PROSPECTIVE COMPARISON OF OPEN INTRAMEDULLARY NAILING AND PLATE FIXATION OF FEMORAL DIAPHYSEAL FRACTURES AT KENYATTA NATIONAL HOSPITAL.

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A DISSERTATION SUBMITTED IN PART FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF MEDICINE [SURGERY] UNIVERSITY OF NAIROBI.
2008
2. DECLARATION

I hereby certify that this dissertation is my own original work and has not been submitted in any other university.

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3. DEDICATIONS

This dissertation is dedicated to all those patients with fractures of the femoral diaphysis who had to undergo surgery in order to be back on their feet again. Observing them walk again filled our hearts with joy.
4. ACKNOWLEDGEMENTS

I would like to sincerely thank the following people without whose assistance the preparation of this dissertation would not have been possible.

First and foremost my heartfelt thanks to my supervisor Prof. John Ating’a for introducing me to the subject and patiently guiding me through all the stages during the preparation of this dissertation. Many thanks to all those who reviewed and made necessary recommendations on the study proposal at the Kenyatta National Hospital ethics and research committee.

I would also like to thank all the surgeons, theatre nurses and all the other staff at Kenyatta National Hospital who participated in the management of the patients who were involved in this study.

It is with pleasure that I acknowledge Mr. James Kiragu of the records department for his contribution in retrieving the patients' medical records during the study period. I am deeply indebted to all the patients who voluntarily agreed to participate in the study without whom this study would have been valueless.

I am very grateful to Mr. Alex Mwaniki for his expertise in the statistical analysis of the study results and Ms Mercy Munguti for her secretarial work.

Last but not least, I would like to thank my family for being so patient during the many days that I spent carrying out this study.
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6. ABSTRACT

This was a prospective comparative study of the outcomes between patients with femoral diaphyseal fractures treated with open intramedullary nailing and those treated with open reduction with plate fixation. It was carried out at Kenyatta National Hospital over a period of six months between April 19, 2007 and October 19, 2007.

Methods.

A consecutive series of thirty-six patients with femoral diaphyseal fractures underwent open intramedullary nailing and another consecutive series of thirty-six patients underwent open reduction with plate fixation of similar fractures. These patients were followed up for twelve weeks post-operatively.

Main outcome measurements included demographic factors such as age, sex, socioeconomic status, body mass index, delay before fracture fixation, associated injuries, implant characteristics, open grade, secondary procedures, operative time, incision length, union rates and complications.

Statistical analysis was done using the statistical package for social sciences (spss). Chi-square and student t-test were used to determine association between categorical variables. Differences were considered significant at p-value < 0.05.

Results.

The mean operative time was significantly shorter in those who underwent open intramedullary nailing than in those who underwent open reduction with plate fixation.(105+-58.89 min vs 248+-38.57min)( p-value<0.001.)

The mean length of incision was significantly shorter in those who underwent open intramedullary nailing compared with that in those who underwent plating(18.19cm+-2.80cm vs 28.67cm+-4.22cm) (p-value<0.001)

General anaesthesia requirements were in 100% of those who underwent open reduction with plate fixation whereas in open intramedullary nailing this was required in 86.1% of the patients.13.9% of open intramedullary nailings were done under regional anaesthesia. This difference was statistically significant (p-value= 0.020.)

Those patients who underwent plating were 1.86 times more likely to be transfused than those who underwent open intramedullary nailing.

The clinical fracture union rates at six weeks post-operatively were 66.9% and 69.4% in those who underwent open reduction with plating and open intramedullary nailing respectively. At twelve completed weeks, the clinical fracture union rates were 81% in open reduction with plating compared with 86.1% obtained in open intramedullary nailing.
The radiological union rates at twelve completed weeks were 86.1% in open intramedullary nailing and 83.3% in open reduction with plating.

The overall intra-operative complication rates were 27.8% in open reduction with plating and 16.7% in open intramedullary nailing. However this difference was not statistically significant (p-value=0.257). The overall post-operative complication rates were 36.6% in open intramedullary nailing and 30.6% in open reduction with plating. This difference was not statistically significant (p-value=0.617)

The average overall costs incurred by each patient were Ksh 46,058.00 when open reduction and interlocking nail was used and Ksh 31,613.90 with simple Kuntscher nailing compared with Ksh 48,017.00 incurred with open reduction and plate fixation.

Conclusions.

Both open reduction with plate fixation and open intramedullary nailing of femoral diaphyseal fractures offer high union rates. However, open intramedullary nailing has the advantages of shorter operative times, smaller and therefore cosmetically better incisions and less blood transfusion requirements compared with open reduction with plate fixation. Moreover, Open Kuntscher nailing is relatively cheaper compared with plate fixation.

In addition to these, use of regional anaesthesia is a valid option in open intramedullary nailing. Open intramedullary nailing has a poor rotational control as compared with open reduction and plate fixation when a simple kuntscher nail is used.
7.1 BACKGROUND INFORMATION

Femoral diaphyseal fractures are frequent in both the adult and paediatric populations. The treatment options of these fractures are based on the patient’s age, fracture patterns, type of trauma, associated injuries and economic status especially in the third world.\(^1\)

The traditional methods of femoral shaft fracture management have been immobilization with external splints, skeletal traction, skin traction, and cast bracing. Operative treatment of femoral fractures provides early patient mobilization and is now the gold standard in their management.\(^1\)

Intramedullary nailing of femoral diaphyseal fractures was first successfully carried out and popularized by Gerhard Kuntscher. In 1940, he presented a paper entitled ‘medullary nailing of fractures to the Germany Surgical society in which he described the successful use of a flexible, compressible, non ionisable stainless steel utilizing the principle of nailing used earlier for fixation of femoral neck fractures. Intramedullary nailing then gained popularity.\(^1\)

Introduction of locking techniques has now allowed even highly comminuted fractures to be stabilized. Nail designs have evolved to allow fixation of more proximal and distal fractures.\(^2\)

The practice of femoral diaphyseal intramedullary nailing involves both open and closed techniques. In open intramedullary nailing, the fracture site is opened directly through the surrounding muscles to achieve reduction and insertion of the nail into the medullary cavity. In closed techniques, the fracture site is not exposed but rather approached in either an antegrade or retrograde manner depending on the starting point for nail insertion.

In antegrade intramedullary nailing, the femoral diaphyseal fracture is approached via the piriform fossa, the femoral canal is then reamed or with it unreamed, the nail is introduced from proximal femur to the distal femur. Adverse outcomes associated with this technique include trendelenberg gait, difficult starting point and post-union implant related pain.\(^3,4\)

In retrograde intramedullary nailing, the optimal portal of entry is located in a safe position anterior to the posterior cruciate ligament insertion and medial to the intercondylar groove. It is indicated in obesity, pregnancy, multiple other fractures or ipsilateral tibial shaft fractures.\(^5\)

The concepts of plate fixation of diaphyseal fractures evolved in the 1960s and 1970s. Open reduction with plating stressing biomechanical principles became the hallmark of diaphyseal fracture fixation. Use of longer plates, fewer lag screws outside the plate and fewer unicortical screws outside the plate periphery led to improvement in femoral

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\(^{1}\) Reference cited in the text.

\(^{2}\) Reference cited in the text.

\(^{3}\) Reference cited in the text.

\(^{4}\) Reference cited in the text.

\(^{5}\) Reference cited in the text.
fracture management as reflected by shorter time to union, decrease in frequency of implant failures, delayed unions malunions and frequency of re-operations.

In plating and indeed overall fracture management, the objective should encompass both biological and mechanical goals. The biological goal is to maintain viability of bone by preserving its soft tissue attachments and blood supply. The mechanical goal is to obtain both axial and rotational alignment with stable fracture fixation. Anatomic reduction and rigid fixation are important in fracture management and should be achieved with least possible soft tissue disturbance.\(^6\)

Open reduction and plate fixation offers the advantages of anatomic reduction without fluoroscopic imaging, ease of insertion, rapid mobilization and applicability to any size of femoral shaft. Its disadvantages include possible secondary procedures to remove the plate, risk of infections, postoperative knee and hip stiffness, thigh scar and increased blood loss.\(^7\)

Current popular methods of plate fixation of femoral diaphyseal fractures are compression plating and bridge plating. Compression plating is used in cases where at least partial contact of the main fracture fragments can be achieved such as in transverse, oblique or simple butterfly fragment fracture patterns. Tensioning of the plate during surgery leads to compression of the fracture fragments resulting in load sharing between bone and plate.

Extramedullary splint without compression of the fracture is indicated in comminuted fractures where interfragmentary compression and absolute stability is unnecessary.
7.2 LITERATURE REVIEW

7.2.1 Relevant anatomy

The femur is the longest bone in the human body. Its length is about one fourth of the height of a person \(^8,9\) Its maturity can be judged by closure of the growth plates, which occur at around 17 years or more in males and between 16 and 21 years in females.

The femoral diaphysis has been defined as the distance between 5 cm distal to the lesser trochanter and 6cm proximal to the most distal part of the medial femoral condyle\(^5\). Hedlund and Lindgren defined it as the part of the femur 10 cm distal to the lesser trochanter and 15 cm proximal to the knee joint line\(^110\).

The femoral diaphysis has a physiologic anterior curve\(^8,9,11,12\). It is almost cylindrical in form, a little broader proximally and somewhat flattened anteroposteriorly distally.

The greatest cortical thickness is posteriorly where the fascia lata inserts to the linear aspera- A prominent longitudinal ridge on the middle third of the bone presenting an external lip, an internal lip and a rough intermediate space.\(^8,9,13\).

The medullary cavity varies in a diameter and shape \(^8,12,14\). It is narrowest at the isthmus with a diameter of about 8mm to 16mm. The isthmus lies slightly proximal to the midshaft \(^9,11\).

The arterial blood supply to the femur is mostly via a nutrient artery derived from the profunda femoris artery \(^8,9,15\). This enters the femur proximally and supplies the endosteal circulation. It supplies the inner two thirds to three quarters of the cortex \(^11,15\). A second artery may be present distally, but no major artery supplies the lower third of the femur. This blood supply is centrifugal in direction \(^11,16,17\).

The periosteal circulation enters posteriorly for most part along the linear aspera. It is almost entirely directed in circumferential direction having little or no longitudinal spread\(^11\) Therefore small wires may be placed around the femur without danger of devascularising an area. The periosteal and endosteal circulations are critical to fracture healing in the diaphysis \(^6\).

Displaced femoral shaft fractures result in medullary vessel disruption and the periosteal vessels predominate as the vascular supply to the fracture during early healing.\(^18,19,20\). Therefore periosteal stripping should be avoided during internal fixation of these fractures.

Preservation of the muscle envelope around the fracture enhances revascularisation of the injured bone and promotes periosteal callus formation.

Displacement in femoral diaphysis fractures is a resultant of three forces; initial violence, muscle action and gravity \(^12\). The proximal fragment of the fragment is under abduction by the gluteus medius and gluteus minimus, the gemelli, the obturator internus and the
quadratus femoris. The proximal fragment is flexed and externally rotated by the iliopsoas. The adductor and hamstring muscles displace the distal fragment upward and medially.

In the middle third, the proximal fragment is adducted with a strong axial and varus force by the adductor muscles\textsuperscript{[9,11,12,13]} It is flexed by the iliopsoas muscles. The distal fragment is externally rotated by the weight of the foot\textsuperscript{[11,12]} It is displaced upward and posteriorly due to adductors and hamstring muscles.

The distal fragment of supracondylar fractures of the femur is flexed posteriorly by the pull of the gastrocnemius and can cause damage to the popliteal artery, the popliteal vein, the tibial nerve and the common peroneal nerve. The proximal fragment is pulled in flexion and adduction by the iliopsoas and adductor muscles.\textsuperscript{[11,21]} The medial angulating forces are resisted by the fascia lata.

7.2.2 Biomechanics of long bone fractures

Biomechanics is defined as mechanics applied to biology. Mechanics in turn is the analysis of any dynamic system be it relative motion of quanta and subatomic particles or motion of galaxies\textsuperscript{[22]}

Bone as a material

Compact (or cortical bone) is a composite of material in the true sense of the word. Two thirds of the weight (and approximately one half of the volume) of compact bone consist of an inorganic material with composition similar to the formula of hydroxyapatite (3Ca 3(po4)2Ca(OH)2). The remaining third is composed of organic material mainly collagen type 1.

Bone is microscopically lamellar in nature. The degree of porosity yields two macroscopically distinct type of bone. The major difference between cortical bone and cancellous bone is in their relative porosity. The porosity in cortical bone varies from 5\% to 30\% whereas that of cancellous bone is 30\% to over 50\%.\textsuperscript{[22]}

Bone strength as a material parameter is defined as the ultimate stress at which failure occurs whereas strength defined structurally is the ultimate load (force) at which failure of a system occurs.

Stress is the distribution of force over cross-sectional area of whole bone (S=F/A). Strain on the other hand is the change in length per unit initial length. Bone strength is higher than either of its components. The softer collagen prevents the stiff apatite from undergoing brittle fracture while apatite acts as a rigid scaffold to prevent collagen from yielding.

Bone strength, stiffness and energy absorption to failure depend not only on the material properties of bone (e.g inherent composition, microscopic morphology of bone components, bonds between fibers and matrix and bonds at points of contact) but also on
its structural properties (e.g. geometry of whole bone, bone length and bone curvature). The material strength of bone varies with age, sex and species of animal. It also varies with the location of bone such as femur versus humerus.

The effect of a force sustained in an accident depends on its magnitude, direction and nature of load; the nature of the bone including bone microarchitecture with mineral content, bone density and geometrical shape and the counteraction of soft tissues.\[^7,22,24\]

The direction of force on bone are tension, compression, shear, bending and torque (torsion)\[^7\]. The fracturing force can be direct or indirect (rotation, axial compression and bending without a direct impact)\[^25\]. Because of brittleness attributed to mineral content, bone breaks when deformed before other musculoskeletal materials.\[^26\]

Thus a fracture is a failure of bone as a material and as a structure.\[^21\]. Under tension and compression loads, bone strength is proportional to the bone cross-sectional area and to the square of the apparent density; small reductions in bone density may be associated with large reductions in bone strength.\[^27\]

The strength of a structure is proportional to the third power of the outer diameter minus the third power of the inner diameter. Stiffness of a tubular structure is proportional to the fourth power of the outer diameter minus the fourth power of the inner diameter.\[^28\]. Cortical bone is two times stronger and stiffer in the longitudinal direction than in the transverse direction. Trabecular bone is strongest along the lamellar of the trabeculae.\[^26\]

Bone remodels in response to forces to which it is subject to according to the Wolff’s law. Every change in form and function of bone or their function alone is followed by certain definite changes in their internal architecture and equally definite alterations in their external conformation.\[^29,30\].

Long bones of the lower extremities are subject to high bending moments and hence high tensile and compressive forces. Any sudden changes in the shape of the bone alters the distribution of stress within the structure, giving rise to stress concentration (or stress risers) that the bone attempts to compensate by remodeling\[^26,27\].

Elasticity of bone decreases with age. However breaking strength and elasticity are not the same throughout the bone.\[^12\]. The density of the bone diminishes with age especially on the anterolateral aspect of femoral shaft.\[^31\].

The breaking torque moment is inversely proportional to age. The spiral fracture pattern is more pronounced with increasing age and osteoporosis.\[^12\]. The strength of the iliotibial tract which is important in absorbing a bending force in the frontal plane, diminishes with age.

Repetitive strains are essential for maintenance of bone mass. However physical activity can either increase the bone mass or diminish bone strength depending on the formation of microscopic cracks within bone. This heralds the development of stress fractures.\[^29,30\].
The incidence of fatigue fractures of the femoral shaft varies from 3%-5% to 25-43% in military recruits and from 3%-7% to 21% in athletes.\textsuperscript{[32]}

A fatigue fracture is a consequence of non-physiologic cyclic loading of bone. Repetitive bending loads produce stresses that peak on the subperiosteal surfaces. The repeated loading can cause microscopic damage to bone tissue with accompanying resorption by osteoclasts. Bone remodeling response is then initiated by osteoblasts. Inadequate adaptation of bone to a mechanical change leads to imbalance between bone microdamage and remodelling and eventually a fracture\textsuperscript{[33]}.

### 7.2.3 Fracture healing, delayed union and non union of diaphyseal bone

Phases of fracture healing include impaction, induction, inflammation, soft and hard callus formation and remodeling. Fractured bone heals by formation of endosteal and periosteal callus\textsuperscript{[34]}. The healing process attempts to bridge the fracture gap with appropriate tissue leading to restoration of skeletal integrity and mechanical properties of bone.

Primary bone healing is characterized by widening of harvesian canals, formation of resorptive cavities and subsequent new bone across the fracture gap. When there are bone gaps, these are initially filled by bone with lamellae oriented parallel to the fracture and then penetrated by osteons in longitudinal direction.

The limit for direct primary osseous bridging of a fracture gap is about 0.5mm. Bone is formed by both endochondral ossification and direct membranous ossification. Fracture healing in long bone with motion between fracture fragments after intramedullary nailing implies the formation of external callus\textsuperscript{[35]}. Conversely absolute stability of plate fixation with anatomic reduction leads to primary bone healing without external callus\textsuperscript{[36]}.

External callus ossifies without intermediate cartilage stage in fractures stabilized with tight fitting nails. Loose fitting nails result in formation of cartilage at fracture site. Fragment dislocated more than 2cm from the medullary canal do not contribute to the healing of the fracture\textsuperscript{[13]}.

Causes of poor bone healing are either technical during operation or can be from biological failure or both.\textsuperscript{[29, 30]}

A delayed union is a failure of fracture repair. This may lead to nonunion in which case bone repair stops before a firm union has been established. Factors that predispose to nonunion include;

1. A gap or bone loss, over distraction or soft tissue interposition at fracture site.
2. Inadequate fracture fixation.
3. Repeated manipulations injuring fracture callus and blood supply.
4. Infection.
5. Impaired innervation.
Atrophic nonunion represent a poor biologic response to injury and usually respond to techniques directed at increasing the vascularity and osteogenic potential at the fracture site.

A hypertrophic nonunion demonstrates an attempt at bone healing. Callus is present; however the fracture is not united. This is usually the result of suboptimal mechanical environment and often responds to increasing stability at the fracture site [37].

Insufficient fixation or premature weight bearing lead to hypervascularised hypertrophic bone at the bone ends with high potential for non union (horse hoof).

Other pseudarthrosis that are viable and capable of biologic reactions are the horse foot which is a slightly hypertrophic pseudarthrosis poor in callus and the oligotrophic pseudoarthrosis without callus [38].

Pseudoarthrosis that are nonviable and incapable of biological reactions include torsion wedge or dystrophic pseudoarthrosis, necrotic pseudoarthrosis from comminution, defect pseudoarthrosis, atrophic pseudoarthrosis [38] and malignancies.

7.2.4 Classification of femoral diaphyseal fractures in adults

Femoral diaphyseal fractures can be classified according to fracture geometry, displacement, alignment, comminution or whether they are open or closed. The common classification systems used include the Winquist-Hansen and the international classification system. Other systems are the Tscherne and Oestern classification of closed fractures, and the Gustillo and Anderson classification of open fractures [39].

The Winquist-Hansen classification [40].

This characterizes the fracture comminution and determines the stability of the fracture.

| Grade 0 | No comminution simple transverse or oblique fractures |
| Grade 1 | Fracture with small butterfly fragment, minimal to no comminution. |
| Grade 11 | Fracture with butterfly fragment with at least 50% of circumference of the two major fragments intact. |
| Grade 111 | Fracture with butterfly fragment with 50-100% of circumference of two major fragments comminuted. |
| Grade 1V | Fracture with circumferential comminution over a segment of bone. All cortical contact is lost. |

The degree of fracture comminution determines the preferred form of medullary fixation and locking of major fragment of the fracture [13].
The Gustillo and Anderson classification of open fractures \[^{39}\]

Grade 1

Clean puncture wound 1cm or less most often occurring from inside out with minimal soft tissue damage. The fracture pattern is transverse or oblique.

Grade II

Skin opening of more than 1cm. Extensive soft tissue damage. The fracture pattern is simple transverse or short oblique or minimal comminution.

Grade III

Massive soft tissue damage more than 10 cm length; may include skin, muscle, structures, most often high energy mechanism of injury. It includes any open fractures that have not been treated within 8hrs. It is subdivided into grades III A, III B and III C.

Grade III A

There is massive soft tissue damage, adequate bone coverage, minimal periosteal stripping. It often occurs with gun shot injuries and often comminuted. It includes segmental fractures.

Grade III B

There is massive soft tissue damage, bone in exposed with presence of periosteal stripping requiring soft tissue flap coverage. It is associated with heavy contamination.

Grade III C

There is presence of major arterial injury requiring vascular repair or reconstruction. It also includes injuries requiring amputation.

Tschere and Oestern classification of soft tissue injuries associated with fractures.

Grade 0

Absent or negligible soft tissue damage. Fracture is a result of indirect forces with a simple fracture pattern.

Grade 1

Superficial abrasion or contusion caused by fragment pressure from within
Grade 11

Deep contaminated abrasion associated with localized skin or muscle contusion from trauma. There is impending compartment syndrome. Is usually a result of indirect violence.

Grade 111

Extensively crushed contused skin, severe muscle damage. Subcutaneous avulsions, decompensated compartment syndrome. Rupture of a major blood vessel and patients usually have complex fracture patterns.

In relation to their location, femoral diaphyseal fractures can be classified as proximal third, mid-shaft or distal third \(^{10}\).

The international and orthopedic trauma association classified femoral shaft fractures into three types: simple, wedge (butterfly fragment) and complex (comminuted). These are further subdivided according to the fracture location with additional two to five ramifications in the complex type of fractures \(^{41}\).

Alms devised a morphologic description of fractures and classified them according to the geometry of the major fracture line \(^{25}\).

According to Alms classification, there can be transverse, oblique, spiral, oblique-transverse fractures. Measured by the angle between a line perpendicular to the long axis of the femur and main fracture line, fractures with an angle less than 30° are considered transverse \(^{42}\).

7.2.5 Fracture mechanisms and injuries causing traumatic femoral shaft fractures.

The causes of femoral diaphyseal fractures can be divided into high energy injuries which include motor vehicle accidents, pedestrian versus motor vehicle accidents, motorcycle accidents, fall from heights more than three to four metres according to Demetriades 2005 \(^{43}\), gunshot wounds \(^{13}\), landmines and other explosives.

Low energy injuries causing femoral shaft fractures include slipping or stumbling at ground level, sports injuries and fall from height less than 1m.

Fractures in younger persons tend to be those due to high energy trauma \(^{12, 13}\), stress and pathological fractures.
7.3.6 Demography and incidence of femoral diaphyseal fractures in adults

Femoral diaphyseal fractures are commonly thought to be a result of severe trauma in young persons.
Kootstra studied 335 traumatic femoral diaphyseal fractures in 329 adults in the Netherlands in 12 years from 1958-1969. The frequencies of femoral shaft fractures in adults were 17-36 fractures per year. 22% of the patients were females. The risk of sustaining femoral shaft fractures was greatest in male aged between 20-29 years \(^{12}\). Literature is scarce on similar studies in Kenya.

7.3.7 Diagnosis of femoral diaphyseal fractures

Diagnosis of these fractures is mainly from the clinical presentation and radiological investigations. The usual history is that of trauma except in pathological fractures whose history may not be consistent with trauma.

Examination reveals tenderness, swelling, shortening and deformity at the fracture site. The pelvic ring and hip are inspected for tenderness, swelling or ecchymosis which may signal concomitant pelvic disruption or hip fractures.

Associated injuries should be looked for. A careful preoperative assessment of the hemodynamic stability of the patient is necessary. Distal pulses should be palpated and circulatory status evaluated. \(^{13}\)

Plain radiographs

Longitudinal traction or splinting of the extremity is applied before radiographs are taken to minimize additional soft tissue injury. Initial radiographs should include anteroposterior view of the pelvis and anteroposterior and lateral views of the knee and entire femur to allow detection of longitudinal cracks and nondisplaced comminution of the proximal and distal fragment. For fractures of the femoral condyles in the coronal plane, lateral and oblique radiographs are recommended. Radiographic changes occur in 2-12 weeks after onset of fatigue fracture symptoms. \(^{16}\)

CT scans

These can be used to detect longitudinal and spiral fractures. CT Scans are less sensitive than conventional radiographs for the detection of fatigue fractures.

Scintigraphic Scan

This is currently the best diagnostic modality for fatigue fractures \(^{44}\). Scintigraphy has a sensitivity of close to 100%.
MRI

This is more specific than scintigraphy in detection of fatigue fractures of bone. It is most accurate in the first three weeks.

Angiography

Angiography is indicated when vascular injury is suspected. Indicators of vascular injury include pulse or neurological ischaemic deficiency, hematoma, hemorrhage, hypotension, ankle-brachial index of less than 1.63. Although few patients with isolated femur fractures are hypovolemic, approximately 1200mls of blood is in the thigh in most cases.

Hematological investigations

Hemoglobin levels and hematocrit should be monitored as relatively large amounts of blood can be lost to compartments of the thigh.

Microbiology

Pus swabs for microscopy, culture and sensitivity tests should be obtained when infection is suspected.

7.3.8 Operative treatment of femoral diaphyseal fractures

History

Early attempts at internal fixation of femoral diaphyseal fractures were complicated by infection and implant failure.[13]

Lane introduced plates and screws in 1905. In 1907 Lambotte introduced the external fixator and in 1918, Hey Groves introduced a massive nail that was used in the medullary cavity.

In 1939, a wartime Germany surgeon Gerhard Kuntscher from Kiel presented his first cases of intramedullary fixation using a v-shaped cross-section designed nail using the principles used earlier for femoral neck fractures.[1]

In 1950s, Kuntscher introduced the cloverleaf cross-sectioned nail and intramedullary reaming.[3] Additional cerclage wiring, external fixation, external cast or postoperative traction was used in rare occasions.[45]

Treatment of more complex and demanding fractures became possible with improvements in the mechanical properties and design of intramedullary nails, innovations in instrumentation, modifications in nail insertion techniques and use of fluoroscopy.[13]
In the 1960s, the AO/ASIF group introduced osteosynthesis techniques consisting of intramedullary fixation and also fixation by means of screws and plates. Intramedullary nailing was further developed by the methods of open and closed nailing, use of interlocking nails, unreamed interlocking techniques and retrograde modifications in the nail insertion.

Small diameter nails are recommended in medullary canals smaller than 8mm, in fractures below non-cemented femoral prosthesis or in fractures that require intramedullary fixation that avoids physeal plates in young children. Titanium nails are now commonly used in adults especially in developed countries.

Early versus delayed fracture stabilization.

Whether femoral diaphyseal fracture should be fixed within 24hrs post injury is a debate that has been going on for a while. Fracture fixation should be completed within 24 hrs especially in patients with chest or head injury. Immediate fracture fixation decreases mortalities, respiratory complications, multisystem organ failure and length of ICU stay.

Fracture stabilization has a positive effect on the patient's pain, metabolism, muscle tone and body temperature and as a result cerebral function.

Studies have demonstrated improved survival of polytrauma patients whose fractures are fixed within 24 hrs of injury due to lower incidences of sepsis due to decrease in rate of pulmonary insufficiency. Higher incidences if pulmonary complications and prolonged ICU stay or hospital stay related to delayed femoral diaphyseal fracture fixation have been demonstrated.

The prevalence of adult respiratory distress syndrome (ARDS) has been significantly lower in plate fixation and in primary intramedullary nailing.

By 1980s, the accepted care of a major fracture was early fixation within 24-48 hrs from injury or admission. Delayed fracture fixation was considered detrimental. This however has been disputed in patients with head injury.

Studies by B. Pahud and H. Vasey showed no significant difference in healing between those treated early and those having delayed internal fixation.

Poole et al in 1992 found a significantly lower prevalence of perioperative neurological complications in patients who underwent early definitive fracture fixation compared with patients treated with delayed fixation.
Closed intramedullary nailing is now the criterion standard in the management of femoral diaphyseal fractures\textsuperscript{[56]}. Intramedullary nailing provides a stable osteosynthesis through flexible impingement of the nail in the bone and represents the ideal treatment of the fracture as it requires no external fixation or special postoperative care and permits early joint movement and weight bearing \textsuperscript{[57]}.

Other advantages of intramedullary nailing include fewer cases of malunion and limb shortening, improved function, shorter hospitalization, earlier return to work and generally faster healing of the fracture \textsuperscript{[58]}

Kuntscher principles of intramedullary nailing of femoral shaft fracture include: (i) nailing under flouroscopy without direct exposure of the fracture site in order to avoid infection, (ii) using a strong nail in order to minimize nail bending or breakage due to stress caused by muscle contraction, joint movement and weight bearing, (iii) using a nail with sufficient elasticity to compress during insertion and re-expand once in place to bind the fragments firmly and avoid rotation of the fracture. This contact or interference fit is thought to contribute to overall stability of the fixation construct\textsuperscript{[59]}.

Although interlocked intramedullary nailing is the criterion standard in the management of femoral diaphyseal fractures, open intramedullary nailing without locking is still relevant in developing countries with good functional and clinical results\textsuperscript{[60]}

The evolution of interlocking techniques expanded the indication for intramedullary nailing to virtually all fractures patterns of the femoral shaft regardless of the extent of comminution.

Reamed versus unreamed intramedullary nailing

Reamed femoral nailing is the gold standard for the treatment of virtually all diaphyseal femur fractures in skeletally mature patients. Adequate length and rotational control can be obtained in virtually any fracture pattern with a union rate exceeding 95%, a low mal-union rate and low infection rate

However intramedullary nailing is associated with potential complications to the patient. This include marked elevation in the intramedullary pressures and embolisation of marrow debri and air into the venous circulation. It can thus cause fat embolism syndrome, adult respiratory distress syndrome and even sudden death.

Besides vascular changes, reaming also result in thermal necrosis of the inner cortex and consequent cortical porosity. Kaartinen in his 1993 study recommended that extensive reaming of the medullary canal especially when combined with open reduction of the fracture should be preferably avoided, because it widens the intramedullary canal and increases the porosity of cortical bone. \textsuperscript{[61]}
Pressure increases within the medullary cavity and vessels are occluded by fat embolism and bone particles. Reaming of the femoral canal results in increased intramedullary pressure from 70mmHg during unreamed nailing to 200-600mmHg during reamed nailing and increase embolisation measured by echocardiography of the inferior venacava and right atrium\textsuperscript{[62]} This is in contrast with plating.

Intramedullary reaming has been proved to be detrimental to the medullary circulation. It induces a reversed centripetal blood flow.

Animal studies have revealed a 70% reduction in blood supply to the tibia that occur with reaming versus only 30% reduction in the unreamed procedure. Scintigraphic postoperative perfusion measurements demonstrate an impairment of perfusion only in the reamed group. Schemitish et al demonstrated that the cortical perfusion in sheep is significantly reduced after the reamed procedure compared with the unreamed procedure for a period of several weeks.\textsuperscript{[63]}

Inflammatory mediators such as neutrophilis, elastase interleukin-6, adhesion molecules have been regarded as the causation of a second hit response (initial being the initial trauma) in patients with femoral diaphyseal fractures\textsuperscript{[64]}

Other reported effects of reaming have been an increased consumption of coagulation factors\textsuperscript{[65]} and an increased risk of infection in open fractures.

Reaming of the canal deposits at the facture site increases the amount of cortical bone fragments and marrow element that are thought to have osteoinductive properties.\textsuperscript{[20,66]}

Unreamed nailing has been associated with lower rate of fracture healing. However, good results after unreamed femoral nailing have been demonstrated as well.\textsuperscript{[67]}

Intramedullary reaming enhances fracture stability with a larger nail. A tightly fit nail however induces a greater periosteal reaction\textsuperscript{[66]}

Interlocked nailing controls femoral length and rotation without the risks of tissue devascularization, quadriceps scarring, blood loss and infection that are encountered in plate fixation. Interlocking enables treatment of the more severe degrees of comminution of the shaft.
Open versus closed intramedullary nailing

Specialized instrumentation and radiographic facilities are required in closed intramedullary nailing. The fracture is reduced by external manipulation and the nail inserted through the end of bone without damage to the periosteal vasculature. Because the fracture hematoma is not evacuated during closed nailing, the earlier action of local cellular and humeral agents critical to normal healing is not disturbed. The lesser surgical dissection indicates a lower infection rate and less quadriceps scarring.

After closed nailing, shaft fractures heal with abundant callus formation with little or no osteopenia of the major fracture fragments.

In open nailing, the fracture site is opened directly via the surrounding muscles to achieve reduction and insertion of the nail. The procedure is faster and doesn't require fluoroscopy. It however predisposes the fracture site to increased infection rate and decreased blood supply to the fracture site.

Interlocking versus simple Kuntscher nailing

The development of interlocking techniques expanded the indications of intramedullary nailing to include virtually all fracture patterns of the femoral shaft regardless of the extent of comminution. Interlocked nails are designed to handle severe fracture comminution, bone loss and proximal or distal fracture levels of open fractures.

The biomechanical demands concerning the intramedullary nail depend on for instance the fracture location and comminution, patient size, and bone morphology. Simple transverse and short oblique fractures of the femoral diaphysis without associated fractures or soft tissue injuries have been recommended to be treated by closed interlocking nailing. Standard cloverleaf nails have been found to be contraindicated in type III and type IV comminuted fractures due to risk of fracture shortening around the nails. Small diameter nails fail to fit the canal and allow even type I and type III comminuted fractures to telescope around the nail.

Before interlocking nails, standard cloverleaf nails supplemented with a minimum two cerclage wirings of major cortical fragments were widely used for comminuted fractures or for spiral or long oblique fractures. This treatment result in slow healing observed in open intramedullary nailing. The clinical result of cerclage wiring is satisfactory and inferior to those of closed static intramedullary nailing.

Dynamic nailing has been recommended in simple fractures of the femoral shaft. Transfixation screws in the proximal hole or the distal hole alone result in dynamic stabilization. This has potential instability of axial compression and rotation.

Static locking with screws in both proximal and distal fragment is indicated in those fractures in which both shortening and malrotation are possible. Locking of the fracture fragment has no deleterious effects on the rapid healing evident after simple Kuntscher nailing.
Antegrade versus retrograde nail insertion

The portal of entry of the nail in antegrade technique is in the piriform fossa. The nail is then advanced distally. This has been shown to have high union rates. It is however associated with trendelenberg gait, weak hip abduction, hip pain and bursal pain in many patients. In the retrograde technique, the portal of entry is in the intercondylar point of the femur. The retrograde technique is advantageous in many settings such as in polytraumatised patients, those with bilateral injuries, in pregnancy and in obese patients. It is also efficacious in treatment of ipsilateral pelvic, acetabular, femoral neck and tibia fractures.

A fractured femur fixed with a standard intramedullary nail of 12–14 mm in diameter is 50% to 70% as stiff as an intact femur in bending regardless of nail design. Fixation stability concerning compression and rotation diminishes when the fracture is located in a distance proximal or distal to the isthmus of the medullary canal.

Technique of open intramedullary nailing

Intramedullary nailing of femoral diaphyseal fractures can be performed with the patient either in the supine or lateral position on the fracture table.

The supine position is preferable in patients with multiple injuries especially when associated with pulmonary injury, unstable spine or pelvic fractures or contralateral femoral fracture.

The fracture site is exposed through a posterolateral incision over the thigh, the vastus lateralis is reflected anteriorly taking care not to strip the soft tissues for more than 3 to 4 cm from the ends of the fracture fragments. After the length of the possible nail is measured, serial reaming starting with the 9mm end-cutting reamer is used to enlarge the medullary canal in both the proximal and distal fragments. The canal is overreamed at least 0.5mm for simple cloverleaf nails and 1mm for interlocking nails to avoid incarceration of the nail or iatrogenic comminution of the fracture.

After introduction of the nail into the medullary canal locking screws are indicated in the Winquist-Hansen grade 111 and grade IV comminuted fractures, segmental oblique and comminuted, in long spiral, in proximal or distal oblique or comminuted fractures.

Transverse mid shaft fractures are considered appropriate for nailing without static locking of major fracture fragments.
Postoperative treatment

Progressive weight bearing and quadriceps strengthening exercises are instructed. Weight bearing is delayed in patients with very proximal or distal fractures that are at risk of implant failure and in patients with ipsilateral extremity injuries.

Full range of motion of the knee is expected in 4 to 6 weeks after simple nailing

Serial radiographs at 0, 1, 3, 6 and 12 months after nailing are obtained until fracture healing and remodeling are achieved.

Nail removal is done 11/2 – 21/2 years after injury if fracture remodeling has proceeded normally.[13]

No protection in form of casts or delayed weight bearing is necessary after nail extraction.

7.2.10 Plate fixation of femoral diaphyseal fractures

The concept of open reduction and internal fixation of femoral diaphyseal fractures gained widespread acceptance during the 1960s and 1970s. Open reduction with plating was employed in nearly all fractures of the femoral diaphysis or its use was limited to fractures that were amenable to intramedullary nailing with or without cerclage wiring. The principle of plate fixation was to create a sufficiently stable unit of plate and bone that with biologic load applied; little or no strain would be created.

Initially, multiple 90°-90° plates were applied to the femoral diaphysis to obtain more secure fixation. Improvements in plate designs and plate strength allowed single plates to be used and also allowed fracture site compression.

Routine bone grafting of comminuted femoral shaft fractures with open plate fixation was recommended.[71]

Plate and screws are mainly indicated for transverse fractures and short oblique fractures irrespective of their level on the femoral shaft.[11]

Contraindications to plate fixation include multiply injured patient with coagulopathy, pre-existing skin infection, cardiac instability and severe head injury with uncontrollable fluctuating intracranial pressure measurements.[13]

The AO technique requires an extensive surgical exposure of the lateral aspect of the femur for a 10 to 12-hole dynamic compression plate (DCP). A minimum of four screws in both the proximal and distal fragments are recommended.[13] Tornkuist, H Hearn, T.C, Schatzker study on the strength of plate in relation to the number and spacing of bone screws revealed that tensional strength of the plate and screw construct is independent of screw placement in plates of a given width and depends on the number of screws used.[72]
The length of plate was found to be of no significance in torsional strength. However, they showed that fewer, more widely spaced screws impart strength on a 4-point bending in a laboratory model of a plated fracture.

All medial cortical defects are preferably grafted. Perioperative antibiotics are used to minimize infection. Active range of motion exercises is advised soon after surgery.

A major disadvantage of plating compared to reamed intramedullary nailing is the delay in weight bearing for 3 to 5 months.

The only remaining advantage of open plating is that it does not require the wide spectrum of specialized operating room equipment and fluoroscopy necessary for closed intramedullary nailing. However plating offers enough rigidity for bone healing and allows post-operative mobilization with good functional outcome.

7.2.11. Treatment of open femoral diaphyseal fractures

Gustillo class I, II and IIIA fractures treated with standard reamed intramedullary nailing is acceptable. Grade IIIB and IIIC should be treated with external fixation after initial debridement.

Treatment of open fractures initiated within 8hrs has been shown to decrease the incidence of infection. Because of the higher rate of infection in any open fracture untreated for longer than 8hrs, the injury should be treated as Grade III open fracture by external fixation.

Studies have shown good result with closed antegrade reamed or unreamed intramedullary nailing in grade III B fractures and a couple of studies have included both grade IIIB and grade IIIC fractures.

Administration of antibiotic is mandatory for all open fractures. The recommended treatment is with 1st generation cephalosporin and an aminoglycoside. Extensively contaminated fractures should be treated with a first generation cephalosporin, an aminoglycoside and penicillin. In addition tetanus prophylaxis should be administered appropriately.

7.2.12 Future and controversies

Open reduction and internal fixation has high success rates. However patients with femoral shaft fractures present with a multitude of injuries including head and chest trauma. Showering of small emboli occur with reaming and also with insertion of the nail into the medullary canal. The clinical implication in those patients with polytrauma including chest injury or those with pre-existing poor pulmonary function is yet to be fully elucidated.

Intramedullary nailing in cases of head injury raises concerns. Potential hypotension in the intra operative period may cause further damage to the CNS. More studies are needed.
to define the role of open reduction and internal fixation and its timing in these patients [1].

7.2.14 Problem statement.

Despite the fact that various studies have shown that intramedullary nailing of femoral diaphyseal fractures result in high union rates and can be applied to almost all fractures of femoral diaphysis, the research question on how open intramedullary nailing and plate fixation of femoral diaphyseal fractures compare in our local set up remains unanswered. This study therefore is set to focus on how these two fundamental methods of fracture fixation compare at Kenyatta National Hospital.
7.3 STUDY JUSTIFICATION

At Kenyatta National Hospital, open intramedullary nailing and plating of femoral diaphyseal fractures are widely practiced techniques and yet no prospective comparative studies have been done in this set-up to conclusively determine the relationship between their outcomes.

Moreover, the timing of open intramedullary nailing and plate fixation of femoral diaphyseal fractures has profound implications on the overall outcome of treatment. Many authors prefer early fracture fixation within 48 hours of injury. This has not been collaborated in our set up with limited resources. Delayed fracture fixation is therefore still an option in our set up.

This study is therefore designed to prospectively compare and contrast the practice of open intramedullary nailing and plating of femoral diaphyseal fractures at Kenyatta National Hospital.

'Man cannot discover new oceans unless he has courage to lose sight of the shore.' - Andre Gide - French writer [1869-1951].
8. STUDY OBJECTIVES

8.1 Broad objectives

To prospectively compare the outcomes of open intramedullary nailing and plate fixation of femoral diaphyseal fractures at KNH.

8.2 Specific objective

To compare the union rates of femoral diaphyseal fractures treated by open intramedullary nailing and those treated by plate fixation at KNH

8.3 Null hypothesis

There is no difference in union rates between femoral diaphyseal fractures treated by either open intramedullary nailing or by plate fixation at KNH.
9. MATERIALS AND METHODS

9.1 Place of study

This study was carried out at Kenyatta National Hospital’s operating theatres, Orthopedics and trauma wards and trauma clinics between April 19, 2007 and October 2007. Institutional approval of the study was obtained from the hospital’s research and ethics committee before commencement of the study.

9.2 Study population.

Patients studied were those with femoral diaphyseal fractures who were treated by either open intramedullary nailing or by plate fixation at Kenyatta National Hospital within the specified period.

9.3 Study design

This was a prospective cross-sectional comparative study.

9.4 Sample size

The estimated sample size was 72 patients. This was calculated from Fischer’s formula:

\[ N = \frac{Z^2PQ}{D^2} \]

Where: 
- \( N \) = Desired sample size,
- \( Z \) = Standard normal deviation corresponding to 95% Confidence level (1.96)
- \( P \) = Expected population of patients with femoral diaphyseal fractures treated by either open Intramedullary nailing or by plate fixation who develop adverse outcome (5%)
- \( Q = 1 - P \)
- \( D \) = Level of precision (5%)

9.5 Sampling method

A consecutive series of thirty six patients with femoral diaphyseal fractures who underwent open intramedullary nailing were recruited into the study and assigned into group A.

Another consecutive series of thirty-six patients with femoral diaphyseal fractures who underwent plate fixation were recruited and assigned into group B. The decision as to which patients were to undergo open intramedullary nailing and which ones underwent plating was left at the discretion of the ward consultants from which the patients were drawn from.
9.6 Inclusion criteria

Patients who participated in the study were those above 13 years of age with femoral diaphyseal fractures. These patients gave informed consent to undergo either open intramedullary nailing or plate fixation of their fractures.

9.7 Exclusion criteria

Those patients who declined to give consent and those below 12 years of age were excluded from the study.

9.8 Ethical considerations

Permission to proceed with the study was obtained from the ethical and research committee of Kenyatta National Hospital. Informed consent was obtained from all patients or their close relatives on recruitment into the study. The information obtained from the participants was kept private and confidential. None of the participants was denied treatment due to him or her for purpose of this study. Information that was obtained from other sources was acknowledged and included in the references section of this dissertation.

9.9 Definitions used in the study, measurements and end points

The femoral diaphysis was defined as the portion of bone located between a point 5cm distal to the lesser trochanter and a point 8cm proximal to the adductor tubercle. Radiological union rates were defined as the percentage of femoral diaphyseal fractures in which callus developed and bridged the fracture site at the end of twelve weeks post fracture fixation. Clinical union rates represented the healed fracture as evidenced by absence of local tenderness on palpation or on stressing the fracture and absence of any abnormal movement on stressing the fracture site.

Other measurable parameters were carried out as follows:

(i) Time to surgical intervention was measured from the time the fracture was sustained to the time the fracture was surgically fixed.

(ii) Time to radiological union was measured from the time of fracture fixation to the end of twelve weeks post operatively.

(iii) Complication rates were evaluated as they arose throughout the study period.

(iv) For open fractures, the size of the skin defect was measured in centimeters and the open grade given according to Gustillo and Anderson [50]

(v) The degree of fracture comminution was obtained from plain radiographs and classified according to the Winquist- Hansen classification system [51]
(vi) The weight of each patient was measured in kilograms and the height in meters. The body mass index was calculated from the formula:

\[
\text{BMI} = \frac{\text{weight (kg)}}{\text{Height (m)}^2}
\]

(vii) The operative time was taken to be the time between making the skin incision through to completion of the operation at skin closure.

(viii) The length of the skin incision was measured in centimeters.

(ix) Cost estimation.
The cost of each implant was taken to be that charged by the hospital's accounts department. Each K-nail cost Ksh 10,000, each interlocking nail cost Ksh 25,000, each plate cost Ksh 7000 and each screw cost Ksh 590.00. Other theatre charges were Ksh 5500.00 for each of the procedures. Other charges included X-rays @Ksh 1000.00, bed @ KSh. 450 per day, nursing @KSh. 30 per day and physiotherapy @Ksh 450 per day.

9.10 Materials

Well-equipped Orthopedics and trauma theatres with facilities for open reduction and internal fixation were essential in this study. A functioning radiology department with X-ray facilities and a laboratory capable of carrying out hematological and microbiological investigations were important.

Patients' records were kept and retrieved from the registry. In addition, patients' return dates to the outpatient clinics were kept in a diary that was in turn kept by the principal investigator. Mobile telephones were also used in obtaining the participants' return dates to the clinics.

Patients' weights were measured using weighing machines and their heights were measured with a measuring tape. Last but not least, writing and printing materials and a calendar for keeping outcome evaluation dates were helpful.

9.11 Procedures

Orthopedics and trauma surgeons, senior registrars and registrars carried out the operations. Nurses and theatre support staff carried out their respective theatre duties. Open intramedullary nailing was performed by a lateral thigh approach. The vastus lateralis muscle was split and the fracture site accessed. Any fibrous tissue on the fracture fragment ends was excised. Both proximal and distal fracture fragments were reamed serially. A standard Kuntscher nail was then driven into the proximal fragment. After reduction, it was then driven into the distal fragment to achieve fixation.

In plate fixation, the fracture site was approached in a similar manner to intramedullary nailing. After achieving fracture reduction via manipulation, a compression or bridge plate was used to maintain the reduction. The number of screws used to secure the plate
proximal and distal to the fracture were counted and recorded. The number was again ascertained on postoperative radiographs.

Radiographs of the fractured femoral diaphysis were obtained and evaluated preoperatively, immediate post operatively and then at the end of four, eight and twelve weeks.
A complete blood count was obtained both preoperatively and post-operatively. In instances where infection was suspected, pus swabs for microbiological studies were taken.

Any complications that arose in the participants were evaluated according to the criteria set out in the questionnaire.

After discharge from the wards, the patients were followed up in the orthopedics and trauma clinics for up to twelve weeks post fracture fixation at 4 weekly intervals.

The after treatment comprised of partial weight bearing on crutches, active knee mobilization and quadriceps muscle exercises.

9.12 Variables

9.12.1 Dependent variables

Union rates

The union rates were used as measures of outcome that were compared between patients who underwent open intramedullary nailing and those who underwent plate fixation.

Clinical union was evaluated at six and twelve weeks post fracture fixation. Radiological union was evaluated at twelve weeks post fracture fixation.

The union rates were calculated as follows:

Clinical union rate;

\[
\text{In group A} = \frac{\text{Number of clinically united fracture in group A}}{\text{Total number of fractures in group A}} \times 100\%
\]

Radiological union rate;

\[
\text{In group A} = \frac{\text{Number of radiologically united fracture in group A}}{\text{Total number of fractures in group A}} \times 100\%
\]
In group B = \( \frac{\text{Number of radiologically united fractures in group B} \times 100}{\text{Total number of fractures in group B}} \)

9.12.2 **Independent variables**

These were regarded as the determinants of the union rates in this study. These were:

1. Whether a fracture was fixed by open intramedullary nailing
2. Whether the fracture was fixed by plating.

9.12.3 **Confounding variables.**

A number of factors intrinsic or extrinsic to the patient may have weakened or strengthened the relationship between open intramedullary nailing or plating of the femoral diaphyseal fracture and the union rates obtained. To give a true picture of this relationship these factors were considered during data analysis. These variables included demographic variables such as age, sex, and socioeconomic status; fracture pattern and characteristics such as degree of comminution, the open grade, fracture etiology, body mass index, implant characteristics, elapsed time before fracture fixation, secondary procedures carried out after initial fracture fixation, the technique of implant fixation, associated injuries and the complications that occurred before, during and after fixation.

9.12 **Data collection instruments**

**Administration of a written questionnaire**

A questionnaire was prepared and the participants were given the opportunity to respond to it with assistance of the principle investigator. For those patients who could not understand English or Kiswahili, their relatives were used as interpreters. A sample questionnaire that was used in this study is annexed at the end of this dissertation. (Annex iv). The questionnaires that were used were numbered.

**Interviews**

Oral questioning of respondents was used to clarify information when need arose. The principle investigator to obtain relevant information interviewed illiterate patients who participated in the study. Mobile telephones were used to trace the patients and to obtain return dates to the out patient clinics.
Observation

The relevant characteristics of femoral diaphyseal fracture such as location, geometry, comminution, open grade were systematically observed and recorded. Radiographs were reviewed preoperatively and postoperatively, at six weeks post fracture fixation and at twelve weeks post fracture fixation.

Review of available information

Data collected by previous researchers on open intramedullary nailing and plate fixation of femoral diaphyseal fractures was reviewed.

9.14 Statistical analysis

Data obtained was processed using both data master sheets and computer using the statistical package for social sciences (SPSS). Descriptive statistics such as mean, frequency, distribution and standard deviation was used for most data. Chi-square and student t-test were used to determine association between categorical variables. Differences were considered significant at p<0.05.

9.15 Study limitations

There were many confounding factors that may have interfered with the establishment of the relationship between union rates observed and the method of fracture fixation. The establishment of union rates may have been hindered by the study period as some patients may have obtained both clinical and radiological unions beyond the twelve weeks of follow up.
10 RESULTS

Table 1: Socio-demographic data (n = 72)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Plating</th>
<th>Intramedullary Nailing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Distribution (Years)</td>
<td>Male, n (%)</td>
<td>Female, n (%)</td>
</tr>
<tr>
<td>&lt;20</td>
<td>2 (6.5)</td>
<td>1 (20.0)</td>
</tr>
<tr>
<td>20-30</td>
<td>13 (41.9)</td>
<td>1 (20.0)</td>
</tr>
<tr>
<td>31-40</td>
<td>11 (35.5)</td>
<td>1 (20.0)</td>
</tr>
<tr>
<td>41-50</td>
<td>3 (9.7)</td>
<td>1 (20.0)</td>
</tr>
<tr>
<td>&gt;50</td>
<td>2 (6.5)</td>
<td>1 (20.0)</td>
</tr>
<tr>
<td>Total</td>
<td>31 (100.0)</td>
<td>5 (100.0)</td>
</tr>
</tbody>
</table>

The mean age of the participants was 33.9 years (std = 13.92) with a range of 15 to 80 years. For those who underwent plating, their mean age was 33.61 years (std = 14.33) and had a range of 15 to 80 years. The mean age for those who underwent intramedullary nailing was 33.17 years (std = 13.69) and the range was between 17 and 76 years. There was no significant difference in the mean ages between the two groups (p=0.893). There were 31 males and 5 females who underwent plating and 28 males and 8 females who underwent intramedullary nailing. Table 1 shows the age and sex distribution of the participants.

Table 2: Distribution of BMI by Sex (n = 72)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Plating</th>
<th>Intramedullary Nailing</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>Male, n (%)</td>
<td>Female, n (%)</td>
</tr>
<tr>
<td>Underweight (&lt;18.5)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Normal (18.5-24.9)</td>
<td>27 (87.1)</td>
<td>4 (80.0)</td>
</tr>
<tr>
<td>Overweight (25-29.9)</td>
<td>4 (12.9)</td>
<td>1 (20.0)</td>
</tr>
<tr>
<td>Obesity (&gt;30.0)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>31 (100.0)</td>
<td>5 (100.0)</td>
</tr>
</tbody>
</table>

The mean BMI for those patients who underwent plating was 22.29 (std = 2.35) and that for those who underwent intramedullary nailing was 23.49 (std = 4.10). By independent t-test, there was no significant difference in the mean BMI between the two groups (p=0.132). Table 2 illustrates the BMI of the patients in both groups.
Table 3: Distribution of Occupation by Sex (n = 72)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Plating</th>
<th>Intramedullary Nailing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male, n (%)</td>
<td>Female, n (%)</td>
</tr>
<tr>
<td>Professional</td>
<td>3 (9.7)</td>
<td>-</td>
</tr>
<tr>
<td>Businessman</td>
<td>2 (6.5)</td>
<td>-</td>
</tr>
<tr>
<td>Self Employed</td>
<td>18 (58.1)</td>
<td>2 (40.0)</td>
</tr>
<tr>
<td>Other</td>
<td>8 (25.8)</td>
<td>3 (60.0)</td>
</tr>
<tr>
<td>Total</td>
<td>31 (100.0)</td>
<td>5 (100.0)</td>
</tr>
</tbody>
</table>

Majority of the participants were self-employed. Professionals and business persons also participated in the study. The distribution of their occupations by sex is as shown in table 3 and their net monthly income is as shown in table 4. The number of the participant’s dependants is as depicted in table 5.

Table 4: Distribution of Monthly income by Sex (n = 72)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Plating</th>
<th>Intramedullary Nailing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male, n (%)</td>
<td>Female, n (%)</td>
</tr>
<tr>
<td>Net Monthly Income (Sh.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1,000</td>
<td>4 (12.9)</td>
<td>2 (40.0)</td>
</tr>
<tr>
<td>1,000 – 10,000</td>
<td>21 (67.7)</td>
<td>3 (60.0)</td>
</tr>
<tr>
<td>10,000 – 20,000</td>
<td>6 (19.4)</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>31(100.0)</td>
<td>5(100.0)</td>
</tr>
</tbody>
</table>

Table 5: Distribution of No. Dependents by Sex (n = 72)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Plating</th>
<th>Intramedullary Nailing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male, n (%)</td>
<td>Female, n (%)</td>
</tr>
<tr>
<td>No of Dependants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>4 (12.9)</td>
<td>2 (40.0)</td>
</tr>
<tr>
<td>1 – 5</td>
<td>21 (67.7)</td>
<td>3 (60.0)</td>
</tr>
<tr>
<td>5 – 10</td>
<td>6 (19.4)</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>31(100.0)</td>
<td>5(100.0)</td>
</tr>
</tbody>
</table>
Figure 1: Fracture: Aetiology

Figure 1 above illustrates the aetiology and frequency of the fractures treated by plating and those treated by intramedullary nailing.

Figure 2: Fracture: Location

Majority of the fractures treated by both intramedullary nailing and by plating were in the middle third of the femoral diaphysis. 21 (29.2%) fractures were plated while 19 (26.4%) were fixed by intramedullary nailing. 14 (19.4%) of intramedullary nailed fractures, 4 (5.6%) of plated fractures and 3 (4.2%) of intramedullary nailed fractures and 11 (15.3%) of plated fractures were in the proximal and distal third respectively. This is as shown in figure 2.
23(32.4%) of plated fractures were on the right side while 12(16.9%) were on the left side. 21(29.6%) of the intramedullary nailed fractures were on the right side whereas those on the left side were 15(21.1%). One patient had bilateral femur fractures. This predilection of fractures to the right femur is illustrated in figure 3.

Closed fractures were 28(77.8%) in the plated group while they comprised of 33(91.7%) of the intramedullary nailed group. Open fractures consisted of 8(22.2%) of the fractures fixed by plating and 3(8.3%) of those fixed by intramedullary nailing. There was no significant difference in the number of open and closed fractures in both groups. This is illustrated in figure 4 above.
14 transverse, 3 spiral, 6 oblique, and 13 comminuted fractures were fixed by open intramedullary nailing while 5 transverse, 9 spiral, 6 oblique, and 16 comminuted fractures were fixed by plating. There was no statistically significant difference in the number of transverse fractures treated by open intramedullary nailing compared to those treated by plating (p=0.056). Figure 5 above illustrates the geometry of the fractures treated by either method.

Figure 6 above compares the frequency versus the degree of comminution of the fractures treated by open intramedullary nailing and those treated by plating. 15 (43%) of the intramedullary nailed fractures were grade 0, 12 (34%) were grade 1, 3 (9%) were grade II, 4 (11%) were grade III, and 1 (3%) were in grade IV. For those treated by plating, 14 (39%) were grade 0, 8 (22%) were grade I, 6 (17%) were grade II, 6 (17%) were grade III, and 2 (6%) were grade IV according to the Winquist-Hansen classification. There was no statistically significant difference in comminution in the fractures treated in these groups.
Table 6: Investigations

<table>
<thead>
<tr>
<th></th>
<th>Type of fixation</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plating, n (%)</td>
<td>Nailing, n (%)</td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemogram</td>
<td>36 (100.0)</td>
<td>36 (100.0)</td>
<td></td>
</tr>
<tr>
<td>Urea, Electrolytes, Creatinine</td>
<td>34 (94.4)</td>
<td>36 (100.0)</td>
<td></td>
</tr>
<tr>
<td>Pus swab/microscopy/culture</td>
<td>2 (5.6)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Radiological</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plain X-ray</td>
<td>36 (100.0)</td>
<td>36 (100.0)</td>
<td></td>
</tr>
<tr>
<td>CT scan</td>
<td>1 (3.4)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Scintigraphic Scan</td>
<td>-</td>
<td>1 (3.4)</td>
<td></td>
</tr>
</tbody>
</table>

All the patients in both groups had a hemogram done before surgery. Urea, electrolytes and creatinine levels were obtained in all patients who underwent intramedullary nailing and in 34(94.4%) of those who underwent plating. Pus swabs were obtained in 2 (5.6%) of the patients in the plating group who had developed infection. Plain radiographs of all the fractures were obtained both before and after surgery. One patient with head injury had a CT scan of the head and one patient with a pathological fracture had a bone scan. The investigations that were done are as summarized in table 6 above.

Table 7: Distribution of Medical treatment by type of fixation

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Type of fixation</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plating, n (%)</td>
<td>Nailing, n (%)</td>
<td>p- value</td>
</tr>
<tr>
<td>Analgesics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nsaids</td>
<td>36 (100.0)</td>
<td>35 (97.2)</td>
<td></td>
</tr>
<tr>
<td>Opioids</td>
<td>36 (100.0)</td>
<td>30 (83.3)</td>
<td></td>
</tr>
<tr>
<td>Antibiotics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penicillin</td>
<td>36 (100.0)</td>
<td>35 (97.2)</td>
<td></td>
</tr>
<tr>
<td>Flagyl</td>
<td>17 (47.2)</td>
<td>12 (33.3)</td>
<td></td>
</tr>
<tr>
<td>Cephalosporin</td>
<td>7 (19.4)</td>
<td>2 (5.6)</td>
<td></td>
</tr>
<tr>
<td>Aminoglycosides</td>
<td>6 (16.7)</td>
<td>4 (11.1)</td>
<td></td>
</tr>
<tr>
<td>Tetanus Prophylaxis</td>
<td>24 (66.7)</td>
<td>26 (72.2)</td>
<td></td>
</tr>
<tr>
<td>Blood transfusion</td>
<td>15 (41.7)</td>
<td>10 (27.8)</td>
<td>0.216</td>
</tr>
</tbody>
</table>

15(41.7%) of patients who underwent plating required blood transfusion compared to 10(27.8%) of those who underwent intramedullary nailing. Those who underwent plating were thus 1.86 times more likely to receive blood transfusion than those who underwent intramedullary nailing. (Odds ratio (95% CI) =1.86(0.69, 4.98)). This however was not statistically significant. (P=0.216). Table 7 above shows the other treatment the patients received.
Fig. 7 Timing from injury to operation

Fig 7 shows the time lapse from injury to fracture fixation in the two groups. On average, the patients who underwent plating were operated on the 25th day (range 2-120 days) while those who underwent intramedullary nailing were operated on the 20th day (range 1-83 days). However, there was no statistically significant difference in the delay prior to operation between the two groups (p=0.696).
Table 8: Implant characteristics: Open Intramedullary Nailing

<table>
<thead>
<tr>
<th>Nail Size</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>1</td>
<td>2.8</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>16.7</td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>11.1</td>
</tr>
<tr>
<td>12</td>
<td>14</td>
<td>38.9</td>
</tr>
<tr>
<td>13</td>
<td>9</td>
<td>25.0</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>5.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nail Length</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>1</td>
<td>2.8</td>
</tr>
<tr>
<td>32</td>
<td>1</td>
<td>2.8</td>
</tr>
<tr>
<td>36</td>
<td>15</td>
<td>41.7</td>
</tr>
<tr>
<td>38</td>
<td>5</td>
<td>13.9</td>
</tr>
<tr>
<td>40</td>
<td>11</td>
<td>30.6</td>
</tr>
<tr>
<td>44</td>
<td>2</td>
<td>5.6</td>
</tr>
<tr>
<td>48</td>
<td>1</td>
<td>2.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nail Material</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless steel</td>
<td>4</td>
<td>11.1</td>
</tr>
<tr>
<td>Titanium</td>
<td>32</td>
<td>88.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nail Type</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interlocking</td>
<td>3</td>
<td>8.3</td>
</tr>
<tr>
<td>K-nail</td>
<td>33</td>
<td>91.7</td>
</tr>
</tbody>
</table>

Table 8 summarizes the characteristics of the implants used in open intramedullary nailing. All the patients whose fractures were fixed with these implants underwent reamed intramedullary nailing. The characteristics of the implant used had a direct impact on the overall costs incurred by the patient.
Table 9: Implant characteristics: Plating

<table>
<thead>
<tr>
<th>Length of Plate (cm)</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3</td>
<td>8.3</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>11.1</td>
</tr>
<tr>
<td>17</td>
<td>4</td>
<td>44.4</td>
</tr>
<tr>
<td>21</td>
<td>16</td>
<td>44.4</td>
</tr>
<tr>
<td>22</td>
<td>5</td>
<td>13.9</td>
</tr>
<tr>
<td>24</td>
<td>4</td>
<td>11.1</td>
</tr>
<tr>
<td>&gt; 24</td>
<td>1</td>
<td>11.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of the Plate</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression</td>
<td>33</td>
<td>91.7</td>
</tr>
<tr>
<td>Bridge</td>
<td>3</td>
<td>8.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plate Material</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless steel</td>
<td>36</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. Of Holes in the Plate</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>3</td>
<td>8.3</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>8.3</td>
</tr>
<tr>
<td>12</td>
<td>24</td>
<td>66.7</td>
</tr>
<tr>
<td>14</td>
<td>4</td>
<td>11.1</td>
</tr>
<tr>
<td>16</td>
<td>2</td>
<td>5.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. Of Screws</th>
<th>Proximal</th>
<th></th>
<th></th>
<th>Distal</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>4</td>
<td>11.1</td>
<td>2</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>4</td>
<td>11.1</td>
<td>3</td>
<td>8.3</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>20</td>
<td>55.6</td>
<td>1</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>6</td>
<td>16.7</td>
<td>4</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>1</td>
<td>2.8</td>
<td>1</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>1</td>
<td>2.8</td>
<td>3</td>
<td>8.3</td>
</tr>
</tbody>
</table>

Table 9 summarizes the characteristics of the implants used in plating. The number of screws used on either side of the fracture determines the stability of the overall construct. Moreover, the type of plate material has a bearing on the cost incurred by the patient and rate of implant failure.
The mean operative time for those who underwent plating was 248 minutes (std = 38.587), and that for those who underwent open intramedullary nailing was 105 minutes (std = 58.89). This operative time for open intramedullary nailing was significantly shorter than that for plating. (p-value < 0.001). This is illustrated in fig 8.

### Table 10: Type Anesthesia given

<table>
<thead>
<tr>
<th>Type of fixation</th>
<th>Plating, n (%)</th>
<th>Nailing, n (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>36 (100.0)</td>
<td>31 (86.1)</td>
<td>0.020</td>
</tr>
<tr>
<td>Regional</td>
<td>-</td>
<td>5 (13.9)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>36 (100.0)</td>
<td>36 (100.0)</td>
<td></td>
</tr>
</tbody>
</table>

General anesthesia was administered to all patients who underwent plating. 86.1% of those who underwent open intramedullary nailing were given general anesthesia while 13.9% received regional anesthesia. There was thus a statistically significant difference in anesthesia requirements between the two groups. (p=0.020)
Table 11: Check X-rays.

<table>
<thead>
<tr>
<th>Acceptable reduction</th>
<th>Plating, n (%)</th>
<th>Nailing, n (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>36 (100.0)</td>
<td>34 (94.4)</td>
<td></td>
<td>0.151</td>
</tr>
</tbody>
</table>

The post-operative check x-rays revealed acceptable reduction in all the patients who underwent plating and in 34 (94.4%) of those who underwent open intramedullary nailing. This however was not statistically significant (p-value=0.151).

Table 12: Association between Secondary procedure and type of fixation (n = 72)

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Type of fixation</th>
<th>Plating, n (%)</th>
<th>Nailing, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-operation</td>
<td>1 (2.8)</td>
<td>1 (2.8)</td>
<td></td>
</tr>
<tr>
<td>Implant removal</td>
<td>1 (2.8)</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Bone grafting</td>
<td>6 (16.7)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Incision and drainage</td>
<td>-</td>
<td>1 (2.8)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8 (22.3)</td>
<td>2 (5.6)</td>
<td></td>
</tr>
</tbody>
</table>

6 (16.7%) of the patients who underwent plating had bone grafting done during the index operation, 1 (2.8%) was re-operated and 1 (2.8%) had the implant removed. For those who underwent intramedullary nailing, 1 (2.8%) underwent incision and drainage for deep-seated infection and 1 (2.8%) underwent re-operation. There was no statistically significant association between the secondary procedures carried out and the type of fracture fixation.

Table 13: Association between Additional Immobilization and type of fixation (n = 72)

<table>
<thead>
<tr>
<th>Immobilization</th>
<th>Type of fixation</th>
<th>Plating, n (%)</th>
<th>Nailing, n (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-rotation bars</td>
<td>-</td>
<td>4 (11.1)</td>
<td></td>
<td>0.030</td>
</tr>
<tr>
<td>Dynacast</td>
<td>3 (8.4)</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Traction</td>
<td>-</td>
<td>1 (2.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-length POP</td>
<td>2 (5.5)</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5 (13.9)</td>
<td>5 (13.9)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4 (11.1%) of patients who underwent open intramedullary nailing required anti-rotation bars post-operatively to maintain reduction. None of those who underwent plating had an anti-rotation bar post-operatively. The other additional immobilization techniques used are as shown in table 13.
Table 14: Association between weight bearing and type of fixation (n = 72)

<table>
<thead>
<tr>
<th>Time in Weeks</th>
<th>Type of fixation</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plating, n (%)</td>
<td>Nailing, n (%)</td>
<td>p-value</td>
<td></td>
</tr>
<tr>
<td>Time to partial weight bearing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 - 6</td>
<td>15 (41.7)</td>
<td>3 (8.3)</td>
<td></td>
<td>0.002</td>
</tr>
<tr>
<td>7 - 8</td>
<td>15 (41.7)</td>
<td>29 (80.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 - 12</td>
<td>6 (16.9)</td>
<td>4 (11.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to full weight bearing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 - 8</td>
<td>3 (8.3)</td>
<td>4 (11.1)</td>
<td></td>
<td>0.890</td>
</tr>
<tr>
<td>9 - 12</td>
<td>27 (75.0)</td>
<td>27 (75.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;12</td>
<td>6 (16.7)</td>
<td>5 (13.9)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

30(83.4%) of patients who underwent open reduction with plate fixation of fractures had started partial weight bearing by the end of eight weeks post-operatively and by the end of twelve weeks, 30(83.3%) of them had began full weight bearing. 32(88.9%) of those who underwent open intramedullary nailing had began partial weight bearing by the end of eight weeks post operatively and 31(86.1%) of them had began full weight bearing by the end of twelve weeks post operatively.

Table 14 illustrates that those patients who underwent plating were instructed to start weight bearing at a significantly shorter post-operative time compared with those who underwent open intramedullary nailing. (p-value=0.002). However there was no significant difference in the post-operative time at which they began full weight bearing. (p-value=0.890)
Table 15: Association between Fracture Union and type of fixation (n = 72)

<table>
<thead>
<tr>
<th>Union Rate</th>
<th>Type of fixation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plating, n (%)</td>
<td>Nailing, n (%)</td>
</tr>
<tr>
<td><strong>Clinical fracture union</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 6 Weeks</td>
<td>24 (66.6%)</td>
<td>25 (69.4%)</td>
</tr>
<tr>
<td>At 12 Weeks</td>
<td>31 (86.1%)</td>
<td>32 (88.9%)</td>
</tr>
<tr>
<td>Not United at 12 weeks</td>
<td>5 (13.8%)</td>
<td>4 (11.1%)</td>
</tr>
<tr>
<td><strong>Radiological union</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 16 weeks</td>
<td>30 (83.3%)</td>
<td>31 (86.1%)</td>
</tr>
</tbody>
</table>

24(66.9%) of patients who underwent plating had achieved clinical fracture union at six weeks post-operatively compared with 25(69.4%) union rate of those who underwent open intramedullary nailing. At twelve weeks post-operatively, 86.1% of those who underwent plating had achieved clinical union compared with 88.9% of those who underwent open intramedullary nailing. There was no statistically significant difference in the clinical union rates observed at six and twelve weeks post-operatively between the two groups. (p-value=0.568)

30(83.3%) of those who underwent plating had achieved radiological union at twelve weeks post-operatively compared with 31(86.1%) of those that underwent open intramedullary nailing. The difference in the union rates was statistically not significant. (p-value=0.589)

Table 16: Association between Post-operative Hospital stay and type of fixation (n = 72)

<table>
<thead>
<tr>
<th>Hospital Stay</th>
<th>Type of fixation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plating, n (%)</td>
<td>Nailing, n (%)</td>
</tr>
<tr>
<td>Weeks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1</td>
<td>2 (5.6)</td>
<td>2 (5.6)</td>
</tr>
<tr>
<td>1–2</td>
<td>17 (47.2)</td>
<td>16 (44.4)</td>
</tr>
<tr>
<td>&gt;2–3</td>
<td>6 (16.7)</td>
<td>4 (11.1)</td>
</tr>
<tr>
<td>&gt;3</td>
<td>11 (30.6)</td>
<td>14 (38.9)</td>
</tr>
<tr>
<td>Total</td>
<td>36(100.0)</td>
<td>36(100.0)</td>
</tr>
</tbody>
</table>

There was no significant difference in the length of post-operative hospital stay period between the two groups. Most patients were discharged between the first and second week post surgery.
Table 17: Association between Intra-operative Complication and type of fixation (n = 72)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Type of fixation</th>
<th>OR (95%CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plating, n (%)</td>
<td>Nailing, n (%)</td>
<td></td>
</tr>
<tr>
<td>Haemorrhage</td>
<td>7 (19.4)</td>
<td>4 (11.1)</td>
<td>1.9 (0.51, 7.3)</td>
</tr>
<tr>
<td>Additional Comm.</td>
<td>4 (11.1)</td>
<td>2 (5.6)</td>
<td>2.1 (0.36, 12.4)</td>
</tr>
<tr>
<td>Total</td>
<td>11 (30.5)</td>
<td>6 (16.7)</td>
<td></td>
</tr>
</tbody>
</table>

7(19.4%) of patients that underwent plating had intra-operative haemorrhage that necessitated blood transfusion as compared to 4(11.1%) of those who underwent open intramedullary nailing. Thus those who underwent plating were 1.9 times more likely to require transfusion than those who underwent open intramedullary nailing.

4(11.1%) of those who underwent plating developed additional comminution intra-operatively as opposed to 2(5.6%) of those who underwent open intramedullary nailing.

Table 18: Association between Technical and Post-operative Complications and type of fixation (n = 72)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Type of fixation</th>
<th>OR (95%CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plating, n (%)</td>
<td>Nailing, n (%)</td>
<td></td>
</tr>
<tr>
<td>Haemorrhage</td>
<td>5 (13.9)</td>
<td>3 (8.3)</td>
<td>1.8 (0.39, 8.1)</td>
</tr>
<tr>
<td>Infection</td>
<td>3 (8.3)</td>
<td>3 (8.3)</td>
<td>1.0 (0.19, 5.3)</td>
</tr>
<tr>
<td>Rotational deformity</td>
<td>1 (2.8)</td>
<td>6 (16.7)</td>
<td>0.14 (0.01, 1.3)</td>
</tr>
<tr>
<td>Leg length discrepancy -</td>
<td>1 (2.8)</td>
<td>1 (2.8)</td>
<td>-</td>
</tr>
<tr>
<td>Delayed Union -</td>
<td>-</td>
<td>1 (2.8)</td>
<td>-</td>
</tr>
<tr>
<td>Implant failure -</td>
<td>1 (2.8)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Restricted range of Knee movement</td>
<td>4 (11.1)</td>
<td>2 (5.6)</td>
<td>2.1 (0.36, 12.41)</td>
</tr>
<tr>
<td>Total</td>
<td>14 (38.9)</td>
<td>16 (44.4)</td>
<td></td>
</tr>
</tbody>
</table>

The incidence of rotational deformity was statistically significantly higher in those who underwent open intramedullary nailing than in those who underwent plating (16.7% vs 2.8%)(p=0.042). The other post-operative complications are as shown in table 18.
Table 19: Association between At least an Intra-operative Complication and type of fixation (n = 72)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Plating, n (%)</th>
<th>Nailing, n (%)</th>
<th>OR (95%CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>10 (27.8)</td>
<td>6 (16.7)</td>
<td>1.92 (0.62, 6.12)</td>
<td>0.257</td>
</tr>
<tr>
<td>No</td>
<td>26 (72.2)</td>
<td>30 (83.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>36(100.0)</td>
<td>36(100.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The overall intra-operative complication rates were 27.8% in those who underwent plating and 16.7% in those who underwent open intramedullary nailing. The difference was not statistically significant. (p-value=0.257).

Table 20: Association between At least a post operative Complication and type of fixation (n = 72)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Plating, n (%)</th>
<th>Nailing, n (%)</th>
<th>OR (95%CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>11 (30.6)</td>
<td>13 (36.1)</td>
<td>0.78 (0.27, 2.08)</td>
<td>0.617</td>
</tr>
<tr>
<td>No</td>
<td>25 (69.4)</td>
<td>23 (63.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>36(100.0)</td>
<td>36(100.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The overall rate of post-operative complications was 13(36.6%) in those who underwent open intramedullary nailing and 11(30.6%) in those who underwent plating. The difference was not statistically significant. (p-value=0.617)
### Table 21: Association between rate of union and other factors (n = 72)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Clinical union at 6 weeks</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes, n (%)</td>
<td>No, n (%)</td>
</tr>
<tr>
<td><strong>Additional Immobilization</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>7 (10.1)</td>
</tr>
<tr>
<td>No</td>
<td>3 (100.0)</td>
<td>62 (89.9)</td>
</tr>
<tr>
<td><strong>Partial Weight bearing (in wks)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 - 6</td>
<td>1 (33.3)</td>
<td>17 (24.6)</td>
</tr>
<tr>
<td>&gt; 6 - 8</td>
<td>2 (66.7)</td>
<td>42 (60.9)</td>
</tr>
<tr>
<td>&gt; 8</td>
<td></td>
<td>10 (14.5)</td>
</tr>
<tr>
<td><strong>Full Weight bearing (in wks)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 - 8</td>
<td>2 (66.7)</td>
<td>5 (7.2)</td>
</tr>
<tr>
<td>&gt; 8 - 12</td>
<td>1 (33.3)</td>
<td>3 (37.5)</td>
</tr>
<tr>
<td>&gt; 12</td>
<td></td>
<td>11 (15.9)</td>
</tr>
</tbody>
</table>

Table 21 illustrates the relationship between the statistically significant different variables between the two groups and the clinical union rates at six weeks post fracture fixation.
Table 22: Association between of rate union and other factors (n = 72)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Clinical union at 12 weeks</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes, n (%)</td>
<td>No, n (%)</td>
<td></td>
<td></td>
<td>p-value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional Immobilization.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>6 (9.4)</td>
<td>1 (12.5)</td>
<td></td>
<td></td>
<td></td>
<td>0.778</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>58 (90.6)</td>
<td>7 (87.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial Weight bearing (in wks)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 - 6</td>
<td>16 (25.0)</td>
<td>2 (25.0)</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 6 - 8</td>
<td>43 (67.2)</td>
<td>1 (12.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-16</td>
<td>5 (7.8)</td>
<td>5 (62.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Weight bearing (in wks)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 - 8</td>
<td>6 (9.4)</td>
<td>1 (12.5)</td>
<td></td>
<td></td>
<td></td>
<td>0.012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 8 - 12</td>
<td>51 (79.7)</td>
<td>3 (37.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 12</td>
<td>7 (10.9)</td>
<td>4 (50.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 22 shows the relationship between the statistically significant different variables between the two groups and the clinical union rates at twelve weeks.

Table 23: Association between rate of union and other factors (n = 72)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Radiological union at 12 weeks</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes, n (%)</td>
<td>No, n (%)</td>
<td></td>
<td></td>
<td>p-value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional Immobilization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>2 (13.3)</td>
<td>5 (8.8)</td>
<td></td>
<td></td>
<td></td>
<td>0.596</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>13 (86.7)</td>
<td>52 (91.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial Weight bearing (in wks)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 - 6</td>
<td>2 (13.3)</td>
<td>16 (28.1)</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 6 - 8</td>
<td>5 (33.3)</td>
<td>39 (68.4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-12</td>
<td>8 (53.3)</td>
<td>2 (3.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Weight bearing (in wks)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 - 8</td>
<td>2 (13.3)</td>
<td>5 (8.8)</td>
<td></td>
<td></td>
<td></td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 8 - 12</td>
<td>6 (40.0)</td>
<td>48 (84.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 12</td>
<td>7 (46.7)</td>
<td>4 (7.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 23 illustrates the relationship between the statistically significant different variables in the two groups and the radiological union rates at twelve weeks post operatively.
Table 24: Cost estimation

<table>
<thead>
<tr>
<th>Charges</th>
<th>Rate</th>
<th>Open Intramedullary Nailing</th>
<th>Plating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>K-Nail (KSh)</td>
<td>Interlocking Nail(KSh)</td>
</tr>
<tr>
<td>Implant</td>
<td>-</td>
<td>10,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Theatre</td>
<td>-</td>
<td>5,500</td>
<td>5,500</td>
</tr>
<tr>
<td>Nursing</td>
<td>@Sh.30 per day</td>
<td>516.67</td>
<td>490</td>
</tr>
<tr>
<td>Bed</td>
<td>@Sh.450 per day</td>
<td>7750</td>
<td>7350</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>@Sh.145 per day</td>
<td>2497.22</td>
<td>2368.30</td>
</tr>
<tr>
<td>X-ray</td>
<td>@Sh1,000 x 4</td>
<td>4,000</td>
<td>4000</td>
</tr>
<tr>
<td>Physiotherapy</td>
<td>@Sh. 450 per session x 3</td>
<td>1350</td>
<td>1350</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>KSh. 31613.00</td>
<td>KSh. 46,058.30</td>
</tr>
</tbody>
</table>
11. DISCUSSION

Socio-demographic data

In this study, males predominated in both those patients who underwent open intramedullary nailing and in those who underwent open reduction and plating of the femoral diaphysis accounting for 77.7% and 86.6% respectively. Females accounted for only 22.2% and 13.9% of those who underwent open intramedullary nailing and plating respectively. This was in concordance with other studies that revealed the predominance of males with femoral diaphyseal fractures over females. (Kootstra,[12] John Rampai Malibo.[76])

The mean age of the participants was 33.9 years. This was older than that reported by John Ramped Malibu [76] of 21 years and younger than that reported by AA Loosened [77] in Nigeria of 35 years as being the mean age for patients who sustain femoral diaphyseal fractures.

The average body mass index (BMI) of the participants was 22.29 (std = 2.35) for those who underwent plating and 23.49 (std = 4.10) for those who underwent open intramedullary nailing. This was within normal range and did not have a statistically significant effect on the rates of union obtained. Ostrum, Agarwal et al studied intramedulary nailing of fractures of the femoral shaft and reported an average BMI of 24.6 in their study population [5]. This does not differ significantly from that of the patients in our population.

Majority of the participants in this study were self-employed with a few professionals and businessmen also participating. In John Rampai Malibo’s 1982 study a significant number of the female participants were housewives [76]. The economic impact of femoral diaphyseal fractures fixed by either method cannot be overemphasized. A higher overall cost will impact negatively on the patients bearing in mind that majority of them are low-income earners as depicted in table 4. The participants were found to be in the economically active age group with a number of dependants and therefore a method of fracture fixation that will get them back to work with minimal cost would be most preferred.

Fracture aetiology

Demetriades studied femoral diaphyseal fractures and found out that most of them were caused by high-energy injuries by motor vehicle accidents, motorcycle accidents and fall from heights more than 4 metres. [43] John Rampai Malibo’s 1982 study revealed that 92% of fractures were caused by road traffic accidents. He showed that traffic accidents are responsible for up to 92% of all femoral fractures. The remaining fractures consist of those due to occupational injuries and domestic accidents. [76]
Table II: aetiology of femoral shaft fractures (John Rampai Malibo 1982)*

<table>
<thead>
<tr>
<th>Cause</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTA</td>
<td>99</td>
<td>92%</td>
</tr>
<tr>
<td>Fall from height</td>
<td>6</td>
<td>5.5%</td>
</tr>
<tr>
<td>Assault</td>
<td>2</td>
<td>1.6%</td>
</tr>
<tr>
<td>Sport injuries</td>
<td>1</td>
<td>0.9%</td>
</tr>
</tbody>
</table>

In the present study motorvehicle accidents accounted for 10(27.8%) of those treated by plating and for 13(36.1%) of those treated by open intramedullary nailing. Fractures caused by pedestrian being struck by motorvehicle accidents accounted for 15(41.7%) and for 8(22.2%) of those who underwent plating and open intramedullary nailing respectively. This shows that road traffic accidents still remain the leading cause of femoral diaphyseal fractures treated by either methods at KNH followed by a fall from heights.

Fracture location

Motor vehicle accidents caused 8(44.4%) fractures in the proximal third, 13(32.5%) in the middle third and 2(14.2%) in the distal third of the femoral diaphysis. 16(40%) of fractures caused by pedestrian versus motor vehicle accidents occurred in the middle third, 4(28.6%) occurred in the distal third and 3(16.7%) occurred in the proximal third. This is in concordance with earlier studies that had shown preponderance of motor vehicle accidents in general causing more fractures in the middle third of the femoral diaphysis.

The predilection of femoral diaphyseal fractures is 53.1% to the right femur and 46.9% to the left femur. Kootstra did not find any significant difference in this predilection.

In the present study, the predilection of femoral diaphyseal fractures to the right femur was evident in 62% of the patients as opposed to 37% on the left femur.

According to Dencker, the most common fracture location was the middle third of the femoral shaft accounting for 60% of all fractures. According to Rampai Malibo the middle third accounted for 63% of the fractures with the upper third and lower third accounting for 28% and 8.1% respectively.

Fracture Geometry

16(45%) of the fractures treated by plating in the present study were comminuted, 9(25%) were spiral, 6(16.67%) were oblique and 5(9.44%) were transverse. Those treated by intramedullary nailing consisted of 14(38.9%) transverse, 13(38.1%) comminuted, 6(16.67%) oblique and 3(8.3%) spiral. Although simple Kuntscher nailing has been recommended for treatment of simple transverse and short oblique femoral diaphyseal
fractures, the present study did not find any statistically significant difference in the number of transverse and oblique fractures treated by open intramedullary nailing and plating (p-value 0.056). This can be explained by the fact that interlocking nails were used in 3 (8.3%) of the total open intramedullary nailing done and this increased the level of significance to greater than 0.005.

The geometry of the fractures was transverse in 32% of patients, comminuted in 19.1%, and spiral in 9.7% according to the Kootstra study [12].

Pedestrian versus motor vehicle accidents and motor vehicle accidents result in transverse fractures because of direct impact to the shaft or indirect force transmitted through the knee subjecting the femur to high bending load. Motorcycle accidents result in comminuted fractures while gunshot wounds create spiral or comminuted fractures [13].

Motor-vehicle accidents caused 11 (37.9%) comminuted fractures, 6 (31.6%) transverse fractures, 3 (25%) spiral fractures and 3 (25%) oblique fractures in this study. Comminuted fractures require a large amount of force to occur and their preponderance in motor vehicle accidents clearly supports this.

Segmental comminution resulted from motor-vehicle accidents in 66% of the cases and fall from a height in 33.3% of cases further elucidating the fact that a large amount of force is required to produce severe comminution.

Transverse fractures result from bending loads applied to bone [25,27]. In this study most of the transverse fractures resulted from pedestrians being struck by motor vehicles, fall from heights and from osteoporosis. A normal adult femoral shaft fractures after 250Nm of bending moment. [32]

Torsion (torque or twisting) causes spiral fractures with long, sharp, pointed ends and a soft tissue hinge on the vertical segment. [27] The course of the spiral is determined by the shearing stress or tension. The spiral curves around the shaft at an angle of 40-45° with the long axis of bone in a direction that would allow the portion of the bone under stress to open up. [27]

Moderate axial compression combined with bending and torsion causes oblique fractures with short and blunt fracture ends without vertical segment. [25,27]

Moderate axial compression together with bending result in oblique transverse (a transverse fracture with one fragment containing a protuberance or beak) or butterfly fractures (a bending wedge on a compression side) by interruptions of continuity in two directions. The soft tissue hinge is on the concave side of the butterfly, where the compressive stresses produce an oblique fracture line due to shearing stresses [12]. The fracture is transverse when the oblique segment of the oblique transverse fracture is very short.
Oblique-transverse and butterfly fractures are seen commonly in the lower extremity when the thigh or calf receives a lateral blow during weight bearing, among pedestrians injured by automobiles.[27]

**Concomitant injuries.**

Kootstra study revealed that the general associated injuries with diaphyseal femur fractures were 45%. Craniocerebral injuries accounted for 2.7% to 10.9% of the associated injuries[12]. John Rampai Malibo found out that 27.5% of patients who underwent intramedullary nailing had associated head injury[76]. In the present study, 36.1% of patients who underwent plating and 27.85% of those who underwent open intramedullary nailing had associated head injuries.

Although no statistically significant difference existed in the associated injuries observed in the present study, their presence will continue to play a role in determining the method of fracture fixation chosen. For instance, prolonged operating times have been found to be detrimental in patients undergoing fracture fixation when they have associated head injury. Therefore a method that will get them off the operating table soonest will be preferable.

The literature reports that femoral artery injuries are associated with femoral diaphyseal fractures in 2% of cases and that the profunda femoris artery is liable to injury in intramedullary nailing [78,79]. In the present comparative series, vascular injury with shock was found in 13.9% of patients who underwent plating and in 2.8% of those who underwent open intramedullary nailing. However, no femoral artery or profunda femoris artery injury during fracture fixation was encountered.

In this study, only one patient had associated blunt abdominal injury that required laparotomy was found. He underwent open intramedullary nailing.

Dencker reported that 12.1% of femoral diaphyseal fractures were associated with facial fractures.[11] In the current study only 2.8% of the patients had an associated facial fracture and this patient underwent plating of the femoral diaphysis. 2(5.4%) patients had dental injuries, 5(13.9%) had associated soft tissue injuries in those patients who underwent plating and 8(21.2%) soft tissue injuries were encountered in those who underwent open intramedullary nailing. Genitourinary trauma was encountered in 2(5.6%) of the patients who underwent plating.

Skeletal injuries accounted for 47.1% and 33.3% of associated injuries in those who underwent plating and intramedullary nailing respectively in this study. Various authors have revealed varied percentages of other injuries associated with femoral shaft fractures.

Thoracic injury is associated with femoral shaft fracture in 6.7%, upper limbs in 5.8%, forearm/hand injuries in 9.7%, and bilateral femoral fracture in 1.8%[12].
Hip dislocation accounts for 0.3%, acetabular fractures 1.5% and femoral neck or pertronchateric fractures 3.4% of femoral shaft fractures.\textsuperscript{112}

Floating hip (ipsilateral pelvis and femoral shaft fractures) is associated with other skeletal fractures or polytrauma. The incidence of these fractures varies from 6.7% to 13%-22%.\textsuperscript{112}

The incidence of ipsilateral tibia fractures varies from 0.5-10.9%\textsuperscript{11,12}\textsuperscript{111,12}\textsuperscript{80}. Meniscal injuries associated with femoral shaft fractures vary from 27-38\%.\textsuperscript{80} Ipsilateral injury to the knee ligament occur in 17-48% of femoral shaft fractures.

Other ipsilateral knee injuries associated with closed femoral fracture injuries demonstrated by MRI include knee effusion 97%, tears of the patella or quadriiceps tendons in 9%, bone bruises in 22%, fractures of patella in 1.7% and fractures of the tibia plateau in 3%. Articular changes or chondromalacia of the ipsilateral knee occur in 50-53% of patients with femoral shaft fractures.\textsuperscript{81}

**Diagnosis of the femoral diaphysis fractures**

As expected, plain radiographs confirmed the femoral diaphyseal fractures in all the patients in both study groups. One patient with a pathological fracture due to suspected metastatic breast cancer had a scintigraphic scan that confirmed presence of metastatic bone lesions. One patient with associated head injury had a head CT scan done although this was not necessary for the diagnosis of the fracture. None of the patients had indications for angiography or MRI.

As part of the pre-operative work up, all the patients in the current study had a hemogram obtained together with urea, electrolytes and creatinine levels. Two patients who developed deep-seated infections among those who had plating had pus swabs taken for microscopy culture and sensitivity.

**Medical treatment**

All the patients had analgesics either before or after surgery for management of pain. The analgesics of choice in this study were found to be NSAIDS and opioids. One patient was however found to be allergic to opioids. Penicillins were found to be the antibiotics in common use. Flagyl, cephalosporins and aminoglycosides were also antibiotics commonly used.

In concordance with other studies blood transfusion requirements were found to be higher in those patients who underwent plating than in those patients who underwent open intramedullary nailing. Those who underwent plating were 1.86 times more likely to receive blood transfusion than those who underwent open intramedullary nailing.

24(66.7%) of patients who underwent plating received tetanus toxoid compared with 26(72.2%) of those who underwent open intramedullary nailing. All patients with open
fractures received the toxoid as did all the others with open wounds or tissue injuries. This was in keeping with the established protocol of open wound treatment.

**Timing of surgical stabilization**

B. Pahud and H. Vasey in a review of 402 fractures of the femoral shaft of which 228 closed and 37 open fractures had been stabilized by plating and 55 by intramedullary nailing did not find any significant difference in healing between those stabilized early and those having delayed internal fixation. They also did not find any correlation between delay before operation and the incidence of post-operative infection.\(^{82}\)

Similarly Abrahan, Lauro in a review of results of delayed intramedullary nailing of fractures concluded that open intramedullary nailing in delayed setting is still a viable option. He found out that those fractures that remained untreated beyond 3 weeks posed a big challenge in management.\(^{83}\). In the present study patients who underwent plating were operated averagely on the 25th day (range 2-120 days) and those who underwent intramedullary nailing were operated averagely on the 20th day (range 11-83 days). This did not represent any statistically significant difference in the delay before operation \(p=0.696\) and neither did the delay affect the union rates.

On the contrary Bone et al on a prospective randomized study consisting of 178 patients followed over a two year study period concluded that delayed fixation increases the length of ICU stay and the incidence of adult respiratory distress syndrome. Early fixation promotes primary long bone osteosynthesis, eliminates cases of fat embolism syndrome and promotes earlier patient mobilization.\(^{84}\)

**Operative time**

A shorter time spent in the operating room by the patient is desirable as not only does it reduce the rate of intra-operative complications but also saves theatre time and reduces the overall theatre charges to the patient. The present study reveals that the operative time for open intramedullary nailing was significantly shorter than that for plating. However this difference did not affect the union rates between the two groups.

**Length of incision**

The desire to have smaller and cosmetically acceptable incisions together with the desire to have minimal tissue disturbance around the fracture calls for a paradigm shift towards minimally invasive surgeries. It is therefore an important note that the mean length of incision for open intramedullary nailing was found to be statistically significantly shorter compared to the incision for plating by 10.48 cm \(p<0.001\). However, no statistically significant difference was noted between the length of incision and the union rates observed.
Anaesthesia requirements

100% the patients who underwent plating required general anaesthesia as opposed to those who underwent open intramedullary nailing. Due to the significantly shorter operative times with open intramedullary nailing, it can be done under regional anaesthesia.

Secondary procedures

In the present study, primary bone grafting was carried out in 16.7% of patients who underwent plating as opposed to none in those who underwent open intramedullary nailing. In other studies, the rate of primary bone grafting has been reported to be between 4%-30%.[73] Bone grafting is contraindicated if soft tissue dissection is necessary to allow placement of the graft. However older studies had recommended routine bone grafting.[73] The rate of re-operations was low in the present study. 1(2.8%) of patients who underwent open intramedullary nailing required re-operation to readjust the length of the nail outside the bone to relieve hip pain. 1(2.8%) patient in the open intramedullary nailing group underwent incision and drainage for deep seated infection.

Additional immobilization techniques

The current study indicates that the practice of simple Kuntscher nailing needs more additional immobilization techniques to maintain reduction as compared with plating. Anti-rotation bars were used post-operatively in 4(11.1%) of those who underwent open intramedullary nailing while it was used in none of those who underwent plating.

Skeletal traction was used in 1(2.8%) of those who underwent open intramedullary nailing. Full length PoP was used in 5(5.5%) of those that underwent plating and none in those that underwent open intramedullary nailing. Use of plate and screws provides a more stable construct compared to simple Kuntscher nailing. However use of proximal and distal locking techniques in open intramedullary nailing provides the optimal fracture stability construct that results in good healing. It also allows for dynamization at the fracture site that promotes healing.

The use of external immobilization casts and even traction are other options available to the surgeon to stabilize an unstable construct.

Fracture union

The goals of all fracture management are an acceptable and lasting functional recovery within a reasonable time considering the severity of injury, the degree of anatomic restoration and duration of bony consolidation. In the present study the clinical fracture union rate in those patients who underwent open intramedullary nailing was 25(69.4%) and for those who underwent open reduction with plate fixation was 24(66.6%) at the end of six weeks post operatively.
At the end of twelve weeks post fracture fixation, 81.1% of those fractures treated by plating had clinically united compared with 88.9% of union rates observed in those who underwent open intramedullary nailing.

At the end of twelve weeks post-operatively, 83.3% radiological union rates were observed in those who underwent plating compared with to 86.1% obtained in those who had undergone open intramedullary nailing.

Magerl et al 1979, Ruedi and Luscher 1979, Sprenger 1983 reported the overall fracture union rate to be between 90 % to 95% with plate fixation achieved at an average of 17.2 weeks. [71]

The rate of union of femoral shaft fractures treated by interlocked nailing has been reported to be between 97% -100%

Anastopoulos et al studied midshaft fractures of the femur in 1993 and reported that they heal both clinically and radiographically within 12-24 weeks after closed nailing. [85]

Bostmann et al in 1989 reported a union rate of 75% in femoral shaft fractures treated by either open intramedullary nailing or by plate fixation. [91]

Non-reaming of the femoral shaft preserves blood supply to the cortex as opposed to reaming that disrupts this supply and can delay fracture healing. [20,86] Earlier studies on blood circulation of long bones fractures treated by intramedullary nailing revealed that this affects the intramedullary vascular system. Intramedullary reaming causes additional destruction of the endosteal circulation of a long bone. [86 87,88]

Unreamed nailing diminishes the circulation of the inner cortex by 30%. [86,88] Extensive reaming may reduce the cortical blood flow by 30-70% and total bone blood flow by up to 50%. [86] Blood flow increases 6-fold after reaming. In the current study, the patients who underwent open intramedullary nailing of the femur had reaming of their femoral canal.

Complications

Although the acute treatment of femoral shaft fractures with open reduction and internal fixation result in high union rates, treatment failures do occur and can be devastating to the patient. [68,89]

Intra-operative complications

In the present study, intra-operative haemorrhage necessitating blood transfusion was more commonly encountered in those patients who underwent plating than in those who underwent open intramedullary nailing. This is due to the fact that plating required more
extensive tissue dissection, longer incisions, and longer operative times as compared to open intramedullary nailing.

As opposed to earlier studies, additional comminution of the fracture was encountered more in those patients who underwent plating than in those who underwent open intramedullary nailing (11.1% vs 5.6%).

Technical difficulties can be created by malalignment, eccentric reaming, pre-existing deformity of the femur and previous nailing. In the present comparative series, rotational deformity was encountered in 1 (2.8%) of those who underwent plating and in 6 (16.7%) of those who underwent open intramedullary nailing.

The incidence of mechanical failure of fixation in intramedullary nailing and plate fixation has been 7.1% including intra-operative additional splitting of the femur.

Technical errors have been reported to occur in 14% of the cases. They include too short nails, too thin nail, impaction, nail perforation through the proximal or distal fragments into the knee joint, splitting the femur and nailing in diastasis.

The reported rate of mortality related to either plating or open intramedullary nailing has varied from 0.2% to 2.2%. Polytrauma patients have higher mortality rate.

In the present comparative series, no mortality was encountered.

The overall intra-operative complications were 27.8% in those who underwent plating as opposed to 16.7% in those who underwent open intramedullary nailing.

**Post-operative complications**

Respiratory failure occurs due to adult respiratory distress, fat embolism, air embolism, pulmonary embolism or pneumonia. The probability of respiratory failure occurring increases in multiple intramedullary nailing procedures to 33%.

Thromboembolic complications vary from 5% to 10%. In elderly patients this is higher. Kootstra reported a 25% rate in 1973. Fat embolism occurs in 2 to 23% of patients with isolated femur fractures. In the present study these were not encountered.

The rate of postoperative haemorrhage necessitating frequent change of dressings was 13.9% in those who underwent plating compared to 8.3% in those who underwent open intramedullary nailing (p = 0.452).

The overall prevalence of infection has been 3% and that of osteomyelitis 0.4%. Onche and O. Adedeji study in Nigeria revealed infection rate of 7.5%. The commonest organism isolated were staphylococcus in 44%, Bacteroides fragilis 11%, Escherichia coli 11%, proteus 11%. Others included pseudomonas, klebsiella, and peptostreptococcus. Cephalosporin were found to be the most effective against staphylococcus aureus while anaerobes responded to metronidazole.
The overall rate of infection after open intramedullary nailing has been between 1.7% to 9%-12% and 14% after non-interlocking open intramedullary nailing with additional cerclage wiring. [93]

The prevalence of infection is related to the technique of fracture treatment and has earlier been 6% in operations of closed fractures [11]. The overall infection rate after open intramedullary nailing has been reported to be 9-12% and 14% in open intramedullary nailing with additional cerclage wiring [93].

In a study of 1950 femoral shaft intramedullary nailing by Chapman et al, the deep infection rate averaged 3.5% of cases. [20]. In closed nailing infection rate have been lower.

The rate of infection in plate fixation has varied from 0.7% to 1% mainly 2-6% of the reported cases [94]. The factors contributing to infection include additional cerclage wiring in closed nailing of comminuted fractures, fractures with gross contamination, exposed bone and extensive soft tissue necrosis [9].

The current study revealed the infection rate to be 8.3% in both open intramedullary nailing and plate fixation. Only 1(2.8%) developed deep-seated infection that necessitated incision and drainage of pus in the open intramedullary nailing group. There was no incidence of osteomyelitis encountered.

The rate of implant failure was 2.8% in those who underwent plating in the current study. None of those patients who underwent open intramedullary nailing had implant failure. Failure of plate fixation has occurred in 5%-10% of reported cases. [83].

Rate of uninfected early loosening of the plate has been 12% in the plated femoral shaft fractures [91]

Plastic deformation (bending) and fatigue failure after intramedullary nailing of femoral shaft are usually associated with small diameter nails of 10mm or less, with nail insertion through tight, narrow canal or with loading of the leg before fracture union. [13] According to Denker, bending of the intramedullary nail occurred in 16% during the first two to four months after intramedullary nailing of femoral shaft fractures. The nail broke in 2% of treated femoral shaft fractures [11].

Bostman et al and Bucholz and Brumback 1996 showed that load shielding implants like plates are prone to failure more often than load sharing implants like nails [13,9]. The present study validates these findings. One patient who had a broken plate in this study however did not have a significant impact on the progress of the fracture healing as it occurred after fracture healing had taken place and the patient went on to have radiological union without exchange of implant.

The incidence of restricted range of knee movement was encountered in 4(11.1%) of those who underwent plating and in 2(5.6%) occurred in those who underwent open
intramedullary nailing. These rates are lower than those reported in the literature. Plate fixation of femoral shaft fractures results in 20-30% of knee stiffness attributed to excessive scarring of the quadriceps muscles. The other post-operative complications reported in the literature but not encountered in this study include mal-union, delayed union, nonunion, and heterotopic bone formation.

Delayed union is said to be present if there is no callus formation at 12 weeks post fracture stabilization. The rate of delayed union has been 1.6%. According to Dencker’s study, delayed union following plate fixation was 5% and that following intramedullary nailing was 12-15%. Delayed union was reported by Dencker to be 18-21% in the treatment of comminuted fractures.

Nonunion of femoral shaft fractures is defined as failure to obtain clinical union at 8 to 9 months following fixation. It is characterized by pain in the preceding months and inability to continue with physical therapy or resume basic activities such as prolonged walking. It signifies a condition, which will not proceed to union without active measures being undertaken.

Nonunion are categorized as hypertrophy, normotrophic (oligotrophic) or atrophic. Hypertrophic nonunions present radiographically with abundant callus but a persistent radiolucent line at the fracture site exists. Normotrophic nonunion has minimal callus but relatively normal bone ends with no resorption. Atrophic nonunion are characterized by absence of callus, resorption of bone ends and a significant fracture gap. The presence or absence of callus is related to local potency of blood supply, the availability of stem cells and growth factors.

Factors predisposing to delayed union and non-union include open fractures, extensive operative stripping of soft tissues around the fracture site in plate fixation, inadequate stabilization in intramedullary nailing and diastesis. Nonunion without callus have impaired biology which result from severe open fractures, infections or systemic disease.

Aseptic nonunions have been reported to be less than 1%, 1-2% or 2-5% depending on the method used.

The reported nonunion rate has been 14% with plating, 0.8% in closed intramedullary nailing and 22% in open non-interlocking intramedullary nailing. In open intramedullary nailing the nonunion rate has been 5% with open fractures. In Chapman’s’ study of 1950 femoral shaft fractures treated by open nailing, the nonunion rate averaged 2.1%.

Reported malunion rates vary from 5% with closed intramedullary nailing to 11% of the nailed fractures and 6.9% of the plated fracture. Malunion leads to abnormal gait, limb- length discrepancy and posttraumatic arthritis of the knee. There can be angular or torsional malunion.
The reported frequency of femoral shortening has been 4.1% [91]. It occurs more commonly in simple nailing or dynamic nailing of unstable fracture patterns in oblique or comminuted fractures [40]. Shortening of 1-1.5 cm is compatible with good function while in 1.3% of fracture; it is greater than 2 cm [91].

Heterotopic bone formation has been reported to occur at the abductor region of the hip after reaming and intramedullary nailing. Kuntscher reported this to be low [95]. Miller et al reported this to be up to 20% cases of closed nailing [96]. Kuntscher suggested that this is caused by prominence of the proximal part of the nail, and significant hematoma [95].

Acute compartment syndrome is relatively infrequent due to capacity of the three compartments of the thigh to accommodate high volumes of blood.

In the present study, the overall rate of post operative complications were higher in those patients who underwent open intramedullary nailing than those who underwent open reduction with plate fixation although this was not statistically significant. (36.6% vs 30.6%) (p-value 0.617.)

In the literature the frequency of local complications in femoral shaft fractures has been 24% when treated with open intramedullary nailing and has varied between 10% and 36% when treated with plate fixation [91].

**Cost estimation**

The average cost of plating was found to be Ksh. 48,017.00 while the average cost of simple Kuntscher nailing was found to be Ksh 31,613.00. The average cost of interlocked nailing was found to be Ksh. 46,058.00. Open intramedullary nailing was therefore found to be relatively cheaper to the patient compared with plate fixation.
Both open intramedullary nailing and plate fixation of femoral diaphyseal fractures offers high union rates for femoral diaphyseal fractures. However open intramedullary nailing offers the advantages of having shorter operative times, smaller and therefore cosmetically better incisions, can be done under regional anaesthesia and has less intra-operative complications compared with open reduction with plate fixation. In addition open intramedullary nailing has less blood transfusion requirements than plating.

The disadvantage of open intramedullary nailing compared with plate fixation is that it has poor rotational control and therefore requires more additional immobilization techniques.

There is no statistically significant difference in union rates of femoral diaphyseal fractures treated by either open intramedullary nailing or by plate fixation at Kenyatta National Hospital at twelve weeks post fracture fixation. However, studies with long term follow up of patients are needed to further elucidate the relationship in outcomes between these two methods of femoral diaphyseal fracture fixation.
13. RECOMMENDATIONS

1. Both open intramedullary nailing and plate fixation of femoral diaphyseal fractures are still relevant methods of fracture fixation in set ups with limited resources.

2. In instances where general anaesthesia is not desirable, then open intramedullary nailing is better method of fracture fixation than plate fixation in femoral diaphyseal fracture management as regional anaesthesia is a valid option.

3. Open intramedullary nailing of femoral diaphyseal fractures is preferable to plating in instances where cosmesis is desirable as it provides a cosmetically smaller incision.

4. In instances where blood transfusion is undesirable for instance by choice of the patient due to religious beliefs or shortage of blood, then open intramedullary nailing is preferable to plate fixation.
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ANNEX II

LIST OF ABBREVIATIONS

AO
Arbeitsgemeinschaft fur Osteosynthesefragen

Acc
Accident

ARDS
Adult respiratory distress syndrome

ASIF
Association for Study of Internal Fixation

BMI
Body Mass Index.

Ca
Calcium

CI
Confidence interval

Clin
Clinical.

CM
Centimeter.

CNS
Central Nervous System.

Comm.
Comminution

CT Scan
Computerised Tomography Scan.

DEC
December.

Feb
February.

Hrs
Hours.

ICU
Intensive Care Unit.

ISS
Injury Severity Score.

J
Journal.

Kg
Kilogram.

KNH
Kenyatta National Hospital.

K-nail
Kuntscher Nail

K-Wire
Kirschner Wire

Mm
Millimeter

MRI
Magnetic Resonance Imaging

MVA
Motor-vehicle accident

Nm
Newton metres.

Nov
November
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>NSAIDS</td>
<td>Nonsteroidal anti inflammatory drugs</td>
</tr>
<tr>
<td>NO</td>
<td>Number</td>
</tr>
<tr>
<td>Oct</td>
<td>October</td>
</tr>
<tr>
<td>OH</td>
<td>Hydroxide</td>
</tr>
<tr>
<td>OR</td>
<td>Odds ratio</td>
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<tr>
<td>Orif</td>
<td>Open reduction and internal fixation</td>
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<tr>
<td>Orthop</td>
<td>Orthopaedics</td>
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<tr>
<td>Paed</td>
<td>Paediatrics</td>
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<tr>
<td>PO₄</td>
<td>Phosphate</td>
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<tr>
<td>POP</td>
<td>Plaster of Paris</td>
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<tr>
<td>Post op</td>
<td>Post operative</td>
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<tr>
<td>Sh</td>
<td>Shilling</td>
</tr>
<tr>
<td>SHO</td>
<td>Senior house officer</td>
</tr>
<tr>
<td>SPSS</td>
<td>Statistical package for social sciences</td>
</tr>
<tr>
<td>Std</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>Tech</td>
<td>Techniques</td>
</tr>
<tr>
<td>UON</td>
<td>University of Nairobi</td>
</tr>
<tr>
<td>Vol</td>
<td>Volume</td>
</tr>
</tbody>
</table>
ANNEX III

CONSENT FORM

STUDY TITLE: PROSPECTIVE COMPARISON OF OPEN INTRAMEDULLARY NAILING AND PLATE FIXATION OF FEMORAL DIAPHYSEAL FRACTURES AT KENYATTA NATIONAL HOSPITAL.

The objective of this study is to prospectively compare the outcomes of femoral diaphyseal fractures treated by open intramedullary nailing and those treated by plate fixation. Approval of the study has been obtained from the ethical committee of Kenyatta National Hospital. No treatment shall be withheld from any participant for purposes of the study and all the information obtained from all the participants shall be kept private and confidential. Moreover, participation in the study is on a voluntary basis.

I ..................................................... Of ......................................................... having been explained to the nature and effect of the above study, hereby voluntarily agree to participate in it.

Date ....................................... Signed ....................................................

Contact address .................................................................

Telephone Number .............................................................

I confirm that I have explained the nature and effect of the above study to the participant.

Date ................................................. Signed ...........................................

Name Dr. Josepha Anyega Ombaye

Contact Address P.O BOX 12197-00100 NAIROBI.
Telephone Number: 0720-701832
ANNEX V

DATA EXTRACTION SHEET

SERIAL NO- - - - - - - - - - - - -

PROSPECTIVE COMPARISON OF OPEN INTRAMEDULLARY NAILING AND PLATE FIXATION OF FEMORAL DIAPHYSEAL FRACTURES AT KNH.

**SOCIODEMOGRAPHIC DATA**

<table>
<thead>
<tr>
<th>Tick (✓)</th>
<th>Appropriately</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. NAME</td>
<td>---------------</td>
</tr>
<tr>
<td>2. AGE</td>
<td>---------------</td>
</tr>
<tr>
<td>3. SEX</td>
<td>---------------</td>
</tr>
<tr>
<td>4. WT (kg)</td>
<td>---------------</td>
</tr>
<tr>
<td>5. HEIGHT (cm)</td>
<td>---------------</td>
</tr>
<tr>
<td>6. INPATIENT NUMBER</td>
<td>---------------</td>
</tr>
</tbody>
</table>
| 7. OCCUPATION | Professional | □
| | Businessman | □
| | Self employed | □
| | Other [specify] | ---------------|
8. NET ANNUAL INCOME [SH]

- <1000
- 1000-10000
- 10,000-20,000
- 20,000-100,000
- >100,000

9. NUMBER OF DEPENDANTS

- NONE
- 1-5
- 5-10
- 10-15
- 16-20
- >20

10. FRACTURE

[i] AETIOLOGY:

- Motor vehicle Accident
- Pedestrian vs motor vehicle accident
- Cyclist vs motor vehicle accident
- Fall from a height
- Gunshot
- Stress fracture
- Metabolic bone disease
- Metastatic disease
- Osteoporosis

Other[specify]..............................................
II Location

Proximal 1/3

Distal 1/3

Middle 1/3

III Classification

Open

Closed

IV Geometry

Transverse

Spiral

Oblique

Comminuted

V Communion According to Winquist-Hansen Classification

0 - No comminution, simple transverse or oblique

I - Small butterfly fragment, minimal to no comminution

II - Butterfly fragment, at least 50% circumference of cortices of 2 major fragments intact

III - Butterfly fragment with 50%- 100% of circumference of the 2 major fragments comminuted.

IV - Segmental comminution all cortices contact lost.
VI] OPEN GRADE ACCORDING TO GUSTILLO AND ANDERSON.

- Grade I - Clean skin opening less than 1cm.
- Grade II - skin opening >1cm. Extensive soft tissue damage.
- Grade III - Massive soft tissue damage >10cm
  - III A - Adequate bone coverage minimal periosteal Stripping.
  - III B - Exposed bone periosteal stripping. Heavy contamination.
  - III C - vascular injury requiring repair.

INVESTIGATIONS

11. LABORATORY

[i] hemogram

[ii] urea, electrolytes, creatinine

[iii] pus swab / microscopy / culture

Organism isolated..............................................

12. RADIOLOGICAL INVESTIGATIONS

I. Plain X-Ray

II. CT Scan

III. Angiography

IV. MRI

V. Scintigraphic Scan

VI. Other [ specify].................................
13. ASSOCIATED INJURIES

[i] Abdominal
[iii] Head
[v] Genitourinary
[vii] Shock / vascular

[ii] Thoracic
[iv] Spinal
[vi] Skeletal
[vii] other [specify]

14. MEDICAL TREATMENT

[I] Analgesics

Nsaids
Opioids

[II] Antibiotics

- Penicillin
- Flagyl
- Cephalosporin
- Aminoglycosides
- Other [specify]

[III] Tetanus prophylaxis
YES
NO

[IV] Blood Transfusion
YES
NO

[V] OTHER [SPECIFY]
TREATMENT

15. SURGERY

A. TIMING FROM INJURY TO OPERATION

<table>
<thead>
<tr>
<th>Time Frame</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 24 Hrs</td>
<td></td>
</tr>
<tr>
<td>24-48Hrs</td>
<td></td>
</tr>
<tr>
<td>48-72Hrs</td>
<td></td>
</tr>
<tr>
<td>Within 1 week</td>
<td></td>
</tr>
<tr>
<td>&gt; 3 Weeks</td>
<td></td>
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</table>

B. OPEN INTRAMEDULLARY NAILING

I. NAIL SIZE [mm]

<table>
<thead>
<tr>
<th>Size [mm]</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
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<td></td>
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<td>14</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Other [specify]</td>
</tr>
</tbody>
</table>

II. NAIL LENGTH [cm]

<table>
<thead>
<tr>
<th>Length [cm]</th>
<th>Options</th>
</tr>
</thead>
</table>

III. NAIL MATERIAL

- Stainless steel
- Titanium
- Other [specify]

IV. NAIL TYPE

- Interlocking
- K - nail
V. ADDITIONAL HARDWARE
- Screws
- Cerclage wires
- Other [specify]...

VI. OPERATIVE TECHNIQUE
a] Reamed intramedullary nailing
b] Unreamed intramedullary nailing

VII. OPERATIVE TIME [MINUTES]...

VIII. TYPE OF ANAESTHESIA
General Regional Other[ specify]...

IX. LENGTH OF INCISION[CM]...

X. CHECK X-RAY
a) Acceptable reduction
b) Unacceptable reduction

XI. SECONDARY PROCEDURES [SPECIFY]

- Re-operation YES NO
- Implant removal YES NO
- Implant exchange YES NO
- Bone grafting YES NO
- Other [specify]...
C PLATE FIXATION

I. PLATE CHARACTERISTICS

Length of plate [cm]..........................................

Type of plate

Compression
Bridge

II. PLATE MATERIAL

Titanium
Other [specify].................................

Stainless steel
Other..........................................

III. NUMBER OF HOLES ON PLATE..........................................

IV. NUMBER OF SCREWS ON EITHER SIDE OF FRACTURE

Proximal................................................
Distal......................................................

V. LENGTH OF INCISION [cm]..........................................

VI. OPERATIVE TIME [MIN]..........................................

VII. TYPE OF ANAESTHESIA

General
Regional
Other specify............................................
XI] CHECK X-RAY FINDINGS

Acceptable reduction

Unacceptable reduction

XII] SECONDARY PROCEDURES

<table>
<thead>
<tr>
<th>Procedure</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implant removal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bone grafting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implant exchange</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other [specify]</td>
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</tbody>
</table>

XIII] ADDITIONAL HARDWARE

<table>
<thead>
<tr>
<th>Hardware</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Cerclage wires</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screws</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other [specify]</td>
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</table>

D) POSTOPERATIVE MANAGEMENT

<table>
<thead>
<tr>
<th>Medication</th>
<th>YES</th>
<th>NO</th>
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<tbody>
<tr>
<td>Analgesics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antibiotics</td>
<td></td>
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</tbody>
</table>

ADDITIONAL IMMOBILISATION METHODS USED

IF YES, SPECIFY

I] TIME TO PARTIAL WEIGHT BEARING

<table>
<thead>
<tr>
<th>Time Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate</td>
</tr>
<tr>
<td>0-4 weeks</td>
</tr>
<tr>
<td>5-6 weeks</td>
</tr>
<tr>
<td>6-8 weeks</td>
</tr>
<tr>
<td>8-12 weeks</td>
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</table>
II] TIME TO FULL WEIGHT BEARING

<table>
<thead>
<tr>
<th></th>
<th>&lt;4weeks</th>
<th>4-6weeks</th>
<th>6-8weeks</th>
<th>8-12weeks</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

III] TIME TO CLINICAL FRACTURE UNION

<table>
<thead>
<tr>
<th></th>
<th>&lt;4weeks</th>
<th>4-6weeks</th>
<th>6-8 weeks</th>
<th>9-12weeks</th>
<th>&gt;12weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

IV] TIME TO RADIOLOGICAL UNION

<table>
<thead>
<tr>
<th></th>
<th>&lt;6weeks</th>
<th>6-8 weeks</th>
<th>9-12 weeks</th>
<th>&gt;12weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

V] POSTOPERATIVE HOSPITAL STAY PERIOD

<table>
<thead>
<tr>
<th></th>
<th>&lt;1 week</th>
<th>1-2weeks</th>
<th>2-3weeks</th>
<th>&gt;3weeks</th>
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<tbody>
<tr>
<td>Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

E COMPLICATIONS

1] INTRAOPERATIVE COMPLICATIONS

i] Haemorrhage necessitating transfusion YES NO

ii] Additional comminution YES NO

iii] Neurovascular injury YES NO

iv] Mortality YES NO

v] Other[ specify.]

.................................................
<table>
<thead>
<tr>
<th></th>
<th>2) POSTOPERATIVE COMPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>Haemorrhage necessitating frequent change of dressings</td>
</tr>
<tr>
<td>ii</td>
<td>Infection</td>
</tr>
<tr>
<td>iii</td>
<td>Rotational deformity</td>
</tr>
<tr>
<td>iv</td>
<td>Leg length discrepancy</td>
</tr>
<tr>
<td>v</td>
<td>Malunion</td>
</tr>
<tr>
<td>vi</td>
<td>Delayed union [3 months without callus formation]</td>
</tr>
<tr>
<td>vii</td>
<td>Nonunion [6 months without callus bridging fracture]</td>
</tr>
<tr>
<td>viii</td>
<td>Mortality</td>
</tr>
<tr>
<td>ix</td>
<td>Implant failure</td>
</tr>
<tr>
<td>x</td>
<td>Re-fracture</td>
</tr>
<tr>
<td>xi</td>
<td>Restricted range of knee movement</td>
</tr>
<tr>
<td>xii</td>
<td>Persistent hip pain</td>
</tr>
<tr>
<td>xiii</td>
<td>Persistent thigh pain</td>
</tr>
<tr>
<td>xiv</td>
<td>Heterotopic bone formation</td>
</tr>
<tr>
<td>xv</td>
<td>Chondromalacia patellae</td>
</tr>
<tr>
<td>xvi</td>
<td>Other [specify]</td>
</tr>
</tbody>
</table>