ORTHOPAEDIC ASPECTS OF SICKLE-CELL DISEASE AT KENYATTA NATIONAL HOSPITAL

A TEN YEAR RETROSPECTIVE STUDY

(JAN 1980 - DEC 1989)

BY

DR SIMON PETER ODWONGO

MB. CHB (MAKERERE)

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

APRIL 1991.

DECLARATION

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

Signed.....DDM-982..... **Date**.....15th May 1991.....

DR. SIMON PETER ODWONGO

MB. CHB. (MAKERERE)

(CANDIDATE)

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

Signed.....JMulimba..... **Date**.....15-5-91.....

PROF. JOSEPHAT A. O. MULIMBA

MMED. (SURG.), FRCS (EDINBURGH)

CHAIRMAN, DEPARTMENT OF ORTHOPAEDIC SURGERY, UNIVERSITY OF NAIROBI.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

Teachers are perhaps the most indebted of all men. Many persons contribute and assist in so many direct and indirect ways and complete recognition and repayment becomes unfeasable. For most of all that can be done is humbly to acknowledge their value and influence.

Despite all the above there are always the outstanding ones: those without whose help, encouragement and criticisms the immediate task would have not been possible. I wish to express my honest thanks to Prof. J. A. O. Mulimba, Chairman of Orthopaedic Department for his guidance, patience, objective criticisms and encouragement, Mr. G. C. N. Anangwe, lecturer, Department of Surgery for his inspiration throughout the period of study and Dr. J. N. Owade, consultant haematologist, Department of Pathology for the tremendous help with electrophoretic data and haematological highlightment.

I am also grateful to the final secretarial duties of Mr. Isaac Ouma Odero which was willingly offered.

Last but not least, I wish to thank The Most Rev. James Odongo, Bishop of Diocese of Tororo for his fatherly act of sending me for studies and offering regular prayers. Finally all my thanks wind-up on my wife Christine Hellen and our children Emmanuel, Lucy, Jacinta and Priska for tolerance and encouragement despite my prolonged absence during the period of study.

SUMMARY

A retrospective study of 100 patients with orthopaedic aspects of sickle-cell disease was carried out. Males and females were almost equally affected in a ratio of 1.3:1.2. A half of the patients (50%) were below 5 years of age and the least number was after 20 years of age. Most patients originated from Nyanza province (76%) followed by Western province (19%) with a few from Rift Valley and Coast provinces (1% and 2% respectively). Most patients presented generally with pain (87%) and swelling (82%) while nearly a half had fever (49%) and limping or loss of function of the affected limb (41%). Swelling, tenderness and warmth were the predominant local signs in percentages of 83, 68 and 31 respectively. The mean haemoglobin level was 7.8 g/dl in the 86 patients who had results in the file. The majority of patients were HbSF (55%) and followed by sickle-cell anaemia (HbSS - 35%). Blood culture and pus swab specimens taken from patients with osteomyelitis and septic arthritis had no growth demonstrated in 31 patients (57.4%) while isolation was done in the remainder of patients. Bacterial isolates revealed *Salmonella typhimurium* to be the predominant organism (8patients (14.8%) and 4 patients (30.8%)) in osteomyelitis and septic arthritis respectively. Radiologically the limbs (appendicular skeleton) was dorminantly affected (99.5%). 119 lesions were diagnosed in the study group. Osteomyelitis ranked first (45.4%) followed by hand and foot syndrome (dactylitis) (24.4%) in the clinical diagnosis. Entities of respective orthopaedic aspects of sickle-cell disease such as haemoglobin electrophoresis, anatomical sites, treatment, results and complications are discussed.

CHAPTER I
INTRODUCTION

Sickle-cell disease is a recognised haemoglobinopathy which is endemic in Kenya. It is prevalent in certain areas, with the highest rates (23.8%) in the Lake Victoria basin (ie Nyanza and Western provinces) and relatively less in the Coast and North Eastern provinces (Bwibo NO, Ojwang PJ and Ogada T et al)[15,53]. Children with sickle-cell disease are frequently seen at Kenyatta National hospital with various types of infections and affections (Bwibo et al)[15].

Clinical presentation in paediatric wards of pmeumonia, septicaemia, meningitis, osteomyelitis and various crises have been reviewed by workers in the recent past and has significantly contributed to the practice in our local setting (Bwibo et al)[15]. The only recent surgical article locally is a case report of a priapism in a juvenile sickler (Haq et al)[20]. Surgical aspects of sickle-cell disease which may have presented to various units have up to date not been documented. In addition my realisation as a medical officer and now a trainee-surgeon; the agony of bone and joint pains, chronicity of skeletal affections and crippling debilities, and not to mention the attendant risks; precarious response to anaesthetic agents and futile hope in life (short life-span) by many sickle-cell patients prompted me to take up this study. Studies on skeletal complications have been done elsewhere such as: West Africa, Jamaica, USA, Britain and Saudi Arabia with variable results[3,4,11,15,17,20,21,22,26,30,34,37,38,42,43,54,55,60,61,63,65,66,68].

A: AIMS AND OBJECTIVES

The aims and objectives of this study include:

a. Analysis of the pattern of presentation of sickle-cell disease patients with orthopaedic complications at Kenyatta National Hospital.

b. To examine the existing management methods.

c. Make recommendations found necessary on recognition and management of the various orthopaedic complications of sickle cell disease.

B: AETIOLOGY

Sickle-cell disease is a heredity affection confined to Africans particularly in West, Central and East Africa and those of African descent in North and South America and West Indies. However, recent reports from Iran and Saudi Arabia dealt with a few cases of causasian of neither Negro nor Arabian extraction (Perrine et al)[55].

Sickle-cell gene is inherited as an autosomal recessive gene. Morphological expression of the disease depends on the possession of two abnormal allelemorphic genes related to haemoglobin formation eg sickle-cell anaemia - HbSS, HbSC, Hb-Thalassaemia, SF high gene and HbSD (Rucknagel et al)[59].

C: INCIDENCE

The incidence of sickle-cell trait varies widely from country to country. In Kenya a study by Ojwang and Ogada et al[53] found the frequency of HbS gene to be as high as 23.8% in the Lake Victoria basin (Nyanza province). In the USA the black population have incidence of 8.42% (Coley and Lee Cardozo et al)[56] and it rises in certain African communities eg Sierra Leone 27.0% (Gosden and Reid et al)[56], Gambia 28.2%, Nigeria 22.3%, Ghana 16.6% and Cameroon 15.2% (Evans et al)[56], Zambia 12.3% (Beet et al)[56] and Uganda 15.0% (Alan and Paper et al)[56]. It is estimated that in Africa over one million people mostly children die of sickle-cell anaemia in each generation (Vandepite et al)[21]. In West Africa 1% of babies born are genotype HbSS[21]. This study has shown that the majority of patients with bone and joint complications in sickle-cell disease originate from Nyanza and Western provinces (76% and 19%) respectively which corresponds to the high incidence above.

D: PATHOPHYSIOLOGY

Sickle-cell disease is a life threatening condition (Hugh et al)[37]. Figures 1, 2, and 3 ilustrate the haemoglobin molecule, beta globin chain and paper electrophoresis respectively (Diggs et al)[20]. The fundamental abnormality resides in the structure of the globin portion of haemoglobin A (ie normal adult haemoglobin) in that valine amino acid is substituted for glutamic acid in the sixth amino acid position in each of the two polypeptide chains. This change in the structure of the haemoglobin molecule alters the net electrical field in an alkaline buffer system with haemoglobin S moving slower than haemoglobin A and intermediate between haemoglobin A and C. This seemingly minor alteration in the clinical structure accounts for the multi-system disease.

Normal haemoglobin in its reduced state is 100 times more soluble than haemoglobin S. If therefore the oxygen tension falls below 45 mmHg. crystallisation of the haemoglobin occurs and this deforms the erythrocytes (Sennara and Gorry et al)[37] ie tactoid formation.

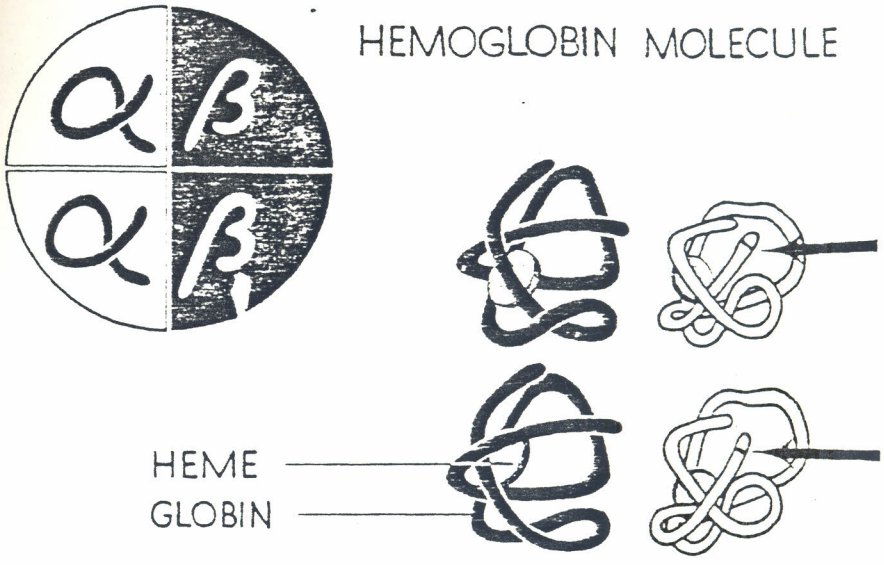


Figure 1: Haemoglobin molecule showing 2 alpha and 2 beta globin chains. Arrows mark spots of amino acid substitution in sickle-cell haemoglobin.

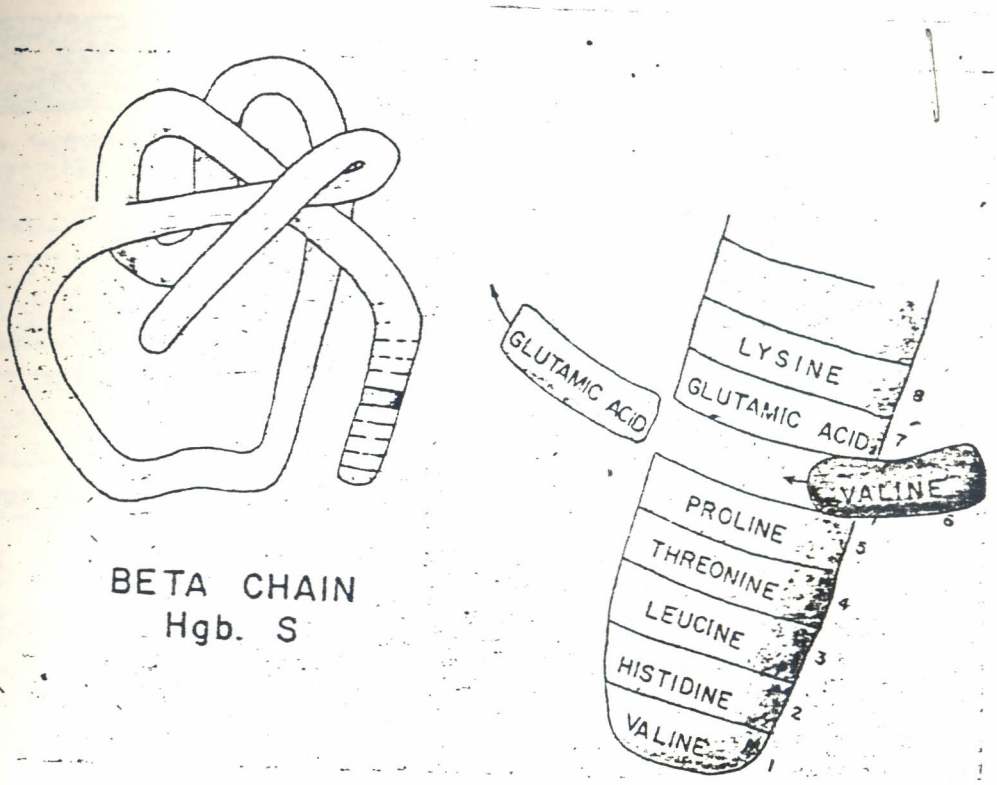


Figure 2: Beta globin chain. Substitution of glutamic acid for valine is characteristic of sickle-cell haemoglobin.

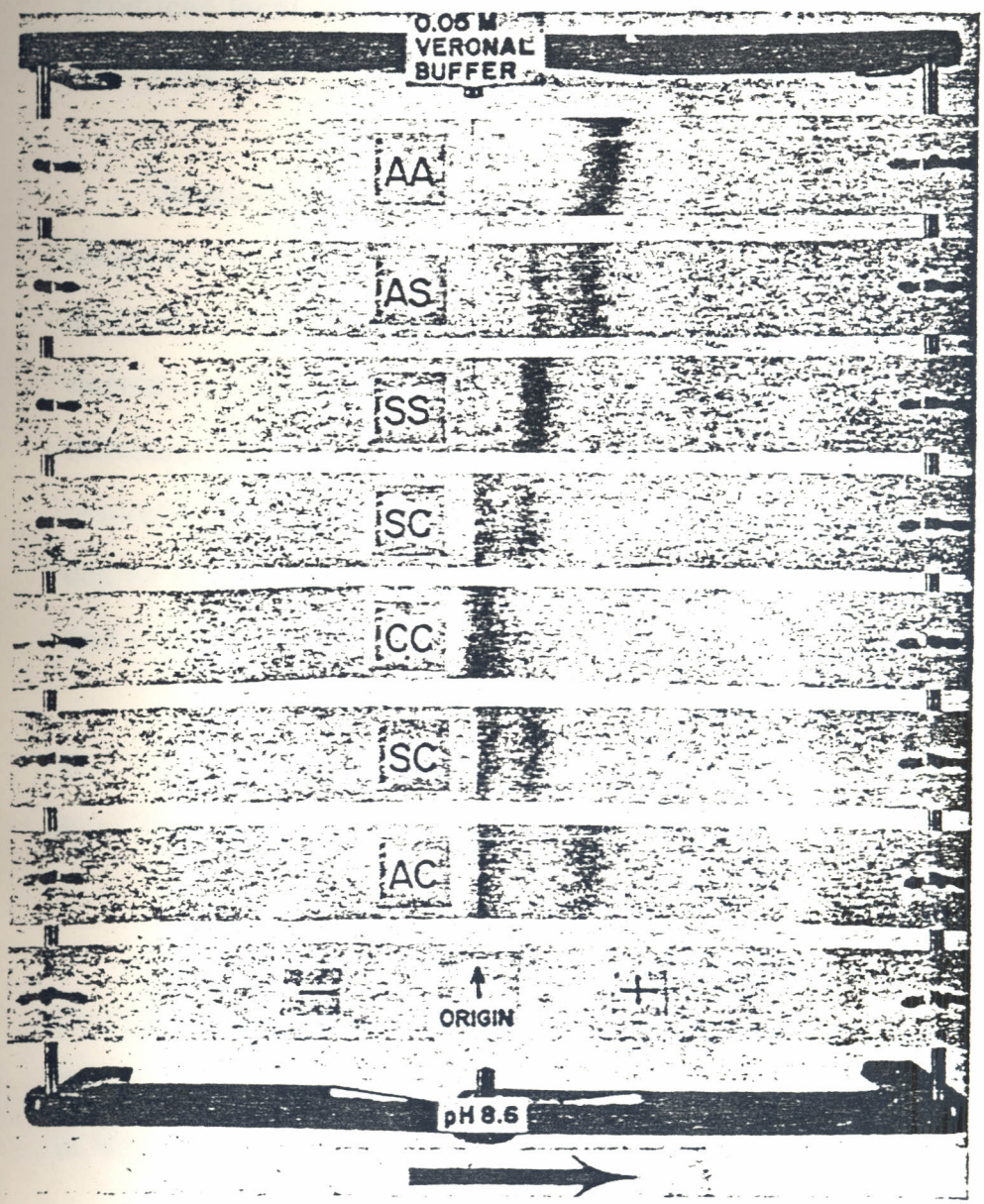


Figure 3: Paper electrophoresis. Sickle-cell haemoglobin (HbS) migrates to a portion intermediate between haemoglobin C and haemoglobin A.

Blood containing sickle-cell cells is more viscid than normal blood. Utilization of oxygen by tisues and endothelial cells favours exaggeration of sickling. Chronic stasis in capillaries and defective oxygenation produces focal or systemic ischaemic necrosis and sclerosis (Berties et al)[7], Klug et al)[40], (Milner et al)[48], (Rickles et al), (White et al)[69].

Sickle-cells are mechanically fragile, easily phagocytosed and are subjected to haemolysis in circulating blood. Increased erythrocyte destruction is associated with haemoglobinaemia, bilirubinaemia, haemosiderosis and increased urobilinogen in urine and faeces. The imbalance between the rate of erythrocyte destruction and formation results in a chronic anaemia of haemolytic and regenerative type. The degree of anaemia varies from an individual to another (Bensinger et al) and Forget et al)[6,27].

E: CLINICAL FEATURES

I: The Sickle-cell crisis

This refers to onset of acute symptoms in sickle cell disease; and Diggs[20] defined it as a sharp turn or definite change in the course of the disease. It is due to sudden in vivo sickling. Observed order of frequency in West African studies (Konotey-Ahulu et al)[42] includes:

a. Vaso-occlusive infarctive crisis - presents with agonizing bone, joints and the organ pains in the chest and abodmen.

b. Haemolytic crisis - presents with all known clinical biochemical and haematological features of sudden haemolysis.

c. Sequestration crisis - presents with sudden massive enlargement of the liver and spleen (if not atrophied) and acute fall of haematocrit.

d. Aplastic or hypoplastic crisis - this is reflected by a greater than usual anaemia, with neither reticulosis nor icterus.

These crises sometimes occur in combination and usually are precipitated by local or systemic infections. These cause qualitative and quantitative changes in the "millieu interieur" that bring on in "vivo" sickling, increased blood viscosity, stasis, hypoxia, infarction of tissues, further stasis and repeated hypoxia (ie a viscious cycle).

II: Orthopaedic aspects

These are basically bone and joint manifestations (complications) of sickle-cell disease. Skeletal changes are a consequence of two pathological processes[3,4,12,17,30,69].:

a. Chronic haemolytic anaemia which leads to bone marrow hyperplasia. This leads to generalised osteoporosis, cortical thinning and softening of bone.

b. Sickling results into thrombosis, tissue ischaemia, infarction and necrosis. Complete necrosis leads to failure of regeneration and also provides a site for bone infections.

Clinical orthopaedic features are varied and may include the following:

i. Hand and foot syndrome: This is a form of dactylitis in which the small tubular bones are affected by infarction. Usually it is a classical presentation under 5 years.[66,69].

ii. Diaphyseal infarction of large tubular bones also occurs (Bohrer et al)[12]. Most frequent sites include proximal aspect of femur, proximal humerus, distal femur and proximal tibia[33].

iii. Epiphyseal infarction may occur; seen in adults more than children. In children may simulate Legg-Calves Perthes' disease. Site of predilection are capital femoral, epiphysis and proximal humerus. Other sites include the talus, distal femur, proximal tibia and distal humerus[3,4,18,20,31,33,63].

iv. Growth disturbances may include epiphyseal shortening which can be due to deformity and delay in closure and changes in spinal contour. This may lead to stunted growth and aesthetic structure of sicklers.

v. Pathological fractures in appendicular or axial skeleton can occur spontaneously or following chronic osteomyelitis. In long bones, marrow hyperplasia causes cortical thinning and may predispose to pathological fractures (Archampong et al)[3], (Bohrer et al)[11] and (Ebong et al)[21].

vi. Osteomyelitis: sickle-cell patients are generally more susceptible to infections than the rest of the population. Reasons for this are given in the discussion. Suleman (1970)[65] estimated that osteomyelitis may be a hundred times commoner in children with

sickle-cell disease than other children in East Africa[3,4,15,20,21,23,24,36,64].

vii. Septic arthritis: Usually occurs and earlier workers quoted it to have poor response to therapy[20,22].

viii. Other skeletal complications (disorders may include)[33]:

1. Crystal deposition in joints (due to hyperuricaemia)
2. Haemoarthrosis
3. Joint effusion; knee and elbow joints being favoured.
4. Chronic synovitis.
5. Spine ankylosis.

CHAPTER II
LITERATURE REVIEW

Centuries before Herrick (1910)[42] published his observation of "thin sickle shaped and crescent shaped" forms in the peripheral blood film of an ailing West Indian student in Chicago, West Africans were conversant with the clinical manifestations of sickle-cell disease to which they gave specific vernacular names whose "onamotopoeia" reflected the relentless and repetitive gnawing pains of bones and joints which are characteristic of the disease. West African forefathers were also able to discern different grades of severity of the disease and designated them "the severe type and and the not severe type", coinciding accurately with the present designations of "SS" and "SC" phenotypes respectively. They knew the disease ran in families and also the vast majority of sickle-cell children's parents were not phenotypically different from normal adults (Konotey -Ahulu et al)[42].

James Africans Horton (1835-1883), an early doctor of medicine who practised in Ghana described the disease in the chapter on "Chronic Rheumatism" in his book "The Diseases of Tropical Climates and their Treatment" (1874)[21].

The presence of abnormal haemoglobin (S) was demonstrated in 1949 by Pauling Itano, Singer and Wells by means of electrophoresis[30]. Neel (1947, 1949 and 1951)[30] showed that haemoglobin S is inherited as a Mendelian dorminant gene and he postulated heterozygous and homozygous state to explain the symptomless sickle-cell trait and the true sickle-cell anaemia.

In sickle-cell trait, less than half the haemoglobin is of S type, the remainder being normal or type A. The sickle-cell trait is usually a benign condition but in certain circumstances, such as flight in an unpressurised aircraft, symptoms may occur. Smith and Conley (1955)[30] described fourteen cases of splenic infarction in patients of this kind.

In 1951 Itano described a second haemoglobin variant (C), which can interact with haemoglobin S to produce sickle-cell haemoglobin C disease (SC)[30]. This condition is clinically milder than sickle-cell anaemia and crises are less, but there is a peculiar tendency to avascular necrosis of epiphyses. Smith and Conley (1954)[30] went so far to suggest that avascular necrosis of bone occurred only in variants of sickle-cell anaemia; but Tanaka, Clifford and Axelrod (1956)[30] and Carrington, Ferguson and Scott (1958) showed that similar changes may be found in true sickle anaemia and described eight cases proved by electrophoresis[30]. This now has been confirmed by later workers (Obisesan and Bohrer, 1972, Sennara and Gorry, 1978 and Konotey-Ahulu et al, 1972)[21, 37,42].

The thalassaemia gene is also present and this condition needs special consideration because with normal haematological techniques and with paper electrophoresis it may be impossible to distinguish it from true sickle-cell anaemia[30].

Most of the knowledge on the lesions of bones and joints in sickle-cell disease has been contributed by radiologists (Golding et al)[30].

Archampong and Korsah (1986) noted that bone and joint disorders in sickle-cell disease as crippling[3].

Diggs (1967)[20] noted infarcts of bone marrow associated with localised bone pains in the skull. The majority of skull X-rays reveal no abnormality or at most a slight widening of the diploic space with fine grained or ground - glass markings. The widening is bilaterally symmetrical and involves the frontal and/or the parietal bones. In approximately 5% of the patients with sickle-cell anaemia the forehead and the dome of the skull are prominent. There is widening of the calvarium ,absence of a visible outer table and "a hair on end" (porcupine quill) trabeculations.

Hand and foot syndrome (sickle-cell dactylitis) was first reported by Danford, Marr and Elsey[20]. Other noteworthy contribution and summary articles were by Haggard et al[69], and Porter et al[20]. This first bone lesion involves the bone marrow in the tubular bones which are most distant from the lungs and are supplied with blood with the lowest oxygen content and therefore the highest sickling of erythrocytes. Distal bones are also most likely to be exposed to the cold. Chilling favours vasoconstriction and arteriovenous shunting of blood. The shunt prevents proper aeration of tissues which are by-passed (Diggs et al)[20].

Patients with sickle-cell disease are perculiarly susceptible to bacterial infection of bones. Golding et al estimated that osteomyelitis in Africa is 200 times more frequent in individuals with sickle-cell diseases than normal individuals. Ninety percent of sickle-cell anaemia individuals suffer from osteomyelitis on one or more bones and always a stormy septicaemia occurs as a common complication (Archampong and Korsah, 1986)[3]. Osteomyelitis is predominantly a disease of children and adults are rarely affected (Hendrickse and Collardo, 1960[34]; Ebrahim and Creck, 1966[23]; Engh et al, 1971[24]). Bacteriological isolates by Huckstep (1968)[36] in East Africa reported 50% *Salmonella* in sickle-cell anaemia and

HbSC disease while Ebong (1975)[21] isolated in 66.7% patients. Other organisms included *Staphylococcus avreus, Pseudomonas, Klebisiella, Escherichia coli* and infants *Haemophilus influenza*[24,64].

Ebong (1979)[22] found a higher incidence of septic arthritis in sickle-cell disease than previously stated by earlier workers in North America (Barret-Connor; Webon and Black et al)[5]. Apart from avascular necrosis of femoral head septic arthritis is the second most important arthropathy in West African environment. Gram negative bacilli were the dorminant organisms isolated (81.8%) while *Staphylococcus aureus* was the only gram positive organism isolated. This contrasted with isolates from North America which were *Pneumococci, Streptococci* and coliforms including *Salmonella* [22].

Avascular necrosis of the femoral head occurs more frequently in HbSC than HbSS (Cockshott, 1958; Golding et al 1954, Obisesan and Bohrer, 1972; Sennara and Gorry, 1978)[4,30,12,21,37]. In Ghana, Konotey-Ahulu (1972)[42] found the incidence of this condition to be 7% for HbSC and 3% for HbSS. The increased longevity of patients with sickle-cell disease due to improvement of medical services means more patients with sickle-cell anaemia (HbSS) will present with avascular necrosis of femoral head in addition to those with HbSC. Presentation has been more on males than females, and is a late bone lesion in sickle-cell disease, occuring around and after puberty. Thus, it is rarely seen in young children. Avascular necrosis of femoral head is usually unilateral but may also be bilateral[12,17,18,21,26,31,43,45,54,55,58,60,61].

In a prospective study done in Ibadan (Bohrer, 1971)[11], sickle cell disease was found to be the commonest cause of pathological fractures in children and adolescents. Pathological fractures were seen more

frequently in patients with HbSS than HbSC, could be single or multiple and shafts of lower bones were affected more than others. Compression fractures of vertebral bodies may complicate osteomyelitis of these bones and multiple sites could be involved (Langudoye, 1970)[21]. Predisposing factors were osteoporosis, bone infarcts and osteomyelitis with an equal frequency.

Theis and Owen (1988)[66] did a study in the United Kingdom on skeletal complications and came up with the following salient conclusions:

1. Painful vaso-occluive crisis often leading to thrombosis was the most common complication.
2. Dactylitis was the characteristic presentation in children under five years.
3. Osteomyelitis was rare.
4. Avascular necrosis of femoral head and humeral head contributed to the most challenging skeletal complication and necessitated orthopaedic treatment.

Subjecting patients of sickle-cell disease to surgery has certain risks. However, there have been a few reports of effects of anaesthesia in patients with abnormal haemoglobin syndromes (Shapiro and Poe, 1955; Bauer, 1958; Browne, 1965; Gilbertson, 1965; Holzman et al, 1969)[14,28,35]. Some authors have recorded low morbidity and mortality after anaethesia (Browne, 1965; Holzman et al, 1969) while others have not (Shapiro and Poe, 1955; Baurer, 1965)[14,35]. There seems to be an agreement that the risks of anaethesia are very high in patients with HbSS and less in patients with other haemoglobin combinations HbSC, HbAS and HbAC. This is because during anaesthesia or immediate post

operative period there is an increased risk of infarctive crisis. Factors which may provoke crisis include:

a. Hypoxaemia (low blood oxygen tension)

b. Circulatory stasis as may be found during shock, circulatory collapse, hypothermia and prolonged applications of torniquets, and;

c. Lowered pH (acidosis).

However, it has been shown that during the past decade or so (Browne, 1965; Holzman et al, 1969; Oduntan and Isaacs, 1971)[14,28,52] that with expert medical care given before, during and after surgery, it is possible to operate on sicklers with considerable reduction in morbidity and mortality.

CHAPTER III
MATERIALS AND METHODS

The patients included in this study were identified by reviewing all hospital admissions and consultations coded with a discharge or follow-up diagnosis of hereditary haemoglobin abnormality (sickle-cell disease) in the records office. By this method 100 patients were obtained to have been admitted or followed up in the prescribed period of study (January 1980 to December 1989) at Kenyatta National Hospital, Nairobi.

These patients were presenting with sickle-cell disease with bone and joint lesions viz osteomyelitis, hand and foot syndrome (sickle-cell dactylitis), septic arthritis and avascular necrosis of the femoral head. Found also associated with osteomyelitis and septic arthritis were pathological fractures. Sickle-cell disease patients with traumatic skeletal injuries following road traffic accidents (RTA's), assaults, sporting activities, missile assaults and domestic falls were excluded from the study.

Each file of a patient was given a study number and full details of in-patient or unit number (IP or U/No.), age, sex and geographical origin were recorded. History and clinical examination were noted, in particular dates of admission and discharge, number of admissions, general symptoms eg pain or irritability, swelling, limping or loss of function of limb, fever, itching, skin ulcers and others.

Record of examination was done. And on stigmata of sicklers eg bossing of skull, jaundice and splenomegally was recorded. Pyrexia, palour and general lymphodenopathy were noted to complete general examination. Locally the following were noted: swelling, warmth,

tenderness, ulceration, sinuses, deformity, loss of function of affected limb and others such as fluctuance, oedema or gangrene. The details of which are found in the study proforma as shown in Appendix 1.

The investigations available in the file were recorded and in particular haemoglobin (Hb), sickle-cell test (SCT), haemoglobin electrophoresis, bacteriology (culture and sensitivity) of blood or pus specimens, and radiology studies.

The diagnosis assigned to the patients was recorded and it ranged from osteomyelitis, hand and foot syndrome (dactylitis), avascular necrosis of femoral head, pathological fractures and others as detailed in the proforma.

The treatment instituted to the patients was recorded; either conservative or surgical; details of each were noted down. Complications recorded were noted. Results of treatment were noted both at discharge and subsequent follow-up.

Follow-up at haematology and orthopaedic clinics were noted. Abscondments from the treatment or follow-up were also recorded.

Radiographs obtained (ie those available) were selected and processed into microform by the Illustration Department, Medical School for illustration of the skeletal conditions in the study.

CHAPTER IV
RESULTS

One hundred patients over a period of ten years (January 1980 to December 1989) were studied and they included all the age groups. The cases summary (patients) is attached in Appendix II and the final analysis is presented below.

A: Age and Sex distribution

The age and sex distribution are shown in Table I. The patients ranged from 3 months to 50 years of age with the highest incidence (50%) occurring between 0-4 years, 17% between 5-9 years, 10% between 10-14 years, 14% between 15-19 years and 9% 20 years and above.

The overall sex ratio is M:F of 1.3:1.2. As shown in the Table I this difference is more in older age group and almost are equally affected below 4 years.

Table I: Age and sex distribution of patients with orthopaedic aspects of sickle-cell disease.

Age Group (Years)	Number of Patients			Percentage
	Female	Male	Total	
0-4	26	24	50	50
5-9	9	8	17	17
10-14	6	4	10	10
15-19	5	9	14	14
≥ 20	2	7	9	9
TOTAL	48	52	100	100
%	48	52	100	100

Sex Ratio M:F = 1.3 : 1.2

B: Geographical distribution

Table II shows the geographical distribution of patients wih orthopaedic aspects of sickle-cell disease. Patients predominantly come from Nyanza province (76%) which comprises of Siaya, Kisumu, South Nyanza and Kisii districts; and followed by the neighbouring Western province (19%) formed by Kakamega, Bungoma and Busia districts. Few patients come from Coast province (2%), Rift Valley (1%) and 2% from neighbouring Uganda.

Table II: Geographical distribution of patients with orthopaedic aspects of sickle-cell disease.

Province	Number	Percentage
Nyanza	76	76
Western	19	19
Rift Valley	1	1
Nairobi	-	-
Central	-	-
Coast	2	2
Eastern	-	-
Others	2	2
TOTAL	100	100

C: CLINICAL PRESENTATION

1. Symptoms

Table III below shows the general distribution of symptoms in patients with orthopaedic aspects of sickle-cell disease.

Most of the patients had two cardinal symptoms of pain (87%) and swelling (82%). Other symptoms which were were present in nearly half of the patients were fever (49%) and limping or loss of function of the affected limb (41%). Depending on skeletal complications, rare symptoms such as skin ulceration (1%), itching (1%) and cold toes (1%) were encountered.

Table III: Symptoms of patients

Symptom	Number	Percentage
Pain or irritability	87	87
Swelling	82	82
Fever	49	49
Limping or loss of limb function	41	41
Ulcer	1	1
Itching	1	1
Cold Toes	1	1

2. Signs

a. General

Table IV shows the general signs of patients studied. Stigmata of sicklers featured prominently with most patients having jaundice (67%), palour (43%), bossing of skull (22%) and splenomegally (16%). Other prominent features included pyrexia in 50% of the patients. Lymphadenopathy either general or regional was seen in 17% of the patients.

b. Local findings

Table V shows local signs. Swelling was evident in 83% of the patients and 68% of patients had demonstrable tenderness. Other signs noted in order of decreasing frequencies were warmth (31%)' loss of limb function (24%), deformity or contracture (16%), sinuses (12%), skin ulceration (5%), fluctuance (4%) and gangrene (1%).

Table IV: General signs of patients

Sign	Number	Percentage
Bossing of skull	22	22
Jaundice	67	67
Splenomegally	16	16
Pyrexia	50	50
Lymphadenopathy	17	17
Palour	43	43

Table V: *Local findings of patients*

Sign	Number	Percentage
Swelling	83	83
Warmth	31	31
Tenderness	68	68
Skin warmth	5	5
Sinuses	12	12
Deformity or contracture	16	16
Loss of limb function	24	24
Fluctuance	4	4
Gangrene	1	1

D: Investgations

1. **Haemoglobin concentration**

Results of haemoglobin concentration were present in 86 patients only. The lowest haemoglobin concentration was 3.5g/dl and the highest was 13.9g/dl. The overall mean haemoglobin concentration was 7.23g/dl.

The haemoglobin distribution in the 86 patients revealed that the majority were ranging between 6.0 - 9.0g/dl (64 patients or 74.4%), followed by 3.0-5.0g/dl with 16 patients (18.6%), 9.0-10.0g/dl 2 patients (2.32%) and beyond 10.0g/dl were 4 patients (4.65%).

2. **Haemoglobin electrophoresis**

The distribution of haemoglobin electrophoresis is shown in Table VI below.

More than half of the patients studied had HbSF (55%), HbSS (sickle-cell anaemia) were 35%, HbAS (sickle-cell trait) 8% but these results followed blood transfusion. One patient showed a rare variant HbSo Arab while another had a positive sickle-cell test with no electrophoretic results. Among the study group, there was no haemoglobin SC or S Thalassaemia which had been reported elsewhere. The method used was Cellulose Acetate Paper Electrophoresis (CAPE).

Table VI: Electrophoretic distribution of patients with orthopaedic aspects of sickle-cell disease.

Genotype	Number	Percentage
AS	8	8
SS	35	35
SC	-	-
SThal	-	-
SF	55	55
HbSo Arab	1	1
SCT(+ve) only	1	1

3. **Bacteriology**

Bacteriology of pus swab and blood cultures taken from patients with osteomyelitis and septic arthritis is shown in Table VII.

a. **Osteomyelitis**

No growth of organisms was demonstrated in 30 patients (56.6%) while isolation was done in the remainder (23 patients, 43.4%). Sixteen patients with positive cultures were chronic osteomyelitis while 7 patients had acute osteomyelitis. More than 75% of the positive cultures were from pus swab specimens. Organisms isolated in decreasing frequencies were: *Salmonella tryphimurium* in 8 patients (14.8%), *Staphylococcus aureus* in 3 patients (5.6%), *Pseudomonas* in 3 patients (5.6%), *Staphylococcus albus* in 2 patients (3.7%), *Proteus* in 2 patients (3.7%) while *Streptococcus viridans and Pyogenes, Salmonella manchester, Escherichia coli* and *Actinobacter* were each isolated in 1 patient (1.9%) respectively.

b. **Septic arthritis**

Growth of organisms was only identified in 4 patients (30.8%) with septic arthritis. These included *Salmonella typhimurium* in 3 patients (23.0%) and *Klebsiella* in one patient (7.7%).

Table VII: Bacteriology of patients with osteomyelitis and septic arthritis.

Organisms	Osteomyelitis	Septic Arthritis
Staphylococcus aureus	3	-
Streptococcus pyogenes	1	-
Streptococcus viridans	1	-
Salmonella typhimurium	8	3
Salmonella manchester	1	-
Pseudomonas	3	-
Klebsiella	-	1
Escherichia coli	1	-
Haemophilus influenza	-	-
Proteus	2	-
Staphylococcus albus	2	-
Actinobacter	1	-
No Growth	30	9
Total	53	13

4. **Radiology**

Anatomical distribution of skeletal lesions are shown in Table VIII. Most afflicted sites were hands and feet with 54 (29.3%) and 35 (19.3%) affections. The tibia and fibula, femur and hip joints were involved in proportions of 32 (17.7%), 16 (8.8%) and 16 (8.8%) respectively. The rest of the lesions are shown in the Table below (Table VIII). Explicitly lesions on the axial skeletal were very rare and only one (0.54%) affection of the cavicle was present.

Details of lesions are present in specific diagnosis below and the illustration of radiographs (Appendix II).

Table VIII: Anatomical distribution of skeletal lesions in patients with sickle cell disease.

	Numbers		
1. Upper Limbs	Right	Left	Total
Shoulder joint	1	-	1
Humerus	4	5	9
Elbow joint	-	2	2
Ulna+Radius	2	2	4
Wrist joint	2	-	2
Hand	25	29	54
2. Lower Limbs			
Hip joint	6	10	16
Femur	9	7	11
Knee joint	-	2	2
Tibia + Fibula	11	21	32
Ankle joint	4	3	7
Foot	19	16	35

E. DIAGNOSIS AND TREATMENT

1. General

Table IX shows the skeletal lesions of patients with sickle-cell disease. 53 (45.4%) patients had osteomyelitis, 30 (24.4%) patients had hand and foot syndrome and were followed respectively by septic arthritis and avascular necrosis of the femoral head with 13 (10.9%) patients each. However, 9 patients (7.6%) had pathological fractures which mostly were associated with chronic osteomyelitis and there was one patient who presented with gangrenous toes of both feet following dactylitis.

In the yearly distribution of patients, majority were in 1986 with 18 patients, 1980 with 17 patients, 1983 and 1987 with 14 patients each. Other years ranking from the highest to the lowest were 1985 with 13 patients, 1989 with 12 patients, 1984 with 9 patients, 1988 with 8 patients and 1981 and 1982 each having 7 patients. The yearly distribution is shown in Figure 4.

Table IX: Skeletal lesions of patients with sickle-cell disease.

Diagnosis	Number	Percentage
Osteomyelitis	53	45.4
Hand and foot syndrome	30	24.4
Septic arthritis	13	10.9
Avascular necrosis femoral head	13	10.9
Pathological fractures	9	7.6
Gangrene	1	0.8
Total	119	100.0

NB: 1. Total number of patients = 100

2. Clinical diagnosis = 119

3. Pathological fractures were diagnoses found in the files and details of their cause is indicated in the literature ahead (Results of Pathological fractures)

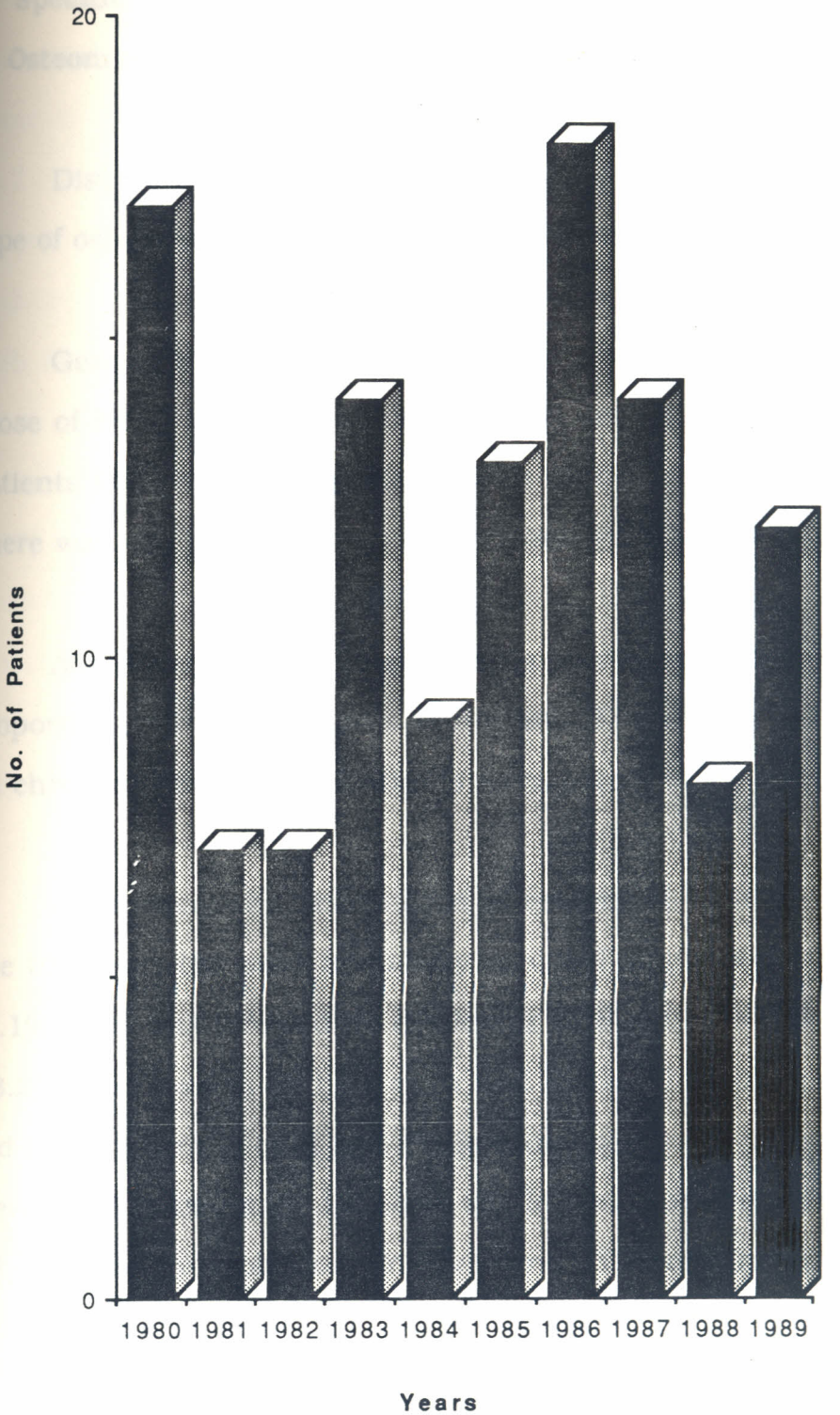


Figure 4: Yearly distribution of patients studied.

2. **Specific diagnosis**

i. Osteomyelitis

Distribution of patients with osteomyelitis in reference to genotype, type of osteomyelitis and results of treatment are shown in Table X.

Genotypic distribution of patients revealed that most of them were those of HbSF with 27 patients (50.9%), sickle-cell anaemia (HbSS) 20 patients (37.7%), and 5 patients with sickle-cell traits (HbAS), 9.5%. There was one patient with a rare variant HbSOo Arab type.

Acute and chronic osteomyelitis tended to present in almost equal proportions with 26 patients (49%) and 27 patients (51%) respectively. All chronic osteomyelitis patients were preceded by the acute phase.

Anatomical site distribution of osteomyelitis is shown in Table X(c). The tibia was the most frequently involved single bone (17 patients - 32.1%) and was followed by the femur in 8 patients (15.1%). 7 patients (13.2%) had lesions on both tibia and fibula while one patient (1.9%) each had involvement of tibia and fibula plus both humerii respectively. In overall, 36 patients (67.9%) had single bone involvement while 17 (32.1%) had multiple bone involvement. The multiplicity makes osteomyelitis in sickle-cell disease unique.

Various forms of treatment instituted is shown in Appendix II. Main approach was conservative with bed rest, splintage and antibiotic therapy. On clinical suspicion antibiotics were started empirically in an aggressive form (intravenously) and duration of treatment continued for a minimum of six weeks. Treatment, however, was modified depending on culture and sensitivity results of either blood or pus swab specimens

which were only present and positive in 23 patients (43.4%). In one patient erythromycin and fusidic acid were used; the currently recommended treatment of osteomyelitis. Drainage of abscess were done in 7 (13.2%) patients while 3 (5.7%) had sequestrectomy done and one patient with associated ulcer of the leg was skin grafted . Thus, the majority of treatment of osteomyelitis in these patients was conservative with a few needing surgical interference.

Results of treatment of patients with osteomyelitis are shown in Table X(e). 38 (71.1%) patients had complete resolution, 3 (5.7%) showed improvement at discharge and 9 (17.0%) had persistent (chronic) osteomyelitis; the common complication of acute osteomyelitis. Two (3.8%) patients absconded and one patient (1.9%) died because of severe anaemia.

Table X: Distribution of patients with osteomyelitis

a. Haemoglobin electrophoresis

Genotype	Number	Percentage
AS	5	9.5
SS	20	37.7
SC/Sthal	-	-
SF	27	50.9
HbSOoArab	1	1.9
Total	53	100.0

b. Type	Number	Percentage
Acute	26	49.0
Chronic	27	51.0
Total	53	100.0

c. Anatomical site	Number	Percentage
Humerus	3	5.7
Ulna	2	3.8
Radius	-	-
Metarcarpal/phalanges	4	7.5
Femur	8	15.1
Tibia	17	32.1
Tibia & Fibula	7	13.2
Fibula	1	1.9
Multiple	7	13.2
Metartarsals	2	3.8
Clavicle	1	1.9
Bilateral tibia & fibula	1	1.9
Bilateral humerii	1	1.9
Total	53	100.0

Table X (continued)

d. Bone involvement	Number	Percentage
Multiple	17	32.1
Single	36	67.9
Total	53	100.0

e. Results of treatment

Results	Number	Percentage
Cured	38	71.1
Improved	3	5.7
Persistent	9	17.0
Absconded	2	3.8
Died	1	1.9
Total	53	100.0

ii. Hand and foot syndrome (Dactylitis)

The distribution of patients with sickle-cell dactylitis is shown in Table XI. It includes genotypic features, age, anatomical site of lesions and the outcome of treatment.

Haemoglobin electrophoresis results revealed 22 patients (76%) had HbSF typifying presence of foetal haemoglobin in this first bone complication. There were 5 (17%) patients with sickle-cell anaemia (HbSS), two with sickle-cell trait (7%) and one with a positive sickle-cell test but no electrophoresis results done.

The anatomical presentation of the syndrome classically presented with involvement of hands and feet in 17 (56.7%) patients. Presentation confined only to the hands was seen in 6 patients (20%), one foot in 2 patients (6.7%), hand and foot in two (6.7%) patients, hands and foot in one (3.2%) patient and none presented with lesions on the feet alone.

The age distribution of patients with sickle-cell dactylitis is unique as shown in Table XI(b). More than half of the patients are below the age of one year (16 patients - 53.3%), and almost 3/4 below the age of 2 years (22 patients - 73.4%). Only four patients (13.3%) were above 5 years. This clinical syndrome is confined to those below five years with the majority at infancy. Reasons for this are given in the discussion.

Treatment in all patients included bed rest, liberal fluid administration both orally and intravenously depending on indication, analgesics and antimalarials. Antimalarials used were chloroquine for therapeutic purposes and pyrimethamine (Paludrine) for prophylaxis. Antibiotics ranging from crystalline penicillin, ampicillin and

Table XI. Distribution of patients with hand and foot syndrome.

a. Haemoglobin electrophoresis

Genotype	Number	Percentage
AS	2	7.0
SS	5	17.0
SC and SThal	-	-
SF	21	
SCT (+ve)	1	3.0
Total	30	100.0

b. Age distribution

Age in Years	Number	Percentage
<1	16	53.3
1-2	6	20.1
2-5	4	13.3
>5	4	13.3
Total	30	100

c. Anatomical site	Number	Percentage
Hands & Feet	17	56.7
Hands	6	20.0
Feet	-	-
Hand	2	6.7
Hands & Foot	1	3.2
Hand & Foot	2	6.7
Total	30	100

d. Results of treatment	Number	Percentage
Cured (Resolved)	29	96.7
Persistent	1	3.3
Total	30	100

gentamycin were used in 9 patients (30%) because of either coexistent osteomyelitis, septic arthritis or septicaemia.

Results of treatment were a tremendous resolution of the condition in almost all the patients (29, 96.7%) with one patient having persistent (recurrent) dactylitis.

iii. Septic arthritis

The distribution of patients with septic arthritis is shown in Table XII. Eight patients (61.5%) had HbSF, 4 (30.8%) patients had sickle-cell anaemia (HbSS) and one patient (7.7%) had sickle-cell trait (HbAS).

Anatomical distribution of septic arthritis is shown in Table XII(b). The most affected joint was the ankle with four patients (30.4%) and followed by elbow and wrist joints with 2 (15.4%) patients each. There was multiple joint presentation in two patients (15.4%) in which one patient had affection of the ankle and elbow joint and the other ankle and wrist joint. The rest of the lesions were present in the shoulder, hip and knee joints in one patient (7.7%) each respectively.

Treatment instituted was antibiotics and bed rest in all patients. The antibiotic treatment was aggressive with intravenous mode of administration in the first 48-72 hours. The duration of treatment extended to a minimum of six weeks as in ostemyelitis. Skin traction was used in one patient and two patients had joint decompression by aspiration and arthrotomy respectively.

All the patients with septic arthritis responded to antibiotic therapy well. Apart from septicaemia reported in three patients, there was no late complications as reported in other series (see Discussion).

Table XII: Distribution of patients with septic arthritis.

a. Haemoglobin electrophoresis

Genotype	Number	Percentage
AS	1	7.7
SS	4	30.8
SC/SThal	-	-
SF	8	61.5
Total	13	100.0

b. Anatomical site

Joint	Number	Percentage
Shoulder	1	7.7
Elbow	2	15.4
Hip	1	7.7
Knee	1	7.7
Wrist	2	15.4
Ankle	4	30.8
Multiple (a. ankle + elbow b. ankle + wrist)	2	15.4
Total	13	100.0

c. Treatment

Type
Antibiotic
Rest
Skin traction
Aspiration/Arthrotomy

d. Results - All (13 patients - 100%) cured (healed)

iv. Avascular necrosis of femoral head

Table XIII shows the distribution of patients with avascular necrosis of femoral head. Six patients (46.2%) had HbSF, five (38.4%) patients had sickle-cell anaemia (HbSS) and one patient (7.7%) had sickle-cell trait (HbAS). There was also a unique HbSOoArab in one patient (7.7%) whom in addition had osteomyelitis.

In this series the left femoral head was the most affected with 7 (53.8%) patients while the right side was affected in 4 (30.8%) patients. The disease was bilateral in two patients (15.4%).

Treatment done included bed rest in 2 patients, analgesics in 6 patients, hip spica in one patient, skeletal traction in 2 patients and supervised negligence in 2 patients. No surgery was done in this series but one patient was programmed for fusion of the hip but he absconded (see Appendix II and discussion).

Outcome of the above treatment was: 4 patients remained in the same state (status quo), 1 patient had progressive destruction of the femoral head, 2 patients had deformity which was mainly shortening, 4 patients absconded from the orthopaedic clinic and 2 patients died during admission for inter-current severe anaemia.

Table XIII: Distribution of patients with avascular necrosis of the femoral head.

a. Haemoglobin electrophoresis

Genotype	Number	Percentage
AS	1	7.7
SS	5	38.4
SC	–	-
SThal	–	–
SF	6	46.2
HbSOoArab	1	7.7
Total	13	100.0

b. Anatomical site	Number	Percentage
Right	4	30.8
Left	7	53.8
Bilateral	2	15.4
Total	13	100.0

c. Treatment

Type	Number
Bed rest	2
Analgesics	6
Hip spica	1
Traction (skeletal)	2
None	2
Surgery	0

d. Results	Number
Same state	4
Progressive	1
Deformity	2
Abscondment	4
Died	2
Total	13

v. Pathological fractures

Patients' results with pathological fractures are shown in Table XIV below. Five patients (55.6%) were of HbSF and 2 patients (22.2%) were of HbSS and HbAS each respectively.

The anatomical distribution was predominant at the humerus (4 patients - 45.5%), the femur and tibia were respectively 2 patients (22.2%) each and there was fracture fibula in one patient (11.1%).

Treatment received by the patients was standard closed method of fracture management. This included plaster of paris in 3 patients, U-slab in 4 patients, hip spica in 1 patient and skin traction in one patient.

Outcome of treatment had union in 5 fractures (55.6%), nonunion occurred in one patient (11.1%) with fracture right humerus and malunion with shortening in 1 patient (11.1%). Two patients absconded with plasters on. The patient with nonunion also absconded from the orthopaedic clinic as per follow-up.

Table XIV: Distribution of patients with pathological fractures

a. Haemoglobin electrophoresis

Genotype	Number	Percentage
AS	2	22.2
SS	2	22.2
SC	-	-
SThal	-	-
SF	5	55.6
Total	9	100.0

b. Anatomical site

Site	Number	Percentage
Humerus	4	45.5
Ulna + Radius	-	-
Femur	2	22.2
Tibia	2	22.2
Fibula	1	11.1
Total	9	100.0

c. Treatment

Form	Number
Plaster of Paris	3
U-Slab	4
Hip spica	1
Skin traction	1
Total	9

d. Results

Type	Number	Percentage
Union	5	55.6
non-union	1	11.1
Malunion (Shortening)	1	11.1
Absconded	2	22.2
Total	9	100

vi. Others

In this series no patients were encountered with reports of spine ankylosis, crystal deposition in joints, haemoarthrosis, joint effusions or chronic synovitis. However, a 12 year old girl presented with gangrenous toes on the right foot; the big toe, 2nd, 3rd and 4th toes were involved and the left foot: 2nd, 3rd and 4th toes were involved. On the right foot 3rd and 4th toes and on the left foot 4th toe were amputated. The rest of the toes which were gangrenous earlier underwent auto-amputation.

vii. Miscellaneous

Patients with more than one diagnosis (or skeletal pathology) are shown in Table XV. Four patients (4%) had both osteomyelitis and pathological fractures, 2 patients (2%) had osteomyelitis and avascular necrosis of the femoral head, 2 (2%) patients had hand and foot syndrome with osteomyelitis, 1 (1%) patient had osteomyelitis with septic arthritis and finally one patient (1%) had three lesions of osteomyelitis, septic arthritis and pathological fractures. These ten patients contributed to the lesions in 100 patients to amount to 119. Common concurrency of osteomyelitis and pathological fractures reflect the latter being a sequelae of the former in more than half (55.6%) of the patients with pathological fractures.

Table XV: Patients with multiple skeletal pathology in sickle-cell disease.

Diagnosis	Number	Percent
A. Pathological fractures and osteomyelitis	4	4
B. Pathological fractures and osteomyelitis + septic arthritis	1	1
C. Osteomyelitis + Avascular necrosis Femur (head)	2	2
D. Osteomyelitis + Septic arthritis	1	1
E. Hand & Foot syndrome + Osteomyelitis	2	2
Total	10	10

CHAPTER V
DISCUSSION

The true incidence of orthopaedic aspects of this multisystem (sickle-cell disease) is difficult to determine. Kenyatta National Hospital being a referral hospital may not receive all the patients with bone and joint manifestations. As shown in Table II, a total of 100 patients were found to have clinical orthopaedic problems over the period of 10 years (January 1980 to December 1989). This means an average of 10 patients are seen yearly. In an orthopaedic clinic running once a week one may see one of such patients per month.

Age Incidence

The disease has no respect for age but the young age group are more affected. In this series 50% of patients were under the age of 5 years and 17% between 5 to 9 years. Being a hereditary affection it usually presents early in life, hence the bigger the number of patients at that age. However, there are a few after teenage life as shown by 9% of patients after 20 years. This is so because of a high morbidity and mortality: "a few sicklers stand a chance of seeing their 20th birthdays'. Respective age related ailments are presented on specific diagnosis.

Sex Incidence

There is almost no sexual predilection of this problem; in this series the overall sex ratio is 1.3:1.2 for male and females respectively. Theis and Owen (1988) in the United Kingdom found a male to female ratio of 1.8:1.7[66]. The mode of inheritence of sickle-cell gene is

autosomal recessive and so in an endemic area there is an equal chance of either sex having the disease[30].

Geographical Distribution

This study has shown that patients are predominantly from the Lake Victoria basin region (95%) covering Nyanza and Western provinces. The rest are distributed to Rift valley province, 1%, Coast province 2% and continuation of Lake Victoria basin, Uganda 2%. The exceptionally high number from Nyanza province (76%) is because of the high frequency of the HbS gene (23.8%)[53].

Symptomatology

Despite varied clinical diagnosis, most of our patients had common symptoms. Pain was present in 87% of patients, swelling in 82% and nearly half of the patients had fever (49%) and 41% had either limping or loss of function of the affected limb. Other symptoms were rare and directly related to the bone or joint manifestations.

Physical Findings

Generally, stigmata of sicklers were present in varrying proportions; jaundice 61%, palour 43%, bossing of the skull 22% and splenomegally 16% of patients respectively. Pyrexia was prominent in 50% of the patients. Lymphadenopathy was also a feature noted in 17% of the patients.

Local findings tallied with most of symptomatology: 83% of the patients had a demonstrable swelling of which 68% were tender.

Depending on the lesion there was warmth in 31%, loss of function of the affected limb in 16%, deformity or contracture in 16%, fluctuance in 4% which coincided with complication of abscess and there was gangrene involving toes of both feet in one patient. Subsequently the gangrene demarcated out of which some toes fell off and others were amputated. The explanation for this is the digital arteries and veins got occluded either by oedema or thrombosis following sickling (dactylitis).

PATTERN OF PRESENTATION OF ORTHOPAEDIC ASPECTS OF SICKLE-CELL DISEASE

General

Pattern of presentation of patients of sickle-cell disease with orthopaedic complications is shown in Table IX.

In this series osteomyelitis ranked top with 53 patients (45.4%). The other conditions included hand and foot syndrome (sickle-cell dactylitis) 24.4%, septic arthritis 10.9%, avascular necrosis of femoral head 10.9%, pathological fractures 7.6% and gangrene of toes 0.8%.

Over the ten year period of study, 1986 had the highest number of patients (18) followed by 1980 with 17 patients. The lowest numbers were in 1981 and 1982 with 7 patients each. The variation of numbers in these years most probably was due to the fact that orthopaedic facilities were at Kabete in the late 1970s and early 1980s. Now with the establishment of Kenyatta National Hospital with variable departments, referrals have been directed to it, thus a build-up in the mid 1980s.

Specific Diagnosis

A. Osteomyelitis

This was the most common bone manifestation in this study (45.4%). It affected all the age groups but with a majority below 10 years (65%), this tallies with work done by Hendrickse and Collard, 1960; Ebrahim and Creck, 1966 and Engh et al, 1971[34, 23, 24].

Sickle-cell disease patients are more prone (susceptible) to infections that the rest of the population. Susceptibility relates to a variety of causes[1,3,15,20,22,23,24,36].

1. Anatomical characteristic of bone in sickle-cell disease following thrombosis, infarction and necrosis provides sites for bone infection.

2. Sickle "cells" and cell fragments block the reticuloendothelial (monocytic-phagocytic) system hence bacteria are not filtered, this leads to bacteraemia which then causes septicaemia.

3. Fibrotic spleen following multiple splenic infarcts during thrombotic crises is similarly unable to filter bacteria from the blood stream resulting in a bacteraemia.

4. Sicklers have a deficiency in opsonization particularly of pneumococci. It is related to an abnormality in properdin pathway (this is still a controversial point)[8,11,13,39,72]; and

5. Haemolysis in sickle-cell disease provides free serum iron and a decreased transferrin level. Free iron is known to encourage rapid growth of bacteria in vitro (Nzanzumuhire and Masawe et al)[51].

Genotypes of patients showed the majority were HbSF with 27 (50.9%) patients and followed by sickle-cell anaemia (HbSS with 20 (37.7%) patients. Acute and chronic osteomyelitis occurred in proportions of 4.9:5.1, the later slightly more because it was always a complication of the former.

The tibia was the most favoured single bone (32.1%) and multiple bone involvement occurred in 17 (32.1) patients. This multiple bone involvement by osteomyelitis is unique to sickle-cell disease compared to normal population. The reason for this is that during thrombotic crises extensive diaphyseal infarction takes place, this provides multiple areas of bone infarction and necrosis. These sites act as a nidus for bacterial growth in situations when bacteraemia or septicaemia ensues.

Huckstep (1968)[36] found multiple limb involvement by osteomyelitis in 64% of patients with sickle-cell anaemia compared to 33% in patients of non-sickle-cell anaemia. He also found upper limbs were more affected than the lower limbs (56%; cf 44%). In this series it contrasted with the above because the lower limbs were more involved than the upper in proportions of 79% and 21% respectively. This result almost tallied with Huckstep's findings in non-sickle-cell anaemia patients were the lower limb involvement was 89% compared to 11% in the upper limbs.

Salmonella typhimurium was isolated in 8 patients (14.8%) and of all positive isolates it was the majority with 35% followed by *Staphylococcus aureus* with 12.5%. Huckstep (1968)[36] found positive isolates of *Salmonella* to be 50% and non-*Salmonella* to be 21% while in non-sickle-cell anaemia no *Salmonella* growth was present and the non-*Salmonella* growth was 67% of which he identified 90% of the isolates to be *Staphylococcus aureus*. In this study, however, 30 patients had negative cultures.

Sickle-cell osteomyelitis can be differentiated from vaso-occlusive crisis by the presence of positive cultures, multiple and often symmetrical bone involvement, a florid involcurum and longitudinal fissuring of the cortex (Engh et al, 1971)[12].

The majority of treatments involve early (prompt) diagnosis, immediate antibiotic treatment, rest both the patient and the limb, support the limb, anti-inflammatory analgesics and rehydration by either oral or intravenous fluids. Treatment extended to a minimum of six weeks and details of treatment are given in Appendix II. Results of treatment were satisfactory, 71.1% of patients had complete resolution, 5.7% showed improvement at discharge and 17.7% had persistent (chronic) osteomyelitis.

In summary, osteomyelitis in sicklers tend to differ from normal individuals in the following aspects:

1. The whole shaft is usually involved.
2. Multiple bone involvement is common.
3. X-ray changes are seen earlier, Huckstep (1966)[36] demonstrated radiological evidence of osteomyelitis as early as three days from onset of symptoms. Also a case was described

by Konotey-Ahulu and Kuma (1965) of a patient with typhoid osteomyelitis in sickle-cell anaemia, in whom there was gross fragmentation of nearly all the long bones, with multiple fractures only one week after the clinical onset of the symptoms.

4. Extensive sequestra formation and sites for pathological fractures may occur.
5. Sequestra is commonly developed and gets resolved under medical treatment (Bohrer et al)[12]. In this study, however,there is no evidence of sequestra resorption. The reason for sequestrum resorption is probably due to great ability of young bone to heal with revascularisation.

B. Hand and Foot Syndrome

This is also referred to as sickle-cell dactylitis. In this series it is the second common affection of bones in sickle-cell disease and it was present in 30 patients (24.4%). The classical presentation of both hands and feet involvement was the commonest type or form (56.7%). Age distribution was unique; more than half the patients were below one year (53.3%) and 73.4% below 2 years. This confirms an earlier work by Theis and Owen (1988)[66] where they observed that dactylitis was a characteristic presentation in children under 5 years. The explanation for this is that the presence of foetal haemoglobin in high concentration protects the foetus and the very young against sickling of erythrocytes. During the later months of the first year, HbSF decreases and HbS increases. At this stage the red cells begin to sickle, and anaemia, haemolytic jaundice and capillary blockage begin. Why hands and feet (extremeties) are involved has been explained in the literature review. The hand and foot syndrome is seldom seen after the 4th year. The

explanation for this is that the red marrow recedes from the relatively cold and distal bones and is replaced by fibrous tissue which is less demanding of oxygen and is capable of anaerobic metabolism[20].

Dactylitis is normally a self-limiting condition hence all patients had complete resolution except for one who had persistent dactylitis.

C. Septic Arthritis

This condition has been quoted to be rare by earlier workers (Barnet et al, 1961; David and Block, 1961; Engh et al, 1971; Dich et al, 1975; Givner et al, 1981; Molyneux and French, 1982)[24,29,49]. Ebong et al (1979)[22] reported higher incidence than that of North American studies. In this series there were 13 patients (10.9%). It had equal proportions as avascular necrosis of femoral head. The ankle joint was the most single joint involved (30.4%). Multiple joint involvement was present in 2 patients (15.4%). The predominant haemoglobin abnormality was HbSF (61.5%). Bacteriology of pus specimen grew *Salmonella typhimurium* in 3 patients (23%) and *Klebsiella* in 1 patient (7.7%).

Purulent arthritis is caused by presence of pyogenic organisms proliferating in the joint cavity. Bacteriological spectrum simulates that seen in osteomyelitis. In normal population under 2 years *Haemophilus influenza* is more often found than *Staphylococcus aureus*. The pathological outcome is determined by interaction of host resistance and the virulence of the organism. Three stages may be described although in reality they merge together. In the first stage there is a serous effusion from synovial membrane producing excess of clear fluid in the joint. The effusion may be reabsorbed or, if defences are overwhelmed, become

serofibrinous. During the second stage, the synovium is inflammed and the fluid becomes turbid owing to the presence of bacteria, leucocytes and fibrin. Fibrinous deposits may mature to form fibrous adhesions and so resolution may be incomplete. In virulent infections, the third stage of purulent arthritis quickly supervenes as the joint capsule becomes distended with a collection of pus. Proteolytic enzymes released from dead bacteria and leucocytes cause necrosis of cartilage and synovium. When the acute chondrolysis affects more than the most superficial layer, permanent joint damage is inevitable, with irregularity, stiffness and ankylosis in severe cases. Rising pressure in the joint may cause further complications:

1. Tamponade of circulation and worsened by sickling (thrombosis) may lead to infarction and sequestration of the epiphysis.
2. Softening and stretching of the supporting ligaments can cause dislocation of the joint.
3. If full thickness of cartilage becomes necrotic and detached, the underlying bone may be exposed. Direct spread of infection causes a local or more generalised osteomyelitis.
4. The capsule may perforate, leading to periarticular soft tissue abscess.

In this series treatment depended on early diagnosis, aggressive antibiotic therapy (initially intravenously), splintage of limb and decompression of the joint by aspiration (1 patient) and arthrotomy (1 patient). Septicaemia was an early complication seen in 3 patients. All the patients recovered well without complications such as ankylosis, residual stiffness or chronicity as reported earlier by Ebong et al[22].

D. Avascular Necrosis of Femoral Head

Majority of patients were HbSF (46.2%) with 38.4% of HbSS. In this series there were no patients with HbSC in which earlier studies revealed a high incidence of osteonecrosis of the femoral head (Cockshott, 1958; Golding et al, 1959; Obisesan and Bohrer, 1972 and Sennara and Gorry, 1978)[21,30,37]. Men are affected more than women in a ratio of 8:5 (same as seen by Konotey-Ahulu, 1972)[42]. It was unilateral in most of the patients (11 patients). Left side was more affected than the right side in proportions of 7 to 4 patients. The disease was bilateral in 2 patients.

The age of patients with avascular necrosis of femoral head ranged from 7 years to 25 years. The majority (11 patients - 85%) were from early teenage life onwards with only 2 patients (15%) below 13 years of age. This has been observed by earlier workers. The explanation for lack of avascular necrosis of femoral head in younger children is that the artery in the ligamentum teres is patent in them giving the femoral head a dual blood supply. Also in young children the arteries entering through the hip capsule are relatively short and relatively large in relationship to the mass of cellular marrow to be supplied with oxygen[20].

The lesions produced by avascular occlusion due to sickle-cells involving the head of femur have radiological appearances similar to those observed in other avascular lesions such as Legge-Calves Perthes' disease, slipped upper femoral epiphysis and infections. Perthes' disease appears in early childhood and tends to involve the entire femoral head, whereas necrosis associated with HbS usually appears in teen-agers or adults, and areas of infarction in initial stages tend to be more localised.

Classification of avascular necrosis of the femoral head has been done by Iwegbu et al (1985)[38] and Ficat et al (1980)[26]. These are shown below in Tables XVI and XVII respectively.

Table XVI: Classification of avascular necrosis of the femoral head in sickle-cell disease.

Stage	Description
A	Subchondral sclerosis
B	Perthe's-like lesion Type I - Segmental Type II - Total
C	Total destruction
D	Central necrosis
E	Diffuse necrosis

Table XVII: Radiological classification of avascular necrosis of femoral head in sickle-cell disease.

Stage	Joint Space	Femoral Head	Bone Quality	Diagnosis by Radiography
Necrosis I	Normal	Normal	Normal or osteoporotic	Impossible
II	Normal	Normal	Osteoporotic or Sclerotic	Probable
Necrosis and Collapse III	Normal	Flattened crescent sign, subchondral fracture	Sequestrum formation	Certain
IV	Decreased	Collapse secondary to acetabular changes	Destruction of superior pole	Appears similar to inflammatory and degenerative arthritis

Treatment of these patients varied. There was no standardised tretment protocol such that some patients absconded (2 patients), splintage with hip spica and skeletal traction was done in 3 patients, analgesics administered in six patients, bed rest in 2 patients and supervised negligence in 2 patients. The outcome of treatment was disatisfying in the 11 patients (85%) and it ranged from status quo, (progressive limiting disability) to abscondment and in the later because no convincing treatment was offered. In one of the patients hip fusion was planned but he absconded.

The approach to treatment of avascular necrosis of femoral head depends on the stage of the disease (Ficat and Arlet et al)[26,65]. Stage I and II (see Table XVII) - avoidance of weight bearing for three to six months; this may prevent collapse and allow healing and preservation of normal femoral head. Unfortunately, diagnosis at this stage is rare because the patient is used to bone and joint pains and does not pay attention to an occassional groin pain. In Stages III and IV: surgery is indicated and depending on the age of the patient, osteotomy (varus, valgus or rotational) or total hip replacement surgery has been used with good early results[9,37,54].

Earlier, Golding et al (1959)[30] stipulated that the adult type of lesion usually required surgical treatment. When the condition is bilateral, a high femoral osteotomy of the McMurray type gives satisfactory results and if the avascular necrosis affects one hip then arthrodesis is advisable, the bone heals satisfactorily at a normal rate.

Osteotomy has a role to play in avascular necrosis of femoral head at stage II especially when there is subluxation of the femoral head with or without coxa plana (Oliver et al, 1990)[54]. Pain relief is often dramatic

and is ascribed to redistribution of the loading forces towards the less damaged parts of the joint and in their Saudi Arabia series three patients (aged 11, 12, and 14 years) who had proximal femoral osteotomy for subluxation of the hip had satisfactory pain relief although deterioration of hip radiologically was seen in two. Progressive joint destruction, with increasing pain, disability and deformity requires reconstructive surgery. Arthrodesis is indicated if the stiffness is acceptable in unilateral disease and neighbouring joints are not likely to be prejudiced. However, study done by Hugh et al (1989)[37] found that the results of both hemiarthroplasty and fusion were poor and could not be recommended. Hemiarthroplasty fails because of soft acetabular bone in many cases, and fusion is ill advised because hip disease was bilateral in most cases in their series. However, the results in the small numbers of total hip arthroplasties recorded were clearly a cause of concern. They found that the prognosis of total hip replacement was worse in younger patients, the estimated risk of loosening for a 50 year old being 2.5 to 3.0 times higher than for an elderly patient with osteoarthritis (Johnson et al, 1988)[37]. Though the study confirmed that total hip replacement had a poor prognosis in sickle-cell disease, they felt that arthroplasty was justified in patients with severe disability caused by the disease as it is the only option available.

The high blood loss and extended operating time, make it important to use all possible measures to prevent blood stasis, including warming the patient. Early post-operative vigilance is necessary to detect any hypoxic episodes.

E. Pathological Fractures

Distribution of patients with pathological fractures is shown in Table XIV. There were a total of nine patients, 5 of which had concurrent osteomyelitis (4) and septic arthritis (1). In this study, pathological fractures are mainly a sequalae of chronic osteomyelitis (62.5%), the ramaining three patients osteoporosis and bone infarction may have played a role in their aetiology. Remarkably when splinted more than half of them united (55.6%) and non-union occurred in 1 patient. There was concurrent treatment of present septic arthritis and osteomyelitis.

F. Miscellaneous

In vaso-occlusive crises, treatment by anti-inflammatory analgesics, oxygen and rehydration (intravenous fluids) proved to be effective. Blood transfusion was needed only when the haemoglobin fell below 5.0g, and should be used with caution because of risks of iron overload and haemachromatosis (Forget, 1985)[27]. In our set-up (tropical environment) prompt treatment of malaria with chloroquine or metakelffin for chloroquine resistant type and continued prophylaxis with pyrimethamine reduces morbidity and mortality remarkably. Supplements of folic acid have also to be provided.

Gangrene of toes was encountered in one patient (female aged 12 years). It occurred following dactylitis. Bohrer et al (1970)[12] noted gangrene in two sickle-cell patients in the lower limbs following use of torniquets. These definitely compromised the already vulnerable circulation, enhances sickling, thrombosis and infarction and prone to

gangrene. This has provided the basis for no use of torniquets in sickle-cell patients.

FOLLOW-UP

The difficulties in obtaining follow-up information in patients with benign disease is well known. In absence of subsidisation, the recall of all patients for follow-up examination or as per appointmet to the clinic is not possible at the best of times. In this study 36 patients (36%) were followed in the haematology clinic, 33 patients (33%) in the orthopaedic clinic and 31 patients (31%) absconded from either clinic without any specific reason. The majority of patients with osteomyelitis, hand and foot syndrome and septic arthritis were managed by paediatricians and physicians. The follow-up was mainly by the haematologists and consultations to orthopaedic department arose when there was chronicity of osteomyelitis, presence of abscess to drain, avascular necrosis of femoral head (late stage) and pathological fractures.

OTHER PROBLEMS

1. There was a delay to start this study because ethical and scientific committee took six months to communicate the go-ahead.

2. X-ray department had only kept records for the last four years of the study, others had been disposed and even in those it was difficult to come by the desired X-rays.

3. Comments of radiological features were scribbled down in most files but most times the X-ray number was not written down and this further curtailed the obtaining of the required radiographs.

4. Other investigations - Haemogram, sickle-cell test (SCT) and haemoglobin electrophoresis; a few were missing from the files and was impossible to trace from the laboratory records.

5. Not all files indicated in the disease cardex were present in the records office. Anyway, all these are part and parcel of a retrospective study.

CHAPTER VI
CONCLUSIONS

This study has shown that:

1. Bone and joint complications (or lesions) of sickle-cell disease are common at Kenyatta National Hospital. Approximately one patient is seen every month.

2. Orthopaedic aspects seen include osteomyelitis, hand and foot syndrome (dactylitis), septic arthritis, avascular necrosis of the femoral head and a complication of osteomyelitis - pathological fractures.

3. Osteomyelitis was the most frequent bone lesion and it occurred mainly in the younger age group (below ten years).

4. Hand and foot syndrome was the commonest bone lesion in children below the age of five years; the majority occurring in the first two years of life.

5. The earliest bone lesion to occur is usually the hand and foot syndrome (dactylitis) seen as early as three months of age.

6. Septic arthritis and avascular necrosis of femoral head occurred in equal frequencies.

7. Avascular necrosis of the femoral head mainly occurs in adolescence and adulthood.

8. The most challenging arthropathy to the orthopaedic team is avascular necrosis of the femoral head.
9. Pathological fractures were mainly a sequale of chronic osteomyelitis.

10. Multiple presentation of sickle cell disease with osteomyelitis, septic arthritis, pathological fractures and avascular necrosis of femoral head occured.

11. Osteomyelitis in sicklers tends to differ from normal individuals (ie have a unique presentation). Osteomyelitis may affect multiple sites (bones), whole diaphyseal involvement, extensive sequestra formation, earlier radiological features and sequestra resorption may occur under medical treatment.

12. Males and females were almost equaly affected (M:F = 1.3:1.2).

13. The majority of patients originated from the Lake Victoria basin ie Nyanza and Western provinces which is the endemic area of sickle-cell disease in Kenya.

14. Treatment of these patients needed (needs) a multidisciplinary approach involving the paediatricians, physicians, haematologists and orthopaedic surgeons.

15. Early and prompt treatment of infective conditions (osteomyelitis and septic arthritis) with antibiotics greatly minimised morbidity and mortality.

16. All patients with hand and foot syndrome resolved spontaneously with supportive care.

17. In all sickle-cell patients the keystone in management is prophylaxis against crises and common infections. Hence, the routine use of folic acid, antimalarials (Pyrimethamine and Chloroquine), fluids and antibiotics where indicated.

18. Surgery is reserved only for a few selected cases eg drainage of abscess, decompression of pyoarthritis, sequestrectomy and management of late stages of avascular necrosis of femoral head.

19. Follow-up was poor in more than a third of patients (31%).

20. Genotypic distribution of patients was HbSF 55%, HbSS 35%, HbAS 8% and HBSOoArab 1%. There was no HBSC disease or HbSThalassaemia.

CHAPTER VII
RECOMMENDATIONS

1. Improvement of record keeping in the records office and X-ray department because without which retrospective studies are very difficult and inadequate.

2. Recording of history, examination and laboratory findings of patients by clinicians ought to be done accurately other than relying on the loose request forms which easily get lost.

3. More liason should exist between orthopaedic and haematology departments.

4. A separate disease cardex (index) should be given to the patients with sickle-cell disease having bone and joint complications. This would ease follow-up in the orthopaedic clinic because many times files get lost as they are put in the general pool of haemolytic anaemias.

5. There is need to do a prospective study on this subject so as to come with a practical incidence, clinical presentation and protocol of management of especially avascular necrosis of the femoral head.

BIBLIOGRAPHY

1. ADEYOKUNNU AA, HENDRICKSE RG. Salmonella osteomyelitis in childhood: a report of 63 cases seen in Nigerian children of whom 57 had sickle-cell anaemia. Arch. Dis. Child. **55**: 175-84. 1980.

2. ALAVI A, SCHUMACHER HR, DORWART B., KUHL DE. Bone marrow scan evaluation of arthropathy in sickle-cell disorders. Arch. Intern. Med. **136**: 436-40. 1976.

3. ARCHAMPONG EQ, KORSAH KG. Surgical aspects of haemoglobinopathies. Textbook: Principles and Practices of Surgery including Pathology in the Tropics. 841-851. 1986.

4. BARTON CJ AND COCKSHOTT WP. Bone changes in sickle-cell disease. Am. Journ. Roent. **88**: 523. (1962).

5. BARRET - CONNOR E. Bacterial infection and sickle-cell anaemia: An analysis of 250 infections in 166 patients with a review of the literature. Medicine (Baltimore). **50**: 97-112. (1971).

6. BENSINGER TA, PETER NG. Haemolysis in sickle-cell disease. Arch. Intern. Med. **133**: 624. (1974).

7. BERTIES JF. Haemoglobin interaction and molecular basis of haemoglobin sickling. Arch. Intern. Med. **133**: 538. (1974).

8. BHORNSON AB, GASTON MH, ZERLBER CL. Decreased opsonization for *Steptococcus pneumoniae* in selected complements and immunoglobins. J. Paed. **91**: 371. (1972).

9. BISHOP AR, ROBERSON JR, ECKMA JR, FLEMING LL. Total hip arthroplasty in patients who have sickle-cell haemoginopathy. J. Bone Joint Surg (AM). **70A**: 853-5. (1988).

10. BLACK PH, KUNZ LJ, SWARTZ MN. Salmonellosis: A review of some unusual aspects. N. Eng. J. Med. **262**: 811-7. (1960).

11. BOHRER SP. Fractures complicating bone infarct and osteomyelitis in sickle-cell disease. Clin. Rad. **22**: 83. (1971).

12. BOHRER SP. Acute diaphyseal infarcts in sickle-cell disease. British *Journal of Radiology. **43**: 685. (1970).*

13. BOGGS DR, HYDE F, SRODES C. Pattern of neutrophil kinetics in sickle-cell anaemia. Blood. **91**: 371. (1973).

14. BROWNE RA. Anaesthesia in patients with sickle-cell anaemia. Br. J. Anaesthesia. **37** 181. (1965).

15. BWIBO NO. Infections in children with sickle-cell anaemia. The Nairobi Journal of Medicine. **1**: 14. (1984).

16. CHARACHE S. Treatment of sickle-cell anaemia. Arch. Int. Med. **133**: 693. (1974).

17. CHUNG SMK, BALTSON EL. Necrosis of the femoral head associated with sickle-cell anaemia. J. Bone Joint Surg. **51(A)**: 33. (1969).

18. CHUNG SMK, ALAVI A, RUSSEL MO. Management of osteonecrosis in sickle-cell anaemia and its genetic variants. Clin. Orthop. **130**: 158-74. (1978).

19. COCKSHOTT WP, WEAVER EJM. Primary Tropical Abscess - A misnomer. Br. J. Surg. **49**: 665. (1962).

20. DIGGS LW. Bone and joint lesions in sickle-cell disease. Clin. Orthop. and Related Research. **52**: 119-43. (1967).

21. EBONG WW, LAGUDOYE SB, ODUNTAN SA, ADELOYE. Sickle cell Disease. Davey's companion to surgery in Africa. 1-7. (1987).

22. EBONG WW. The treatment of severely ill patients with sickle-cell anaemia and associated septic arthritis. Clin. Orthop. and Related Research. 145. (1979).

23. EBRAHIM GJ, GRECK P. *Salmonella osteomyelitis* in infants. J. Bone Joint Surg. **48-B**: 350. (1966).

24. ENGH CA, HUGHES JL, ABRAMS RC, BOWERMAM JW. Osteomyelitis in the patient with sickle-cell disease: Diagnosis and Management. J. Bone Joint Surg. (AM). **53-A**: 1-15. (1971).

25. EPPS CH Jr., CASTRO O. Complications of total hip replacements in sickle-cell disease. Orthop. Trans. **2**: 236-7. (1978).

26. FICAT RT, ARLET J. Ischaemia and necrosis of bone. Baltimore: Williams and Wilkins, 1980.

27. FORGET BG. *Sickle-cell anaemia and associated* haemoglobinopathies. In. Wyngaarden JB, Smith LH Jr. (eds.) Cecil Textbook of Medicine. 17th edition. Philadelphia, etc. WB Saunders Co. *927-32. (1985).*

28. *GILBERTSON AA. Anaesthesia* in West African patients with sickle-cell anaemia, HbSC disease and sickle *cell trait. Br. J.* Anaesth. **37**: 614. (1964).

29. GIVNER LB, LUDDY RE, SCHWARTZ AD. Etiology of osteomyelitis in patients with major sickle cell haemoglobinopathies. J. Paediatr. **99**: 411-3. (1981).

30. GOLDING JSR, MACIVER JE, WENT LN. The bone changes in sickle cell anaemia and its genetic variants. J. Bone Joint. Surg. (BR). **41(B):** 711-8. (1959).

31. HANKER GJ, AMSTUTZ HC. Oteonecrosis of the hip in the sickle-cell disease: Treatment and Complications. J. Bone Joint Surg. (AM). **70(A)**: 499-550. (1988).

32. HAQ A. *Priapism in a juvenile sickler - A case report.* EAMJ **65**: 407. (1988).

33. Haemoglobinopathies and other anaemias. Textbook of muskoskeletal disease (1988 ed), 55. (1985).

34. HENDRICKE RG, COLLARD P. *Salmonella osteitis* in Nigerian children. Lancet. **1**: 80-2. (1960).

35. HOLZMANN L, FINN H, LITCHMAN HC, HARMEL M. Anaesthesia in patients with sickle cell disease. J. Anaesthesia and Analgesia. **48**: 566. (1969).

36. HUCKSTEP RL. The management of osteomyelitis in East Africa. EAMJ. **45**:7. (1968).

37. HUGH JC, RIYAZ HJ, ANDREW FB, JIM DM. Total replacment of the hip avascular necrosis in sickle-cell disease. J. Bone. Joint. Surg. (BR) **71(B)**: 465-470. (1989).

38. IWEGBU CG, FLEMING AF. Avascular necrosis of the femoral head in sickle-cell disease. J. Bone Joint Surg. (BR). **67(B)**: 29-32. (1985).

39. JOHNSON RB, NEWMAN SL, SMITH AG. Abnormalities of the alternative pathway of the complement activation in sickle-cell disease. New Engl. J. Med. **288**: 803. (1973).

40. KLUG PP, RADICE P. Rheological aspects of sickle-cell disease. Arch Int. Med. **133**: 577. (1974).

41. KOLAWOLE TM, BOHRER SP. Splenic abscess and the gene of haemoglobin S. South America Journal of Roent. **119**: 175. (1973).

42. KOTONEY-AHULU FID. The sickle-cell diseases: Clinical manifestations including the "sickle-cell crisis". Arch. Int. Med. **133**: 611 (1974).

43. LAGUNDOYE SB. Radiological features of sickle cell anaemia and related haemoglobinopathies in Nigeria. Afr. J. Med. Sci. **1**: 315-42. (1970).

44. LEADING ARTICLE. Sickle cell anaemia and anaesthesia. BMJ. 1263. (1965).

45. LEGANT O, BALL RP. Sickle cell anaemia in adults: Roentgenographic findings. Radiology. **51**: 665-75 (1948).

46. LESIN LS, WALLACE JN. Sickle-cell anaemia 1910-1973. Arch. Int. Med. **133**: 529. (1974).

47. MABAYOJE JO. Sickle-cell anaemia: A major disase in West Africa. BMJ. **1**: 196. (1956).

48. MILNER PJ. Oxygen transport in sickle cell anaemia. Arch. Int. Med. **133**: 565. (1974).

49. MOLYNEUX E, FRENCH G. Salmonella joint infection in Malawian children. J. Infect. **4**: 131-8. (1982).

50. NELSON JD. Sickle-cell disease and bacterial bone and joint infections. New England J. Med. **292**: 534 (1975).

51. NZANZUMUHIRE H, MASSAWE AEJ. Growth of bacteria in vitro in blood from patients with severe iron deficiency anaemia and from patients with sickle cell anaemia. Am. J. Clin. Path. **59**: 706. (1973).

52. ODUNTAN SA, ISAACS WA. Anaesthesia in patients with abnormal haemoglobin syndromes. A preliminary report. Br. J. Anaesth. **43**: 1159 (1971).

53. OJWANG PJ, OGADA J. A review of the molecular characteristic of sickle-cell anaemia in patients from Western Kenya. The Nairobi J. Medicine. **2**: 70-75. (1989).

54. OLIVER MB, SIMON SM. Bone manifestations of sickle-cell anaemia. J. Bone Joint Surg. (BR) **72(B)**: 494-9. (1990).

55. PATEL AR. Arthropathy in sickle cell disease. N. Engl. J. Med. **288**: 970-1. (1973).

56. PERRINE RP, PEMBREY ME, JOHN P, PERRINE S, SHOUP F. Natural history of sickle-cell anaemia in Saudi Arabia: A study of 270 subjects. Ann. Intern. Med. **88**: 1-6.

57. RAPER AB, ALLAN B. Sudden death in sickle cell disease. EAMJ. (1949 Jan.).

58. REYNOLDS J. Radiologic manifestations of sickle cell haemoglobinopathy. JAMA. **288**: 247-50. (1977).

59. RICKLES FR, O'LEARLY DS. Role of coagulation system in pathophysiology of sickle cell disease. Arch. Int. Med. **133**: 643. (1974).

60. RUCKNAGEL DL. The genetics of sickle-cell anaemia and related syndromes. Arch. Int. Med. **133**: 549 (1974).

61. SCHUMACHER HR, ANDREWS R, McLAUGHLIN G. Anthropathy in sickle cell disease. Ann. Intern. Med. **78**: 203-11. (1973).

62. SERJEANT GR. Leg ulceration in sickle cell anaemia. Arch. Int. Med. **133**: 690. (1974).

63. SHERMAN M. Pathogenesis of disintergration of the hip in sickle cell anaemia. South Med. J. **52**: 632-7. (1959).

64. SMITH WS. Sickle cell anaemia and *Salmonella osteomyelitis*. Ohio Med J. **49**: 692-5. (1953).

65. SULEIMAN SK. Bone changes in sickle cell disease J. Bone Joint (BR) **52(B)**: 396. (1970).

66. THEIS JC, OWEN P. Skeletal complications in sickle cell disease in the United Kingdom. J. Royal College of Surgeons Edinburgh. **33**: 306. (1988).

67. de TORREGROSA MV, DAPENA RB, HERNANDEZ H, ORTIZ A. Association of *Salmonella*-caused osteomyelitis and sickle cell disease: Report of three cases. JAMA. **174**: 354-6. (1960).

68. WALDVOGER FA, MEDOFF G, SWARTZ MN. Osteomyelitis. J. Med. **282**: 198. (1970).

69. WATSON RJ, BURKO H, MEGAS H, ROBINSON M. The hand and foot syndrome in sickle cell disease in young children. Paediatrics. **31**: 975-82. (1963).

70. WHITE JG. Ultrastructural features of erythrocytes and haemoglobin sickling. Arch. Int. med. **133**: 565. (1974).

71. WHITTEN CF, FISCHOFF J. Psychosocial effects in sickle cell disease. Arch. Int. Med. **133**: 693. (1974).

72. WINKELSTEIN JA, DRACHMAN RH. Deficiency of pneumococcal serum opsonizing activity in sickle-cell disease. N. Engl. Med. **279**: 459-66. (1966).

APPENDICES

APPENDIX I - PROFORMA

ORTHOPAEDIC ASPECTS OF SICKLE-CELL DISEASE AT KENYATTA NATIONAL HOSPITAL

(DR. S. P. ODWONGO)

A. GENERAL INFORMATION

Study No:_____

IP/Unit No._____

NAME OF PATIENT:_____

AGE_____ SEX_____DISTRICT_____

Date of Admission_____

Date of Discharge_____

Number of Admissions_____

B. SPECIFIC INFORMATION

I. HISTORY:

SYMPTOMS:

1. Pain or irritability_____
2. Swelling_____
3. Limping or loss of limb function_____
4. Fever_____
5. Others_____

II EXAMINATION:

SIGNS:

a. General: Stigmata of sicklers:

1. Bossing of skull_____
2. Pyrexia_____
3. Splenomegally_____
4. Jaundice_____
5. Regional lymphadenopathy_____

6. Palour_____

b. Local:

1. Swelling_____

2. Warmth_____

3. Tenderness_____

4. Ulcerations_____

5. Sinuses_____

6. Deformity or contracture_____

7. Loss of function_____

8. Bone involved_____

9. Joint involved_____

III INVESTIGATIONS:

1. Haemoglobin (Hb)_____

2. Sickle-cell test (SCT)_____

3. Haemoglobin electrophoresis:

AS_____

SS_____

SC_____

SThal_____

SF_____

Others_____

4. Bacteriology:

Plain X-ray_____

Contrast (Arthrography)_____

IV DIAGNOSIS:

1. Osteomyelitis_____

2. Hand and foot syndrome_____

3. Septic Arthritis_____

4. Avascular necrosis of femoral head_____

5. Pathological features_____

6. Others:

a. Spine ankylosis_____

b. Crystal deposition in joints_____

c. Haemoarthrosis_____

d. Joint effusion_____

e. Chronic synovitis_____

V TREATMENT:

a. Conservative_____

b. Surgery_____

VI COMPLICATIONS_____

_____

_____

_____

VII RESULTS_____

_____

_____

_____

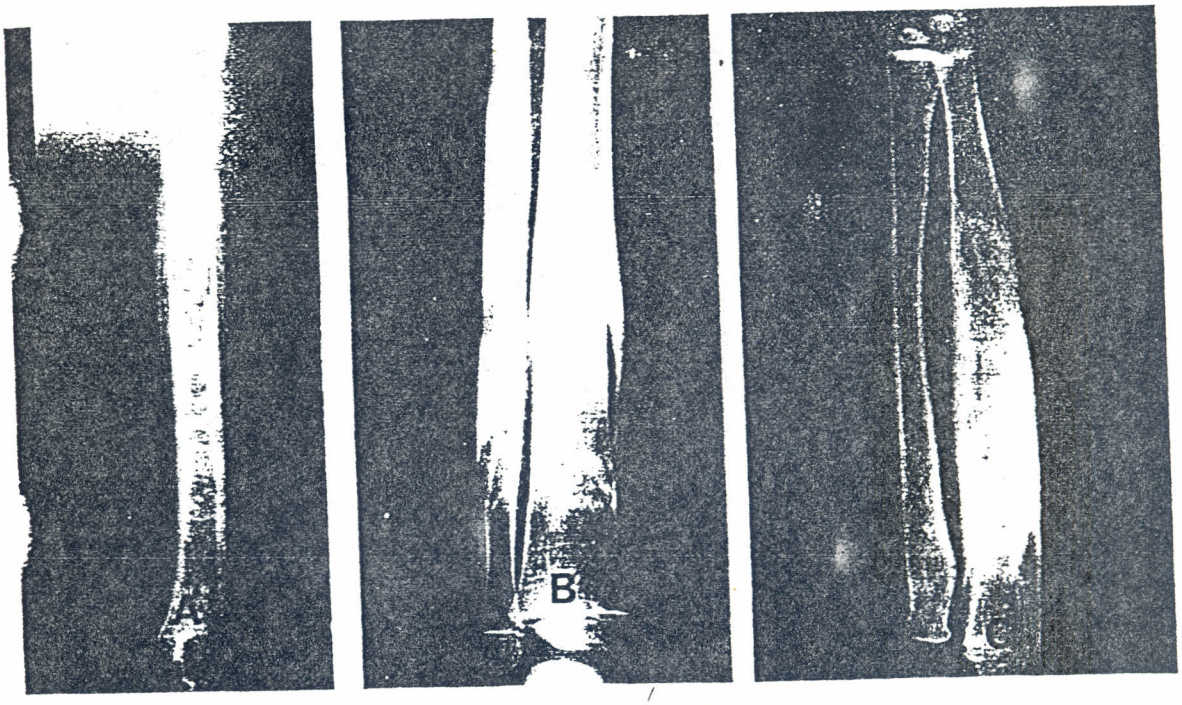
_____

APPENDIX II
ILLUSTRATIONS (RADIOGRAPHS)

A: HbSS - Five year old humerus. The lesion is localised at the junction between central and intermediate segments.

B: Haemoglobin SS - Six year old distal tibia and fibula. There are well formed sequestra in the somewhat older lesion.

C: HBSF - Four year old. This old central lesion extends to the intermediate segments.

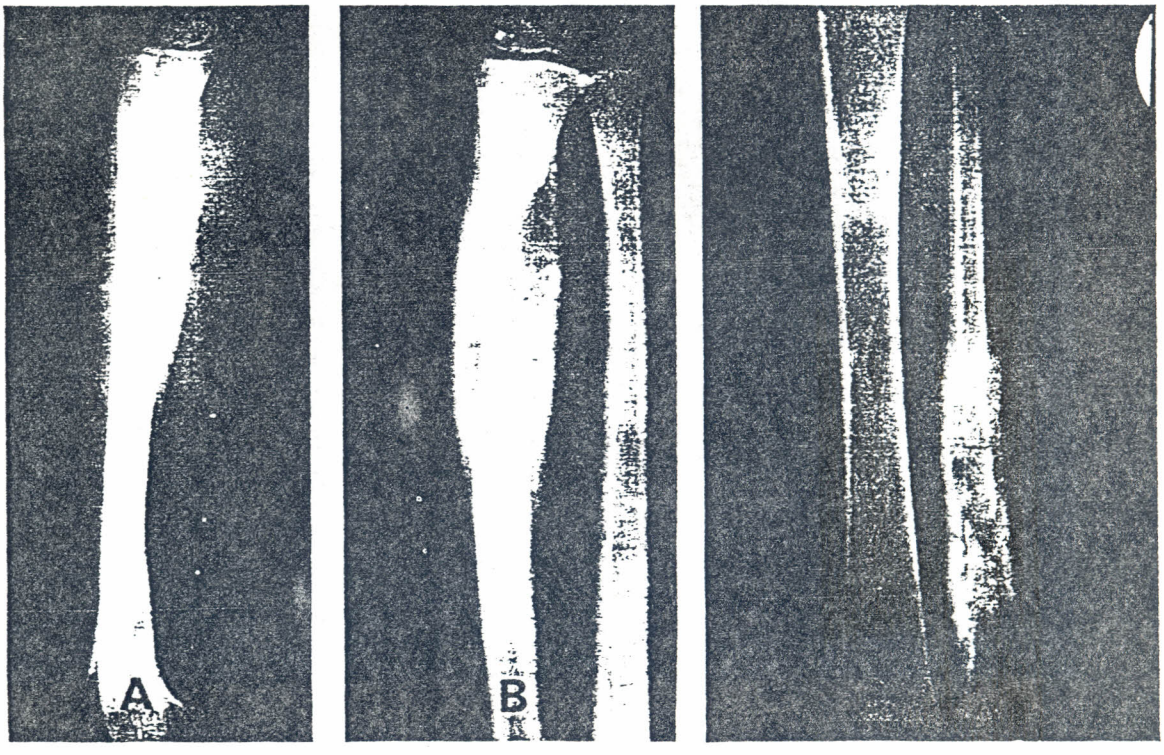


More advanced intermediate segment lesions with early sequestra formation (Osteomyelitis).

A: Haemoglobib SS - Five year old distal radius.

B: Haemoglobin SS - Four year old distal radius

C: Haemoglobib SS - Two year old distal fibula. This lesion extends to the central segment.

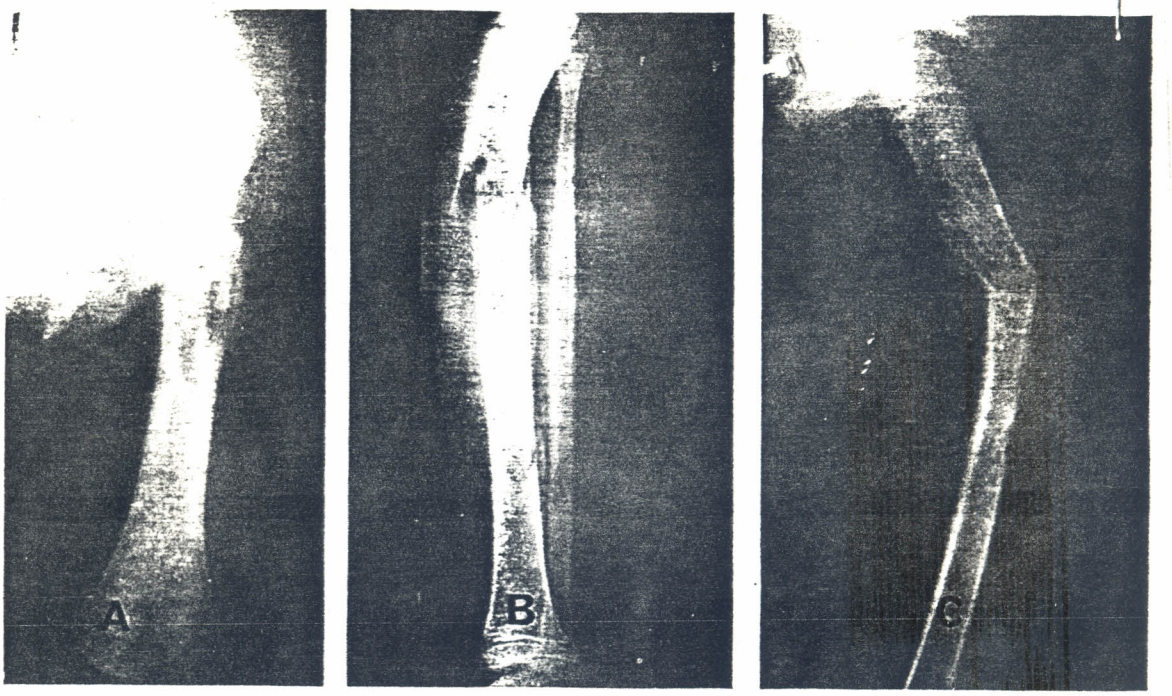


Intermediate segment lesions with fractures.

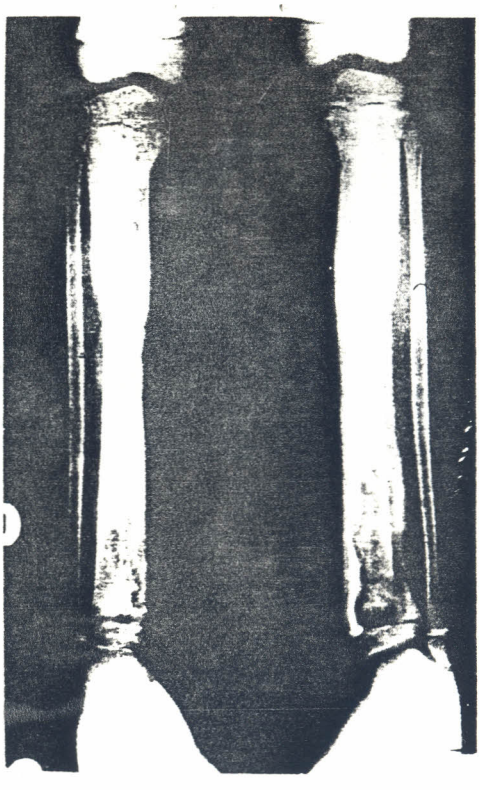
A: Haemoglobin SS - One year old proximal humerus

B: Haemoglobin SS - Five year old proximal tibia

C: Haemoglobin SS - Two year old proximal femur



Osteomyelitis of the whole diaphyses of both tibia in HbSS. Note "the bone in bone" appearance.



Avascular necrosis of left hip.

HbSS - Seven year old with features resembling Legg-Perthes disease.