axis of the neck but is inclined at an angle of $160 - 170^\circ$. The compressive component tends to bend the neck medially. The force $R$ acts in the version of a third degree lever system. Near the head of the femur the force acts at the end of the arm lever. Near the trochanter, the force acts at the full length of the arm lever. Hence the effects of this force increases towards the trochanters. Figure 8.

In the neck, also, the resultant force $R$ has a shearing component of the same magnitude at all levels of the neck of femur (inclination of the resultant force $R$ to the axis of the neck of femur is the same at all levels of the neck, and is the one that determines the magnitude of $S$). Of note is the fact that resolving the reaction to $R$ into the forces $L$ and $Q$ gives additional useful information. Force $L$ tends to displace the head upward (longitudinal component). Force $Q$ (transverse)
Intra-articular pressure (IP) = 22 KP/CM$^2$ for head size 5 cm. diameter.

R is purely compressive on the femoral head as the head is a sphere and R always acts perpendicular to its articular surface. R has a medial compressive component (stressing in bending) and a lateral tensile (stressing in stretching) in the neck of femur designated D and Z respectively.

S is the shearing component of R also acting in the neck of femur.

**FIGURE 9**: PHYSIOLOGICAL STRESS AT THE UPPER END OF THE FEMUR

SOURCE: PAUWELS$^{39}$
tends to push the head against the bottom of the socket. Figure 8 shows these forces at play.

The effect (stress) of the load (Resultant force R) has the following characteristics on the upper extremity of femur:

**Stress on head of femur due to resultant force R**

The compressive stress D (figure 9) is evenly distributed over the weight bearing area and is inversely proportional to the surface area of the head (head size). For a femoral head 5 cm. diameter, the area of compression is 9 cm². A force R of 200 KP causes an intrarticular pressure of 22 KP/cms. This is the stressing force in the normal hip joint (Pauwels).**

**Stress in the neck of femur due to resultant force R**

Stressing in the neck of femur has two important characteristics:

1. Stressing in bending (due to R which does not act in the axis of the neck but at the end of the lever and outside the core of the neck). There is a compressive force medially (designated D in figure 9) and a smaller tensile force (Z in figure 9) acting laterally as a result of the bending effect of R.
X is the point of intersection of the line of action of muscular force M and the line of action of partial body weight K.

In coxa vara, X is lower than normal (trochanter higher). Consequently lever arm (h) is longer than normal. R and M are widely separated. In coxa valga this is reversed. The equilibrium is maintained at the hip by less muscle force M in coxa vara and more muscle force in coxa valga (moments about O are given by $H \times M = OC \times K$ where K and OC are constant).

These facts are represented by the parallelogram of forces at the top of the diagram.

**FIGURE 10**: DIAGRAMATIC ILLUSTRATION OF THE INFLUENCE OF THE NECK SHAFT ANGLE ON MUSCULAR DISTRIBUTION.
(ii) R has another component in the neck of femur -
stressing in shearing (S in figure 9).

In other words load R has a pure compressive stress
in the femoral head inversely proportional to the size
of the head. The same force R, due to the angle of the
neck of femur (125°-140°) has two stresses. Bending
stress (compressive medially and a tensile laterally)
and a shearing stress attempting to shift the head and
proximal neck of femur medially and the distal neck of
femur with the rest of femur laterally. Under physiological
states, these forces are at equilibrium. But if there
is discontinuity in the femoral neck as in fracture these
forces freely interplay. Their effect can be predicted
and is related to the mechanical translation of these
forces in magnitude and direction (Pauwels\textsuperscript{39}). The upper
end being under the influence of bending stress will rotate
medially while due to the shearing stress it will also
shift medially.

Pauwels\textsuperscript{39} noted two important physiological factors
that influence the biomechanics at the hip joint, the
length of the neck of femur and the angle of inclination
of the neck of femur.

1. A long neck increases the lever arm h (Figures 10,
   11 and 12) and consequently reduces the muscular
   force, M, necessary to maintain equilibrium at the
   hip. This consequently reduces the compressive
   force R.
In coxa vara while the intra articular pressure is reduced, the stressing in bending compressive force $D$ and stressing in shearing as well stressing in stretching (lateral tensile force) are greatly increased. The observations made in coxa valga are a reverse of this. The values above are given by Pauwels.

FIGURE 12  STRESSING AT THE UPPER END OF FEMUR AT DIFFERENT NECK/SHAFT ANGLES.
The magnitude of physiological loading increases in coxa valga while the shearing force is almost eliminated. In coxa vara the loading is reduced while the shearing force is increased. The reaction $R$, to the resultant force is almost twice in coxa valga as it is in coxa vara ($L=252$ and 137 respectively).

Pauwels has documented the figures above.

**FIGURE 11: PHYSIOLOGICAL LOADING ON THE UPPER END OF THE FEMUR AT DIFFERENT NECK/SHAFT ANGLES (CCD).**
2. Increase in the femoral neck angle (making it steeper) as in coxa valga decreases the lever arm (h) and consequently increases the muscular force M (and therefore R). Coxa vara has opposite effects. Figure 11 and 12.

3. The femoral neck angle also alters the surface of the femoral head in contact with the acetabulum - important in weight transmission and intraarticular pressure.

   At both extremes of coxa vara and coxa valga, the surface area of the femoral head in contact with the articular area of the acetabulum is least. Hence the intraarticular pressure is maximum at these positions. In the neck, changes of the femoral neck angle have important implications (figure 12):

   1. Increased femoral neck angle (CCD) increases the femoral neck steepness and brings its core almost in line with the compressive force R so that the bending and shearing component are eliminated almost completely. This phenomena occurs in the valganization of the femur. In coxa valga the line of action of R and the core of the neck approach each other, the effect is elimination of tensile and shearing forces with reduced bending effect in preference to compression.
2. Reduced femoral neck angle greatly increases all stresses especially stressing in bending. The distance between core of the neck and the line of action of R is increased thereby increasing the compressive tensile, and shearing forces. There is increased tendency to bend the neck in coxa vara. Other mathematical observations from figure 11 and 12 are:

(i) In coxa vara, shearing force $S$ is increased but the upward component $L$ (the longitudinal component of reaction to $R$) is reduced.

(ii) In coxa valga, the shearing force is almost eliminated but $L$ is greatly increased.

In other words, in coxa vara there is increased tendency to bend the neck while reducing the tendency to abut the head to the acetabular roof. In coxa valga there is increased tendency for the head to abut on against the acetabular roof with elimination of shearing stress.

**The effects of stress on healing of fracture neck of femur**

The fracture of the neck of femur heals by intermediate callus. There is no periosteal callus that would eliminate mechanical stress. This type of healing allows the mechanical stresses to freely interplay and theoretically have the following resultant effects.
FIGURE 13  PAUWEL'S CLASSIFICATION OF FEMORAL NECK FRACTURES.
(i) Pure compression stress (of physiological magnitude) encourages bone healing.

(ii) Tensile stress retards bone formation (and encourages fibrous tissue formation).

(iii) Shearing stress prevents new bone formation due to intermittent stretching of primitive bone.

Application of Biomechanics of hip in fracture neck femur

The biomechanics of femoral neck fractures have the following practical application:

(a) Classification of fractures of neck of femur

In the classification of femoral neck fractures Pauwels\(^{39}\) has utilized the inclination of the fracture in relation to the line of action of the resultant force \(R\). He has classified the fractures into three types:

**Type I** \((< 30^\circ)\) Figure 13 a

The fracture line is almost perpendicular to the resultant compressive \(R\). These fractures are almost horizontal. There is no (or minimal) shearing force. These fractures heal even with the minimal of nailing procedure.

**Type 2** \((\geq 30^\circ \leq 50^\circ)\) Figure 13 b.

The inclination of the fracture from the horizontal is as high as \(50^\circ\) with the shearing force compromising healing. The shearing component must be eliminated by rigid fixation.
FIGURE 14: STRESSING AT UPPER END OF FEMUR
a) IN PHYSIOLOGICAL STATE.
b) IN ABDUCTION FRACTURE (IMPACTED FRACTURE).
Type 3 ($\geq 50^\circ$) Figure 13 (c)

These are fractures with inclination almost in the same line as resultant force R (almost vertical). Rigid fixation is not enough to eliminate shearing forces. It has to be augmented by osteotomy, to convert the fracture line to type I.

He further added a fourth group - abduction fractures. These are securely impacted and usually heal with conservative management. The abduction fracture is characterised by increased neck shaft angle that converts all forces acting at the neck to pure compression with no functional disturbance. However Bentley, Crawford, Garden, Nieminen have reported cases of disimpaction. Bed rest for 3 weeks is generally all that is required for union to occur.

This classification has been criticized for being less indicative of the prognosis of fractures at the neck of femur (Nieminen). This is more so in Type I fractures. Garden in 1961 proposed the classification based on displacement of the fragments. He however did not base this on the biomechanics of the hip. This classification of Garden, figure 15, although easy to use, its application to practical management of the fracture of the neck of femur has not proved superior to Pauwels and has not found wide application in this Country.
GARDEN'S CLASSIFICATION

TYPE I  Incomplete fracture (impacted valgus or abduction). Conservative management adequate.

TYPE II Complete fractures without displacement only traction essential.

TYPE III Complete fracture with partial displacement (intact posterior capsule of the joint). Early compression after correcting displacement while retaining the posterior retinacular attachment.

TYPE IV Complete fracture with full displacement. Rigid fixation with valgus osteotomy is absolutely necessary. There is an associated high failure rate of these unresolved fracture. Garden

FIGURE 15
Nieminens\textsuperscript{34} has reported another group to Pauwel's fracture classification. This is the most unstable group with a "tongue like basal spoon" on the lower femur (added by Leitz).

In the study a significant number of patients has not been classified according to radiological findings. In some cases the management has not been based on Pauwels or Garden's recommendation, an omission responsible for complications seen in some patients of type III fracture who received type II management.

In this study most patients operated fell into either type II or III category and only three were in type I. Crawford\textsuperscript{12} has demonstrated the validity of Pauwels recommendation on type I fractures.

b) In the management of the femoral neck fractures, healing is enhanced and complications reduced by rigid immobilisation and accurate reduction of the fragments (Garden\textsuperscript{17}, 1971). Malreduction was associated with avascular necrosis. Graham\textsuperscript{18} in 1968 demonstrated the importance of accurate reduction.

c) Discontinuity of the femoral neck allows free interplay of all forces acting on the upper extremity of the femur. To eliminate this interplay surgical devices have to be employed, the femur having no such natural device, (Garden\textsuperscript{16/17}, Pauwel\textsuperscript{39}, Nieminens\textsuperscript{34}).
d) Healing is not to be expected for fractures that are almost vertical (type III) unless converted to type I and fixed (Garden\textsuperscript{16/17}, Pauwel\textsuperscript{39}).

C) Intraarticular pressure in the hip joint

The hip joint is enclosed in a thick capsule that allows little if any distension. Anteriorly the capsule is attached along the intertrochanteric line while posteriorly it extends only halfway down the neck. This capsule is made up of dense fibrous tissue reinforced anteriorly by the sturdy, iliofemoral ligament and below by the pubofemoral ligament. Posteriorly it is reinforced by the ischiofemoral ligament. The zone orbicularis is a condensed group of deeply placed circular fibres which reinforce the action of the labrum. The femoral attachment of the capsule is reinforced by the fibrous extensions into the many vascular foramina at the base of the neck. Some of the innermost fibres are reflected in a medial direction as retinacula on the neck along which they pass to the subcapital articular sulcus. Covered by the synovial membrane, these retinacular fibres are concentrated superiorly, inferiorly and occasionally anteriorly and provide a relatively safe passage for blood vessels to the femoral head.

Just like the cranium, the dense capsule can only slightly distend. There is evidence (Muller\textsuperscript{32}) that
bleeding into the capsule results in increased intraarticular pressure. This pressure is probably responsible for avascular necrosis of the head following fracture neck of femur (Muller\textsuperscript{32}).

Early evacuation of the hemarthrosis following fracture of the neck of femur or aspiration has been demonstrated to reduce the incidence of avascular necrosis. At Kenyatta, however, there is no effort to document the intraarticular pressure nor as stated before, was it possible to operate within 24 hours of injury.

D) General factors affecting bone healing: Mechanical stress

Stress (tissue reaction to external force or load) is the major factor that influences the dynamic physiological equilibrium achieved in the living tissue. For bone, mechanical stress is the major physiological determinant of this dynamic equilibrium.

Mechanical stress has two possible effects on bone. The bone can either undergo passive deformity or the bone metrix can undergo differentiation. The latter is a normal reaction of living tissue.

As passive deformity is of no practical relevance in the fracture of neck of femur, it is the differentiation of the bone metrix that is crucial and of primary significance in the management and prognosis of fractures.
Mechanical stress affects the elements of bone in a specific way depending on whether this is mature bone or supporting elements. For mature bone, its reaction to stressing (within physiological limits) is proportional to the magnitude of the stress (Pauwels\textsuperscript{34}). The stress acts as the stimulus for oppositional bone growth and the extent of oppositional growth is proportional to the magnitude of the stress. Beyond physiological limits passive changes such as deformity, cyst formation or bone resorption occurs.

This interaction of stress/response is evidenced in the hip by the formation of the 'Sourcil' (acetabular roof) and the maintenance of its increased density by stimulating the laying down of bone in different states of loading (i.e. intra-articular pressure).

Supporting tissues on the other hand respond in accordance to the type of mechanical stress imposed. The only stressing that influences bone metrix is stretch and hydrostatic pressure. Stretching stimulates production of collagen fibrils, i.e., connective tissue formation. On the other hand hydrostatic pressure stimulates the production of cartilage tissue (Pauwels\textsuperscript{39}).

For new bone formation, there is no particular stimulus essential that induces the osteogenic cell to lay down bone - except the presence of an environment where the
cell is protected from intermittent stretching. In nature this is provided for by the scaffolding that proceeds bone union. The scaffolding may be of bony trabeculae or calcified cartilage. Pauwels has made the following observations on factors that influence bone healing:

(i) If a force of constant magnitude is applied, then stretching due to shearing is 30% greater than stretching due to tension. Hence oblique fractures form pseudoarthrosis much more often.

(ii) A combination of stretching and hydrostatic pressure yields 'hybrid' tissue, between hyaline cartilage and fibril formation (fibrotendinous tissue.

These factors affect and influence bone healing at any site. Absence of rigid fixation (stability) at any fracture site allows one or more of these forces to predominate and impede osteogenesis. The effect ranges from delayed union to pseudoarthrosis. Rigid fixation results in immediate new bone formation.

The above features have been demonstrated in pseudoarthroses: As a result non-union is described as either oligotrophic or hypertrophic (Muller).
Non-union of the femoral neck fracture is one of the commonest complications of fractures managed conservatively or through improper fixation (Pauwels\textsuperscript{39}). There is evidence, that the non-union is attended by actual fibrous union commonly digotrophic (Muller\textsuperscript{32}).

**AGE**

48 or two thirds of the patients were below the age of 60 years with a mean age of 45 years. There was no significant difference between the sexes. This is in contrast to most European studies that indicate a higher mean age between 60 and 70 years.

Niemin\textsuperscript{33} in Scandinavia reported a mean age of 70.7 years ($\pm$ 11.4 years). Burcharth\textsuperscript{8} reported a similar mean age of 75.7 years. Among English populations, Bentley\textsuperscript{4} reported a mean age of 72 years. In the series of Osborne\textsuperscript{35} two thirds (66.7\%) of patients were in the age group 45 to 65 years. From this study it would appear that femoral neck fractures are basically those of elderly patients.

The study revealed involvement of a young group of patients as compared to European series. This age difference may reflect differences between the age distribution patterns of Kenyan population and those of Scandinavian and other West European countries. The age distribution of Kenyans is pyramid shaped (figure 16)
AGE DISTRIBUTION

MALES

FEMALES

PERCENT OF TOTAL POPULATION

CENTRAL BUREAU OF STATISTICS

FIGURE 16.
according to the Central Bureau of Statistics\textsuperscript{10}, whereas that of Scandinavian and West European countries is dome shaped (United Nations\textsuperscript{46}).

The Kenyan population above 60 years of age is just 4.6\% (Central Bureau of Statistics\textsuperscript{11}) while in West European countries the proportion is between 12 and 15\% (United Nations\textsuperscript{46}). Equally significant is the aetiology associated with the femoral neck fracture. Fatigue is the major contribution factor in the West European series. In this study fatigue played only a minor role and traffic accidents was the major factor. As people in the young age group are more active, it is expected that they would be involved in accidents more often than the aged.

**SEX**

There was a marked preponderance for males. The ratio for male to female was 3:1. This also does not confirm studies elsewhere that have indicated a female preponderance. Bentley\textsuperscript{4} showed a ratio of female to male of 7.5:1. This was confirmed by Nieminen\textsuperscript{33}, Osborne\textsuperscript{35}. These differences can not be explained on the sex distribution patterns between Kenyans and populations of those countries. From the statistics the proportion of women above 60 years of age is almost equal to that of males both in Kenya and Western Europe. Of significance is the causation of the fracture. In Western Europe and the United States fatigue is a major factor while in Kenya traffic accidents are much more common (per capita) than West
European countries (Kenya Police). As elderly females will suffer more from osteoporosis than males (Freeman), the proportion above would be expected for European countries and not for Kenya.

AETIOLOGY

As stated above unlike European studies fatigue was not a major factor in the causation of femoral neck fractures in this study. Bentley, Nieminen and Hageberg have reported the significant role fatigue plays in the population they studied. Below the age of 60 years, fatigue would not be operational in the causation of femoral neck fractures.

There were only two (2.8%) cases of pathological fractures. Both were metastases from the breast and prostate respectively. Similar results have been reported by Mickelson. Of the 21 patients with pathological fractures all were secondaries to the neck distributed as follows:

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast</td>
<td>10</td>
</tr>
<tr>
<td>Prostate</td>
<td>4</td>
</tr>
<tr>
<td>Colon</td>
<td>1</td>
</tr>
<tr>
<td>Lung</td>
<td>1</td>
</tr>
</tbody>
</table>

With the rest from uterus, liver, carotid body tumour, a lymphoma (and one not identified).

In the literature there are reported cases of pathological fractures due to primary neoplasm of the neck of femur (both benign and malignant). Also reported are metabolic disturbances as osteoporosis, osteomalacia
and endocrine disorders involving parathyroids and adrenals. Irradiation of the pelvis has also been associated with femoral neck fractures.

**DURATION OF STAY IN THE HOSPITAL.**

There was a significant period of time spent in hospital by patients waiting for operation. Referred patients spent up to twenty weeks before operation and only two weeks after operation. It is estimated that to keep a patient in hospital (Kenyatta) it costs K shs. 154 per day (Oduori\(^36\)). For patients who stayed in hospital for 19 weeks this amounts to K shs. 20,000 per patient. Recent evidence indicates that early operation (within 24 hours) and early mobilisation not only facilitates healing but reduces complications (Abraham\(^1\)). This however has been disputed by Graham\(^{18}\).

It is estimated that the dependence ratio (i.e. proportion of people above 60 years of age and those below 15 years of age) is 0.53 (Central Bureau of Statistics\(^{11}\)). 53% of the population depend on 47% (age group 15 – 59). It would therefore appear uneconomical to use methods of therapy that keep people in this age group out of their contributory economic activity.
Several methods have been used with inconsistent results to treat the fracture of neck of femur. However, with understanding of the basic biomechanics of the hip and its basic anatomy better, more scientific methods have been devised in recent years. Pauwels was probably the first to recognise this and pave way for modification of his principles. The methods of management have evolved through conservative, palliative procedures such as excision arthroplasty to the present generation of therapy.

The present modalities of therapy show a wide range of variability of results unless similar basic criteria are applied. The criteria available include the utilisation of the fracture line (Pauwels\textsuperscript{39}) or displacement (Garden\textsuperscript{16}). Application of any of these methods gives fairly uniform results within the diagnostic accuracy of the classification (Niemin\textsuperscript{34}). Four methods were used at the Orthopaedic unit of Kenyatta National Hospital. These include traditional methods of reducing the fracture on an orthopaedic table, temporary fixation with guide wires under x-ray control and fixation with a nail and plate, open reduction and fixation according to AO group, primary prosthetic replacement and excision arthroplasty. There were no cases of primary arthrodesis and a primary mode of management (figures 17, 18, 19, 20).
A 49 year old sustained femoral neck fracture following road traffic accident on 8.6.79

29.6.79
Pauwel I undisplaced.
Guide wires in position.

3.8.79
Pin and plate applied without loss of position. Patient on full weight bearing at the end of the year.

FIGURE 17 FIXATION BY TRADITIONAL METHODS
27 years old male. He fell on 10.9.80 and sustained Pauwel I fracture.

10.10.80
Pauwel I fracture.
No displacement

2.4.81
Radiological evidence of union with no pain on full weight bearing

15.1.81
Fixed by AO technique with compression/Impaction

21.1.82
Lateral view anatomical integrity of neck reconstituted and that of hip joint.
A.A., a 16 years old girl with poliomyelitis who fell and sustained femoral neck fracture in September 1978.

4.9.78
incomplete fracture of femoral neck

22.9.79
Harris Miller plate applied improperly with intetrochentric osteotomy

4.8.80
complete union in varus revealed

FIGURE 20 HARRIS MILLER FIXATION WITH OSTEOTOMY
In his article, Laros makes the following observations regarding modern management:

1. The greatest improvement in the treatment of hip fractures was the change from recumbency to mobilisation care.

2. The major residual problems are:
   
i. Medical complications: (age, general medical condition of the patient suffering from hip fracture that predispose them to complications of recumbency such as thrombo-embolic disease, urinary tract infections, pneumonia, senile psychosis and decubitus ulcers).

   ii. Technical complications: The forces acting at the region of the hip tend to produce varus at the fracture site. These forces lead to complications of fixation that may limit the stability of the hip, interfere with bone healing or produce functional problems in ambulation and thus defeat or compromise our efforts for mobilisation care.

   iii. Poor local blood supply may lead to avascular necrosis of the femoral head and (or) non-union of the fracture.

3. In most cases treatment of hip fractures in the elderly by surgery is the conservative course in that it carries less risk than prolonged bed rest.
These views by Laros\textsuperscript{25} adequately summarise current thinking on the management of these fractures. In this country, however, there is still no coherent policy on the principles of managing these fractures. The result is the picture described and the outcome shown.

Pankovich\textsuperscript{37} advocates internal fixation for all stress fractures. He also argues for internal fixation of impacted fractures although there is room according to individual patient circumstances for conservative management. Those patients (alcoholics and feeble individuals) where disimpaction is anticipated, internal fixation is the treatment of choice even if the criteria for conservative management (roentgenographic evidence of valgus position of the head, the neck fragment under the head and apposition of the fragments) are met. All displaced fractures should be treated by either internal fixation or prosthetic replacement. The choice of either being made on age of patient. Pankovich\textsuperscript{37} advocates prosthetic replacement for those over 70 years to ensure definitive procedures at the extreme ages and avoid further intervention in case of necrosis or non-union. All the other cases being internally fixed.

By the above criteria only 11.2\% of patients in this study would qualify for prosthetic replacement (above 70 years) as opposed to 26.8\% that had primary replacement
arthroplasty. This high proportion may partly reflect a non scientific approach to the problem or the effect of delayed management. Probably in favour of replacement arthroplasty for this high proportion of patients is the low life expectancy of Kenyans given as 46.9 years for males and 51.2 years for females (Central Bureau of Statistics). This definitely falls within the expected life of the prosthesis but can not justify early replacement arthroplasty.

Many writers including Pankovich advocate operation on a semi emergency basis as this is the time the patient is most fit and least likely to develop complications. There is a growing consensus of opinion and conviction that where medically feasible patient should be operated within 12 - 24 hours of injury.

In the orthopaedic unit two major types of internal fixation are currently in use. Of these, the fixation according to AO group meets the cardinal requirements i.e. firm immobilisation of displaced fractures. The Smith Paterson nail should be reserved for the fixation of undisplaced fractures and other devices employed if rigid immobilization is to be achieved. As the only other devices (other than the AO compression) available in the market include a sliding Triflange nail plate, multiple plates-pins system and sliding screw compression plate, the Smith-Paterson nail is not a satisfactory substitute but one that is likely to produce inferior results. Frandsen has demonstrated this point. In his study, Frandsen
that contact compression (and impaction) by AO technique produced superior results ($P < 0.05$) to any others.

Garden\textsuperscript{17} and Graham\textsuperscript{18} have demonstrated the significance of accurate (adequate) reduction and firm fixation. The reconstitution of the functional integrity of the hip joint is of paramount importance. By so doing healing is facilitated especially with slight valganization. In 1971 Garden demonstrated that accurate reduction and not extreme valgus that tends to compromise the congruity of articulation and which may lead to arthritis is more important and necessary. He argues for reduction of the extreme valgus in some abduction (impacted) fractures - in order to maintain acceptable congruity between femoral head and the acetabulum. However, as the risk of converting this into a complete fracture is high, he suggests that other than unleash a cascade of unwanted complications the valgus position is to be left alone.

Many other devices are currently being developed to meet optimum requirement of the biomechanics at the hip (Frandsen\textsuperscript{14} Garden\textsuperscript{17} and Laros\textsuperscript{25}). Refinements of these devices and surgical techniques has continued because problems and complications associated with treatment still remain (Laros\textsuperscript{25}).

Much as the methods of internal fixation vary so varies the duration of weight bearing. In the present study no useful data was available on the weight bearing period.
In the subject studied in the companion Table 9, without a stick, the force designated R is 385 pounds. A cane used in the left hand supports the body weight, K, without requiring as much pull of the abductor muscles. The cane works through a long lever so that a moderate push on the stick greatly relieves the pressure on the hip. Here and in Table I, the various lines labelled 1, 2, and 3 refer to relationships in this average case with varying forces on the cane, while the levers remain constant in length.
However current views are of the opinion that early weight bearing is to be preferred (Frandsen\textsuperscript{14}, Bentley\textsuperscript{4}, Garden\textsuperscript{16}, Rennie\textsuperscript{42}, Nieminen\textsuperscript{33} and Graham\textsuperscript{18}). Blount\textsuperscript{6} while recommending early weight bearing, argues for the use of the cane. This he recommends to be used indefinitely for the age over 60 years following fracture neck "to protect the injured part from further insult". Table 10 and figure 21 demonstrate the contribution of the cane in reducing weight borne on the injured hip.

**TABLE 9**

**DISTRIBUTION OF WEIGHT BETWEEN FEMORAL HEAD AND THE CANE**

<table>
<thead>
<tr>
<th></th>
<th>POUNDS OF PRESSURE ON THE CANE</th>
<th>POUNDS OF PRESSURE ON FEMORAL HEAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>0</td>
<td>385</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>220</td>
</tr>
<tr>
<td>2</td>
<td>33</td>
<td>113</td>
</tr>
<tr>
<td>3</td>
<td>38</td>
<td>66</td>
</tr>
</tbody>
</table>
Blount further notes that "the position of valgus that ensures rapid healing also reduces the lateral lever in the system and greatly increases the pressure that is brought to bear on the hip as soon as the cane or crutches are discarded". He points out the possibility of reducing the number of cases which go on to develop arthritis and avascular necrosis because they discard the cane too early.

Using efficient techniques with proper application should theoretically reduce complications of fixation to as near zero as possible. However, Pankovich notes that "if all technical problems were to be eliminated, still there remains a fraction of patients who would develop avascular necrosis, due to blood supply. There is still need to identify viable from non-viable femoral head within 24 hours of admission and thus establish objective indications for internal fixation and prosthetic replacement". In other words the objective criteria for prosthetic replacement would be viability of the affected femoral head. Equally affected would be those patients that presented late to hospital after femoral neck fracture. A further group of patients for replacement arthroplasty (internal fixation would be contraindicated) would also include patients with seizures and where previous fixation has failed (Carnisale). Carnisale however notes a 30% rate of complications with 5% mortality in replacement arthroplasty. Sadr findings for replacement arthroplasty, a further factor to be borne in mind.
Excision arthroplasty has only a limited application in any country. In the study only two patients had this type of management. However, "patients tolerate this salvage procedure better than a painful hip (Albright\(^2\), Parr\(^38\)). No patient required primary arthrodesis a salvage procedure better tolerated in childhood (Albright\(^2\)). These findings are in agreement with femoral neck fracture management elsewhere. There were no efforts to document the viability of the femoral head or attempts to improve vascularity. Using \(^{85}\text{Sr}\), scintimetry Asnis\(^3\) demonstrated that useful information regarding the viability of the femoral head could be gained. This however, has not received widespread or uniform application elsewhere. Meyers\(^{30}\) and Albright\(^2\) have attempted to improve the vascularity of the femoral head following fracture of the neck. Albright used tibial bone graft while Meyers used a muscle, bone pedicle graft. In either case good results were achieved for a limited number of patients.

In line with Pauwels\(^{39}\) proposition, valgus osteotomy was performed for patients who had type III fracture. This was done almost exclusively by the group advocating AO technique of fixation. No osteotomy according to McMurray\(^{29}\) was performed.
FIGURE 22  CLASSIFICATION OF FEMORAL NECK FRACTURES IN CHILDHOOD (AFTER RATLIFF $^{41}$)
MANAGEMENT OF FEMORAL NECK FRACTURES IN CHILDHOOD

Fracture neck of femur is rare in childhood. Only five patients under the age of 15 years were seen in the orthopaedic unit of Kenyatta in the period 1976 to 1980. As the classification management and prognosis in childhood is different from adults, a separate discussion of the problem in childhood is essential.

The most satisfactory classification of childhood femoral fractures is that suggested by Ratliff shown in figure 22. This classification recognises four types of fractures. Transepiphyseal, transcervical, basal and pertrochanteric. Ratliff found the following distribution of patients.

- **Type a**: Transepiphyseal 2
- **Type b**: Transcervical 38
- **Type c**: Basal 26
- **Type d**: Pertrochanteric 4

Type a had severe upper epiphyseal displacement with its premature fusion. Type b was associated with 50% avascular necrosis rate. Type c had 25% incidence of necrosis. Unlike adults type d was also associated with avascular necrosis. This corresponded to the development of blood supply shown in figures 3/30.

There was no attempt to classify the fractures of the five patients seen at Kenyatta. They were however
managed as follows:

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pins</td>
<td>4</td>
</tr>
<tr>
<td>Osteotomy</td>
<td>1</td>
</tr>
</tbody>
</table>

These patients were aged 4 years, 10, 12, 13 and 15 years.

Ratliff\textsuperscript{41} and Lam\textsuperscript{27} have recommended the following management for childhood fractures.

1. **Undisplaced fractures**:
   - Single hip spica for 6 - 12 weeks.
   - Check x-ray in 1 - 2 weeks to rule out displacement.

2. **Displaced fractures**
   - Closed manipulation and reduction.
   - Internal fixation using multiple Moores pins.

Ratliff\textsuperscript{41} has recommended primary displacement osteotomy for displaced fractures occurring in patients under the age of 10 years. For patients above the age of 10 years, he recommends closed reduction, under anaesthesia and internal fixation if reduction was achieved. If reduction is not achieved then primary osteotomy should be done. McDougall\textsuperscript{28} has recommended non-weight bearing for at least twelve (12) months following injury to avoid deformity at the fracture site. He advocates the use of Moores pins or Knowles pins and not the pin with plate.
There were relatively very few complications associated with operative surgery of femoral neck fractures. These included infection, avascular necrosis, intra-operative problems and sciatic neuropraxia.

There were six cases (8.5%) who developed wound sepsis. Boyd has reported a low incidence of 4.5% where post operative prophylactic antibiotics were not used, and 0.8% where prophylactic antibiotics were used. It is difficult to draw a conclusion from this small study as to the usefulness of prophylactic antibiotics. However noted is the fact that 5 of the six patients who developed infection were on post-operative prophylactic antibiotics. This may reflect earlier apprehension regarding the risk to infection. Similar conflicting results have been reported by Laros.

Five patients (7%) developed avascular necrosis of the femoral head. Garden has reported a lower incidence of 4%. Higher rates have been reported by other writers. Frandsen and Bentley separately reported incidences of 21%. The incidence of avascular necrosis varies greatly and increases with a longer duration of follow up (Garden). Avascular necrosis is difficult to diagnose early in radiographs but careful assessment should raise doubts of the viability of the femoral head.
H.K. 46 years old male. He sustained femoral neck and shaft fractures on 29.11.79. Neck fracture initially missed and only K nail applied. Subsequent management and progress is shown below.

2.3.76 Knail and two lag screws in position

18.8.76 Non union of femoral neck fracture.

21.12.76 AO fixation of Pauwel III fracture with 70° wedge osteotomy and conversion to Pauwel I


FIGURE 23: AO FIXATION
K G 70 year male fell and sustained Pauwel II fracture 22.6.77

9.11.77
Pin and plate in situ since 6.7.77. No compression of fracture.

5.4.78
Pin in hip joint causing severe pain with clinical union medially. On full weight bearing.

23.5.79
Pin and plate removed on full weight bearing. No pain.
M.A. 27 years old Somali developed femoral neck fracture following traffic accident 1.1.79.

3.1.79  
Pauwel Type III fracture and femoral shaft (not shown)

29.1.79  
A.O. fixation done and 40° wedge osteotomy

30.8.79  
Excessive callus medially with radiological and clinical union.

FIGURE 25 AO FIXATION WITH EXCESS CALLUS.
E.K.: is 63 years old male who sustained femoral neck fracture in December 1974

10.1.75 Pawel II fracture

21.1.75 Early avascular Necrosis and no evidence of union

8.3.78 K. nail applied

4.7.79 Union and K nail removal and conversion

8.3.78 Excision arthroplasty

FIGURE 26: A VASCULAR NECROSIS FOLLOWING TRADITIONAL FIXATION.
I W. 60 years old male who sustained injury on 14.5.79. He was operated on 24.10.79.

7.8.79
Pauwel type III fracture.
No evidence of union

8.5.80
A O plate applied protruding into joint and required to be changed

21.12.80
Pin partially in Joint:
Increased density of femoral head

12.3.81
Disintegrated femoral head
requiring arthrodesis

5.11.81
Arthrodesis results satisfactory.

FIGURE 27 AVASCULAR NECROSIS FOLLOWING A.O. FIXATION
M.V. 35 years old female who fell off a bicycle on 24.3.76

16.9.76
Pauwel femoral neck fracture fixed with two screws

5.10.77
Femoral head collapsed and replaced by Austin Moore prosthesis

6.6.79
Austin Moore prosthesis eroded upper femoral shaft and completely extruded medially. Total Hip replacement done

FIGURE 28: AVASCULAR NECROSIS FOLLOWING IMPROPER FIXATION.
J.B., 45 years old male sustained femoral neck fracture in April 1976. Pin and plate was improperly inserted on 18.6.76 (No entry into femoral head).

18.6.76
Guide wires in situ.
The longer wire apparently not gone into the femoral head.

19.6.76
False impression of satisfactory fixation as demonstrated later by head collapse on weight bearing.

26.6.76
Pin in Hip joint apparently having not been inserted into the femoral head.

5.1.77
Pin and Plate removal due to excessive Hip pain. Later excision arthroplasty done.
The earliest indicator of necrosis is the change in
density of the head. Most writers have reported increased
density but some have doubted this and have attributed
this to shadows from the acetabulum (Garden\textsuperscript{16}). Later
indicators include loss of position, non-union and collapse
of the femoral head seen in radiographs. Like similar
studies elsewhere necrosis was commoner in those patients
where adequate reduction and rigid fixation had not been
achieved at operation. The role played by vasculature can
not be over-emphasised. Nieminen\textsuperscript{34} and Crawford\textsuperscript{12}
have documented that vascular damage occurs at the time
of injury and not during operation. They have also demonstrated
that early weight bearing does not increase the incidence
of necrosis. Noteworthy is the low incidence of avascular
necrosis (7\%) in the six year period. Probably a longer
period of follow up may indicate more cases than those
currently seen.

Intra-operative complications included three cases
of improper fixation. These included one case where the
nail was outside the femoral head, a case of fracture upper
femoral shaft and some cases of too long nails that required
change. The incidences of these complications are however
rare and of little practical application. Neuropraxia
of the sciatic nerve occurred in one patient. The patient
had no associated dislocation of the hip, or evidence of
sciatic nerve injury before surgery. Meyers\textsuperscript{30} has reported one case of sciatic neuropraxia in a series of 150 patients. This was not related to the approach used during surgery.

Thromboembolic disease is a fairly common occurrence in European series. Bergquist\textsuperscript{5} and Burcharth\textsuperscript{8} have reported an incidence ranging between 36\% and 52\%. They further reported remarkable reduction of this incidence using prophylactic anticoagulants. Only one patient developed respiratory symptoms and congestive failure attributed to pulmonary embolism. No patients were put on anticoagulants. Burcharth\textsuperscript{8} reported very low incidence of pulmonary embolism despite the high incidence of deep vein thrombosis demonstrated at phlebography. Laros\textsuperscript{25} reported 80\% thrombosis at phlebography not clinically diagnosed.

No mortality following surgery was noted at Kenyatta. In his series Bentley\textsuperscript{4} had no mortality in his series. 7 patients died in a study of 150 patients conducted by Meyers\textsuperscript{30}. Frandsen\textsuperscript{14} reported 1 case in 65 patients. From these and similar studies it would appear that operative mortality is rare even in the very old.

Laros\textsuperscript{25}, Meyers\textsuperscript{30}, Frandsen\textsuperscript{14} and Bentley\textsuperscript{4} have reported other rarer complications not seen at Kenyatta. These included decubitus ulcers, cardiac-disease, pulmonary disease, capsular calcification, Pudental neurapraxia, varus union, and pin irritation. Subtrochanteric fracture has been reported.
TYPES OF AVASCULAR NECROSIS

TYPE I: Lateral epiphysis, damaged before branching.

TYPE 2: Damage as vessels enter bone.

TYPE 3: Damage at fracture site with sparing 2 epiphysis.

FIGURE 30  TYPES OF AVASCULAR NECROSIS (AFTER RATLIFF)
Complications of femoral neck fractures in childhood are more commoner than adults. This is due to the pattern of blood supply during growth. Trueta\textsuperscript{45} pointed out the vulnerability at the age 4 - 8 years of the epiphysis and diaphysis. In this age group the blood supply to the capital epiphysis is from the lateral epiphyseal group only with little if any contribution from the ligamentum teres and medial epiphyseal vessels.

The rate of avascular necrosis is estimated to be around 42\% (Ratliff\textsuperscript{41}). This occurred regardless of the site of the fracture. (McDougall\textsuperscript{28}, Ratliff\textsuperscript{41}). However, it was rare in undisplaced fractures. Ratliff\textsuperscript{41} has reported three types of avascular necrosis (figure 30).

**TYPE I:** The whole of the femoral head, neck to the fracture site is involved. There is damage to the lateral epiphyseal vessels.

**TYPE II:** Supero lateral epiphysis and metaphysis is affected. The lateral epiphyseal are damaged after entry into the bone.

**TYPE III:** The area between the diaphysis and the fracture site is affected. The epiphysis is spared. This occurs in children under 11 years. The damaged vessels are those at the fracture site only. The lateral epiphyseal vessels are spared.
Delayed union occurred in 17 out of 70 patients seen by Ratliff (no radiological union after 5 months). There was premature fusion of upper femoral epiphysis in 10% of his patients. Lam had 17% patients who had premature fusion, with subsequent shortening and coxa vara. These were part of 32% who had coxa vara deformity following fracture at the femoral neck. McDougall reported similar figures for premature fusion. At Kenyatta however, the series were too small to draw conclusion from. However only one patient was painfree one year after operation.

FOLLOW UP AND RECORDS

In the study there was no uniform system of record keeping very often useful information such as indication or radiological findings were not recorded. Nor were objective follow up results recorded at all times. Larson has suggested a clinical rating scale for hip disabilities widely applied in United States for femoral neck fracture followup. This rating if used could form a basis for objective comparison and follow up of patients before and after surgery. This scale based on function, freedom from pain, gait, absence of deformity and range of motion is reproduced.
CONCLUSIONS

1. An average of 40 patients are admitted to Kenyatta National Hospital every year. A majority of these (62.5%) are referred cases from peripheral hospitals.

2. These patients spend a long time at the peripheral hospitals waiting for specialised care at Kenyatta Hospital. The cost in some cases is up to twenty

3. More males than females (3:1) had femoral neck fracture.

4. The major cause of the fracture was motor accidents.

5. The mean age of the patients was 45 years.

6. Radiological examination was often not objectively recorded and correlated to management in a majority of these patients.

7. Being referred patients (and having delayed in definitive management) up to 20% of them had replacement arthroplasty.

8. The AO technique got better results than the traditional methods of fixation.

9. There was no standardised method on the management of the patients nor were there clear cut guidelines on this and those of patient follow up.

10. The system of record keeping was inadequate as many files, x-rays and other patient data was either missing or difficult to trace.
11. The incidence of complications was relatively low with no mortality recorded nor any cardio-pulmonary complications.

12. The onset of weight bearing varied between a few months and one year. No case was found to have suffered ill effects attributable to early weight bearing.
RECOMMENDATIONS

1. All femoral neck fractures should be considered as dire emergencies and rated as a peritonitis for a general surgeon.

2. Facilities should be provided at provincial level with to deal/them as surgical emergencies and also if necessary for referring them to Kenyatta National Hospital to be dealt with as dire emergencies. Late handling of these cases increase the morbidity and mortality rates due to various complications inherent in these fractures.

3. A standard protocol should be established particularly at a teaching or referral hospital like Kenyatta National Hospital to promote the future plans for the whole Country. After looking at the various series and through available literature, I suggest the following plan:-

(a) In fresh cases, replacement arthroplasty for all subcapital fractures above the age of fifty years irrespective of Pauwel's classification. In old and neglected cases, two to four weeks of skeletal traction to bring the displaced shaft down should be given before replacement arthroplasty is attempted.
(b) Between the ages of 20 to 50 years in Pauwel's type I open reduction and rigid internal fixation with fixed 130° angled plate and two lag screws keeping the head in slight valgus position to achieve compression during weight bearing, should be done.

(c) Below the age of 20 years if minimum displacement has occurred traction in abduction and immobilisation for a period of twelve weeks is likely to be satisfactory. If grossly displaced, open reduction and fixation with either children's epiphyseal plates or Knowle's pins should be done.

(d) In Pauwel's type II and III whether mid cervical or basal, in all adults an abduction osteotomy to convert the fracture to Pauwel's type I and rigid fixation after open reduction with 120° angled plate and two lag screws is to be preferred.

(e) Early mobilisation after four to five days post-operatively is necessary to prevent all general complications but early weight bearing is not encouraged because of social, transportation and homely environments present.

(f) In late cases in types II and III where non-union osteoporosis, osteoarthritis etc. are very much likely to develop in aged people, it is always safer to go for replacement arthroplasty than to take chances with osteotomy and fixations.
4. Prophylactic use of antibiotics is not usually to be encouraged unless there are some definite indications for the same.

5. In aged people, heparinisation, intra and post operatively is preferred to avoid the complications of deep venous thrombosis, pulmonary embolisation etc. so common to these fractures.

6. All pathological fractures due to metastases should preferably be treated by replacement, if possible, since the life span being short a comfortably moving limb should be the ideal goal.

7. In all fractures of femoral neck complicated by fractures of femoral shaft on the same side open reduction and rigid fixation of both fractures should be the only treatment to avoid all complications.
REFERENCES


APPENDIX I

OPERATIVE MANAGEMENT
OF
FEMORAL NECK FRACTURE
AT THE
ORTHOPAEDIC UNIT OF
KENYATTA NATIONAL HOSPITAL
JANUARY 1976 - DECEMBER 1980

DATA FORM

PERSONAL HISTORY

NAME: .............................................

ADDRESS: ...........................................

......................................................

AGE: .............................................. SEX

IN PATIENT NUMBER ............... TRIBE: ...............

DATE OF INJURY ...........................................

DATE OF ADMISSION \{I_1\} \_WEEKS

DATE OF OPERATION \{I_2\} \_WEEKS

DATE OF DISCHARGE \{I_3\} \_WEEKS

NATURE OF ADMISSION TO KENYATTA:-
direct ☐ referred ☐

REFERRING HOSPITAL: ...................

DATE OF REFER: ...................

TIME INTERVAL BEFORE TRANSFER \{I_4\} \_WEEKS.
## Aetiology

<table>
<thead>
<tr>
<th>Motor Accident</th>
<th>Fall</th>
<th>Animal Assault</th>
<th>Pathological</th>
</tr>
</thead>
</table>

### Radiological Finding

- Impacted Fracture
- PAUWEL I
- PAUWEL II
- PAUWEL III
- Associated Dislocation of Ipsilateral Hip
- Associated Ipsilateral Femoral Shaft Fracture

## Treatment

- Non Operative
- Traditional Fixations
- AO Fixation
- Replacement Arthroplasty
- Excision Arthroplasty
- Prophylactic Antibiotic Use: Yes

## Indication(s)

- Age
- Non-Union
- Malunion
- Avascular Necrosis
- Other

Specify: ........................................

## Complications

- Intraoperative
- Infection
- Malunion
- Avascular Necrosis
- Loose Prosthesis
- D.V.T.

Specify: ........................................
### Follow Up

<table>
<thead>
<tr>
<th>Pain in the Hip</th>
<th>Period of Non-Weight Bearing</th>
<th>Weight Bearing Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-6 Months</td>
<td>&gt;6 Months</td>
</tr>
<tr>
<td></td>
<td>&lt;12 Months</td>
<td>≥12 Months</td>
</tr>
</tbody>
</table>

| Limp            |                             |                       |

| Limited Movement|                             |                       |

| Patient Back to Normal Life |                             |                       |

| Radiological Non-Union |                             |                       |

| Avascular Necrosis     |                             |                       |

| Further Intervention Specify |                             |                       |

### Assessment of Outcome

- **Excellent**
- **Good**
- **Poor**
APPENDIX II
ONE HUNDRED POINT SCALE FOR HIP EVALUATION

A. FUNCTION (35 POINTS)

Does most of housework or job that requires moving about 5
Dresses unaided (includes tying shoes and putting on socks) 5
Walks enough to be independent 5
Sits without difficulty at table or toilet 4
Picks up objects from floor by squating 3
Bathes without help 3
Negotiates stairs foot over foot 3
Negotiates stairs in any manner 2
Carries objects comparable to suitcase 2
Gets into car or public conveyance unaided and rides comfortably 2
Drives 1

B. FREEDOM FROM PAIN (35 points)

No pain 35
Pain only with fatigue 30
Pain only with weight bearing 20
Pain at rest but not with weight bearing 15
Pain sitting or in bed 10
Continuous pain 0

C. GAIT (10 POINTS)

No limp; no support 10
No limp using cane 8
Abductor limp 8

.../cont.
Appendix II (cont.)

Short leg limp 8
Needs two canes 6
Needs two crutches 4
Cannot walk 0

D. ABSENCE OF DEFORMITY (10 POINTS)
No fixed flexion over $30^\circ$ 3
No fixed adduction over ten degrees 3
No fixed rotation over ten degrees 2
Not over 2.5 cm. shortening 2

E. RANGE OF MOTION (10 POINTS)
Flexion-extension (normal $140^\circ$)
Abduction-adduction (normal $80^\circ$)
External-internal rotation (normal $80^\circ$)
Total degrees
Points (1 point/$30^\circ$)

MUSCLE STRENGTH (NO POINTS)
Straight leg raising less than gravity Gravity
Abduction: less than gravity Gravity
Extension: less than gravity Gravity