THE SPECTRUM OF RADIOGRAPHIC AND SONOGRAPHIC FINDINGS IN PATIENTS WITH SHOULDER PAIN AT THE DEPARTMENT OF DIAGNOSTIC IMAGING AND RADIATION MEDICINE, UNIVERSITY OF NAIROBI

DR. DESMOND MBONDO MANG'OKA

DISSERTATION SUBMITTED AS PART FULFILMENT OF MASTERS OF MEDICINE DEGREE IN DIAGNOSTIC IMAGING AND RADIATION MEDICINE, UNIVERSITY OF NAIROBI

DECLARATION

I declare that this dissertation is my original work written under the supervision of Dr Callen Kwamboka Onyambu and Dr Ian Mathenge Muriithi.

Dr. Desmond Mbondo Mang'oka

Resident

Department of Diagnostic Imaging and Radiation Medicine

University of Nairobi

Signature: ………………………………………….. Date:……………………………

CERTIFICATE OF SUPERVISION

This is to certify that this dissertation was written under our supervision.

1. Dr. Callen Kwamboka Onyambu,

Senior Lecturer,

Department of Diagnostic Imaging and Radiation Medicine,

University of Nairobi.

Signature: ………………………………………….. Date:……………………………

2. Dr. Ian Mathenge Muriithi

Lecturer,

Department of Diagnostic Imaging and Radiation Medicine,

University of Nairobi.

Signature: ………………………………………….. Date:……………………………

DECLARATION OF ORIGINALITY FORM

Declaration Form for Students

UNIVERSITY OF NAIROBI

This form must be completed and signed for all works submitted to the University for Examination.

Name of Student ____

Registration Number ____

College ____

Faculty/School/Institute____

Department ____

Course Name ____

Title of the work

DECLARATION

1. I understand what Plagiarism is and I am aware of the University's policy in this regard

2. I declare that this __________________ (Thesis, project, essay, assignment, paper, report, etc) is my original work and has not been submitted elsewhere for examination, award of a Degree or publication. Where other people's work or my own work has been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements.

3. I have not sought or used the services of any professional agencies to produce this work

4. I have not allowed, and shall not allow anyone to copy my work with the intention of passing it off as his/her own work

5. I understand that any false claim in respect of this work shall result in disciplinary action, in accordance with University Plagiarism Policy.

Signature ____

Date ____

DEDICATION

This work is dedicated to my loving wife Dr. Mary Ingabo and children Mark Muuo, Joy Ndanu and Angela Ndumi for their patience and support during the study.

ACKNOWLEDGEMENT

I sincerely express my heartfelt gratitude to my supervisors Dr Callen Onyambu and Dr Ian Mathenge for their professional guidance and mentorship during the entire process of the study.

Special thanks to the Department of diagnostic imaging and radiation medicine for waiving the fees for all the shoulder ultrasounds without which the study would have been impossible to accomplish.

To the biostatistician, radiographers, receptionists and study participants this work is the culmination of your respective efforts. Thank you .

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

FIGURES

TABLES

LIST OF ABBREVIATIONS

US	Ultrasound
CT	Computed Tomography
MRI	Magnetic Resonance Imaging
MRA	Magnetic Resonance Arthrography
OR	Odds Ratio
UK	United Kingdom
SASD	Subacromial Subdeltoid Bursa
SGHL	Superior Glenohumeral Ligament
MGHL	Middle Glenohumeral Ligament
IGHL	Inferior Glenohumeral Ligament
RCTs	Rotator Cuff Tears
ACJ	AcromioClavicular Joint
AP	Anteroposterior
LAT	Lateral
FFD	Film Focus Distance
UON	University of Nairobi
DDIRM	Department of Diagnostic Imaging and Radiation Medicine

ABSTRACT

Background: Shoulder pain is a common cause of musculoskeletal pain. Prevalence estimates vary from 6.9% to 26% in the general population. The most frequent cause of shoulder pain is rotator cuff disease. Shoulder radiography is the primary imaging modality in shoulder pain but is limited in the evaluation of the soft tissues. MRI is the chief modality used in the evaluation of shoulder soft tissues locally but is limited by cost and availability. Shoulder ultrasonography is a cost effective modality for evaluating the soft tissues but is underutilized locally. No data is available in our local population regarding spectrum of findings in shoulder radiographs and ultrasound.

Objective: This study was designed to determine the spectrum of shoulder radiographic and sonographic findings in patients with shoulder pain at the Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi.

Setting: Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi. It is located within the old wing of Kenyatta National Hospital .

Study design: This was a cross sectional descriptive study.

Study subjects: A total of 72 patients with shoulder pain who were referred for shoulder radiographs .

Method: The study was conducted over a period of four months between the months of January 2016 to April 2016. 72 consecutive patients with shoulder pain referred for Shoulder radiographs had a complementary shoulder ultrasound scan done and findings of both examinations recorded in the data collection form. Statistical analysis of the findings was then done using SPSS version 20 IBM. No surgery findings were available to correlate with the imaging findings..

Results :. Radiographs identified abnormalities in 36 (50%) patients majority of which were degenerative changes. Ultrasound identified abnormalities in 57(79%) patients with the bulk of lesions seen within the rotator cuff. There was statistically significant association between presence of greater tuberosity degenerative changes and rotator cuff tears ($p<0.001$).

Conclusion: The combination of shoulder radiography and ultrasound significantly increased the diagnostic yield by evaluating both osseous and soft tissue components. These findings aim to increase the awareness and utility of shoulder ultrasound locally.

1.0 CHAPTER ONE

1.1 Introduction and Literature Review

Shoulder pain is a common cause of musculoskeletal discomfort (1). Pain and stiffness in the shoulder cause significant impairment to activities of daily living imposing a medical and socioeconomic burden to society (2). No local data is available on the burden of shoulder pain.

The shoulder is a complex region with osseous ,articular and soft tissue components . Accurately localizing the source of pain presents a diagnostic challenge due to overlap of the clinical signs . Imaging therefore plays a key role in assessment of the patient with shoulder pain by identifying the abnormalities and increasing the diagnostic confidence (3).

The imaging modalities for shoulder evaluation are plain radiography, Arthrography, Ultrasonography (US), Computed Tomography (CT) and Magnetic Resonance Imaging. The primary imaging modality is radiography which is useful in trauma and assessment of bone lesions but limited in visualization of the soft tissues. Majority of shoulder lesions arise from the soft tissues thus the need for a modality capable of directly visualizing the soft tissues. US and MRI are used in this regard and many studies demonstrate similar accuracy in their assessment of the rotator cuff (4).

Several authors have shown a high prevalence of shoulder pain. A study on the prevalence of musculoskeletal pain in Netherlands found a point prevalence of shoulder pain at 20.9%, second to low back pain at 26.9%. In three out of ten cases there was some degree of limitation to daily activities (1). Another study in a Dutch general practice setting established a cumulative incidence of 11.2/1000/year with incidence rates higher in females than men . Peak incidence was in the 45-64 years age group(5).

Studies from Norway and the United Kingdom parallel above findings. The HUNT study in Norway evaluated the one year prevalence of long standing musculoskeletal discomfort at different anatomical regions and showed overall prevalence of 44.6% (6).The highest prevalence was shoulder pain at 18.1% which increased with age peaking in the 60-69years category .In a similar study in Greater Manchester ,UK the shoulder ranked third (16%) after back (23%) and knee (19%) regions(7). Majority had multifocal pain and physical debility rose with age.

Population based surveys demonstrate a higher burden of shoulder disease than studies done in the primary care setting suggesting that not all people with shoulder discomfort solicit medical care .

Linsell et al using primary care data showed annual prevalence of 2.36% and incidence of 1.47% for visits due to shoulder conditions (8). The prevalence increased with age and 13.6% were still seeking medical care for persistent shoulder problems.

Wide variation in the prevalence and incidence rates from various studies has been noted. A systematic review of 18 studies showed incidence figures varying from 0.9 to 2.2% , point prevalence of 6.9 – 26% , one month prevalence of 18.6 – 31%, one year prevalence of 4.6 – 46.7% and lifetime estimates of 6.7- 66.7% (9). The variation in the figures was attributed to methodological differences in the studies as well as varying case definitions of shoulder pain. Pope et al demonstrated that varying case definitions of shoulder pain altered the prevalence estimates (10).

Certain sports and occupations are associated with increased shoulder disease. Miranda et al in a review of the relation between physical work and shoulder disorders established that work exposure to repetitive movements (odds ratio 2.3) and vibration (OR 2.5) increased the risk of shoulder disease (11). Hagberg demonstrated significantly high risk (OR 11) for rotator cuff tendinosis in occupations with work at the level of the shoulder (12) . A systematic review of 29 studies examining vocational risks for shoulder abnormalities found significant positive associations for vibration , recurring movements and length of exposure (13).

There are many causes of shoulder pain ranging from extrinsic (referred pain) and intrinsic causes. Intrinsic causes include osseous, glenohumeral / ACJ articular disorders, rotator cuff and other soft tissue abnormalities. Referred pain may arise from the diaphragm, neck, lungs and myocardium.

Rotator cuff infirmity is the leading cause of shoulder pain. An evaluation of patients with shoulder pain in two general practice settings found rotator cuff tendinosis in 85%, impingement in 74%, ACJ disease in 24% and adhesive capsulitis in 15% . Majority (77%) had more than one clinical diagnosis with 57% having both tendinosis and impingement (14). Vecchio et al found rotator cuff disease in 65 % and acromioclavicular disease in 10% of cases of shoulder pain presenting in a community rheumatology practice (15).

There is limited data on shoulder pain in the African population. A community study in Ibadan, Nigeria found shoulder soft tissue pathology in 14% of the study population .All symptomatic individuals reported some degree of interference in their activities though none had sought medical attention(16). A 2009 Nairobi study on MRI findings in patients with shoulder pain found rotator cuff lesions in 54% of the total lesions seen and subacromial bursitis in 12% (17). This parallels other studies demonstrating the bulk of shoulder pathology within the rotator cuff.

The spectrum of imaged pathology varies between plain radiography and ultrasound which is a reflection of their different capabilities. Cadogan (2011) examined 202 patients using both modalities and 64% of the radiographs were reported as ‘normal ‘compared to only 15% normal ultrasound scans. The commonest radiographic findings were ACJ pathology (17%) while in ultrasound rotator cuff pathology was seen in 50% (18).

Correlation of clinical and imaging findings is important. Various cadaveric and radiological studies have shown a high prevalence of shoulder pathology in people without symptoms. Milgrom using ultrasound studied the rotator cuffs of 90 asymptomatic persons and found tears in more than 50% in the seventh decade and in 80% of those above 80years (19). Reilly et al showed a prevalence of tears of 38.9% in asymptomatic individuals on ultrasound and 26.2 % on MRI (20). This underscores the importance of correlating both clinical and radiologic findings.

There is need for both early detection and management of rotator cuff tears. There is evidence of disease progression in a significant proportion of patients and development of pain in previously painless tears. As tears become painful shoulder function deteriorates. In addition long standing tears are associated with deterioration of the rotator cuff musculature compromising outcomes after surgical repair (21, 22).

Musculoskeletal ultrasound was first studied in 1958 by Dussik et al who established the sonographic properties of articular tissues including skin, adipose tissue, tendons, muscle and bones. This laid the foundation for its future utilization in musculoskeletal imaging . In 1978 Cooperberg used gray scale ultrasound to demonstrate popliteal cysts, suprapatellar fluid and synovial thickening while in 1980 Seltzer visualised joint effusions and intraarticular loose bodies (23, 24 and 25).

The first study on sonography of the rotator cuff was done by Middleton in 1984 who studied 10 patients and established the normal sonographic rotator cuff anatomy (26).His work offered a significant breakthrough in getting an alternative imaging modality for the rotator cuff which at the time was limited to plain radiography, arthrography and bursography. Plain film was sensitive only to advanced lesions and arthrography/bursography were invasive and time consuming modalities. More studies during the 1983-1984 period established a high accuracy for ultrasound in examining the rotator cuff .Crass et al achieved a higher accuracy for ultrasound (95%) versus arthrography (75%) while Mack et al showed ultrasound accuracy (94%) and arthrography (98%) .Both studies used surgical findings as the reference standard. By 1988 Crass consistently achieved accuracy greater than 90% thereby establishing ultrasound as an accurate noninvasive method for evaluating the rotator cuff (27,28,29).

Increased utilization of musculoskeletal ultrasound has resulted from continued technological improvements in ultrasound scanners, computer processors and sonographic technique. In the shoulder it is currently used for evaluation of rotator and non rotator cuff structures . These include the biceps tendon, subacromial subdeltoid (SASD) bursa, greater tuberosity, humeral head cartilage, glenohumeral joint effusion, loose bodies, ganglions , some parts of the labrum, acromioclavicular joint abnormalities, soft tissue masses and infections (30).

There are several advantages of Ultrasound compared to other imaging modalities. It is relatively cheaper, more available, non invasive, well tolerated by patients and has no demonstrable side effects. It allows dynamic evaluation of the shoulder which is crucial in identification of subacromial impingement. A patient can point to the region of maximal tenderness thus allowing a targeted approach of the area which improves the diagnostic precision. It is also used in ultrasound guided procedures like injections, aspirations and biopsy. Its disadvantages include operator dependence and a long learning curve.

Shoulder sonography is not limited to radiologists alone. The portability of ultrasound machines enables use at points of care like the bedside or clinic set up with good accuracy. Al-Shawi (2008) studied 143 ultrasound scans done by an Orthopaedic surgeon and correlated with arthroscopy as the reference standard. The results were impressive with overall accuracy of 95.5% for full thickness tears and 89.5% for partial thickness tears (31). Point of care ultrasound leads to faster diagnosis and decision making reducing the turnaround time for patients .This translates to improved efficiency (32).

The growth of musculoskeletal ultrasound spurred on by continuous technological improvements and standardization of technique has seen it perform similarly to MRI in examining the rotator cuff. Recognizing the lack of a consensus on the most accurate test Jesus et al (2009) did a meta-analysis comparing the accuracy of MRI, MR Arthrography and Ultrasound in the detection of rotator cuff tears. The study included 65 studies which had surgical findings as the reference . The three modalities had no significant difference in sensitivity for full thickness tears. There was no significant statistical difference between MRI (sensitivity 87%,specificity 81.7%) and Ultrasound (sensitivity 85.1%,specificity 86.1%) in the detection of partial or full thickness rotator cuff tears. In fact US were more sensitive (66.7%) and specific (93.5%) than MRI (sensitivity 63.6%,specificity (91.7%) in the diagnosis of partial thickness tears.MR Arthrography was more accurate than both MRI and US.

These findings imply that shoulder ultrasound is potentially the more cost effective modality for assessing rotator cuff tears (4).This is noteworthy especially in our local set up where both availability and costs of MRI make it inaccessible to majority of the population. MR arthrography is an invasive modality and is recommended where ultrasound and MRI are inconclusive.

A multidisciplinary panel of specialists met in December 2011 to establish a consensus on the roles of various imaging modalities in evaluating rotator cuff disease. The panel recommended ultrasound as the initial modality in assessing the rotator cuff in those less than 40 years of age and MRI/ MRA if ultrasound findings were inconclusive .In suspected labral or ligamentous lesions MRI/MRA is the initial modality of choice (33).

Locally shoulder ultrasound remains underutilized despite the strong evidence demonstrating the bulk of shoulder lesions occurring at the rotator cuff and similar accuracy between Ultrasound and MRI in evaluation of the rotator cuff. Shoulder radiography results in ‘normal’ radiographs in symptomatic patients. Shoulder MRI is the main modality used for detailed evaluation of the shoulder but its cost and availability makes it inaccessible to majority of our population. This delays the definitive diagnosis and further management . Shoulder ultrasound offers a cheaper , more accessible option in the examination of patients with shoulder pain resulting in faster diagnosis and decision making translating to more efficient patient care. Ultrasound is noninvasive, does not use ionizing radiation and has no side effects. This study aims at providing baseline data on shoulder sonography locally which will provide a platform for further utility of this modality .

2.0 CHAPTER TWO

2.1 Anatomy of the Shoulder

The shoulder constitutes three bones (scapula, clavicle and humerus) and two joints namely the glenohumeral and acromioclavicular joints.

The glenohumeral joint is a synovial joint of the ball and socket type. Its articular surfaces are formed by the head of the humerus and the glenoid fossa of the scapula .The glenoid fossa is shallow which confers increased range of motion but at the expense of joint stability. This makes the joint potentially unstable and reliant on soft tissue structures for stability.

The joint capsule is attached to the glenoid and head of humerus except inferiorly where is extends as the axillary pouch. In addition to lining the capsule of the joint the synovium extends along the long head of biceps tendon sheath and beneath the tendon of subscapularis muscle as the subscapular bursa.

Stability of the shoulder joint depends on several factors:

- Ligaments - three glenohumeral ligaments, coracohumeral and transverse humeral ligaments
- Rotator cuff muscles - supraspinatus,infraspinatus,teres minor and subscapularis
- Other muscles including long head of biceps, pectoralis major, latissimus dorsi, teres major and deltoid muscles.
- Glenoid labrum
- Coracoacromial arch

2.2 Rotator Cuff

This is made up of the tendons of supraspinatus, infraspinatus, teres minor and subscapularis muscles.

Subscapularis muscle arises from the subscapular fossa of the scapula and inserts into the lesser tuberosity of the humerus.

Supraspinatus muscle arises from the supraspinous fossa of the scapula and attaches to the anterior part of the greater tuberosity of the humerus.

Infraspinatus muscle arises from the infraspinous fossa of the scapula and inserts into the posterior part of the greater tuberosity.

Teres minor muscle arises from the lower border of the scapula and inserts inferior to the infraspinatus tendon.

2.3 Non Rotator Cuff

The tendon of the long head of the biceps muscle (LHBT) arises from the supraglenoid tubercle and the superior glenoid labrum, courses over the top of the humeral head into the bicipital groove. Its tendon sheath communicates with the synovial joint. The LHBT is anchored by the superior glenohumeral ligament, coracohumeral ligament, transverse humeral ligament, and the tendon of the pectoralis major muscle.

The rotator interval is defined by the coracoid process (base), superiorly by the anterior margin of supraspinatus tendon and inferiorly by the superior margin of subscapularis tendon. It is strengthened by the coracohumeral and superior glenohumeral ligaments. It contains the intraarticular portion of the long head of biceps tendon.

Several bursae are located around the glenohumeral articulation. The subacromial subdeltoid bursa lies between the deltoid muscle,acromion and joint capsule. It does not communicate with the shoulder joint (34) . Subscapularis bursa lies between subscapularis tendon and the capsule. It communicates with the joint cavity. The subcoracoid bursa is between the anterior surface of subscapularis and the coracoid process.

The acromioclavicular joint between the distal clavicle and medial acromial surface is a synovial joint of the planar variety. Its capsule attaches to the articular margins and is strengthened by the superior and inferior acromioclavicular ligaments. A fibrocartilaginous disc of variable size is present. The coracoacromial and coracoclavicular ligaments also stabilize the ACJ.

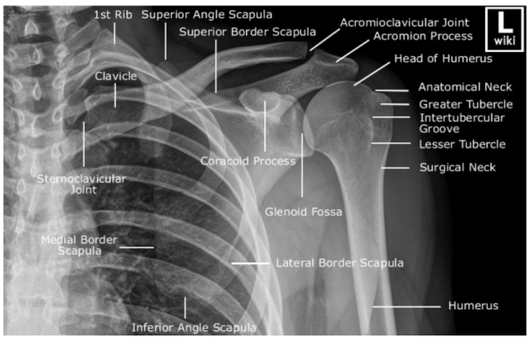


Figure 1: Adult shoulder radiograph (AP View). *Courtesy of wikiradiography.net*

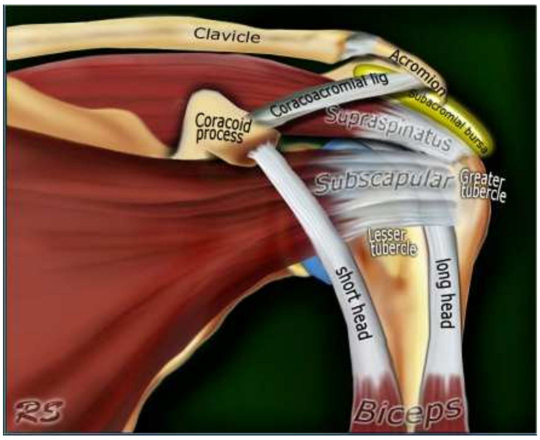


Figure 2 : Anterior graphic of the shoulder: *Courtesy of radiologyassistant.net*

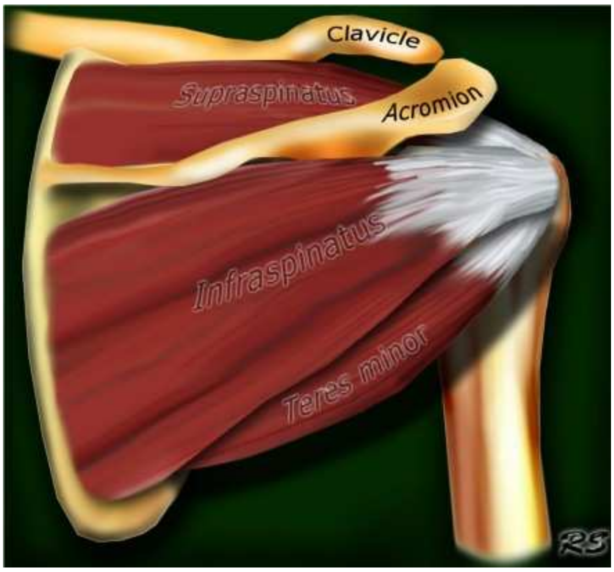


Figure 3: Posterior graphic of the shoulder : *Courtesy of radiologyassistant.nl*

2.4 Sonographic Anatomy

Echogenicity of tissues

Skin – appears as a thin hyperechoic layer.

Subcutaneous tissue –subcutaneous fat is hypoechoic with scattered linear hyperechoic septa parallel to the skin.

Muscle –skeletal muscle fibres are hypoechoic and separated by hyperechoic perimysium.

Fascia – hyperechoic, thin and separates muscle groups

Tendons – consist of linear parallel hyperechoic strands running in the long axis of the tendon. The tendon sheaths are hyperechoic and separated from the tendon by a thin hypoechoic zone.

Ligaments – are hyperechoic .

Hyaline cartilage –hypoechoic and seen against highly echogenic cortical bone.

Bone –seen as a highly echogenic line with acoustic shadowing (35)

2.5 Imaging of the Shoulder Joint

There are various imaging modalities for the shoulder including standard radiography, ultrasonography, Computed Tomography (CT) and CT Arthrography, Magnetic Resonance Imaging (MRI) and MR Arthrography. Each modality has its strengths and weaknesses and choice of a particular method depends on the clinical question that needs to be addressed.

2.5.1 Plain radiography

This is first imaging modality in the assessment of a patient with shoulder infirmity (36).It is useful in trauma, arthritis, subacromial impingement and evaluation of bone lesions.

Several studies have demonstrated an association between some radiographic findings and rotator cuff disorder . These include include subacromial spurs, type 3 acromion and ACJ hypertrophy (37).In acute rotator cuff tears radiographs are normal. The active abduction view as described by Bloom can be used to assess for acute complete supraspinatus tears when the acromiohumeral interval is 2mm or less in abduction (38). In chronic complete rotator cuff tears retraction of the medial part of the cuff and muscle atrophy results in reduction of the acromiohumeral interval.

Repeated contact between the humeral head, greater tuberosity and the coracoacromial arch results in remodeling changes on the two surfaces. This is demonstrated as humeral head subchondral cysts, sclerosis, cortical fraying of the greater tuberosity and reciprocal degenerative changes of the subacromial surface (37). Wohlwend showed that irregularity of the greater tuberosity at the insertion of supraspinatus has sensitivity of 90% for a rotator cuff tear (39).Pearsall studied radiographic findings in patients with surgery proven full thickness rotator cuff tears in comparison with asymptomatic group and demonstrated that greater tuberosity sclerosis ,osteophytes ,subchondral cysts and osteolysis were notable in patients with rotator cuff tears as opposed to the asymptomatic group (40). Acromial spurring and acromial shape showed no association with cuff tears.

In 2011 Goutalier et al demonstrated that an acromiohumeral distance below 6mm is strongly associated with a chronic full thickness infraspinatus tear and surgery is not always viable due to advanced fatty degenerative changes of the muscles (41). Secondary osteophytes eventually develop in the glenohumeral joint to maintain joint congruency.

Not all radiographic findings are attributable to a deficient rotator cuff as some of them could simply be due to age. Bonsell examined the correlation between age and degenerative changes seen on shoulder radiographs in asymptomatic individuals and showed that most age related changes occur in the acromion and clavicle. The specific sites noted were degenerative changes of the ACJ, sclerosis of medial acromion and lateral clavicle and subchondral acromial cysts. No significant gender difference was seen in the findings (42).

2.6 Radiographic Projections

Several projections are used in the examination of the shoulder each aimed at enhancing the visualization of a specific part. The standard projections are the Anteroposterior (AP) and lateral (Y) scapular view.

2.6.1 Antero-posterior projection.

This is done with the patient in upright or prone position and with the coronal plane of the body parallel to the cassette. The X-Ray beam is directed in the AP direction . It is performed with the arm in neutral, internal or external rotation. Since there is overlap between the humeral head and glenoid assessment of the glenohumeral joint space is suboptimal.

2.6.2 Glenohumeral AP (Grashey) view

The patient is rotated approximately 35-45 degrees posteriorly so that the plane of the scapula is parallel to the cassette. This eliminates the overlap of the glenoid rim and humeral head .

2.6.3 Lateral scapular (Y) view

This is obtained with the patient upright or prone with the anterior aspect of the affected side rotated 30-45 degrees towards the cassette. The beam is tangential to the scapulothoracic joint. The humeral head is centred in the Y formed by the coracoid, body of scapula and the acromion. It is useful in assessing the coracoid process, scapula, and acromion .

2.6.4 Axillary view

This view can be obtained in the erect or horizontal positions depending on the patient's infirmity. Its main utility is to image the anterior and posterior aspects of the glenoid fossa and to assess glenohumeral relations. Abduction of 30-40 degrees is necessary and the views can be obtained either in superoinferior or inferosuperior projections.

2.7 Shoulder Ultrasound

The primary role of shoulder ultrasound is the evaluation of the rotator cuff.The subacromial bursa, long head of biceps tendon, acromioclavicular joint, glenohumeral joint effusion ,posterior labrum and soft tissue lesions can also be assessed. The scanning protocol is based on the European Society of Musculoskeletal Radiology guidelines for the shoulder (43). This is outlined in the study methodology section.

2.7.1 Computed Tomography

Computed tomography is suited for evaluation of bony structures and soft tissue calcification. 3D surface rendered reformats aid in surgical planning for instance in complex fractures of the humeral head. It has limitations in assessment of fat and muscle.

CT arthrography involves distension of the joint capsule with contrast medium to allow visualisation of the glenoid labrum and capsular attachments. Wilson et al demonstrated high accuracy of arthrographic CT in detection of labral disorders and complete rotator cuff tears (44).

2.7.1 Magnetic Resonance Imaging

MRI allows imaging of all shoulder structures including soft tissues, bone marrow and cartilage. Its high contrast resolution combined with a wide field of view enables comprehensive evaluation of the shoulder. It is the modality of choice in assessing the glenoid labrum, ligaments and articular cartilage. MR arthrography is indicated where thorough assessment of the labrum and ligamentous structures is required (33).Among its disadvantages are cost, availability and patient factors like claustrophobia. Certain metallic implants and electronic devices also limit its use.

3.0 CHAPTER THREE

3.1 Study Justification

Shoulder pain is a common cause of musculoskeletal pain. There are many causes of shoulder pain the most frequent cause being rotator cuff disease. Considerable overlap in symptoms combined with limited accuracy of clinical physical examination necessitates the need for imaging to improve the diagnostic accuracy.

Shoulder radiography is the primary imaging modality in shoulder pain but is limited in the evaluation of soft tissues. Shoulder ultrasound is underutilized locally yet it has been proven to be of similar accuracy to MRI in diagnosis of rotator cuff disease. Ultrasound is noninvasive, cheaper, more accessible and has no contraindications or side effects. Bearing in mind the costs and availability of MRI which make it inaccessible to majority of our population ,shoulder ultrasound offers a cheaper complementary option in the evaluation of shoulder pain especially in suspected rotator cuff disease.

No study has been carried out in our country to assess the spectrum of findings in both shoulder radiography and sonography among patients with shoulder pain. This study aims to provide baseline data for both modalities locally . The findings are hoped to increase the awareness and utility of shoulder ultrasound locally.

3.2 Study Question

What is the spectrum of shoulder radiograph and shoulder ultrasound findings in patients with shoulder pain at the Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi?

3.3 Study Objective

The objective of this study was to establish the spectrum of shoulder radiographic and ultrasound findings in patients with shoulder pain at the Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi.

3.3.1 Broad Objective

To determine the spectrum of shoulder radiographic and ultrasound findings in patients presenting with shoulder pain.

3.3.2 Specific Objective

The specific objectives of this study are:

1. To determine the spectrum of shoulder radiographic findings in patients with shoulder pain.

2. To establish the spectrum of shoulder ultrasound findings in patients with shoulder pain.

3. To determine the marginal increase in diagnostic yield of shoulder ultrasound used in series with shoulder radiographs.

4. To determine the sociodemographic distribution of imaged shoulder pathology.

3.4 Study Design and Methodology

3.4.1 Study Design

This study was a cross sectional descriptive study.

3.5 Study Area

This study was carried out at the Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi. It is located within the old wing of Kenyatta National Hospital and provides general radiography, fluoroscopy and ultrasound services.

3.6 Study Population

The study population comprised patients referred for shoulder radiographs by the primary physician during the study period. The department provided the shoulder ultrasound examination at no extra cost to the patients.

3.7 Inclusion Criteria

Consenting patients above 18 years of age who were referred for shoulder radiography during the study period between January 2016 and April 2016 were included in the study .

3.8 Exclusion Criteria

1. Patients who declined to participate in the study.

2. Patients under the age of 18 years.

3. Patients with severe conditions around the shoulder complex precluding the use of sonography .

3.9 Sample Size Calculation

Fishers formula for estimating sample size in prevalence studies was used with finite population correction as suggested by Daniels (1999) accounting for the limited number of potential subjects undergoing shoulder radiographs at the imaging department of the University of Nairobi (maximum N = 96 during study period).

$$n = \frac{NZ^2P(1-P)}{d^2(N-1)+Z^2P(1-P)}$$

N = Total population of patients undergoing shoulder radiographs in UON-DDIRM during the 3-month study period (estimated at 8 per week for 12 weeks yielding a population of 96 patients)

P = Prevalence of shoulder pain in the general population. This is set at 6.9% based on the metaanalysis by Luime et al (9) on prevalence of shoulder pain. No local data is available on the prevalence of shoulder pain.

1-P = 1 minus the prevalence of patients with shoulder pain

Z = Z statistic representing 95% level of confidence (1.96)

d = desired level of precision set to 3.0 % for CIN prevalence of 6.9%

$$n = \frac{96 \times 1.96^2 0.069(1-0.069)}{0.03^2(96-1)+1.96^2 \times 0.069(1-0.069)}$$

n = 72

3.10 Sampling Method

Consecutive patients who were referred for shoulder radiography examination at the department of Diagnostic Imaging and Radiation Medicine, UON and who gave consent were included in the study.

3.11 Recruitment and Consenting Procedure

The patients referred for shoulder radiograph examination were explained to about the overall objective of the study. The procedure of shoulder radiography and ultrasound was discussed and signed informed consent obtained. This was done by the principal investigator.

3.12 Data Collection Procedures

A questionnaire was used for data collection (appendix A).The patient's biodata, clinical summary and imaging findings for both radiographic and ultrasound modalities were recorded by the principal investigator .All the images were reviewed by the researcher together with the supervising consultant radiologists.

3.13 Materials and Equipment

3.13.1 Radiography

This was done using the AGFA CR-X Computed Radiography machine in the department .It has inbuilt software which allows objective distance measurements to be made.

Standard AP view in neutral position and scapular Y views were obtained. Additional views like the abduction view were done guided by the initial findings. With the patient standing the beam was centred at the glenohumeral joint and a Film Focus Distance of 100cm used.

The acromiohumeral interval was measured electronically at the workstation .It was obtained from the AP view where the shortest distance between the inferior cortex of the acromion and the superior cortex of the humeral head was measured in millimeters.

3.13.2 Ultrasonography

Sonography was done by the principal investigator using a General Electric LOGIC S7 Expert ultrasound scanner with a 7.5 – 12 MHZ linear probe.

3.13.1 Ultrasound scanning procedure

The scanning protocol was based on the European Society of Musculoskeletal Radiology technical guidelines for the shoulder (43).

Systematic evaluation of the anterior, lateral and posterior aspects of the shoulder was done with the patient seated on the examination couch.

Each tendon was evaluated in its short and long axes in the positions described ;

1. Long head of biceps tendon - The arm was placed in internal rotation with the elbow flexed 90^0 and palm facing up. It was evaluated from its intraarticular part to the myotendinous junction.

2. Subscapularis tendon - The arm was rotated externally with the elbow fixed on the iliac crest to show the subscapularis tendon and its insertion to the lesser tuberosity.

3. Supraspinatus tendon- The arm was placed posteriorly with the palm of the hand at the region of the back pocket and the elbow flexed and directed posteriorly.

4. Infraspinatus and teres minor tendons- The arm was placed in internal rotation with the palm placed on the contralateral shoulder. The transducer was placed over the posterior aspect of the glenohumeral joint.

5. Acromioclavicular joint .The probe was placed in the coronal plane and swept anteroposteriorly to examine the joint.

3.14 Personnel

Radiography was done by any of the three experienced radiographers in the department.

The ultrasound scans were performed by the principal investigator supervised by two faculty experienced radiologists with a musculoskeletal bias.

A biostatistician guided in formulation of sample size to ensure the study is statistically sound and later performed the statistical analysis.

3.15 Quality Assurance Procedures

The radiographs were done in the standard projections used in the department i.e. Anteroposterior and lateral scapular Y views. Any additional views were dictated by the clinical question to be answered.

The ultrasound scans were done in a standardized manner according to the European Society of Musculoskeletal Radiology musculoskeletal ultrasound technical guidelines.

All the images were analyzed by the principal investigator and the supervisors.

3.16 Ethical Considerations

1. The research proposal was submitted to KNH/UON Research and Ethics committee for review and approval prior to commencement of the study.

2. A signed informed consent was obtained from the patients before inclusion into the study population.

3. The patient’s name was not included in the study in order to maintain confidentiality. The information acquired will not be used for any other purpose other than the study.

4. The study did not interfere with the management of the patients in any way.

5. The department of diagnostic imaging and radiation medicine waived the costs of ultrasound for the patients. There were no added cost implications to the patient.

3.17 Data Management and Statistical Analysis

Data was recorded in the data collection form (Appendix A) and analyzed using Statistical Package for Social scientists (SPSS Version 20 IBM). Descriptive analysis of sociodemographic variables was conducted by calculating mean and standard deviation for continuous variables like age and determining frequency distribution of categorical data . Chi square and Fishers tests were used to test associations for example between acromiohumeral interval and rotator cuff tears. Representative images of some of the cases are presented

4.0 CHAPTER FOUR

4.1 Results

4.1.1 Participants' characteristics

A total of 72 patients with shoulder pain were imaged at the University of Nairobi radiology unit. The mean age of the patients was 47.3 years (SD ± 16.2) with an age range between 18 and 79 years. The most common age group was 60 years and above 19 (26.4%) and 50-59 years 16 (22.2%). There were 28 males presenting with shoulder pain giving a male-to-female ratio of approximately 2: 3.

Figure 4: Age characteristics

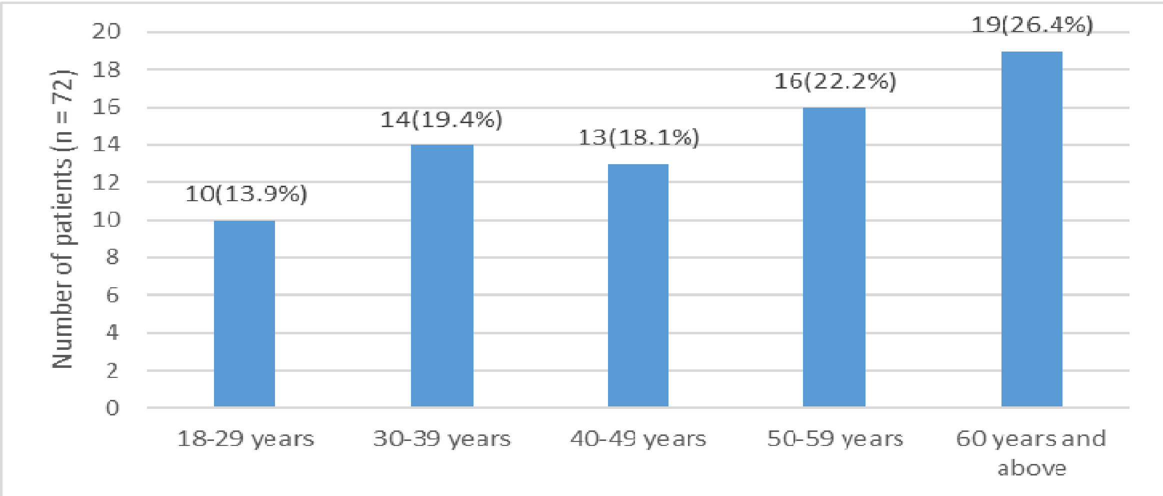
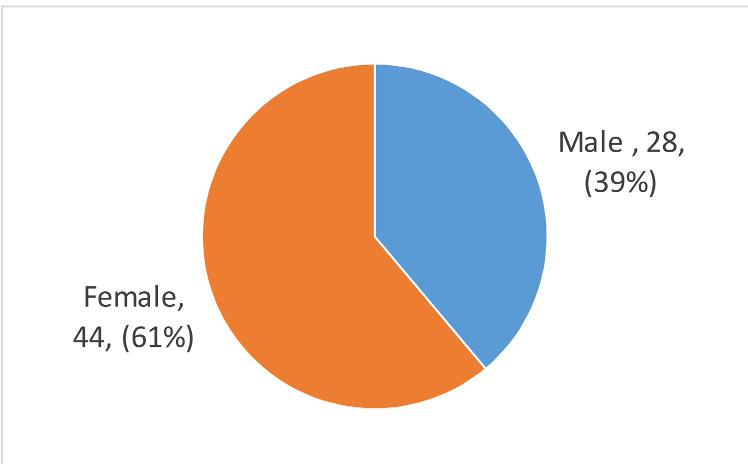


Figure 5 : Gender distribution



4.2 Occupation

38 (52.8%) patients with shoulder pain were engaged in manual employment(figure 6). There were 16 (22.2%) formally employed persons and 16 (22.2%) patients reported that they were unemployed.

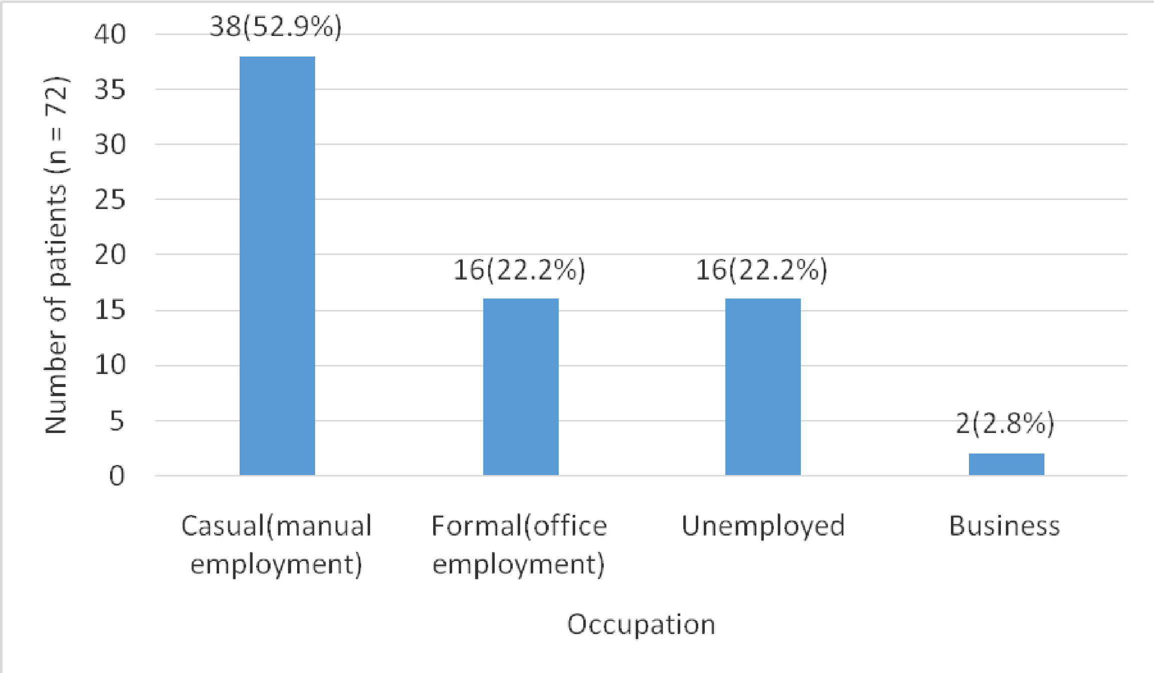


Figure 6 : Occupation of patients

4.3 Radiographic Findings

36 (50%) Radiographs were normal . The most common radiographic findings were degenerative changes in the greater tuberosity (36.1%) acromioclavicular joint (32%) and subacromial spurs (21.1%) . One patient had ACJ subluxation while another had a fracture dislocation of the ACJ. Most radiographs of the study population had normal glenohumeral joints 63 (87.5%), Figure 7.

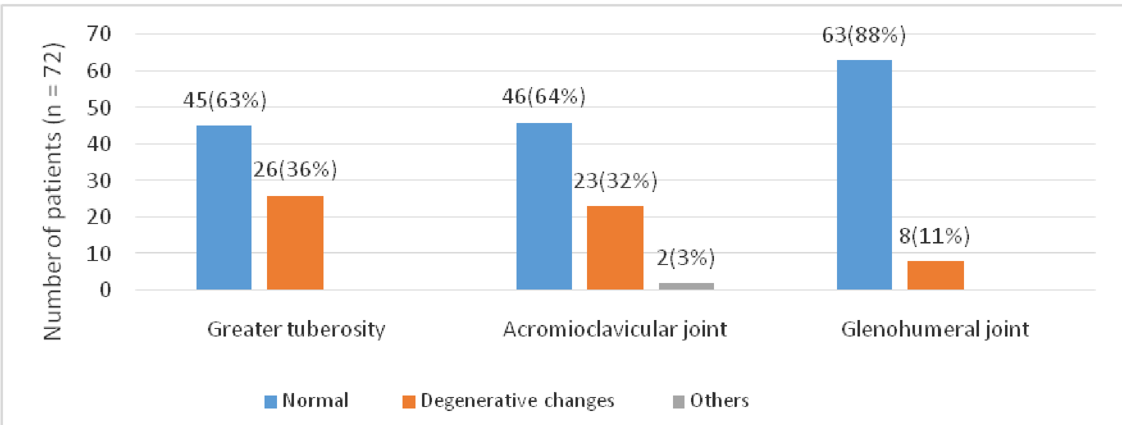


Figure 7 : Degenerative changes on radiographs

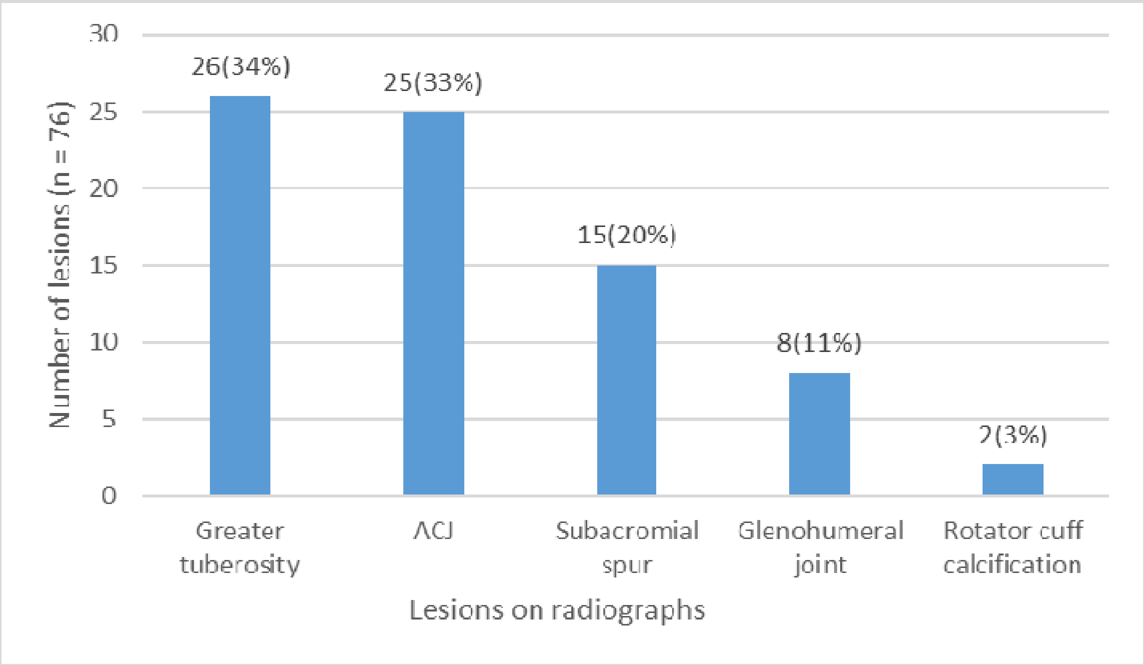
4.4 Acromial Spurs and Rotator cuff calcification.

Subacromial spurs and inferior ACJ osteophytes were each visualized in 21.1%(15/72) of patients while 2.8% (2/72) patients had rotator cuff calcification (Table 1).

Table 1: Radiographic findings of spurring and rotator cuff calcification

	Yes	No
Radiographic finding		
Sub acromial spurring	15(21.1)	56(78.9)
Inferior AC joint spurring	15(21.1)	56(78.9)
Rotator cuff calcification	2(2.8)	69(97.2)

Figure 8 : Overall distribution of lesions on radiographs

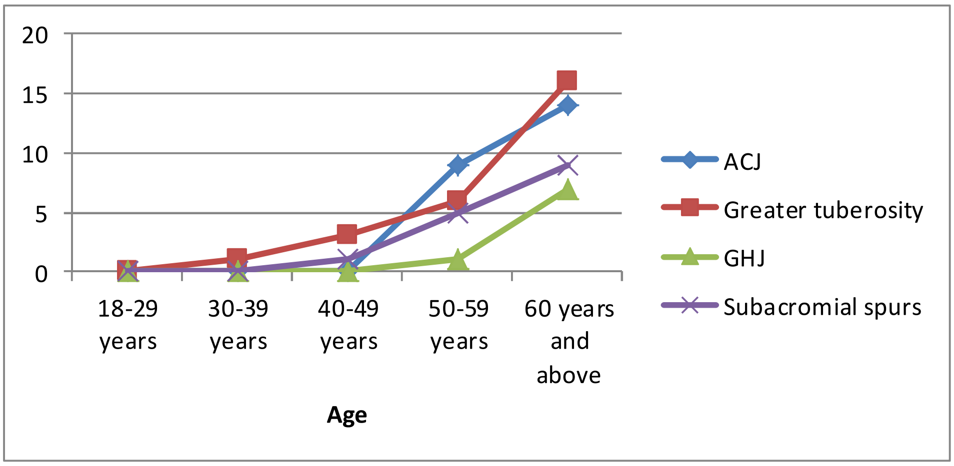


A total of 76 lesions were picked on radiographs indicative of multiple lesions in some of the patients.

4.5 Age distribution of radiographic findings.

Degenerative changes of the acromioclavicular joint, greater tuberosity, glenohumeral joint and subacromial spurs were seen with increasing age starting at around 40 years (figure 9).

Figure 9 : Age distribution of radiographic findings



Chi square analysis showed a significant association between increasing age and degenerative changes.

4.6 Acromion type

Radiographic findings of the acromion type were reported in only 29 (40.3%) cases. Of these 17 (59%) had Type 2 and 12 (41%) had Type 1 acromion. No type 3 acromion was observed.

Table 2 : Acromion types

	Frequency (n)	Percent (%)
Acromion type		
Type 1	12	41
Type 2	17	59
Type 3	0	0
Total	**29**	**100**

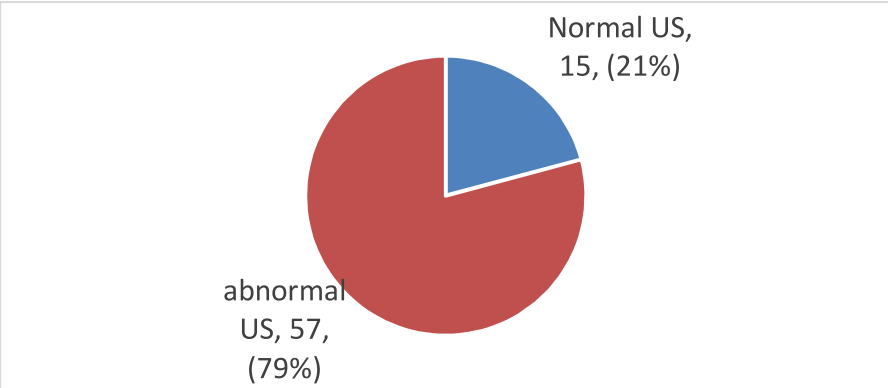
4.7 Acromiohumeral distance

The mean acromiohumeral distance was 9.1mm (SD ± 2.8mm) in the 60 patients with an estimate for this interval and ranged from 1 to 12 mm. There were 6 (10%) patients with acromiohumeral distances < 7 mm.

4.8 Ultrasound Findings

At Ultrasound shoulder pathology was identified in 79 %(57/72) of the study participants, figure 10. A total of 174 shoulder lesions were demonstrated**.**

Figure 10 : Normal vs. Abnormal ultrasound



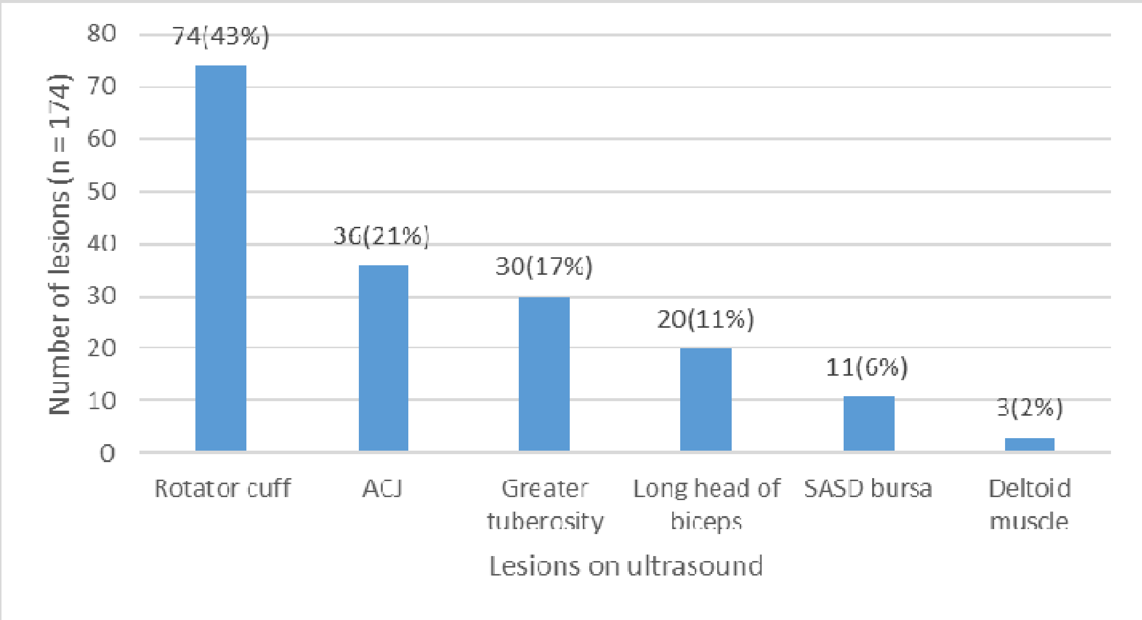
4.9 Rotator Cuff Findings

Rotator cuff pathology was the most common pathology contributing to 42% of lesions (figure 11). Supraspinatus pathology was present in 60% of the study participants (table 3) and accounted for 58% of rotator cuff pathology (figure 12) .Tears comprised 84% of supraspinatus lesions with partial tears forming 61% of tears (table 3). In all cases where subscapularis and infraspinatus pathology was present there was coexistent supraspinatus involvement. No isolated subscapularis or infraspinatus lesion was seen. No teres minor tendon abnormality was seen in the study population. One patient had calcification within the supraspinatus tendon.

Table 3 : Shoulder ultrasound ; Rotator cuff findings

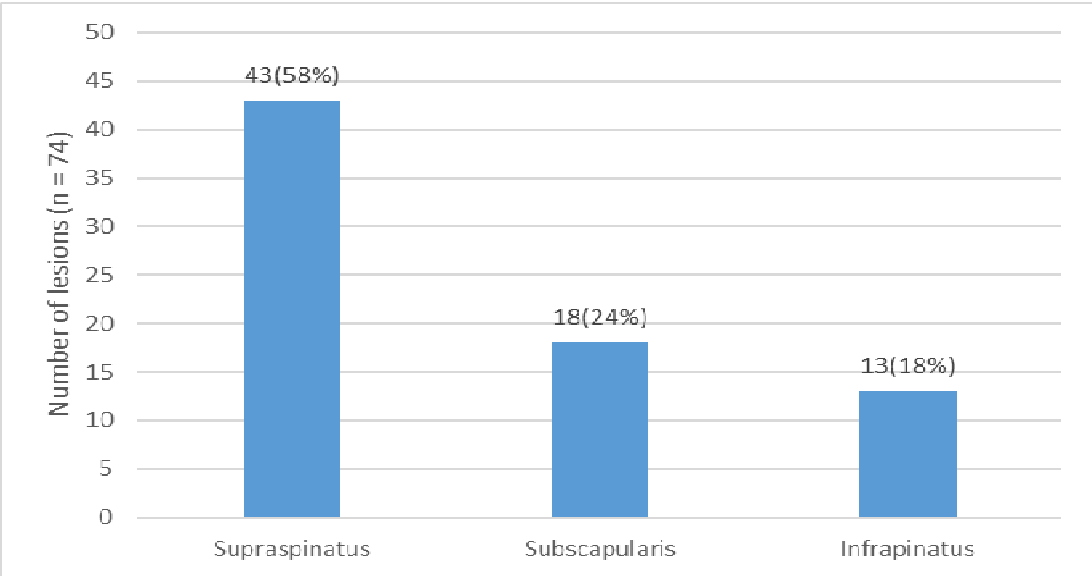
	Normal	Tendinitis	Calcification	Partial tear	Full tear	Tendinitis & partial tear	Tendinitis & full tear
Subscapularis	54(75)	11(15.3)	-	1(1.4)	-	6(8.3)	-
Supraspinatus	29(40.3)	6(8.3)	1(1.4)	3(4.2)	11(15.3)	19(26.4)	3(4.2)
Infraspinatus	59(81.9)	12(16.7)	-	1(1.4)	-	-	-
Teres minor	72(100)	-	-	-	-	-	-

Figure 11 : Lesions on ultrasound



A total of 174 lesions were identified on sonography.

Figure 12 : Rotator cuff lesions



4.10 Shoulder Ultrasound: Non Rotator Cuff Findings

These are presented in table 4 below.

The most prevalent findings were degenerative changes of the acromioclavicular joint and greater tuberosity seen in 47.2% and 41.7% of the study participants respectively .Long head of biceps abnormalities were seen in 28%. Ultrasound picked up more degenerative lesions in the ACJ (n=34) compared to radiography(n=23) and greater tuberosity (30 versus 26).

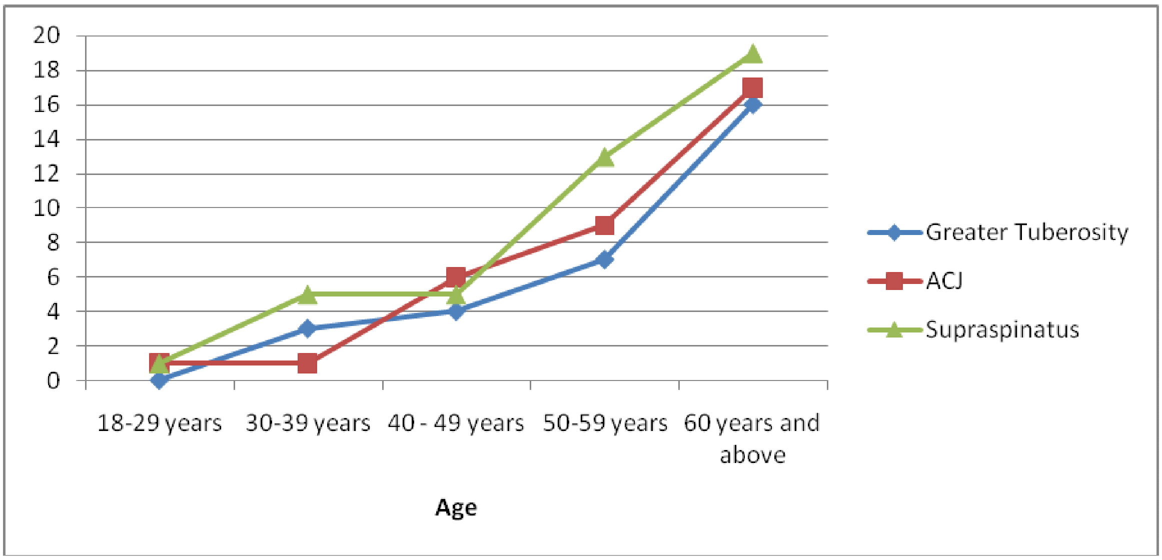
Table 4 : Non rotator cuff ultrasound findings

	Frequency	Percent(%)
Long head of biceps tendon		
Normal	52	72.2
Effusion	10	13.9
Tendinosis	5	6.9
Effusion and tendinosis	4	5.6
Effusion, tendinosis and subluxation/dislocation	1	1.4
Acromioclavicular joint		
Normal	36	50
Degenerative changes	34	47.2
Others	2	2.8
Subacromial subdeltoid bursa		
Normal	61	84.7
Effusion	10	13.9
Thickening	1	1.4
Greater tuberosity irregularity		
Present	30	41.7
Absent	42	58.3
Deltoid muscle and subcutaneous tissues		
Normal	69	95.8
Mass/cyst	1	1.4
Other	2	2.8

4.11 Age distribution of shoulder lesions at Ultrasound

The prevalence of rotator cuff pathology increased with age . No normal supraspinatus tendon was seen in patients above 60 years. Degenerative changes of the ACJ and greater tuberosity similarly increased with age (figure 13).

Figure 13 : Age distribution of lesions at ultrasound



4.12 Associations

1. Association between greater tuberosity irregularity on radiographs and supraspinatus tears (partial thickness + full thickness tears)

The presence of degenerative changes of the greater tuberosity on radiographs was significantly associated with occurrence of either full or partial supraspinatus tears ($p < 0.001$). 23(89%) of patients with greater tuberosity irregularity had a tear compared to 3(11.5%) having degenerative changes but no tears.

	Supraspinatus tear(partial+full thickness)			**P**
	Yes	No		
Greater tuberosity irregularity				
Normal	13(28.9)	32(71.1)	1.00(Ref)	
Degenerative changes	23(88.5)	3(11.5)	18.87(4.82-73.89)	<0.001
		95% CI		
Sensitivity	63.9%	46.2%	79.2%	
Specificity	91.4%	76.9%	98.2%	
PPV	88.5%	69.8%	97.6%	
NPV	71.1%	55.7%	83.6%	

2. Association between greater tuberosity irregularity on Ultrasound and Supraspinatus tears (partial thickness + full thickness).

The presence of degenerative changes of the greater tuberosity on sonography was also significantly associated with occurrence of either full or partial supraspinatus tears ($p < 0.001$).Sonography picked 3 more degenerative changes at the greater tuberosity than radiography.27(90%) of patients with degenerative changes of the greater tuberosity had supraspinatus tears compared to 3 (10%) patients with no tears who also had degenerative changes. Degenerative changes had a sensitivity of 75% and specificity of 92% for supraspinatus tears.

	Supraspinatus tear(partial+full thickness)			
	Yes	No	OR (95% CI)	P
Greater tuberosity irregularity				
Present	27(90.0)	3(10.0)	1.00(Ref)	
Absent	9(21.4)	33(78.6)	0.03(0.01-0.12)	<0.001
		95% CI		
Sensitivity	75%	58%	88%	
Specificity	92%	78%	98%	
PPV	90%	74%	98%	
NPV	79%	63%	90%	

3. Association between acromiohumeral interval of less than 7 mm and full thickness Supraspinatus tears

Acromiohumeral interval less than 7mm was significantly associated with occurrence of full thickness supraspinatus tears ($p < 0.001$). All (6) patients with an interval less than 7mm had a full thickness tear. 8 patients with full thickness supraspinatus tear had an interval greater than 7mm. An acromiohumeral interval of 7mm had a sensitivity 43%,specificity 100%,PPV 100% and NPV 85% for full thickness supraspinatus tear.

	Supraspinatus full tear		
	Yes	No	P
Acromiohumeral interval			
< 7 mm	6(100.0)	0(0.0)	
7 mm and above	8(14.8)	46(85.2)	<0.001
		95% CI	
Sensitivity	43%	18%	71%
Specificity	100%	92%	100%
PPV	100%	54%	100%
NPV	85%	73%	93%

4. Association between subacromial spurring and supraspinatus tears

	Supraspinatus tear			
	Yes	No	OR (95% CI)	P
Subacromial spurring				
Yes	12(80.0)	3(20.0)	1.00(Ref)	
No	24(42.9)	32(57.1)	0.19(0.05-0.74)	0.017
		95% CI		
Sensitivity	33%	19%	51%	
Specificity	91%	77%	98%	
PPV	80%	52%	96%	
NPV	57%	43%	70%	

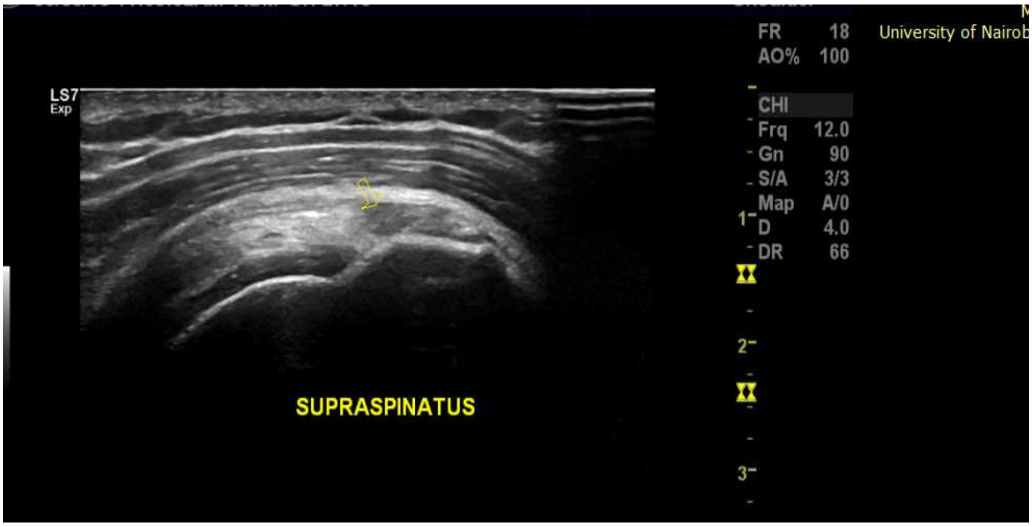
Significant association was also seen between subacromial spurs and supraspinatus tears(p=0.017). 12(80%) of the patients with a subacromial spur had a supraspinatus tear.

4.13 Illustrative Cases

1. **59 year old male with shoulder pain .**

    a) normal radiograph

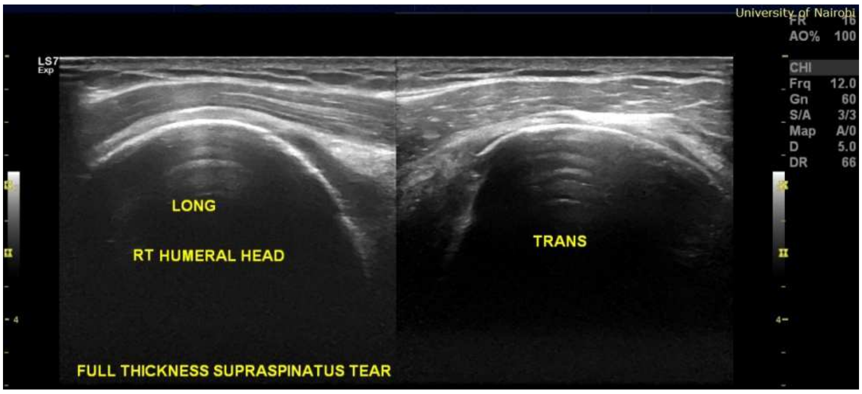
b. full thickness supraspinatus tear



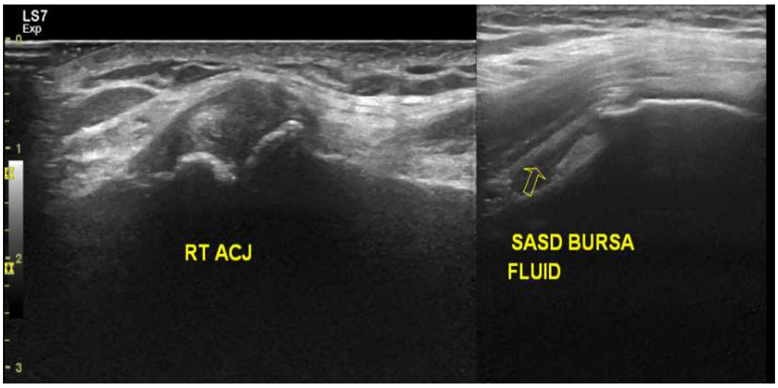
2. 69 year old male. Radiograph (a) shows markedly reduced acromiohumeral interval, subacromial and glenohumeral degenerative changes. The ultrasound shows complete supraspinatus tear (b) , ACJ degenerative changes and fluid in the subdeltoid bursa(c).

a.

b.



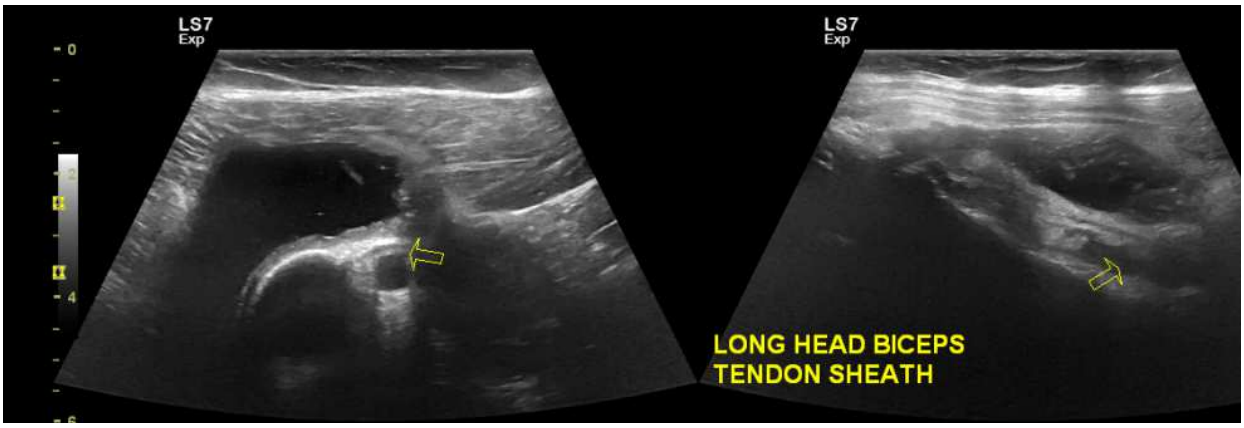
c.



3. 69 year old female with chronic shoulder pain, currently unable to abduct the arm.

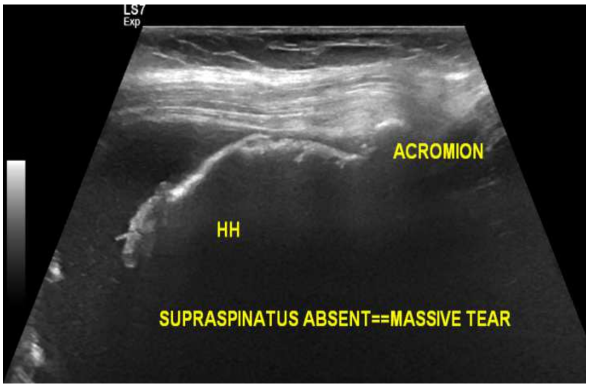
Radiograph shows reduced acromiohumeral interval and subacromial degenerative changes

b.



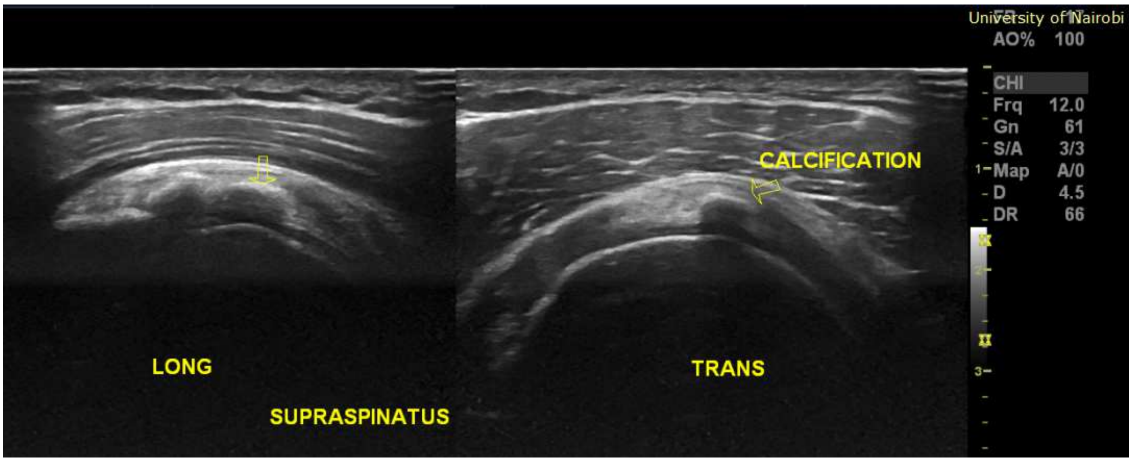
Ultrasound shows a large Subacromial subdeltoid effusion and long head of biceps effusion(b) with a massive supraspinatus tear (c).

c.



4. 35 yr male. Supraspinatus calcification on radiograph (a) and ultrasound (b).

b.



None of these patients had surgery during the duration of the study to determine the correlation of the radiographic/ultrasound findings with operative findings.

5.0 CHAPTER FIVE

5.1 Discussion

Shoulder pain is a common cause of musculoskeletal pain and is most frequently due to rotator cuff disease (14). Comprehensive evaluation of the shoulder therefore needs assessment of the rotator cuff. Locally shoulder ultrasonography is underutilized despite being an accurate, cheaper and more available modality.MRI is the main modality in the evaluation of the shoulder soft tissues but its accessibility is limited by cost and availability. This study is the first report on the spectrum of findings in shoulder radiographs and ultrasound locally.

Our study showed increasing prevalence of shoulder pain with age as well as higher prevalence in females which is corroborated in other studies . Linsell (8) showed increasing prevalence of shoulder pain with age and a higher prevalence in females . 52.8% of the patients were engaged in manual employment which is a known risk factor for shoulder pain (13).

5.1.1 Radiographic findings

Half the radiographs were normal and degenerative changes were the predominant abnormality. One patient had a healing fracture dislocation of the ACJ which had been missed in previous radiographs and the patient had persistent shoulder pain. In Cadogan's study (18) 64% of radiographs were normal and the most common abnormalities were ACJ degenerative changes (17%) and rotator cuff calcification(13%).

Both studies show a high percentage of normal radiographs despite the patients being symptomatic. The major difference is seen in the prevalence of rotator cuff calcification which is 3% in the present study and 13% in Cadogan's series. A likely explanation for this could be intrinsic race or environmental differences between the study populations. Another local study on the spectrum of shoulder MRI pathology did not report any rotator cuff calcification (17).

Subacromial spurring was present in 21% (15/72) of patients all of whom were above 40 years. 80 percent of those with subacromial spurs had a rotator cuff tear. This compares favourably with other studies. In Cone's study 26% (26/103) had subacromial spurs and of those with a spur and who subsequently had an arthrogram 63% had rotator cuff tears(45).

Hardy reported subacromial spurring in 68% and greater tuberosity degenerative changes in 66% of his study population . Notably the study population comprised specifically of patients with clinical subacromial impingement and this could explain the high occurence of radiographic features of impingement in that series (46).

This study demonstrates increasing prevalence of degenerative changes with age and Chi square analysis showed a significant association between increasing age and degenerative changes .Bonsell also documented this association (42).The interpretation of this finding is that some of these changes are normal age related phenomena and their contribution to patient's symptoms should be placed in the clinical context.

The poor yield of shoulder radiographs in patients below forty years was highlighted in the Society of Radiologists in Ultrasound multidisciplinary consensus statement in 2011.After evaluating the evidence on various shoulder imaging modalities based on factors such as accuracy and cost effectiveness it recommended ultrasound as the first line modality in evaluation of suspected rotator cuff disease in patients younger than 40 years(33).

5.1.2Acromion type

Due to several reasons only 29(40.3%) of this series had their acromion type determined. A number of patients had radiographs done at other facilities and came to our department specifically for shoulder ultrasound. The scapular Y view is not standard protocol for shoulder radiography in most imaging facilities and thus we were unable to document the acromion type in these patients. Additionally some of the Y view radiographs were technically inadequate for accurate depiction of the acromion.

Of the 29 radiographs in this series 12(41%) had type 1 flat acromion and 17(59%) had a type 2 curved acromion . No type 3 hooked acromion was seen. However because of the small number not much statistical inference can be made from this observation.

5.1.3 Acromiohumeral interval

The mean acromiohumeral interval was 9.1mm .In Saupe's series the mean interval was 8.7mm.The cut off for abnormal acromiohumeral interval is 7mm (47) . In our study an acromiohumeral interval less than 7mm was significantly associated with occurrence of full thickness supraspinatus tears ($p < 0.001$). 100% (6/6) patients with an interval less than 7mm had a full thickness tear. 8 patients with full thickness supraspinatus tear had an interval greater than 7mm.In Saupe's study 90% (19/21) of patients with an interval of less than 7mm had a full thickness tear . This compares well with our study .

Both studies showed the presence of a normal acromiohumeral interval in a significant number of full thickness cuff tears implying the possible role of other factors like the size of tear,chronicity and muscle atrophy. Goutallier showed that a chronic full thickness infraspinatus tear is a requisite for an acromiohumeral interval less than 6mm (41).

5.2 Sonographic Findings

Rotator cuff pathology was the most common accounting for 42% of lesions. Supraspinatus pathology was present in 60% of the study participants .The prevalence of rotator cuff disease increased with age and no normal supraspinatus tendon was seen in patients above 60 years . Subscapularis and infraspinatus lesions accounted for 24% and 18% of the other cuff lesions respectively . No isolated subscapularis or infraspinatus lesion was seen.

Similar findings have been seen in other studies. Mugambi demonstrated similar distribution of shoulder lesions on MRI in Nairobi with rotator cuff pathology constituting majority (54%) of the lesions(17).In Cadogan's series rotator cuff pathology constituted 50% of lesions (18).Supraspinatus component was most affected accounting for 85% of overall rotator cuff lesions.

A major difference noted between the studies is the high prevalence of rotator cuff calcification in Cadogan's series accounting for 39% of supraspinatus abnormalities .This could possibly be explained by race or environmental differences between the study populations. In this series one case of rotator cuff calcification identified on radiographs could not be confidently re-demonstrated on ultrasound because of associated irregularity of the humeral anatomical neck and greater tuberosity suggestive of a fracture .

5.2.1 Non rotator cuff findings

The frequency of pathology was 47.2% in the ACJ, 27.8% long head of biceps tendon and 15.3% in the subacromial subdeltoid bursa . One case each of a superficial lipoma, supraclavicular cellulitis and intradeltoid hematoma in a patient on anticoagulants were seen.

These findings are also reflected in other studies. Cadogan showed pathology in 31% SASD and 17% long head of biceps tendon although their study did not evaluate the ACJ and greater tuberosity changes in ultrasound(18).

Girish et al in a study of assymptomatic shoulders in men aged 40-70 years found SASD thickening in 78% of study participants and ACJ degenerative changes in 65%. Importantly abnormalities were present in 96% of the subjects in that study (48).This underscores the significance of correlating imaging with clinical findings.

The presence of degenerative changes of the greater tuberosity in radiographs and ultrasound was significantly associated with occurrence of supraspinatus tears ($p < 0.001$). At sonography the degenerative changes had a sensitivity of 75% and specificity 92% for supraspinatus tears. Wohlwend (39) showed a sensitivity of 90% and specificity 89%. Even after adjusting for age the association was significant.

5.2.2 Combined diagnostic yield

The combination of shoulder radiography and ultrasound significantly increased the diagnostic yield by assessing both osseous and soft tissues abnormalities. A recently published study (May 2016) by Sheehan has demonstrated that combination of radiograph and ultrasound is adequate in diagnosing majority of shoulder lesions at a much cheaper cost to the health care system (49).
This is especially critical in our set up where shoulder ultrasound is underutilized and MRI remains out of reach for the majority.

The main limitation in this study was the absence of surgery findings to correlate with the imaging findings. It was not feasible to obtain surgery findings within the duration of the study . Additionally studies have shown a similar accuracy between ultrasound and MRI hence the use of ultrasound as a standalone modality.

5.3 Conclusion

1. Shoulder pain is more common in females than males and prevalence increases with age.
2. The diagnostic yield of non traumatic shoulder radiographs is low in patients below 40 years.
3. Degenerative changes seen in both radiographs and ultrasound increase with age.
4. Rotator cuff disease constitutes the bulk of pathology at ultrasound . Non rotator cuff structures are also depicted at ultrasound.
5. There is a significant association between greater tuberosity degenerative changes with rotator cuff tears ($p<0.001$). Their presence on radiographs can be used to predict the presence of tears.
6. There is a significant association between an acromiohumeral interval less than 7mm and full thickness supraspinatus tears ($p<0.001$).
7. Combination of shoulder radiograph and ultrasound increases the diagnostic yield by evaluating both osseous and soft tissue structures.

5.4 Recommendations.

1. Increase the awareness to clinicians about the utility of shoulder ultrasound as a cost effective modality in the evaluation of shoulder pain.
2. Shoulder radiographs and ultrasound should be considered as first line modalities in the evaluation of shoulder pain in line with the Society of Radiologists in Ultrasound consensus statement.
3. Clear shoulder radiography protocol should be implemented. The scapular Y View proved a challenge to the radiographers due to lack of practice.

REFERENCES

1. Picavet H S and Schouten J S. Musculoskeletal pain in the Netherlands: Prevalence, consequences and risk groups, the DMC3 study. *Pain 2003; 102:167-178*

2. Nygren A, Berglund A and von Koch M.Neck and shoulder pain, an increasing problem. Strategies for using insurance material to follow trends. *Scandinavian Journal of Rehabilitative medicine suppl 1995; 32:107-112*

3. Hegedus EJ, Goode A, Campbell S et al. Physical examination tests of the shoulder: a systematic review with meta-analysis of individual tests. *British Journal of Sports Medicine2008; 42: 80-92*

4. Joseph O de Jesus, Laurence Parker, Andrea J Frangos et al.Accuracy of MRI, MR Arthrography and Ultrasound in diagnosis of rotator cuff tears: A Meta-Analysis. *American journal of roentgenology 2009; 192:1701-1707*

5. Danielle A W M van der Windt,Bart K Koes,Bareld A de Jong et al. Shoulder disorders in general practice ; incidence, patient characteristics and management. *Annals of the Rheumatic Diseases 1995;54: 954 - 969*

6. Svebak S, Hagen K and Zwart JA. One year prevalence of chronic musculoskeletal pain in a large adult Norwegian county population: relations with age and gender- The HUNT study. *Journal of Musculoskeletal Pain; Vol 14(1) 2006*

7. Michelle Urwin, Deborah Symmons, Timothy Allison et al. Estimating the burden of musculoskeletal disorders in the community: the comparative prevalence of symptoms at different anatomical sites, and the relation to social deprivation. *Annals of the Rheumatic Diseases 1998;57:649-655.*

8. L.Linsell,J. Dawson,K.Zondervan et al. Prevalence and incidence of adults consulting for shoulder conditions in UK primary care; patterns of diagnosis and referral. *Rheumatology 2006;45:215- 221*

9. JJ Luime,BW Koes,IJM Hendriksen et al. Prevalence and incidence of shoulder pain in the general population; a systematic review. *Scandinavian Journal of Rheumatology 2004; 33:73-81*

10. Daniel P Pope, Peter R Croft, Christina M Pritchard et al. Prevalence of shoulder pain in the community: the influence of case definition. *Annals of the Rheumatic Diseases 1997; 56:308-312*

11. H.Miranda,L Punnett,E Viikari-Juntura et at. Physical work and chronic shoulder disorder. Results of a prospective population based study. *Annals of the Rheumatic Diseases 2008; 67:218-223*

12. M Hagberg,D H Wegman.Prevalence rates and odds ratios of shoulder –neck diseases in different occupational groups. *British Journal of Industrial Medicine 1987;44:602-610*

13. Daniëlle A W M van der Windt, Elaine Thomas, Daniel P Pope et al. Occupational risk factors for shoulder pain ;a systematic review. *Occupational and Environmental Medicine 2000;57:433-442*

14. A J K Ostor,C A Richards, A T Prevost et al.Diagnosis and relation to general health of shoulder disorder presenting to primary care. *Rheumatology 2005;44:800-805*

15. Vecchio P,Kavanagh R,Hazleman BLet al.Shoulder pain in a community based rheumatology clinic. *British Journal of Rheumatology 1995;34:440-442*.

16. A O Adebajo and B C Hazleman.Soft tissue shoulder lesions in the African. *British Journal of Rheumatology 1992;31:272-276*

17. Lawrence Mugambi.The pattern of MRI findings in patients with shoulder pain at three imaging centres in Nairobi. University of Nairobi 2009

18 . Angela Cadogan,Mark Laslett,Wayne A Hing et al.A prospective study of shoulder pain in primary care; prevalence of imaged pathology and response to guided diagnostic blocks.*BMC Musculoskeletal disorders 2011,12:119*

19. C Milgrom,M Schaffler, S Gilbert et al. Rotator cuff changes in asymptomatic adults .The effect of age ,hand dominance and gender. *Journal of Bone and Joint Surgery (British) 1995; 77-B 296-298*

20. P Reilly,I Macleod,R Macfarlane et al. Dead men and radiologists don’t lie: A review of cadaveric and radiological studies of cuff tear prevalence. *Annals of the Royal college of surgeons, England 2006; 88:116-121.*

21. N A Mall,H M Kim,J D Keener et al.Symptomatic progression of asymptomatic rotator cuff tears .A prospective study of clinical and sonographic variables. *Journal of Bone and Joint Surgery(American) 2010;92:2623-2633*

22. J N Gladstone, J Y Bishop and Ian K Lo et al.Fatty infiltration and atrophy of rotator cuff do not improve after repair and correlate with poor functional outcome. *The American Journal of Sports Medicine 2007;vol 35 no 5*

23. Dussik K T,Fritch DJ and Kyriazidou M et al. Measurements of articular tissues with ultrasound. *American Journal of Physical Medicine 1958;37:160-5*

24. Cooperberg PL,Tsang I , Truelove L et al. Grayscale ultrasound in the evaluation of rheumatoid arthritis of the knee. *Radiology 1978 ; 126:759-63*

25. Seltzer SE,Finberg H J and Weissman B N. Arthrosonography - Technique,Sonographic anatomy and pathology.*Investigative Radiology 1980 vol 15 issue 1*

26. Middleton W D,Edelstein G, Reinus W R et al. Ultrasonography of the rotator cuff,technique and normal anatomy. *Journal of Ultrasound in Medicine 1984;3:549-551.*

27. Jeffrey Crass,Edward Craig ,Samuel Feinberg et al. Ultrasonography of the rotator cuff. *Radiographics .November 1985 Volume 5 number 6*

28. Mack AL,Matsen F A,Kilcoyne MD et al. US evaluation of the rotator cuff. *Radiology 1985;157:205-209*

29. Jeffrey Crass,Edward Craig ,Samuel Feinberg et al. Ultrasonography of rotator cuff tears: a review of 500 diagnostic studies. *Journal of Clinical Ultrasound 1988;16:313-32*

30. C Martinoli, S Bianchi,N Prato et al Ultrasound of the shoulder ,Non rotator cuff disorders. *Radiographics 2003; 23:381-401*

31. A Al-Shawi,R Badge and T Bunker. The detection of full thickness rotator cuff tears using Ultrasound. *Journal of Bone and Joint Surgery (British) 2008;90-B:889-892*

32. R Seagger, T Bunker and P Hamer. Surgeon operated ultrasonography in a one stop shoulder clinic. *Annals of the Royal College of Surgeons of England 2011; 93:528-531*

33. L N Nazarian,J A Jacobson,C B Benson et al. Imaging algorithms for evaluating suspected rotator cuff disease: Society of Radiologists in Ultrasound consensus conference statement. *Radiology 2013; 267:589-595*

34. Gray's Anatomy. Thirty-Ninth edition.

35. Grainger and Allisons' Diagnostic radiology. A textbook of medical imaging. Sixth edition.

36. Richard G Stiles and Michael T Otte. Imaging of the shoulder. *Radiology 1993; 188:603-613*

37. Moosikasuwan JB, Miller T M and Buerke B J. Rotator cuff tears: Clinical, Radiographic and US findings. *Radiographics 2005;25:1591-1607*

38. Ronald A Bloom. The active abduction view : A new manouvre in the diagnosis of rotator cuff tears. *Skeletal Radiology (1991) 20:255-258*

39. J R Wohlwend,M van Holsbeek,J Craig et al. The association between irregular greater tuberosities and rotator cuff tears: A sonographic study. *American Journal of Roentgenology 1998; 171:229-233*

40. Pearsall A W ,Bonsell S, Heitman R J et al. Radiographic findings associated with symptomatic rotator cuff tears. *Journal of Shoulder and Elbow Surgery 2003; 12: 122- 127*

41. D Goutallier, P L Guillox, J M Postel et al. Acromiohumeral distance less than 6 millimetres: Its meaning in Full thickness rotator cuff tear. *Orthopaedics and Traumatology: Surgery and Research (2011)97,246-251*

42. S Bonsell, A W Pearsall, R J Heitman et al. The relationship of age, gender and degenerative changes observed on radiographs oh the shoulder in asymptomatic individuals. *Journal of Bone and Joint Surgery (Br) 2000; 82-B : 1135-1139*

43. Musculoskeletal ultrasound technical guidelines – Shoulder. European Society of Musculoskletal Radiology.

44. A J Wilson,W G Totty,W A Murphy et al. Shoulder joint: Arthrographic CT and long term follow up with surgical correlation. *Radiology 1989; 173:329-333*

45. Robert Cone ,Donald Resnick and Larry Danzig. Shoulder impingement syndrome:Radiographic evaluation. *Radiology 1984;150:29-33*

46. David C Hardy,James B Vogler and Richard H White. The shoulder impingement syndrome: Prevalence of radiographic findings and correlation with response to therapy. *AJR 147:557-561,September 1986*

47. Nadja Saupe, Christian Pfirmann, Matius R Schmid et al. Association between rotator cuff abnormalities and reduced acromiohumeral interval. *AJR 2006;187:376-382*

48.Gandikota Girish, Lucas G Lobo and Jon A Jacobson. Ultrasound of the shoulder: Assymptomatic findings in men.*AJR 2011;197:W713-W719*

49.Scott E Sheehan, John A Coburn and Hardeep Singh. Reducing unnecessary shoulder MRI examinations within a capitated health care system; A potential role for shoulder ultrasound. *J Am Coll Radiol 2016.* Article in press. *http://dx.doi.org/10.1016/j.jacr.2016.03.015*

APPENDICES

Appendix I: Questionnaire

SPECTRUM OF SHOULDER RADIOGRAPHIC AND ULTRASOUND FINDINGS IN PATIENTS WITH SHOULDER PAIN AT THE DEPARTMENT OF DIAGNOSTIC IMAGING AND RADIATION MEDICINE, UNIVERSITY OF NAIROBI

Patients study number……………………….

Demographic data

Age ………………………………….

Sex 01. Male 02. Female

Occupation 01. Formal (office employment)

02. Casual (manual employment)

03. Business

04.Unemployed

History of shoulder pain 01. Yes 02. No

Radiographic findings

Acromion 01. Type 1 02. Type 2 03. Type 3

Acromiohumeral interval ……………………(mm)

Spurring

Subacromial 01. Yes 02. No

Inferior AC joint 01. Yes 02. No

Greater tuberosity 01. Normal 02. Degenerative changes 03. Other

Acromioclavicular joint 01. Normal 02. Degenerative changes 03. Other

Glenohumeral joint 01. Normal 02. Degenerative changes 03. Other

Rotator cuff calcifications 01. Yes 02. No

ULTRASOUND FINDINGS

TENDON	Normal	Tendinitis	Calcification	Partial Tear	Full Tear
Subscapularis					
Supraspinatus					
Infraspinatus					
Teres minor					

Long head of biceps tendon

01.Normal 02.Tendinosis 03. Tear 04.Effusion
05.Subluxation/dislocation

Acromioclavicular joint

01.Normal 02.Degenerative changes 03.Other

Subacromial Subdeltoid bursa

01.Normal 02.Effusion 03.Thickening 04.Other

Greater tuberosity cortical irregularity

01.Present 02.Absent

Deltoid muscle and subcutaneous tissues

01.Normal 02.Mass/cyst 03.Other

Appendix II : Imaging Diagnostic Criteria

A. RADIOGRAPHS

Degenerative change- joint space narrowing, subchondral sclerosis, subchondral cysts or marginal osteophytes

B. ULTRASOUND

ROTATOR CUFF

**Normal - ** normal contour and echogenicity

Calcification - focal increase in echogenicity with or without narrowing

Tendinosis - tendon thickening or decreased echogenicity

Partial thickness tear- Hypoechoic defect that involves the articular or bursa surface, thinning of the cuff or straight outer cuff border with loss of convexity

Full thickness tear -Nonvisualisation of cuff tissue, localized hypoechoic zones involving entire cuff tissue

SUBACROMIAL BURSA

Bursitis – hypoechoic fluid present

Bursal thickening – more than 2mm thickness

Glenohumeral effusion – joint fluid more than 2mm between the posterior glenoid labrum and posterior capsule.

Acromioclavicular pathology – cortical irregularity, osteophytes, capsular hypertrophy, joint space narrowing.

Appendix III : Consent Form For Participation

CONSENT FORM FOR PARTICIPATION IN A STUDY ON THE SPECTRUM OF RADIOGRAPHIC AND SONOGRAPHIC FINDINGS IN PATIENTS WITH SHOULDER PAIN AT THE DEPARTMENT OF DIAGNOSTIC IMAGING AND RADIATION MEDICINE,UNIVERSITY OF NAIROBI.

I am Dr. Desmond Mbondo Mangoka , a postgraduate student at the University of Nairobi, Department of Diagnostic Imaging and Radiation Medicine. I am carrying out a study on the spectrum of shoulder radiograph and ultrasound findings in patients with shoulder pain. The study aims at providing us with knowledge of shoulder ultrasound findings in our country.

Ultrasound is a safe, painless way of evaluating the shoulder. You shall not pay any additional cost for this study. There are no risks to you in the study.

I wish to recruit you to participate. The information obtained will be treated with utmost confidentiality. Your name will not be included and only the serial number will be used for identification.

Your participation in the study is purely voluntary and you have a right to accept or decline taking part in the study.

If you accept please sign below.

Signature ………………………………… Date …………………………………………….

I certify that the patient has understood and consented participation in the study.

Signature ……………………………………. Date………………………………………………….

In case you have any questions or need further information please contact the following persons:

1. **Principal investigator**

   Dr Desmond Mbondo Mango'ka

   Tel : 0722691483

2. Lead supervisor

Dr. Callen Kwamboka Onyambu,

Senior Lecturer,

Department of Diagnostic Imaging and Radiation Medicine,

University of Nairobi.

Telephone number : 0721539987

3 The Secretary

KNH-UON ERC,

Kenyatta National Hospital,

P.O BOX 20723-00202,Nairobi.

Telephone : 020-2726300 Ext 44102

Appendix IV : Kibali Cha Mgonjwa

Mimi ni Daktari Desmond Mbondo Mango'ka ,mwanafunzi wa masomo ya juu katika chuo kikuu cha Nairobi.

Ninafanya utafiti kuhusu mbinu za Xray na Ultrasound ambazo tunatumia kuchungunza magonjwa ya mabega. Huu utafiti utatuwezesha kupata maarifa ambayo yatatumika kuelekeza uchunguzi wa magonja ya mabega.Utafiti huu hauna madhara yoyote kwa afya yako.Hakuna malipo yoyote utakayotozwa kwa picha ya Ultrasound. Naomba ruhusa yako ili tuyatumie majibu yako katika uchunguzi huu. Majibu yote ambayo tutayapokea ni ya siri.Jina lako halitawekwa mahali popote ila nambari ya fomu peke yake.

Tafadhali elewa kushiriki kwenye utafiti huu ni kwa hiari yako.Hakuna atakayekulazimu kushiriki.

Ukikubali kuhusiana nasi tafadhali weka sahihi hapa chini.

Sahihi……………………………….Tarehe…………………………………………….

Ninakiri kwamba mgonjwa ameelewa na amekubali kuhusiana nasi katika uchunguzi.

Sahihi…………………………… Tarehe………………………………………..

Kwa maswali au maelezo zaidi wasiliana na wahusika wa utafiti huu kupitia nambari hizi :

1. **Mchunguzi mkuu**

   Daktari Desmond Mbondo Mang'oka

   Nambari ya simu : 0722691483

2. **Msimamizi mkuu**

   Daktari Callen Kwamboka Onyambu

   Idara ya Radiology

   Chuo Kikuu cha Nairobi.

   Nambari ya simu : 0721539987

3. **Jopo la usimamizi wa uchunguzi wa kisayansi la Hospitali kuu ya Kenyatta na Chuo Kikuu cha Nairobi**

   Sanduku la Posta 20723-00200,Nairobi.

   Nambari ya simu: 020-2726300 Ext 44102

Appendix V : KNH/ERC Letter of Approval

UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
(254-020) 2726300 Ext 44355

KENYATTA NATIONAL HOSPITAL APPROVED 13 JAN 2016 KNH/UoN-ERC P.O. Box 20723-00202 NRB.

KNH-UON ERC
Email: uonknh_erc@uonbi.ac.ke
Website: http://www.erc.uonbi.ac.ke
Facebook: https://www.facebook.com/uonknh.erc
Twitter: @UONKNH_ERC https://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref: KNH-ERC/A/10

13th January 2016

Dr.Desmond Mbondo Mang'oka
Reg. No.H58/80829/2012
Dept.of Diagnostic Imaging & Rad. Medicine
School of Medicine
College of Health Sciences
University of Nairobi

Dear Dr. Mbondo

Revised research proposal: The spectrum of radiographic and sonographic findings in patients with shoulder pain at the Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi (P673/10/2015)

This is to inform you that the KNH- UoN Ethics & Research Committee (KNH-UoN ERC) has reviewed and **approved** your above proposal. The approval periods are 13th January 2016 –12th January 2017.

This approval is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc) are submitted for review and approval by KNH-UoN ERC before implementation.
c) Death and life threatening problems and serious adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH-UoN ERC within 72 hours of notification.
d) Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
e) Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
f) Clearance for export of biological specimens must be obtained from KNH- UoN ERC for each batch of shipment.
g) Submission of an *executive summary* report within 90 days upon completion of the study.
This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/ or plagiarism.

For more details consult the KNH- UoN ERC website **http://www.erc.uonbi.ac.ke**

Protect to discover

Yours sincerely,

PROF. M.L. CHINDIA
SECRETARY, KNH-UoN ERC

c.c. The Principal, College of Health Sciences, UoN
The Deputy Director, CS, KNH
The Chair, KNH-UoN ERC
The Assistant Director, Health Information, KNH
The Dean, School of Medicine,UoN
The Chair, Dept.of Diagnostic Imaging and Rad. Medicine,UoN
Supervisors: Dr.Callen Kwamboka Onyambu, Dr. Ian Mathenge Muriithi

Protect to discover