UNIVERSITY OF NAIROBI

THE ASSOCIATION BETWEEN MEDIAL COMPARTMENT OSTEOARTHRITIS OF THE KNEE AND FOOT POSTURE CHARACTERISTICS AMONG PATIENTS ATTENDING KENYATTA NATIONAL HOSPITAL, NAIROBI

BY:

DR. DANIEL MOCHOGE

H58/70112/2011

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE AWARD OF DEGREE OF MASTER OF MEDICINE (M.MED) IN ORTHOPEDIC SURGERY IN THE UNIVERSITY OF NAIROBI

Department of Orthopedic Surgery

DECLARATION

1. I understand what plagiarism is and I am aware of the university's policy in this regard
2. I hereby make a declaration that this dissertation proposal is my original work and has not been presented at any other university. Where other people's work has been used , this has been properly acknowledged and referenced following the University of Nairobi's requirements
3. I have not sought or used services of any professional agencies to produce this work.
4. I have not allowed and shall not allow anyone to copy my work and pass it on as their own
5. I understand that any false claim in respect to this shall result in disciplinary action as per University plagiarism policy

Signed ......(signature)................ Date.........2../08/..2022

DR. DANIEL MAKOYO MOCHOGE

REGISTRATION NUMBER: H58/70112/2011

Tel: +254729320313

Email: dmochoge@gmail.com

DEDICATION

I dedicate this study to my Father Prof Benson mochoge, my late loving mum Eunice mochoge, my wife and my children, for their patience love and support during my study without which it would not have been possible

ACKNOWLEDGEMENT

I wish to acknowledge with gratitude the guidance from my supervisors, Prof. John Atingá and Dr. Vincent Mutiso and faculty in Orthopedic surgery unit at large in carrying out this study.

I am thankful to my family and friends as well for support during this period.

SUPERVISORS APPROVAL

Department of Orthopaedic Surgery, School of Medicine, University of Nairobi

This proposal is being submitted with our approval as university supervisors.

Signature.................................

Date....2/8/22..............

PROF. JOHN E.O. ATING'A

MB.ChB(Nrb), MMed Surg (Nrb), Mch Orth (Liv)

Prof, unit of Orthopedic Surgery,

Department of surgery, faculty of Health Sciences

And

Consultant Orthopedic Surgeon and Spine surgeon, Kenyatta National hospital

Email: atinga08@gmail.com

Signature:.................................

Date.......22nd Aug 2022.

DR. MUTISO, VINCENT MUOKI

(MB.ChB Nrb., MMed(surgery) Nrb.,Certificate in Microsurgery(Hand), Fellow AO-international,FCS), Clinical Fellow in Orthopaedics (Arthroscopy & Arthroplasty)(UK.)

Head, Unit of Orthopedic Surgery,

Department of Surgery, Faculty of Health sciences, University of Nairobi

And

Consultant orthopedic and Trauma surgeon, Kenyatta national Hospital

Email: mutiso@uonbi.ac.ke

DEPARTMENTAL CLEARANCE

This proposal has been presented in the Department of Orthopedic Surgery and is hereby approved for the submission to the Kenyatta National Hosspital –University of Nairobi Ethics and Research committee (KNH-UON ERC)

Signature...

Date ....22nd Aug 2022..........

DR. MUTISO, VINCENT MUOKI

(MB.ChB Nrb., MMed(surgery) Nrb.,Certificate in Microsurgery(Hand), Fellow AO-international,FCS), Clinical Fellow in Orthopaedics (Arthroscopy & Arthroplasty)(UK.)

Head, Unit of Orthopedic Surgery,

Department of Surgery, Faculty of Health sciences, University of Nairobi

And

Consultant orthopedic and Trauma surgeon, Kenyatta national Hospital

Email: mutiso@uonbi.ac.ke

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

BMI	Body Mass Index
ERC	Ethical Research Committee
FPI	Foot Posture Index
FPC	Foot Posture Characteristics
GRF	Ground Reaction Force
KAM	Knee Adduction Moment
KNH	Kenyatta National Hospital
KOA	Knee Osteoarthritis
LWI	Lateral Wedge Insole
MCL	Medial Collateral Ligament
MCOA	Medial Compartment Osteoarthritis
MTP	Metatarsal phalangeal joint
OA	Osteoarthritis
PF	Patellofemoral
TF	Tibiofemoral
UON	University of Nairobi

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Background: Foot posture characteristics such as foot posture index (particularly pronated foot posture), medial arch index, navicular height and drop have been postulated to modify the risk of Medial Compartment Osteoarthritits (MCOA) of the knee by altering the mechanical alignment and loading of the knee joint. Furthermore, altered foot posture may cause other musculoskeletal conditions of the lower limb such as postural instability. Focus has therefore been shifted to foot posture in patients with MCOA, to further clarify its association with knee osteoarthritis (KOA), as well as inform non-invasive therapeutic avenues such as foot orthoses and footwear for treatment of MCOA.

Study objective: To determine the association between MCOA and foot posture characteristics among patients presenting at Kenyatta National Hospital (KNH).

Study design: Case-control study.

Study setting: The study was conducted at the orthopaedic clinic (OC) and medical outpatient clinics (MOPC) in the Kenyatta National Hospital (KNH).

Study duration: December 2021 to February 2022.

Patients and methods: The study population included 80 consenting patients (40 cases and 40 controls) above the age of 18 years visiting the OC (cases) and MOPC (controls) in KNH between December 2021 and February 2022. Cases included patients visiting the OC with a diagnosis of medial compartment osteoarthritis (MCOA), defined on the basis of knee radiograph assessment using the Kellgren Lawrence Classification system (K-L grade). Patients with grade 1 OA and above were defined as cases (with MCOA). Patients visiting MOPC, who were asymptomatic and with a K-L grade of 0 served as the control group (without MCOA). Variables collected included patient age, sex, body mass index, presence of medial

compartment osteoarthritis (MCOA), as well as foot posture characteristics (foot posture index, medial arch index, navicular height and navicular drop).

Data management and analysis: The collected data were transferred from password-coded data digital collection sheets into analysis software for data cleaning and coding prior to analysis. Data were stored in password-protected computer folders to maintain anonymity of the study subjects. Analysis of the data was carried out using Prism 7 (GraphPad Software, San Diego, CA, USA) and SPSS (IBM Statistics Software Version 25, Armonk, New York, USA). Categorial data were reported as frequencies (%). Continuous data were subjected to normality tests (histogram and Q-Q plots with Kolmogorov-Smirnov test), and reported as mean and standard deviation (SD) since it was normally distributed. Comparison of foot posture characteristics (foot posture index, medial arch index, navicular height and navicular drop) between patients with medial compartment osteoarthritis (MCOA) (cases) and without MCOA (NMCOA/control group) was carried out using the Independent Student's t-test. Multivariate logistic regression analysis was performed to estimate the effect of foot posture characteristics on MCOA, adjusting for age, sex and body mass index, and to calculate adjusted odds ratios (ORs) with the corresponding 95% Wald CI. Throughout the analysis, a $p<0.05$ was considered statistically significant at a 95% confidence interval.

Results: No significant differences in age (61.7±13.2 vs 58.9±11.1 years, p=0.311), sex composition (males- 45% vs 55%, p= 0.503) or body mass index (BMI) (24.8±3.3 vs 25.3±3.4 Kg/M^2, p= 0.528) were observed between the cases and controls. The foot posture index (FPI) was found to be significantly higher in the MCOA group than NMCOA group (3.4±2.2 vs 0.3±2.1, p<0.001). Similarly, patients with MCOA had a significantly higher medial arch index (MAI) (0.32±0.1 vs 0.25±0.1, p<0.001), and navicular drop (ND) (0.79±0.3 vs 0.55±0.2, p<0.001) than NMCOA group. No significant differences in the navicular height (NH) were observed between the two group (4.7±0.4 vs 4.8±0.3, p=0.415). Foot posture index (FPI)

(r=0.675, p<0.001), MAI (r=0.576, p<0.001) and ND (r=0.573, p<0.001) positively correlated with Kellgren-Lawrence (K-L) grade of MCOA. In the multivariate adjusted logistic regression model, pronated foot posture (OR= 1.79, 95% CI 1.22-2.65, p=0.003), higher medial arch index (OR= 4.93, 1.27-19.10, p=0.021) were significant predictors of MCOA.

Conclusion: Foot posture characteristics such as pronated foot posture are associated with MCOA. We therefore recommend that foot characteristics be routinely assessed in these patients to guide therapeutic interventions.

CHAPTER 1: INTRODUCTION

1.1 Background

Osteoarthritis of the knee (KO) is a degenerative joint disease characterized by progressive loss of articular cartilage. It is one of the most common musculoskeletal disease among the elderly, and is leading cause of disability (1). Based on etiology, OA is subclassified into primary and secondary OA. Primary OA usually occurs without any identifiable cause, whereas secondary OA usually has identifiable cause such as trauma, endocrine dysfunctions (e.g., acromegaly), rheumatic diseases (e.g., rheumatoid arthritis, psoriasis), metabolic disorders (e.g., rickets, Wilson disease) and hematological conditions (e.g., hemophilia, sickle cell disease, hemochromatosis) among other causes (2). The clinical presentation of OA ranges from asymptomatic disease discovered incidentally during imaging of the knee, to severe incapacitating symptoms that significantly impair daily functions of patients. Typical symptoms include joint pain that is worsened by movement and relieved by rest, as well as joint stiffness, deformities and bony swellings (1–3).

A subset of OA patients usually presents with unicompartmental disease, with medial compartment OA (MCOA) being the commonest variety. This has been attributed to the differential loading of the knee joint compartments, with majority of the load being transmitted through the medial compartment (4). Changes in posture of the foot have been postulated to further modify the risk of MCOA by altering the mechanical alignment and loading of the knee joint (5–7). Furthermore, altered foot posture may cause other musculoskeletal conditions of the lower limb such as postural instability (8). Focus has therefore been shifted to foot posture in patients with MCOA, to further clarify its association with knee OA, as well as inform non-invasive therapeutic avenues such as foot orthoses and footwears for treatment of MCOA (5).

Despite OA being a common condition within our setting (9), there is still paucity of data on the relationship between MCOA and foot posture characteristics within the Kenyan population to inform proper therapeutic interventions. The aim of this study is therefore to determine the association between MCOA and foot posture characteristics (foot posture index, medial arch index, navicular height and navicular drop) among patients presenting at Kenyatta National Hospital (KNH).

1.2 Study justification

Foot posture characteristics such as foot posture index (particularly pronated foot posture), medial arch index, navicular height and drop have been postulated to modify the risk of MCOA by altering the mechanical alignment and loading of the knee joint. Furthermore, altered foot posture may cause other musculoskeletal conditions of the lower limb such as postural instability. Focus has therefore been shifted to foot posture in patients with MCOA, to further clarify its association with knee OA, as well as inform non-invasive therapeutic avenues such as foot orthoses and footwears for treatment of MCOA. Despite OA being a common condition within our setting, there is still paucity of data on the relationship between MCOA and foot posture characteristics within the Kenyan population to inform proper therapeutic interventions among MCOA patients.

1.3 Study question

Is there an association between MCOA and foot posture characteristics among patients presenting at Kenyatta National Hospital (KNH)?

1.4 Study Objectives

Broad objective

To determine the association between MCOA and foot posture characteristics among patients presenting at Kenyatta National Hospital (KNH).

Specific objectives

To compare the following foot posture characteristics between patients with MCOA (cases) and without MCOA (controls):

1. Foot posture index (FPI)
2. Medial arch index (MAI)
3. Navicular height
4. Navicular drop

CHAPTER 2: LITERATURE REVIEW

2.1 Overview and epidemiology of medial compartment osteoarthritis

Knee medial compartment osteoarthritis refers to a medical situation involving the deterioration of the cushioning layer between the knee bones. The deterioration that occurs over time takes place on the cushion layer of the meniscus and the cartilage and leading to the two bones of the knee, rubbing against each other. With time, the situation develops into a painful condition ridden with swelling and stiffness (10). Patients with complaints of medial knee pain are likely to have medial compartment osteoarthritis, medial meniscal wear, Pes anserine bursitis, and MCL strain. Other causes might include second or third-degree medial knee injuries/sprain, fractures of the tibial plateau, tears of the medial meniscus (11).

In the knee joint, the medial, meniscus refers to the pad of fibrocartilage situated between the femur or the thigh bone and the tibia or the shin bone. In a healthy person's knee, the medial meniscus is both smooth and permits the two bones to glide without significant generation of friction. This fibrocartilage also facilitates the absorption of shock arising from movement (12). A knee presenting with the medial compartment osteoarthritis condition has its medial meniscus and articular cartilage worn out sometimes to the point of being nonexistent, leading to friction occurring between the tibia and the femur every time a person moves or even bends the knee. With time, the damage that has occurred at the joint can further manifest as a complication leading to malfunctioning of the knee. Small deposits of bone may also be observed around the joint of the knee, referred to as bone spurs or osteophytes (13).

Knee osteoarthritis is a concern that needs to be taken into special consideration when dealing with foot posture abnormalities. This can be confirmed by a study by Al- Bayati et al (14), conducted in Turkey which captured a total of 150 patients with knee osteoarthritis. It revealed that 22.66%, 68.66% and 8.66% of the patients had supination, neutral and pronation foot postures respectively. Additionally, the foot posture index (FPI) of the pronation group had changes in the varus direction (14). Another study by Paterson et al(15), revealed that foot/ankle symptoms which occur in both feet significantly increases the odds of developing knee complications.

In Africa, Lekpa et al (16) captured the factors associated with the occurrence of knee osteoarthritis such as education, income and obesity as being common among men and women in sub-Saharan Africa. Agarwal et al (17) also notes that knee osteoarthritis is a major concern given its association with the causation of pain and functional disability globally. KOA is one of the most common causes of pain as well as disability among old people. Around 12% of adults in the USA above the age of 60 years, experience symptomatic KOA. The global prevalence rates show that the prevalence of KOA stands at 9% for men and 18% for women (18). There are few studies conducted in Kenya in relation to the association between knee osteoarthritis and foot posture. One study however notes that 77% of patients in the country have KOA which is highly prevalent among obese and overweight patients(19).

2.2 Factors associated with medial compartment osteoarthritis of the knee

Osteoarthritis (OA) is associated with several factors that include age, obesity, sex, and race, which may exhibit both a sociocultural and genetic influence. Specifically, OA is common among the aged, females, obese and overweight individuals, individuals after knee injury, those with poor bone density, repetitive use of joints, weakness in the muscles, and laxity in the joints, especially in the joints that bear weight. Modification of these factors means a reduction of OA as well as preventing disability and subsequent pain (20).

2.2.1 Demographic factors

The knee joint is at a higher risk of OA than the hip and ankle joint. This is because the knee joint is a weight-bearing joint that is exposed to various risk factors including old age, overweight, gender, repetitive use of joints, injuries, weakness of the muscles, bone density issues, and laxity of the joints. Further, the bicondylar setup of the knee joint makes it highly vulnerable to changes in the environment related to mechanics, injuries such as muscle tears and aging because of the adduction or abduction moment in the bicondylar joint moves the net point of contact as well as load towards the direction of one compartment. On the other hand, the talocrural and subtalar joints of the ankle of a healthy person have high surfaces that are highly congruent.

A concave surface on the medial side as well as a convex one on the lateral side are visible on the tibial plateau. The concavity on the medial plateau leads to a higher level of conformism in the medial compartment, and thus, the location of contact is more sensitive to the medial side rotation as opposed to the lateral side. The medial meniscus stands as being more susceptible to injuries as opposed to the lateral meniscus. This is considered to be due to the medial meniscus' lower mobility as well as to the connection to the medial collateral ligament. According to Valderrabano, the prevalence of symptomatic hip and KOA among people aged more than 30 years is 3% and 6% respectively, while the prevalence of ankle OA stands at 1%.

According to Heiden et al(21), KOA is higher among the aged. The incidence and prevalence of KOA are higher as age increases. It further increases as the average height and longevity of the population increases. Research findings show that among 10% of men and 13% of women above 60 years have asymptomatic KOA. Barg et al(22) similarly found that, more than 10% of people who are 55 years and above reported KOA that is both painful and disabling (22).

Several studies support the earlier assertion that women are at a higher risk of KOA. In one study, there have been findings that KOA is more prevalent among younger women who are obese. Women, especially those who are aged more than 55 years, tend to have more severe knee OA. The differences in KOA are particularly demonstrated after the menopausal age (22). In a prospective study where radiograph data were availed along with details of physical assessment, the prevalence of KOA was shown to be dependent on age among women but for the same population of men it was not. Hence, the prevalence of KOA is more common among women as opposed to men. Further, it was found to be more common among participants from rural areas as opposed to those from urban areas (23).

A more in-depth review of the literature reveals that most of the studies have placed their focus on the 1st MTP joint of the foot and midfoot joints have been neglected. Thus, the clustering and symmetry of OA are largely unknown. Findings show that the isolated 1st MTP has higher chances of radiographic OA, but lower chances of midfoot involvement. The polyarticular class has been shown to have a high probability of being female, and presenting nodal hand OA, more severe pain that is persistent (20).

Several studies have examined the link between the posture of the foot and radiographic OA of the first MTP joint. A systematic analysis of case-control researches shows that there were no statistical differences of arch height between people with hallux rigidus and those without the hallux rigidus. The dose-response association between the severity of the radiograph and the hallux valgus, the hyperextension of the first interphalangeal joint, skin lesions, and decreased dorsiflexion suggest that the 1st MTP joint of the foot OA bears both biochemical and structural consequences for the entire foot and ankle complex (20).

2.2.2 Meniscectomy

Further assessment of the factors associated with medial compartment osteoarthritis has shown that meniscectomy and knee injury are highly associated. These two variables are greatly associated with KOA without any concomitant tear of the meniscus. The strong link between meniscal tear and consequent loss of the cartilage of the knee, changes in the size of the bone, and prevalence of the radiographic KOA in people who have not been diagnosed to have KOA gives the suggestion that meniscal tear is an early precursor to the process of the disease, and a strong predicting factor for the development of osteoarthritis (20). The highest prognostic factor linked with the development of osteoarthritis changes in individuals who have previously gone through open as well as an arthroscopic meniscectomy.

There is no agreement on the categorization of patients as traumatic or degenerative meniscal injury. Injuries are further grouped based on the mechanism of the injury, either low or high, and the form of lesion, either vertical or buckle. Degenerative tears can be regarded as horizontal cleavages, complex tears, or flap tears. These are majorly seen in the medial meniscus and are usually found in asymptomatic individuals. The etiology is still unclear for patients who have undergone surgery for degenerative tears. This is an indication that meniscal injury is in itself an explanation of the KOA.

2.2.3 External knee adduction moment

Specifically, research has shown that the adduction of the knee while walking impacts the distribution of forces between the lateral and medial compartments of an individual's knee, hence serving as a useful measure to assess the medial and lateral variations with regards to the thickness of the cartilage (24). The degree of the knee adduction moment (KAM) while one assumes normal gait has been associated with the medial to lateral ratio thickness of the cartilage in the load-bearing regions that are common to the knee while walking and the progression of osteoarthritis on the knee. In specific, for healthy cartilage, the thickness of the medial cartilage relatively adapts to greater repetitive loads while walking by a higher regional or local thickness (25). On the contrary, in the regions where there is a load in the medial compartments of the patient, there is decreased thickness.

2.2.4 Mechanotransduction

The mechanism through which mechanical stimulus like KAM is changed into chemical or electrical signals in chondrocyte activity is checked by an intricate interaction between environmental, genetic, and biomechanical factors. Cytokines, growth factors and extracellular matrix compounds are some of the underlying factors that determine the environment for these cells. Biomechanical factors are due to the mechanical loads that are dispersed on the extracellular matrix and chondrocytes. These subsume the compression, tension, shear, fluid pressure, osmotic pressure, and other electrokinetic effects. The local loads around the cartilage along with the substructures are determined by the conveyance and sharing of mechanical loads on the body level. The distribution of loads at tissue level is different from one local region to another on both the superficial as well as the deep zones as determined by microstructural properties. The architecture of the collagen fiber in the extracellular matrix and the specific matrix interlinked with the chondrocyte shape and distribution offer a basis for cellular deformations as well as fiber loading. Most significantly, the strength of the collagen architecture and their health are reliant on regular and sufficient joint loading (21).

2.2.5 Gait biomechanics and knee pain

As opposed to the general commonplace perception, pain is not the best indicator to determine the degree of articular damage, but the risk of experiencing symptomatic OA of the knee is higher with the frequency of structural changes. Pain, though, is the primary reported symptom, and treatment-related to pain hence a priority. Mechanisms of knee pain are, nonetheless, normally intricate and usually associated with several factors, such as central and peripheral sensitization, psychosocial component of pain, referred pain, subchondral bone, inflammation compression of the osteophytes, cartilage, malalignment of capsule, ligament and menisci as well as soreness of the muscle and trigger points.

Several studies have reported that induced pain or pain relief may change the loading of the knee during walking (26). This indicates that pain may be regarded as a mechanism for protection, causing reduction of the loading on the medial knee. However, the prerequisites remain largely unknown, and it is not understood fully if and how pain can be best minimized to slow the progression of the disease (27). As highlighted above, there are a series of changes that occur potentially with osteoarthritis of the knee, including deformities of the joint, weakness of the muscle, instability, minimized proprioception, joint effusion, and inflammation.

2.2.6 Alignment

While there is a correlation between the static knee and the level of KOA, dynamic alignment, on the other hand, is impacted by both the alignment of the static limb and the dynamics of loading at the knee while movement is occurring. The dynamic loading at the knee area can be as a result of the subconscious control of the position of the limb like the placement of the foot, stability of the passive soft tissue, gait-related velocity, and active muscle contraction. The loads that result from these inherently dynamic activities are greater compared to those that are related to static postures. Thus, the alignment of the limb the static radiographic assessment offers one element of the entire analysis of the factors that influence the knee joint loading. Dynamic malalignment takes place when activities such as gait are considered in assessing the progression of disease processes and the selection of the right treatment modalities (21).

2.3 Pathophysiology of osteoarthritis of the knee

There are classification OA which is inclusive of primary (idiopathic or non-traumatic) and secondary (usually due to trauma or mechanical misalignment). Disease severity can be graded in relation to radiographical findings of the Kellgren-Lawrence (KL) system of 1957. OA is believed to be a disease that leads to degeneration of the cartilage but there is evidence that proves that is a multifactorial entity which involves multiple causative factors such as inflammation, trauma, biochemical, reactions, and metabolic arrangements. The cartilaginous tissue was not the only tissue that was involved largely due to its lack of vasculature and innervation, the cartilage by itself was unable to produce inflammation or pain especially in the initial stages of the diseases. The pain source was mainly attributed to the changes in components of the joint that are non-cartilaginous such as changes on the ligaments, synovium, joint capsule peri-articular muscles and subchondral bone (28).

The role that inflammation plays is not a particularly well understood topic and there is an ongoing debate in relation to the determining whether the inflammatory reaction results into the causation of OA changes or the inflammation was secondary to the OA changes. OA is a chronic and low-grade inflammation which captures innate immune mechanisms which is contrary to inflammatory arthritis. In the initial stages of the OA synovitis may be present however it is usually more prevalent in more advanced stages which relates with the extent of severity. The synovial fluid in the OA contains a number of inflammatory mediators which includes plasma proteins (C-reactive protein), leukotrienes (LKB4), cytokines (TNF, IL1β, IL6, IL15, IL17, IL18, IL21) prostaglandins (PGE2), nitric oxidecomplement components and growth factors (TGFβ, FGFs, VEGF, NGF) (19,29).

They have the capability of inducing the metalloproteinases in the matrix and hydrolytic enzymes such as cyclooxygenase two and prostaglandin E thus leading to the breakdown of the cartilage followed by proteoglycan and the destruction of collagen. The WBCs are also involved as the extracellular breakdown of the matrix contributes to the release of (damage-associated molecular patterns)-DAMPs which identified by (macrophages and mast cells) of the innate immune system, as a protective mechanism. Due to the inflammation that is prolonged and dysregulated it has the capability of tissue destruction. Studies that focused on animals reveal that in OA osteophytes may develop as a pathological feature. Additionally, growth factors such as (platelet derived, insulin like, TGF-beta and fibroblast) that act as protective molecular mechanisms may be altered in the patient’s knee which may be harmful to the joint (30).

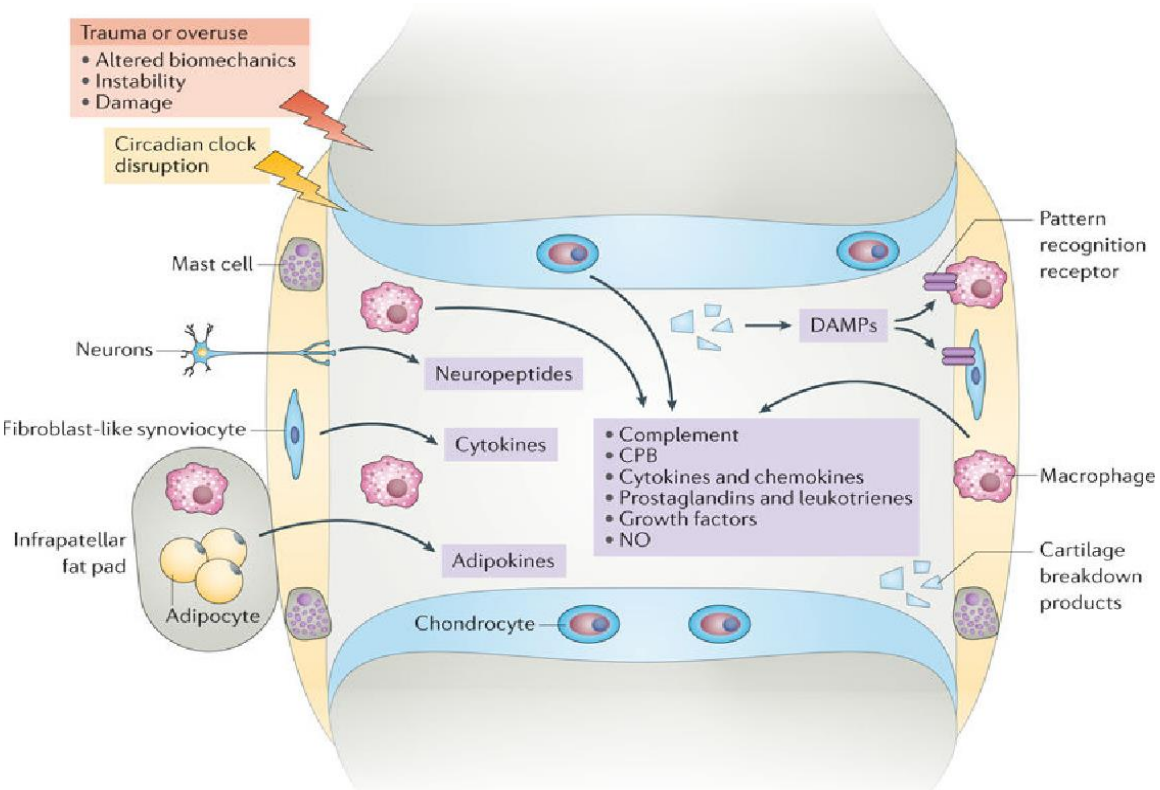


Figure 1: Pathophysiology of Osteoarthritis (Adopted from British association of sports and exercise medicine)

2.4 Mechanism of injury

Generally, the tibiofemoral KOA has been reported as being more common in the medial compartment compared to the lateral compartment, perhaps due to the fact that there is heavier loading in the former case (18). A separate study showed that medial compartment osteoarthritis is a common chronic, progressive and degenerative disease, particularly among the elderly. The knee varus malformations are typified by a perfunctory femorotibial axis that is less than 180 degrees on anteroposterior radiographs portraying a full leg in standing posture, and a tapered medial joint space is commonplace among patients with medial compartment osteoarthritis. This manifestation is visible among 74% of the patients with idiopathic medial compartment osteoarthritis (31).

The mechanical axis runs from the midpoint of femoral head to that of the talus dome. Ideally the knee joint should also be centered along this line in a neutral fashion that would ensure equitable weight transmission in both the medial and lateral compartments. Any imbalance in this aspect results in a corresponding increase of force in either of the compartments as the case may be. It is important to note that the normal gait results in the medial compartment receiving 50% more load than the lateral compartment, accounting for the assertion that 90% of primary KOA cases start in the medial compartment (32).

In a multicenter cross-sectional study conducted to describe the prevalence of narrowing of the tibiofemoral joint space (JSN) in lateral and medial compartments and assess whether it differs by gender and ethnic groups, 29.5% of patients had medial joint space narrowing and 8.2% had lateral joint space narrowing, women were reported to be more at risk of the lateral compartment arthritis compared to men. On the other hand, men were shown to be more at risk of developing the medial compartment osteoarthritis. Further, higher BMI values were shown to correlate with a higher incidence of medial compartment osteoarthritis. Association with history or injuries and age did not show to have any significant impact on either lateral or medial compartment osteoarthritis (33).

KOA is common among the elderly, and it is a source of pain and pronated foot posture (34). Foot posture might alter the mechanical alignment, dynamic function, and the development of the lower limb's musculoskeletal conditions. Knee braces, foot orthoses, and footwear are non-intrusive interventions for KOA that minimize the knee adduction moment as well as the corresponding medial compartment loading. Therefore, assessment posture of the foot should be one of the first requirement used to select MKOA patients who can qualify for the nonintrusive intervention. The foot posture assessment should subsume the foot posture index referred to as FPI, medial arch index, and navicular height. The FPI is a tool that has been clinically validated, and has good reliability and it is able to quantify the level to which a foot can be regarded as being in supination, neutral, or pronation position. The assessment of the index of the medial arch can be achieved through the Djian Annonier angle or radiograph of the lateral view of the foot. It is drawn from the lowest part of the foot, the calcaneus, sesamoids, and the talar head. Further, the navicular height assessment is a direct anthropometric measure of the distance between the ground and the tuberosity of the navicular with the participant being measured relaxed in a calcaneal stance (35).

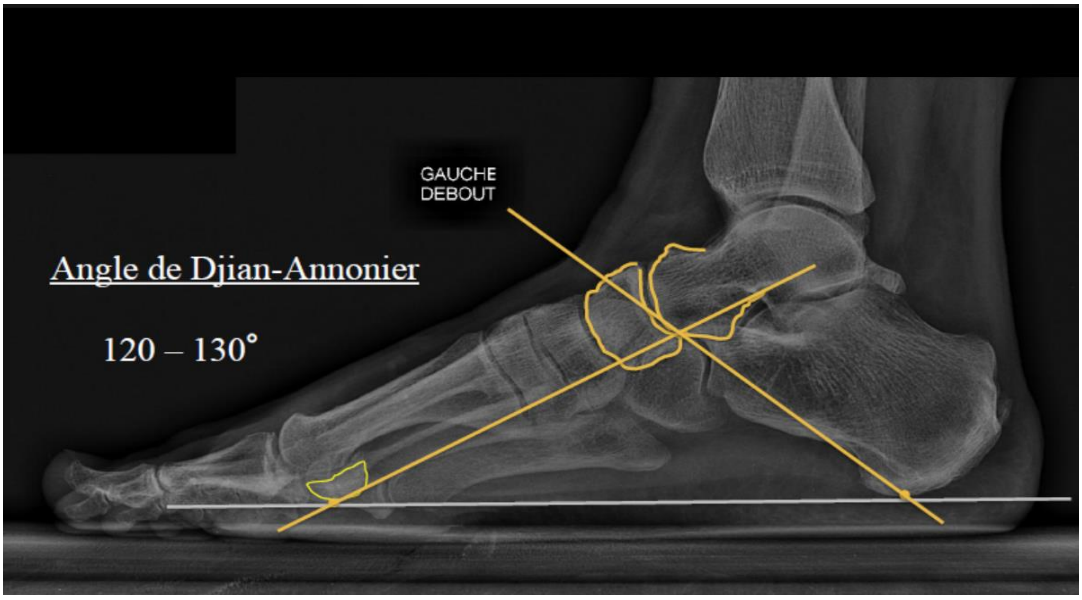


Figure 2: Foot Posture (Adopted musculoskeletal imaging. locoregional pathologies. Elsevier Mason. 2008)

2.5 Axes of the lower limb

In describing the deformities in the lower limb, normal alignment is determined by the arrangement of the femur, tibia, hip, knee, and ankle. Physiologically speaking the lower limb can be described by either anatomical or mechanical axes. The mechanical axis refers to the angle created through a line drawn from the center of the femoral head to the tibial spine on the medial side and another line drawn from the tibial spine on the medial side and the center of the ankle joint (36). It should not be confused with the weight bearing axis which runs from the central point of the femoral head to the center of the ankle (36). Given the fact that the hips are wider than the knees and ankles, the mechanical axis lies 3 degrees of valgus from true vertical axis of the body (extending from the center of gravity of the ground). Thus, it defines neutral alignment regardless of projectional variation. This is shown in Figure 3.

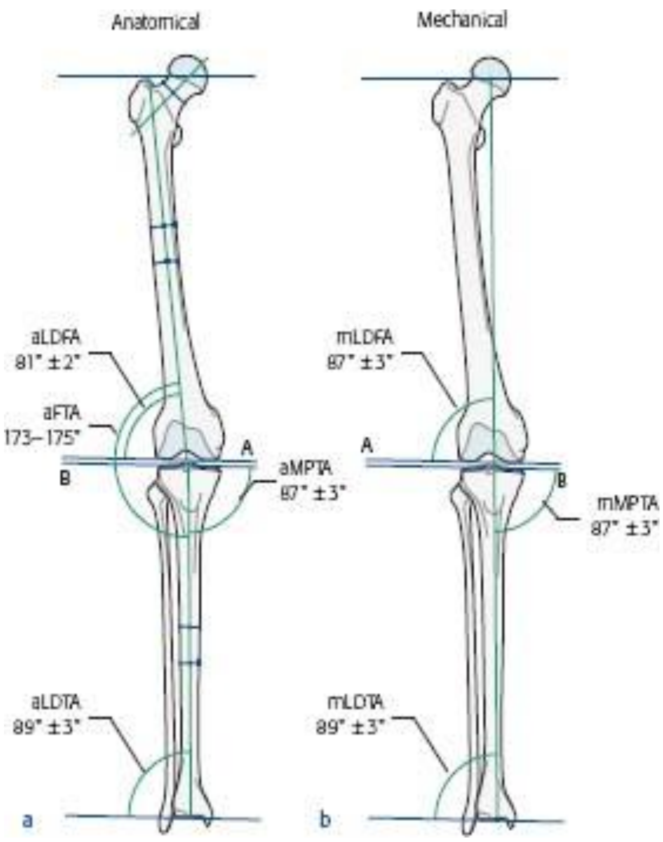


Diagram of the leg axes and joint angles in the fronatal plane. a Anatomical axes and joint angles with standard values. Anatomical femorotibial angle (aFTA) = 173-175°, anatomical lateral distal femoral angle (aLDFA) = 81° ± 2°, anatomical medial proximal tibial angle (aMPTA) = 87° ± 3°, anatomical lateral distal tibial angle (aLDTA) = 89° ± 3°. b Mechanical axes and joint angles with standard values. Mechanical lateral distal femoral angle (mLDFA) = 87° ± 3°, mechanical medial proximal tibial angle (mMPTA) = 87° ± 3°, mechanical lateral distal tibial angle (mLDTA) = 89° ± 3°. A = Tangent to the femoral condyles (knee base line). B = Tangent to the tibial plateau.

Figure 3: Axes of the Lower Limb (Adopted from musculoskeletalkey.com)

Mechanical axis deviation refers to a situation where the mechanical axis does not lie close to the center of the knee (37). Mechanical axis deviation may be medial (varus) or lateral (valgus) (37). Several studies have demonstrated increased risk of medial compartment osteoarthritis when mechanical axis deviation is present (38–40). When walking, the forces that are transmitted across the knee joint are greater in the medial compartment as compared to the lateral side (41), and increased loading of the medial compartment has been noticed in patients with MCOA. The mechanics of gait, in particular the KAM have been shown to be a contributing factor to the progression of MCOA (42–45).

2.6 Medial compartment osteoarthritis

Medial compartment osteoarthritis is a chronic and progressive disease with high teratogenicity and disability in the joints (46). In literature, osteoarthritis is also referred to as primary OA, a degenerative joint disease involving wear and tear of the joints, arthritis, or age-associated arthritis, and is one of the leading causes of disability everywhere in the world. The medical term arthritis is normally used to imply inflammation in the joint areas. Public health departments use the term arthritis as a blanket term to mean more than 100 different forms of rheumatic diseases as well as conditions that influence the efficiency of the joints, and the tissues that surround the area as well as other related connective tissues (47). Discussions regarding these conditions are beyond the scope of this research; the focus in this study is on MCOA of the knee.

The deterioration of the articular cartilage and the fibrocartilage of the menisci that supports the knee are the main issues associated with medial compartment osteoarthritis, which decreases the space in the joints between the femur and the tibia. 18% of people older than 45 years of age seek treatment for osteoarthritis of the knee. Statistics also show that 12% (aged between 25 and 75 years) exhibit symptoms related to osteoarthritis. This condition becomes significantly disabling for patients who develop it, with few solutions presenting as definitive. The osteoarthritis patients soon stop responding to conservative techniques such as modification of lifestyle, physiotherapy, as well as rehabilitation programs. Procedures that may be less invasive, for instance, the intra-articular injection or the debridement of the joint, also do not work as long term solutions (48).

The malalignment in either valgus or varus is a cause of pathophysiology, particularly for unicompartmental knee osteoarthritis (49). It leads to significant levels of friction between the two bones hence generating inflammation and consequently triggering pain via the nerve endings attached to the joints. This characterized by further disintegration of the joint matrix and a significant reduction of chondrocytes (46). It has also been noted that the clinical manifestation of medial compartment osteoarthritis includes stiffness swelling and joint pain among other symptoms, which are significantly related to the quality of life for the patient and leads to a huge economic as well as social burden. Patients who suffer from MCOA of the knee majorly feature genu varum on the knee bearing weight. The changing of alignment shifts the mechanical axis in a medial direction and the knee joint level thus increasing the level of stress on the middle compartment of the patient's knee and consequently exacerbating osteoarthritis of the knee.

Sasaki and Yasuda (1987) first reported on the potential impacts of medial compartment osteoarthritis on foot posture, they looked at the clinical efficiency of newly designed wedged insoles in patient with MCOA. A rating system for pain and walking ability was used to evaluate the patients. They found that wedged insoles was significantly more effective in patients with mild osteoarthritis (stages I,II and III) than those with severe osteoarthritis (stage IV) (50). The impact or association between medial compartment osteoarthritis and abnormal posture of the foot is to be well understood to provide interventions of this nature.

2.7 Foot posture

The pronated posture of the foot has been considered as one of the contributing factors leading to the development of a myriad of conditions of the lower limb as it may cause alternation on the dynamic function and mechanical alignment of the lower limb. Special attention is thus worthy of the areas of footwear modifications and orthoses as a non-operative alternative to treat the knee. In past studies, medial knee osteoarthritis has been associated with the abnormal posture of the foot. Several studies have looked into the advantages of orthotics in reducing the load on the knee for those affected (35). However, to provide more conclusive directions for intervention, greater knowledge regarding the foot posture among patients with MCOA is required.

The anatomy of the human foot is an intricate articular structure comprising of 34 synovial joints with 18 of them having a curved surface while the rest have plane surfaces. The foot consists of various innervations that allow visceral functions as well as fight and flight responses in case of injury (51). Morphologically, the foot of the human being has arches that contribute to the shape of the foot that is indicative and inherent for every individual (34,52). The human foot shape is static as well as dynamic and should possess qualities that should allow it to adapt during activities that are weight-bearing such as walking, standing, running, sports activities, or even jumping. Patho-anatomically, the human foot commonly has abnormalities from birth that could lead to alterations in the structure and shape of the foot (53). Other reasons that could affect the shape of the foot include alterations of the venous pump mechanism that further manifests as pedal edema owing to the increased interstitial pressure. The foot's biomechanism comprises of distinct functional units along with a mobile functional unit that is navicular to the initial metatarsal or and static functional units being navicular as well as a cuboid. Kinetic evaluations of various foot types have shown that there are differences in the amount of pressure distributed under the foot, both dynamic and static for the presumably efficient functioning of the foot (54).

The load distribution that is transferred to the medial as well as the lateral compartments of the knee during various activities can be approximated by the exterior KAM; a higher level of exterior KAM indicates higher loads on the medial compartment as opposed to the lateral compartment. The initial peak KAM while waking has been demonstrated to be a key precursor for the presence, gravity, and development of the medial compartment knee osteoarthritis. Although research on the contribution of external KAM to the progression of medial compartment osteoarthritis is not consistent, several studies have provided significant evidence that high KAM leads to the development of knee OA as well as the misalignment of the varus (55). The KAM is affected by the variation of the alignment of the lower limb and the motion during a persons' gait. The alignment of the varus limb, which is usually observed in individuals with medial compartment OA, has been shown to become severe and progress in knee OA. Current studies have also reported that individuals affected with a medial compartment OA of the knee have been seen to have a relatively pronated posture of the foot and then demonstrate kinematic patterns of the foot that are indicative of everted, less mobile foot forms compared to the controls (54). Further, the level of the alignment of the varus may also influence the motion of the foot during ambulation leading to a response that is compensatory to allow the typical function of the foot during the ambulating process. Valgus and varus deformities overload the lateral and medial knee compartments. Examining the compensatory changes in the pressure of the foot among various grades of osteoarthritis of the knee may assist in understanding the role of footwear modifications and foot orthoses on alignment as well as the function of the lower limb. Osteophytes are a common radiographic typifying characteristic of OA that they have been considered in defining the occurrence of disease or grading it (52).

It is reported that the medial compartment of the knee of a healthy person bears around 70% of the weight of the body while the lateral one carries the rest of the weight. This is due to the path of what is referred to as a ground reaction force or GRF vector at the joint. The GRF path follows a medial and posterior trajectory on the knee joint. Any degenerative variations in the knee OA cause a shift of the adduction of the knee moment about the specific compartment that is directly linked with the narrowing of the joint space, loosening of the joint capsule, and degrees of pain as well as a functional limitation (54). The muscles situated around the respective knee compartment take a bracing mechanism through which they contract entirely to stabilize that aspect of the joint of the knee to overcome the instability. Unfortunately, this bracing also leads to increased loads in the medial compartment.

2.8 Hollow foot

A hollow or pes cavus or supinated foot refers to a posture of the foot in which the metatarsal heads become lower while the longitudinal arches become accentuated with regards to the hindfoot so much so that there is a dropping of the forefoot at the tarsometatarsal joints on the hindfoot. The sole's soft tissues become abnormally short, giving the foot a rather short ended look (52). This form of deformity results in a rigid foot that has little capacity to absorb much shock and corresponding stress. Patients presenting this form of deformity have a hard time doing activities that generate stress.

Studies on the medial compartment osteoarthritis and foot posture have shown that there is a significant difference in the range of dorsiflexion and FPI scores for people with OA compared to those who do not have OA. On average, patients with OA at the hip area have been shown to have the supinated foot posture while patients presenting with medial compartment OA of the knee exhibit pronated feet. In a study where the healthy controls were checked and fell within the normal range, those with OA of the hip had a foot posture index of around -4.5 while those with medial compartment OA recorded an FPI of around 7.0. The mean difference recorded between patients who have OA and those who are healthy was 12, and between patients with OA of the hip and the healthy hip was 6, and between those with OA of the knee and the healthy group was 5. Dorsiflexion and foot posture were moderately significantly correlated with the pronated feet having a higher range of dorsiflexion (56).

2.9 Flat foot

A flat or pes planus or pronated foot refers to a posture of the foot where the calcaneus assumes a valgus position, while the metatarsal area is in pronation. The talus faces downward and medially, whereas the navicular is laterally and dorsally displaced on the talus. They accompany the contracture of the soft tissue and the bony changes. The posture of the foot has been considered for long as a contributing factor for the development of the myriad range of musculoskeletal conditions of the lower limb during activities that are weight-bearing (52). Changes in the posture of the foot may lead to increased stress resulting from increased mechanical rotation of the knee joint while the higher degree of the OA of the knee may impact the motion of the foot during walking leading to compensatory response to permit typical function of the foot while in ambulation and accelerates the degenerative variations at the knee joint (34).

The planus foot posture or flat-footedness has been suggested to be a contributing factor for tibiofemoral (TF) or patellofemoral (PF) compartments pathology, and primary findings posit that cases among the elderly with MCOA may vary from aged-matched controls in various common clinical indicators of planus foot in standing. When one is engaged in weight-bearing activities, the motion and posture of the foot and knee are coupled with a kinematic chain that is closed. Closed chain coupling can relate to excessively the morphology of planus foot to excessive internal rotation of the lower sections of the limb. The outcome of such a rotation is not known, but it may lead to mechanical stress across the areas of the knee, possibly leading to heightened rotational stress on the tissues that are load-bearing on the TF compartments and increasing the contact between the articulating surfaces of the lateral patella as well as the lateral trochlea femoris (54). The details regarding this biomechanical model are not clear, and the kinematics may be hard to infer from only static morphologic measures, but there is a growing body of literature supporting the basic principle that knee and foot mechanics are interdependent. Their interdependence may lead to some pathologies of the knee, including OA (54).

2.10 Management of OA and pronated foot posture

Strategies for treating the medial compartment osteoarthritis work towards reducing the forces experienced in the medial compartment of the patient’s knee. High tibial osteotomy (HTO) holds the objective of unloading the medial compartment by relieving it from the tibia’s wedge, hence making the static extremity on the lower end more improved. However, the association between the dynamic loading and the static alignment of the medial compartment stands equivocal, and it is not surprising that the protracted outcome of the post-HTO is not predictable. Research has shown that regardless of a good and excellent initial clinical finding, around 50% of the post HTO subjects remain with abnormal joint loadings.

Conservative strategies for treatment include braces for the knee and heel wedges for the valgus. These strategies can unload the knee's medial compartment in dynamic scenarios such as walking. Studies done on knee bracing have shown consistently that a valgus or neutral brace is linked with improved function and reduced pain in the subject with a medial compartment of the knee (57,58). However, the influence of the intervention on the adduction moment is not clear. A lateral or valgus wedge refers to a shoe that is set into the lateral border that is thicker than the medial, thus tipping the calcaneus into assuming a valgus position (59). The theory states that the valgus wedges alter the alignment of the knee mechanically and therefore affect the loading patterns, hence changing the position of the ankle as well as the subtalar joints in situations of bearing weight. Reduced pain and enhanced function in the subjects with mild to moderate presentation of medial compartment osteoarthritis has been continuously seen with the usage of a valgus heel wedge (57).

From research, footwear and orthotic interventions have been recorded as the most common methods of managing medial compartment osteoarthritis. In specific, research shows that laterally wedged soles have been prescribed for people with this condition, as they have been reported to minimize the level of KAM and minimize other symptoms (24). However, such an intervention can also alter the motion of those affected, particularly by increasing the pronation of the rearfoot. Further, accentuation may lead to results that may be detrimental to the variations of the kinematics of the lower limb, and subsequently lead to the progression of musculoskeletal issues in other areas.

Unicompartment knee replacement is another possible intervention, characterized by surgical exposure of only one compartment of the knee and is minimally invasive (60). As an elective procedure, it is recommended after more conservative approaches have failed. It is indicated for "low-demand patients older than 60 years of age, weight less than 82 kg (181 lbs.), osteoarthritis or osteonecrosis confined to one compartment, low pain at rest, greater than 90 degrees of preoperative arc of motion, less than 5 degrees of flexion contracture, and less than 15 degrees of angular deformity that is passively correctable to neutral (61)." It is worth noting that survivability and efficacy long term is not guaranteed for all – with success shown among younger and obese patients often attributed to improvements in implant design (60).

2.11 Outcomes

Interestingly, research reports the biomechanical impacts of laterally wedged shoes and their insoles may be inconsistent, with some of the participants demonstrating high numbers in the KAM. Recently, Nakajima and colleagues have reported that by adding a medial arch support to the wedged insoles, it ensures a normal rearfoot motion while ensuring the capacity of the insoles to minimize the KAM (21). According to these findings, thus, the biomechanical impacts of insoles that are wedged laterally may be impacted by the personal variation in the foot function. Thus, there may be a need to conduct screening of foot posture to correctly identify patients who are likely to experience the benefits of laterally wedged insoles, to guide the selection of the right modification to serve as extra arch supports.

2.12 summary of literature review

Medial compartment OA impairs dynamic function and mechanical alignment of the knee. Additionally, it results in pain, impairing walking and day to day functioning. The medial compartment carries more than two-thirds of body weight due to the ground force reaction vector at the joint. Through this mechanism, degenerative variations in the knee OA cause a shift of the adduction of the knee moment about the specific compartment that is directly linked with the narrowing of the joint space, loosening of the joint capsule, and degrees of pain as well as a functional limitation. There are several factors that have been associated with medial compartment OA. These include: foot characteristics such foot posture index, medial arch index and navicular height and drop.

CHAPTER 3: PATIENTS AND METHODS

3.1 Study design

Case control study

3.2 Study setting

The study took place at the orthopaedic clinic (OC) and medical outpatient clinics (MOPC) in the Kenyatta National Hospital (KNH), a 1800-bed tertiary referral hospital that also serves as the teaching hospital for University of Nairobi medical school. Each of the clinics usually receives approximately 50 patients each day, with around 10% having knee joint osteoarthritis (OA).

3.3 Study population

The study population included consenting patients above the age of 18 years visiting the OC and MOPC at KNH between December 2021 and February 2022.

Definition of cases and controls

Cases included patients visiting the OC with a diagnosis of medial compartment osteoarthritis (MCOA), defined on the basis of knee radiograph assessment using the Kellgren Lawrence Classification system (K-L grade). Patients with grade 1 OA and were defined as cases (with MCOA) (Figure 5). Patients visiting MOPC, who are asymptomatic and with a K-L grade of 0 served as the control group (without MCOA).

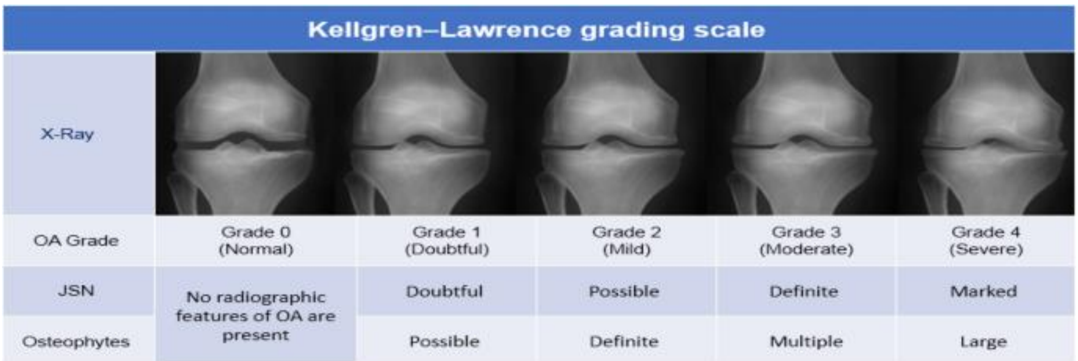


Figure 4: The Kellgren-Lawrence grading scale for osteoarthritis. JSN- joint space narrowing (Adopted from www.nature.com)

Exclusion criteria

a) Cases

Patients with a history of inflammatory arthritis (e.g., rheumatoid arthritis, psoriatic arthritis, peripheral arthritides etc.), those with injury to the knee that has osteoarthritis, those with pre-existing neurological or orthopaedic condition that affects their walking as well as non-consenting patients were excluded from the case group.

b) Controls

Similarly, patients visiting MOPC diagnosed with inflammatory arthritis (e.g., rheumatoid arthritis, psoriatic arthritis, peripheral arthritides), those with pre-existing neurological conditions that affects their walking as well as non-consenting patients were excluded from the control group

3.4 Sample size determination

Sample size for the study was calculated using Kelsey formula through Epi Info Stat Calc software as shown below:

$$n = \frac{\left(z_{1-\propto/2} + z_{1-\beta}\right)^2 \times p(1-p) \times (r+1)}{r \times (p_0 - p_1)^2}$$

Sample size for the study was calculated using with the following parameters.

Two-sided confidence level=95% $z_{1-\propto/2} = 1.96$

Power=80% ($z_{1-\beta} = 0.84$); Ratio of controls to cases=1 (r); Percent of controls; exposed=20% (estimated) ($p_1 = 0.2$); Percent of cases exposed=50% ($p_0 = 0.5$)

Hence, Odds ratio of 4, and n=40.

Based on these parameters, the total sample size for the study was **80**. That is **40 controls** and **40 cases**.

3.5 Sampling procedure

The sampling frame included patients presenting at the orthopaedic clinic (OC) (for cases) and medical outpatient clinic (MOPC) (for controls) between December 2021 and February 2022. All consenting patients meeting the study selection criteria (as outlined in section 3.3 above) were recruited into the study. Consecutive recruitment method was applied until the predetermined sample size was met.

3.6 Study variables

Independent variable

Independent variables included foot posture characteristics (foot posture index, medial arch index, navicular height and navicular drop).

Dependent variable

The dependent variable included the medial compartment osteoarthritis (MCOA) of the knee

Intermediate variables

Intermediate variables included patient characteristics (age, sex, body mass index)

3.7 limitations

1. Covid -19 pandemic lead to stringent measures while collecting data e.g use of PPE's that had to be purchased thus increasing the budget for the thesis.
2. Data collection took longer than expected due to the low number of patients booked for the orthopedic clinic due to the measures taken during the covid -19 pandemic.

3.8 Data collection procedure

Those who meet the pre-defined study criteria as assessed by the principal investigator (PI) and the research assistant (RA) were then subjected to consenting procedures (Appendix A). The research assistant was a trained clinical officer based at Kenyatta National Hospital. He was trained on the respondent selection, consenting procedures as well as the foot posture observations.

Determination of the presence of medial compartment osteoarthritis

Patients' x-rays were examined and the severity of medial compartment osteoarthritis (MCOA) graded using the Kellgren Lawrence Classification system. It is a widely accepted international scoring system for MCOA., with a severity grade of 0 to 4. Patients with grade 1-4 were considered as having MCOA (Figure 5).

Assessment of foot posture index

For both cases and controls, the foot posture index (FPI) was determined on the basis of scoring of six-foot posture observations. Assessment was done on the symptomatic leg. With the patient standing the following were assessed on a scale of -2 to +2 as displayed in figure 6:

1. Position of the talar head
2. Superior and Inferior curvature of the lateral malleoli (viewed from behind the patient)
3. Position of the calcaneal frontal plane position (viewed from behind the patient)
4. Prominence in region of talonavicular joint (viewed from medial side of the foot)
5. Medial longitudinal arch congruence (viewed from medial side of the foot)
6. Abduction/adduction of forefoot on rearfoot (viewed from behind the patient)

	-2	-1	0	1	2
Talar head palpation	Talar head palpable on lateral side/but not on medial side	Talar head palpable on lateral side/ slightly palpable on medial side	Talar head equally palpable on lateral and medial side	Talar head slightly palpable on lateral side/palpable on medial side	Talar head not palpable on lateral side/but palpable on medial side
Supra and infra lateral malleolar curvature	Curve below the malleolus either straight or convex	Curve below the malleolus concave, but flatter/more than the curve above the malleolus	Both infra and supra malleolar curves roughly equal	Curve below the malleolus more concave than curve above malleolus	Curve below the malleolus markedly more concave than curve above malleolus
Calcaneal frontal plane position	More than an estimated 5° inverted (varus)	Between vertical and an estimated 5° inverted (varus)	Vertical	Between vertical and an estimated 5° everted (valgus)	More than an estimated 5° everted (valgus)
Prominence in the region of the talonavicular joint (TNJ)	Area of TNJ markedly concave	Area of TNJ slightly, but definitely concave	Area of TNJ flat	Area of TNJ bulging slightly	Area of TNJ bulging markedly
Congruence of the medial longitudinal arch	Arch high and acutely angled towards the posterior end of the medial arch	Arch moderately high and slightly acute posteriorly	Arch height normal and concentrically curved	Arch lowered with some flattening in the central portion	Arch very low with severe flattening in the central portion – arch making ground contact
Abduction/adduction of the forefoot on the rarefoot	No lateral toes visible. Medial toes clearly visible	Medial toes clearly more visible than lateral	Medial and lateral toes equally visible	Lateral toes clearly more visible than medial	No medial toes visible. Lateral toes clearly visible

Figure 5: Scoring system for assessment of foot posture index (Adopted from europepmc.org)

The FPI is an additive index. The scores for the 6 items assessed were added together. A Negative score implies that the foot is supinated, 0 is neutral and a positive score implies that the foot is pronated.

Calculation of medial arch index

Medial arch index (MAI) was calculated by getting the measurement of the foot (excluding the toes) which was then divided into equal thirds to give three regions: A – forefoot; B – midfoot; and C – heel. The arch index was then calculated by dividing the midfoot region (B) by the entire footprint area (i.e., Arch index = B/[A+B+C]). The foot print was gotten by patient standing on carbon paper then print was transferred to plain paper and measurements taken (Figure 6).

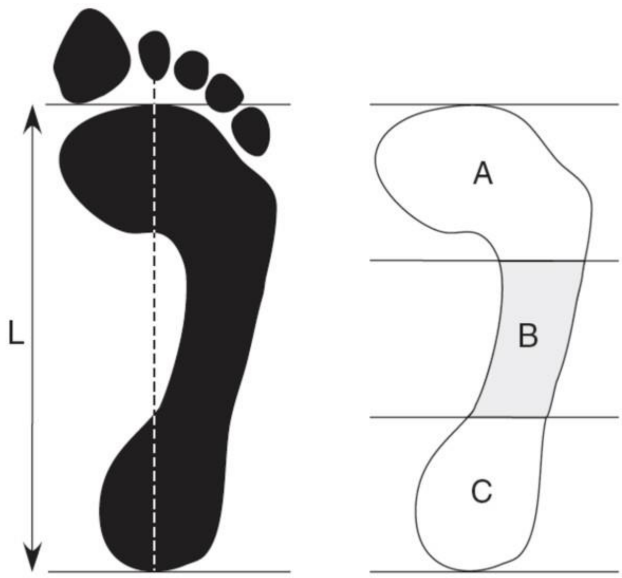


Figure 6: Measurement of Medial arch index

Measurement of navicular height and drop

Measurement of the Navicular height and navicular drop was done in subtalar joint neutral (STJN) position and with the patient standing relaxed posture using a business card. STJN was defined as the position of the foot when the talar head could be palpated just anterior to the ankle mortise with equal prominence both medially and laterally. The position of the subtalar joint was then maintained in a neutral position and the vertical height of the navicular marked on a business card. The participants were then asked to relax and the vertical height of the navicular marked on the card. Navicular drop was defined as the difference between the STJN and relaxed stance of the navicular height. Both measures were normalised to each participant's truncated foot length. Truncated foot length was measured from the most posterior aspect of the calcaneus to the first metatarsophalangeal joint. Truncated foot length was used for normalisation due to the potential presence of toe deformity in older people which can affect the foot length value.

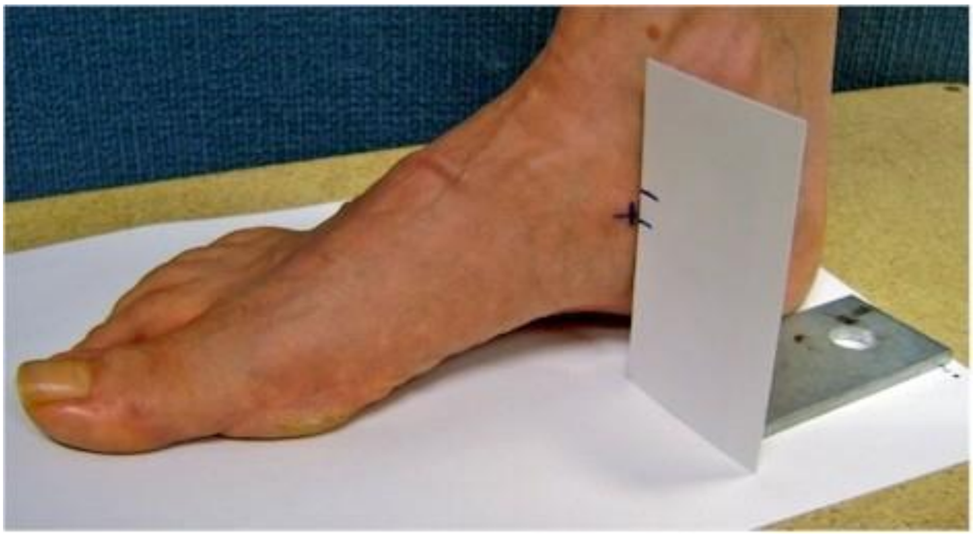


Figure 7: Navicular height and drop

3.9 Quality assurance procedures

With the help of a trained research assistant, only patients meeting the pre-specified selection criteria were included in this study. A radiologist was consulted to confirm the grading of severity of MCOA as assessed from patients' knee radiographs. All data was collected by 2 independent investigators (principal investigator and trained research assistant) to minimize intra-observer variability. All data was transferred from password-coded data digital collection sheets into the Statistical Package for Social Sciences (SPSS) software for data cleaning to flag and remove any erroneous entries, inconsistencies or missing data prior to analysis. Data was stored in password-protected computer folders to maintain anonymity of the study subjects.

3.10 Ethical consideration

All governmental (NACOSTI- appendix F) and institutional regulations pertaining to the ethical use of human volunteers were adhered to in this study. Specifically, ethical permission from the Kenyatta National Hospital, Ethics, and Research Committee (KNH/UON-ERC) was obtained, (Approval No. P390/05/2021- appendix D). All the participants in this study were given a written as well as informed consent, and only those who signed against the consents were included in the study. Only then was data collection process commenced. The principal investigator, along with the research assistants, confirmed to the participants in the study that their involvement in the study was free and would not be coerced in any manner hence assuring their freedom. The participants were allowed to maintain anonymity. No private information has been published as the data collection tools were coded. Further, information collected from the study was kept in a secured place.

3.11 Precautions against Covid-19

The primary investigator and the research assistant were provided with daily personal protective gears i.e., gloves, disposable gowns, N95 masks, hand sanitizers and face shield/goggles. Physical distancing during data collection was also be used to protect the investigators and study subjects from COVID-19 disease.

3.12 Data management and analysis

The collected data were transferred from password-coded data digital collection sheets into analysis software for data cleaning and coding prior to analysis. Data were stored in password-protected computer folders to maintain anonymity of the study subjects. Analysis of the data was carried out using Prism 7 (GraphPad Software, San Diego, CA, USA) and SPSS (IBM Statistics Software Version 25, Armonk, New York, USA). Categorial data were reported as frequencies (%). Continuous data were subjected to normality tests (histogram and Q-Q plots with Kolmogorov-Smirnov test), and reported as mean and standard deviation (SD) since it was normally distributed. Comparison of foot posture characteristics (foot posture index, medial arch index, navicular height and navicular drop) between patients with medial compartment osteoarthritis (MCOA) (cases) and without MCOA (NMCOA/control group) was carried out using the Independent Student's t-test. Multivariate logistic regression analysis was performed to estimate the effect of foot posture characteristics on MCOA, adjusting for age, sex and body mass index, and to calculate adjusted odds ratios (ORs) with the corresponding 95% Wald CI. Throughout the analysis, a $p<0.05$ was considered statistically significant at a 95% confidence interval.

CHAPTER 4: RESULTS

4.1 Patient characteristics

A total of 80 patients were included in this study. Of these, 40 (50%) had medial compartment osteoarthritis (MCOA group) (cases), while 40 (50%) had no MCOA (control group). No significant differences in age (61.7±13.2 vs 58.9±11.1 years, p=0.311), sex composition (males- 45% vs 55%, p= 0.503) or body mass index (BMI) (24.8±3.3 vs 25.3±3.4 Kg/M^2, p= 0.528) were observed between the two groups. The mean Kellgren-Lawrence grade of osteoarthritis was 2.2±0.7 for the case group and 0.0±0.0 in the control group (Table 1).

Table 1: Characteristics of included patients

Variable	**MCOA (n=40; 50%)**	**NMCOA (n=40; 50%)**	***p*-value***
Age (Years) (Mean±SD)	61.7±13.2	58.9±11.1	0.311¶
Sex (Male)	18 (45%)	22 (55%)	0.503#
BMI (Kg/M^2)	24.8±3.3	25.3±3.4	0.528¶
K-L Score (Mean±SD)	2.2±0.7	0.0±0.0	<0.001¶

NB: **-the p-values are for MCOA-NMCOA comparison.* ¶- *Independent Student's t-test, #- Chi-square test; MCOA- medial compartment osteoarthritis group (cases), NMCOA- non-medial compartment osteoarthritis group (controls).*

4.2 Comparison of foot posture characteristics between MCOA and NMCOA group

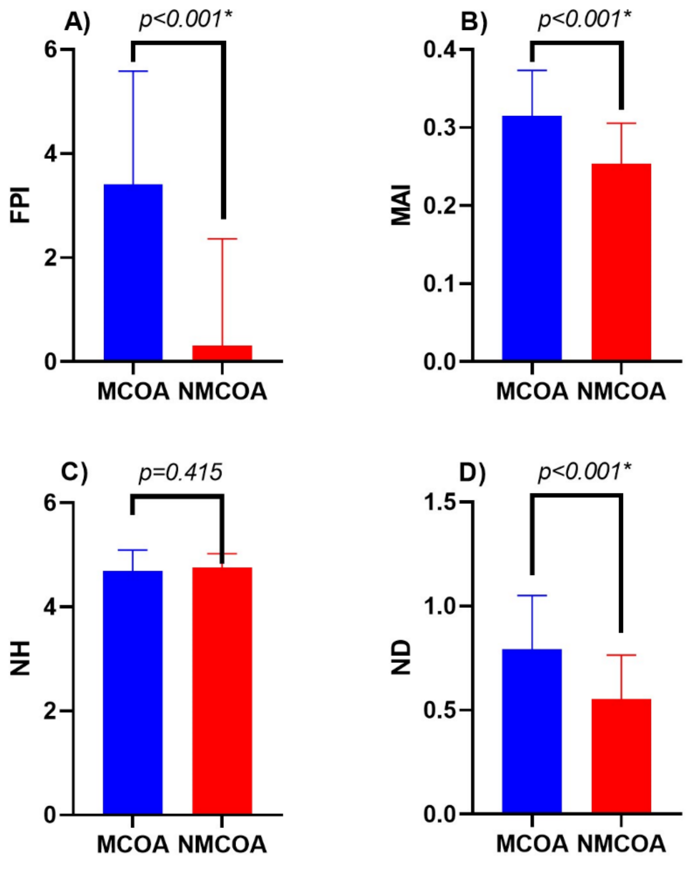
The foot posture index (FPI) was found to be significantly higher in the MCOA group than NMCOA group (3.4±2.2 vs 0.3±2.1, p<0.001). Similarly, patients with MCOA had a significantly higher medial arch index (MAI) (0.32±0.1 vs 0.25±0.1, p<0.001), and navicular drop (ND) (0.79±0.3 vs 0.55±0.2, p<0.001) than NMCOA group. No significant differences in the navicular height (NH) were observed between the two group (4.7±0.4 vs 4.8±0.3, p=0.415) (Table 2, Figures A-D).

Table 2: Difference in foot posture characteristics between the MCOA and NMCOA groups

¶- Independent Student's t-test, FPI- foot posture index, MAI- medial arch index, NH- navicular height, ND- navicular drop, MCOA- medial compartment osteoarthritis group (cases), NMCOA- non-medial compartment osteoarthritis group (controls). Bolded= statistically significant

Variable	MCOA (40 patients)	NMCOA (40 patients)	p-value
FPI (Mean±SD)	3.4±2.2	0.3±2.1	**p<0.001**¶
MAI (Mean±SD)	0.32±0.1	0.25±0.1	**p<0.001**¶
NH (Mean±SD)	4.7±0.4	4.8±0.3	p=0.415¶
ND (Mean±SD)	0.79±0.3	0.55±0.2	**p<0.001**¶

Figure 8A-D: Graphs of comparing foot posture characteristics between MCOA and NMCOA groups



*FPI- foot posture index, MAI- medial arch index, NH- navicular height, ND- navicular drop, MCOA- medial compartment osteoarthritis group (cases), NMCOA- non-medial compartment osteoarthritis group (controls). *-statistically significant.*

4.3 Correlation between foot posture characteristics and patient characteristics

Foot posture index (FPI) positively correlated with Kellgren-Lawrence (K-L) grade of medial compartment osteoarthritis (MCOA) ($r=0.675$, $p<0.001$), medial arch index (MAI) ($r=0.473$, $p<0.001$) and navicular drop ($r=0.506$, $p<0.001$). Similarly, MAI positively correlated with K-L grade of MCOA ($r=0.576$, $p<0.001$). Navicular height (NH) positively correlated with patient weight ($r=0.276$, $p=0.014$) and height ($r=0.243$, $p=0.031$). Navicular drop on other hand correlated with the K-L grade of MCOA ($r=0.573$, $p<0.001$) (Table 3).

Table 3: Correlation between foot posture characteristics and patient characteristics

Variable	FPI	MAI	NH	ND
Age	r=0.031, p=0.789	r=0.089, p=0.433	r=0.056, p=0.625	r=0.163, p=0.143
Weight	r=0.041, p=0.721	r=0.078, p=0.495	r=0.276*, p=0.014	r=-0.020, p=0.864
Height	r=-0.027, p=0.812	r=0.120, p=0.292	r=0.243*, p=0.031	r=0.072, p=0.532
BMI	r=0.050, p=0.661	r=0.001, p=0.992	r=0.091, p=0.423	r=-0.067, p=0.559
KL Score	r=0.675**, p<0.001	r=0.576**, p<0.001	r=-0.082, p=0.472	r=0.573**, p<0.001
FPI	r=1.000	r=0.473**, p<0.001	r=-0.206, p=0.069	r=0.506**, p<0.001
MAI	r=0.473**, p<0.001	r=1.000	r=0.132, p=0.245	r=0.401**, p<0.001
NH	r=-0.206, p=0.069	r=0.132, p=0.245	r=1.000	r=0.143, p=0.211
ND	r=0.506**, p<0.001	r=0.401**, p<0.001	r=0.143, p=0.211	1.000

*FPI- foot posture index, MAI- medial arch index, NH- navicular height, ND- navicular drop, **- statistically significant, KL- Kellgren-Lawrence score*

4.4 Association between foot posture characteristics and MCOA

Univariate logistic regression analysis for patient features and foot posture characteristics as predictors of MCOA revealed that foot posture index (pronated) (OR= 11.97, 95% CI 1.45-2.67, p<0.001), higher medial arch index (OR= 7.65, 95% CI 2.76-21.34, p<0.001) and higher navicular depth (OR= 91.6, 95% CI 8.2-1019.5, p<0.001) were associated with increased odds of MCOA. However, in the multivariate adjusted logistic regression model, only pronated foot posture (OR= 1.79, 95% CI 1.22-2.65, p=0.003), higher medial arch index (OR= 4.93, 1.27-19.10, p=0.021) remained as significant predictors of MCOA (Table 3)

Table 4: Crude and adjusted odds ratio of factors predictive of MCOA

Variable	Crude OR (95% CI)	Adjusted OR (95% CI)
Age	1.02 (0.98-1.06), *p=0.308*	1.03 (0.97-1.10), *p=0.300*
Sex	1.49 (0.62-3.61), *p=0.372*	0.51 (0.12-2.13), *p=0.352*
BMI	1.05 (0.91-1.19), *p=0.523*	0.91 (0.74-1.12), *p=0.366*
FPI (pronated posture)	1.97 (1.45-2.67), ***p<0.001****	1.79 (1.22-2.65), ***p=0.003****
MAI	7.65 (2.76-21.34), ***p<0.001****	4.93 (1.27-19.10), ***p=0.021****
NH	1.73 (0.47-6.41), *p=0.411*	5.23 (0.57-49.52), *p=0.354*
ND	91.6 (8.2-1019.5), ***p<0.001****	28.33 (0.75-1070.93), *p=0.352*

*FPI- foot posture index, MAI- medial arch index, NH- navicular height, ND- navicular drop, **- statistically significant, OR- odds ratio*

CHAPTER 5: DISCUSSION

Foot posture characteristics (FPC) are thought to influence the knee joint alignment and kinematics, and therefore modify risk of development of medial compartment osteoarthritis (MCOA). As such, focus has been shifted to FPC as they are a potential target for nonsurgical therapeutic interventions for MCOA. To this end, we determined FPC among MCOA patients at Kenyatta National Hospital to better understand their FPC, and potentially influence management plan.

The study found that MCOA patients were more likely to have a pronated foot posture (based on foot posture index, FPI), which mirrors results from previous studies done by Levinger et al, Abourazzack et al and Reilley et al who all compared foot posture characteristics and found out that patients with MCOA tended to have a more pronated foot posture as compared to patient without MCOA. For instance, Abourazzak et al., (35) compared foot characteristics among 100 MCOA patients and 80 controls (without MCOA). He found that MCOA patients tended to have a more pronated foot posture than asymptomatic patients (35). Similarly, Reilley et al., (56) compared FPI between 20 patients with MCOA and 20 age-matched healthy volunteers, and demonstrated that MCOA patients were more likely to have a pronated foot posture. Levinger et al., (34) on the other hand compared foot posture between 32 patients with MCOA and 28 healthy controls, and found that MCOA patients exhibited a more pronated foot posture based on FPI measurement.

Higher medial arch index (MAI) in multivariate analysis, were significantly associated with MCOA. These results mirror that of previous studies (34,35,56).

Most of the studies did not look at the navicular height and drop as done in the current study as part of the foot posture characteristic, the navicular drop was significant in the patient with MCOA than the patients without MCOA and signified a more pronated foot.

The findings, coupled with that of previous studies therefore suggest that foot posture characteristics (FPC) are significant modifiers of risk of medial compartment osteoarthritis. This is thought to occur through effects of foot posture on knee joint loading and biomechanics. It is noteworthy that our study, as well as previous ones (34,35,56) are all cross-sectional studies, and as such, cannot determine the exact nature (direction) of association between FPC and MCOA. Although FPC (e.g., pronated foot posture) are thought to increase risk of MCOA, some authors have postulated that pronation may be a result of effect of MCOA on biomechanics of subtalar joint (34). Individuals with MCOA usually have genu varus deformity of the knee, which is thought to result in a compensatory pronation of the foot at the subtalar joint to allow the foot to be plantigrade during stance phase of walking (34), a hypothesis supported by a kinetic gait study by Van Gheluwe et al., (62). These authors simulated genu varum (GV) among 15 healthy subjects, and demonstrated GV tended to increase subtalar pronation moment (62). As such, the relationship between foot posture characteristics and MCOA may be bidirectional. This should be a subject of future research.

Our findings may have implications in the non-operative management of MCOA. Recently, use of lateral wedge insoles (LWI) has been suggested as an adjunct therapeutic intervention of MCOA, albeit inconsistent outcomes (39,63). Some studies have demonstrated benefit (39), whereas others have shown that use of such soles actually accentuates rear foot pronation, further increasing MCOA symptoms (63). The inconsistencies in outcomes of LWI could plausibly be attributed to inter-individual variation in foot posture characteristics (e.g., degree of foot pronation), as suggested by a recent systematic review and meta-analysis of currently available literature (63). As such, LWI should be customized based on individual foot features.

CHAPTER 6: CONCLUSION AND RECOMENDATIONS

In conclusion, foot posture characteristics such as pronated foot posture and medial arch index are associated with MCOA. We therefore recommend that foot characteristics be routinely assessed in these patients with MCOA so as to guide therapeutic interventions in the clinical practice.

Further studies may be carried out to establish the benefit of foot orthoses like lateral wedged insoles on the management of medial compartment osteoarthritis of the knee.

REFERENCES

1. Primorac D, Molnar V, Rod E, Jeleč Ž, Čukelj F, Matišić V, et al. Knee Osteoarthritis: A Review of Pathogenesis and State-Of-The-Art Non-Operative Therapeutic Considerations. Genes. 2020 Jul 26;11(8):E854.

2. Hsu H, Siwiec RM. Knee Osteoarthritis. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 [cited 2021 Nov 21]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK507884/

3. Heidari B. Knee osteoarthritis prevalence, risk factors, pathogenesis and features: Part I. Casp J Intern Med. 2011;2(2):205–212.

4. Miyazaki T, Wada M, Kawahara H, Sato M, Baba H, Shimada S. Dynamic load at baseline can predict radiographic disease progression in medial compartment knee osteoarthritis. Ann Rheum Dis. 2002, Jul 1;61(7):617–622.

5. Levinger P, Menz HB, Fotoohabadi MR, Feller JA, Bartlett JR, Bergman NR. Foot posture in people with medial compartment knee osteoarthritis. J Foot Ankle Res. 2010 Dec 16;3(1):29.

6. Chen Z, Shen Z, Ye X, Wu J, Wu H, Xu X. Association between Foot Posture Asymmetry and Static Stability in Patients with Knee Osteoarthritis: A Case-Control Study. BioMed Res Int. 2020, Jun 6:e1890917.

7. F.E A, N K, H A, F L, A N, C N, et al. A Positive Association Between Foot Posture Index and Medial Compartment Knee Osteoarthritis in Moroccan People. Open Rheumatol J. 2014, Dec 11;8:96–99.

8. Cote KP, Brunet ME, Gansneder BM, Shultz SJ. Effects of Pronated and Supinated Foot Postures on Static and Dynamic Postural Stability. J Athl Train. 2005;40(1):41–6.

9. Nour HA, Oyoo GO, Joshi MD, Otsyeno FMT. Patterns of knee, hip and hand osteoarthritis in Kenyatta National Hospital. East Afr Orthop J [Internet]. 2013 [cited 2021,Nov21];7(1).Availablefrom: https://www.ajol.info/index.php/eaoj/article/view/99199

10. Paley D. Principles of Deformity Correction. Springer; 2014. 821 p.

11. Anderson BC. Office Orthopedics for Primary Care: Diagnosis. Elsevier Health Sciences; 2005. 316 p.

12. Moskowitz RW. Osteoarthritis: Diagnosis and Medical/surgical Management. Lippincott Williams & Wilkins; 2007. 492 p.

13. Beaufils P, Verdonk R. The Meniscus. Springer Science & Business Media; 2010. 397 p.

14. Al-Bayati Z, Benlidayi I, Gokcen N. Posture of the foot: Dont Keep it out of sight, out of mind in knee osteoarthritis. Gait Posture. 2018;66:130–134.

15. Paterson K, Kasza J, Hunter D. The relationship between foot and ankle symptoms and risk of developing knee osteoarthritis: data from the osteoarthritis initiative. Osteoarthritis Cartilage. 2017;25(5):639–646.

16. Lekpa F, Kamkui A, Namme H. Clinical features of women with knee osteoarthritis at diagnosis in Cameroon, sub-Saharan Africa. Ann Rheum Dis. 2020;79(Suppl 1):1736–1737.

17. Agarwal B, Advani M, van Deursen R. Influence of varying squat exposure on knee pain and function among people with knee osteoarthritis. Crit Rev Phys Rehabil Med. 2019;31(1).

18. Akinpelu A, Maduagwu S, Odole A, Alonge T. Prevalence and Pattern of Knee Osteoarthritis in North Eastern Nigeria Rural Community. East Afr Orthop J. 2011;5(1):5–11.

19. Sanchis-Alfonso V, Dye SF. How to Deal With Anterior Knee Pain in the Active Young Patient. Sports Health. 2016 Nov 1;9(4):346–351.

20. Prasad A. Introduction: Global Assemblages of Technoscience. Sci Technol Soc. 2017 Mar 1;22(1):1–5.

21. Heiden TL, Lloyd DG, Ackland TR. Knee joint kinematics, kinetics and muscle co-contraction in knee osteoarthritis patient gait. Clin Biomech Bristol Avon. 2009 Dec;24(10):833–841.

22. Barg A, Pagenstert GI, Hügle T, Gloyer M, Wiewiorski M, Henninger HB, et al. Ankle osteoarthritis: etiology, diagnostics, and classification. Foot Ankle Clin. 2013 Sep;18(3):411–426.

23. Øiestad BE, Engebretsen L, Storheim K, Risberg MA. Knee osteoarthritis after anterior cruciate ligament injury: a systematic review. Am J Sports Med. 2009 Jul;37(7):1434–1443.

24. Nakajima K, Kakihana W, Nakagawa T, Mitomi H, Hikita A, Suzuki R, et al. Addition of an arch support improves the biomechanical effect of a laterally wedged insole. Gait Posture. 2009 Feb;29(2):208–213.

25. Sharma L, Lou C, Cahue S, Dunlop DD. The mechanism of the effect of obesity in knee osteoarthritis: the mediating role of malalignment. Arthritis Rheum. 2000 Mar;43(3):568–575.

26. Neogi T. The epidemiology and impact of pain in osteoarthritis. Osteoarthritis Cartilage. 2013 Sep;21(9):1145–1153.

27. Felson DT, Zhang Y. An update on the epidemiology of knee and hip osteoarthritis with a view to prevention. Arthritis Rheum. 1998 Aug;41(8):1343–1355.

28. Nour H, Oyoo G, Joshi M. Patterns of knee, hip and hand osteoarthris in Kenyatta National Hospital. East Afr Orthop J. 2014;8(2).

29. Mora J, Przkora R, Cruz-Almeida Y. Knee osteoarthritis: pathophysiology and current treatment modalities. J Pain Res. 2018;11:2189–2196.

30. Herrero-Beaumont G, Roman-Blas JA, Bruyère O, Cooper C, Kanis J, Maggi S, et al. Clinical settings in knee osteoarthritis: Pathophysiology guides treatment. Maturitas. 2017 Feb;96:54–57.

31. Lynn SK, Reid SM, Costigan PA. The influence of gait pattern on signs of knee osteoarthritis in older adults over a 5-11 year follow-up period: a case study analysis. The Knee. 2007 Jan;14(1):22–28.

32. Papaioannou TA, Digas G, Bikos C, Karamoulas V, Magnissalis EA. Femoral Neck Version Affects Medial Femorotibial Loading. ISRN Orthop [Internet]. 2013 [cited 2020 Nov29];2013.Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4045292/

33. Lu N, Jingbo N, Choi H, Zhang Y. Difference in Risk Factor Profile Between Medial and Lateral Compartment Involvement in Tibiofemoral Knee Osteoarthritis. Arthritis Rheumatol. 2016;68(10):69–79.

34. Levinger P, Menz HB, Fotoohabadi MR, Feller JA, Bartlett JR, Bergman NR. Foot posture in people with medial compartment knee osteoarthritis. J Foot Ankle Res. 2010 Dec 16;3(1):29.

35. Abourazzak F, Kadi N, Azzouzi H, Lazrak F, Najdi A, Nejjari C, et al. A Positive Association Between Foot Posture Index and Medial Compartment Knee Osteoarthritis in Moroccan People. Open Rheumatol J. 2014 Dec 11;8:96–99.

36. Wheeless III CR. Physiological axes of the lower limb [Internet]. Musculoskeletal Key. 2020 [cited 2021 Jan 4]. [Available from: https://musculoskeletalkey.com/1-physiological-axes-of-the-lower-limb/]

37. Singh AP. Normal Alignment of Lower Limb - Axes and Orientation [Internet]. Bone and Spine. 2020 [cited 2021 Jan 4]. Available from: https://boneandspine.com/normal-alignment-of-lower-limb/

38. Cooke T, Harrison L, Khan B, Scudamore A, Chaudhary A. Analysis of limb alignment in the pathogenesis of osteoarthritis: A comparison of Saudi Arabian and Canadian cases. Rheumatol Int. 2002 Aug 1;22:160–164.

39. Nejima S, Akamatsu Y, Kobayashi H, Tsuji M, Mitsuhashi S, Sasaki T, et al. Relationship between lower limb torsion and coronal morphologies of the femur and tibia in patients with medial knee osteoarthritis. BMC Musculoskelet Disord. 2020 Apr 17;21(1):254.

40. Keenan A-M, Redmond AC, Horton M, Conaghan PG, Tennant A. The Foot Posture Index: Rasch analysis of a novel, foot-specific outcome measure. Arch Phys Med Rehabil. 2007 Jan;88(1):88–93.

41. Schipplein O, Andriacchi T. Interaction between active and passive knee stabilizers during level walking. J Orthop Res Off Publ Orthop Res Soc. 1991;

42. Miyazaki T, Wada M, Kawahara H, Sato M, Baba H, Shimada S. Dynamic load at baseline can predict radiographic disease progression in medial compartment knee osteoarthritis. Ann Rheum Dis. 2002 Jul;61(7):617–622.

43. Lynn SK, Reid SM, Costigan PA. The influence of gait pattern on signs of knee osteoarthritis in older adults over a 5–11 year follow-up period: A case study analysis. The Knee. 2007 Jan 1;14(1):22–28.

44. Baliunas AJ, Hurwitz DE, Ryals AB, Karrar A, Case JP, Block JA, et al. Increased knee joint loads during walking are present in subjects with knee osteoarthritis. Osteoarthritis Cartilage. 2002 Jul;10(7):573–579.

45. Mündermann A, Dyrby CO, Andriacchi TP. Secondary gait changes in patients with medial compartment knee osteoarthritis: increased load at the ankle, knee, and hip during walking. Arthritis Rheum. 2005 Sep;52(9):2835–2844.

46. Xu H, Zhao G, Xia F, Liu X, Gong L, Wen X. The diagnosis and treatment of knee osteoarthritis: a literature review. 2019;12(5):11.

47. Lespasio MJ, Piuzzi NS, Husni ME, Muschler GF, Guarino A, Mont MA. Knee Osteoarthritis: A Primer. Perm J [Internet]. 2017 Sep 13 [cited 2019 Aug 2];21. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5638628/

48. Goyal D, Goyal A, Adachi N. Joint Preservation Surgery for Medial Compartment Osteoarthritis. Arthrosc Tech. 2017 Jun 5;6(3):e717–728.

49. Mistry DA, Chandratreya A, Lee PYF. An Update on Unloading Knee Braces in the Treatment of Unicompartmental Knee Osteoarthritis from the Last 10 Years: A Literature Review. Surg J. 2018 Jul 2;4(3):e110–118.

50. Sasaki T, Yasuda K. Clinical evaluation of the treatment of osteoarthritic knees using a newly designed wedged insole. Clin Orthop. 1987;(221):181–187.

51. Aiello L, Dean C. An Introduction to Human Evolutionary Anatomy. Academic Press; 1990. 609 p.

52. Surlakar SS, Sarfare BM, Ghodey S, Bhise S. Prevalence of atltered foot posture in osteoarthritis of the knee. J Appl Adv Res. 2017 Jun 8;2(3):144.

53. Hertel J. Functional Anatomy, Pathomechanics, and Pathophysiology of Lateral Ankle Instability. J Athl Train. 2002;37(4):364–375.

54. Tribhuvan S, Kulkarni N. Correlation between foot posture index (FPI) and knee osteoarthritis (OA) in elderly individuals. Int J Yoga Physiother Phys Educ. 2019;4(2):39–43.

55. Andriacchi TP, Koo S, Scanlan SF. Gait mechanics influence healthy cartilage morphology and osteoarthritis of the knee. J Bone Joint Surg Am. 2009 Feb;91 Suppl 1:95–101.

56. Reilly K, Barker K, Shamley D, Newman M, Oskrochi GR, Sandall S. The role of foot and ankle assessment of patients with lower limb osteoarthritis. Physiotherapy. 2009 Sep;95(3):164–169.

57. Niehoff A, Kersting UG, Helling S, Dargel J, Maurer J, Thevis M, et al. Different mechanical loading protocols influence serum cartilage oligomeric matrix protein levels in young healthy humans. Eur J Appl Physiol. 2010 Oct;110(3):651–657.

58. Netravali NA, Koo S, Giori NJ, Andriacchi TP. The effect of kinematic and kinetic changes on meniscal strains during gait. J Biomech Eng. 2011 Jan;133(1):011006.

59. Hinman RS, Bowles KA, Bennell KL. Laterally wedged insoles in knee osteoarthritis: do biomechanical effects decline after one month of wear? BMC Musculoskelet Disord. 2009 Nov 25;10:146.

60. Luo TD, Hubbard JB. Arthroplasty Knee Unicompartmental. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 [cited 2020 Nov 29]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK538267/

61. Ritter MA, Faris PM, Thong AE, Davis KE, Meding JB, Berend ME. Intra-operative findings in varus osteoarthritis of the knee. An analysis of pre-operative alignment in potential candidates for unicompartmental arthroplasty. J Bone Joint Surg Br. 2004 Jan;86(1):43–47.

62. Van Gheluwe B, Kirby KA, Hagman F. Effects of simulated genu valgum and genu varum on ground reaction forces and subtalar joint function during gait. J Am Podiatr Med Assoc. 2005 Dec;95(6):531–541.

63. Xing F, Lu B, Kuang M-J, Wang Y, Zhao Y-L, Zhao J, et al. A systematic review and meta-analysis into the effect of lateral wedge arch support insoles for reducing knee joint load in patients with medial knee osteoarthritis. Medicine (Baltimore). 2017 Jun;96(24):e7168.

APPENDIX A: PATIENT CONSENT FORM

Title of Study: **THE ASSOCIATION OF MEDIAL COMPARTMENT OSTEOARTHRITIS OF THE KNEE AND PRONATED FOOT POSTURE AMONG PATIENTS ATTENDING KENYATTA NATIONAL HOSPITAL**

Principal Investigator\and institutional affiliation: ___________________________________

Co-Investigators and institutional affiliation: _______________________________________

Introduction:

I would like to tell you about a study being conducted by the above listed researchers. The purpose of this consent form is to give you the information you will need to help you decide whether or not to be a participant in the study. Feel free to ask any questions about the purpose of the research, what happens if you participate in the study, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When we have answered all your questions to your satisfaction, you may decide to be in the study or not. This process is called 'informed consent'. Once you understand and agree to be in the study, I will request you to sign your name on this form. You should understand the general principles which apply to all participants in a medical research: i) Your decision to participate is entirely voluntary ii) You may withdraw from the study at any time without necessarily giving a reason for your withdrawal

iii) Refusal to participate in the research will not affect the services you are entitled to in this health facility or other facilities. We will give you a copy of this form for your records.

May I continue? YES / NO

This study has approval by The Kenyatta National Hospital-University of Nairobi Ethics and Research Committee protocol No. ____________________________

WHAT IS THIS STUDY ABOUT?

The purpose of this study is to assess the association of medial compartment osteoarthritis of the knee and pronated foot posture among patients attending Kenyatta National Hospital. I would like to recruit you into the study. Your participation in this study involves the collection of information regarding your demographic characteristics as well as your osteoarthritis condition (OA). This information will help in analyzing and improving the management of medial compartment osteoarthritis.

WHAT WILL HAPPEN IF YOU DECIDE TO BE IN THIS RESEARCH STUDY?

If you agree to participate in this study, the following things will happen:

You will be interviewed by a trained interviewer in a private area where you feel comfortable answering questions. The interview will last approximately 20 minutes. The interview will cover topics such as where you live, your occupation and other characteristics about you.

After the interview has finished, there will be examination of your foot posture and some measurements will be taken. None of the procedures will be invasive

We will ask for a telephone number where we can contact you if necessary. If you agree to provide your contact information, it will be used only by people working for this study and will never be shared with others. The reasons why we may need to contact you include: _________________

ARE THERE ANY RISKS, HARMS DISCOMFORTS ASSOCIATED WITH THIS STUDY?

Medical research has the potential to introduce psychological, social, emotional and physical risks. Effort should always be put in place to minimize the risks. One potential risk of being in the study is loss of privacy. We will keep everything you tell us as confidential as possible. We will use a code number to identify you in a password-protected computer database and will keep all of our paper records in a locked file cabinet. However, no system of protecting your confidentiality can be absolutely secure, so it is still possible that someone could find out you were in this study and could find out information about you.

Also, answering questions in the interview may be uncomfortable for you. If there are any questions you do not want to answer, you can skip them. You have the right to refuse the interview or any questions asked during the interview.

Other than these, there are no risks from you getting involved in this study. The study findings will not be used for any monetary benefits.

ARE THERE ANY BENEFITS BEING IN THIS STUDY?

You may benefit by receiving proper correction of your foot posture.

We will refer you to a hospital for care and support where necessary. Also, the information you provide will help us better understand medial compartment osteoarthrirtis. This information is a contribution to science and orthopedic practice.

WILL BEING IN THIS STUDY COST YOU ANYTHING?

Participation in this study will only take a few minutes of your time and will not cost you anything in financial terms.

WILL YOU GET REFUND FOR ANY MONEY SPENT AS PART OF THIS STUDY?

As there are no monetary costs to participation, there will be no refunds.

WHAT IF YOU HAVE QUESTIONS IN FUTURE?

If you have further questions or concerns about participating in this study, please call or send a text message to the study staff at the number provided at the bottom of this page.

For more information about your rights as a research participant you may contact the Secretary/Chairperson, Kenyatta National Hospital-University of Nairobi Ethics and Research Committee Telephone No. 2726300 Ext. 44102 email uonknh_erc@uonbi.ac.ke.

The study staff will pay you back for your charges to these numbers if the call is for study-related communication.

WHAT ARE YOUR OTHER CHOICES?

Your decision to participate in research is voluntary. You are free to decline participation in the study and you can withdraw from the study at any time without injustice or loss of any benefits.

CONSENT FORM (STATEMENT OF CONSENT)

Participant's statement

I have read this consent form or had the information read to me. I have had the chance to discuss this research study with a study counselor. I have had my questions answered in a language that I understand. The risks and benefits have been explained to me. I understand that my participation in this study is voluntary and that I may choose to withdraw any time. I freely agree to participate in this research study.

I understand that all efforts will be made to keep information regarding my personal identity confidential.

By signing this consent form, I have not given up any of the legal rights that I have as a participant in a research study.

I agree to participate in this research study: Yes No

I agree to have (define specimen) preserved for later study: Yes No

I agree to provide contact information for follow-up: Yes No

Participant printed name: ____

Participant signature / Thumb stamp ______________________ Date ______________

Researcher's statement

I, the undersigned, have fully explained the relevant details of this research study to the participant named above and believe that the participant has understood and has willingly and freely given his/her consent.

Researcher's Name: ________________________________**Date**: ______________

Signature ____

Role in the study: __________________________ [i.e. study staff who explained informed consent form.]

For more information contact _______________________ at ___________________ from __________________________ to _________________________

Witness Printed Name (If witness is necessary, A witness is a person mutually acceptable to both the researcher and participant)

Name ________________________________ Contact information ____________________

Signature /Thumb stamp: ________________ **Date**; ________________________________

Your participation in this study is voluntary, and any data collected in this study will remain confidential. Your identity will not be required, and data collected from you will be coded for anonymity. The benefits to you for being involved in the study include proper correction of foot posture. There are no risks from you getting involved in this study. The study findings will not be used for any monetary benefits. Should you decide to withdraw from the study at any point, you will not be subjected to any discriminatory treatment. Should you require any further information or clarification then the main researcher may be contacted using the contacts :

Dr. Daniel Mochoge

Phone number: 0729320313

Email address: dmochoge@gmail.com

APPENDIX B: PATIENT CONSENT FORM (KISWAHILI)

KICHWA CHA UTAFITI: UHUSIANO WA UGONJWA WENYE GOTI NA MKAO USIOKUA WA KAWAIDAKATI YA WAGONJWA WANAOHUDHURIA HOSPITALI YA KITAIFA YA KENYATTA

Mpelelezi mkuu\na ushirikishwaji wa taasisi: ____________________________________

Wachunguzi wa ushirikiano an ushirikishwaji wa taasisi: __________________________

Ningependa kukujulisha kuhusu utafiti unaofanywa na watafiti walioorodheshwa hapo juu. Madhumuni ya fomu hii ya idhini ni kukupa habari utakayohitaji kukusaidia kuamua kama utakubali kishiriki au la. Jisikie huru kuuliza maswali yoyote juu ya kusudi la utafiti, nini kinatokea ikiwa unashiriki katika utafiti, hatari na faida zinazowezekana, haki zako kama kujitolea, na chochote kingine juu ya utafiti au fomu hii ambayo haijulikani wazi. Wakati tumejibu maswali yako yote kukuridhisha, unaweza kuamua kuwa kwenye somo au la. Utaratibu huu unaitwa 'ridhaa inayofahamishwa'. Mara tu utakapoelewa na kukubali kuwa kwenye utafiti, nitakuomba utie sahihi jina lako kwenye fomu hii. Unapaswa kuelewa kanuni za jumla ambazo zinatumika kwa washiriki wote katika utafiti wa matibabu:

Uamuzi wako wa kushiriki ni wa hiari kabisa

Unaweza kujiondoa kwenye utafiti wakati wowote bila kutoa sababu ya kujiondoa kwako

Naweza kuendelea? NDIO/LA

Utafiti huu umeidhinishwa na Itifaki ya Kamati ya Maadili na Utafiti ya Chuo Kikuu cha kitaifa cha Kenyatta-Chuo Kikuu cha Nairobi ____________________________

UTAFITI HUU UNAHUSU NINI?

Madhumuni ya utafiti huu ni kutathmini ushirika wa sehemu ya kati ya ugonjwa wa goti na mkao wa miguu usiokuwa wa kawaida kati ya wagonjwa wanaohudhuria Hospitali ya Kitaifa ya Kenyatta. Ningependa kukuajiri kwenye utafiti. Ushiriki wako katika somo hili unajumuisha ukusanyaji wa habari kuhusu sifa zako za idadi ya watu na hali yako ya ugonjwa. Habari hii itasaidia katika kuchambua na kuboresha usimamizi wa arthrosis ya sehemu ya kati.

NINI KITATOKEA UKIAMUA KUWA KWENYE UTAFITI HUU WA UTAFITI?

Ikiwa unakubali kushiriki katika utafiti huu, mambo yafuatayo yatatokea:

Utahojiwa na mhojiwa aliyefunzwa katika eneo la kibinafsi ambapo unahisi raha kujibu maswali. Mahojiano hayo yatachukua takriban dakika ihshirini. Mahojiano yatashughulikia mada kama vile unapoishi, kazi yako na vitu vingine kukuhusu.

Baada ya mahojiano, kutakuwa na uchunguzi na vipimo kadhaa vitachukuliwa. Hakuna utaratibu wowote utakaotumika

Tutauliza nambari ya simu ambapo tunaweza kuwasiliana nawe ikiwa ni lazima. Ikiwa unakubali kutoa anwani yako ya mawasiliano, itatumika tu na watu wanaofanya kazi kwa utafiti huu na hawatashirikishwa na wengine kamwe. Sababu ambazo tunaweza kuhitaji kuwasiliana nawe ni pamoja na: __________________

KUNA ATHARI ZOZOTE, ZINAZIDHARAU HASARA ZINAZOHUSIANA NA UTAFITI HUU?

Utafiti wa kimatibabu una uwezo wa kuanzisha hatari za kisaikolojia, kijamii, kihemko na kiafya. Jitihada inapaswa kuwekwa kila wakati ili kupunguza hatari. Hatari moja ya kuwa katika utafiti ni kupoteza faragha. Tutaweka kila kitu unatuambia kama siri iwezekanavyo.

Tutatumia nambari zako kukutambulisha kwenye hifadhidata ya kompyuta inayolindwa na nywila na tutaweka rekodi zetu zote za karatasi kwenye kabati la faili lililofungwa. Walakini, hakuna mfumo wowote wa kulinda usiri wako ambao unaweza kuwa salama kabisa, kwa hivyo bado inawezekana kwamba mtu anaweza kugundua kuwa ulikuwa kwenye utafiti huu na angeweza kupata habari kukuhusu.

Pia, kujibu maswali kwenye mahojiano inaweza kuwa mbaya kwako. Ikiwa kuna maswali ambayo hautaki kujibu, unaweza kuyaruka. Una haki ya kukataa mahojiano au maswali yoyote yanayoulizwa wakati wa mahojiano.

Zaidi ya haya, hakuna hatari kutoka kwako kujihusisha na utafiti huu. Matokeo ya utafiti hayatatumika kwa faida yoyote ya kifedha.

Je! Kuna faida zozote za kushiriki katikat msomo huu?

Unaweza kufaidika kwa kupokea marekebisho sahihi ya mkao wako wa mguu.

Tutakupeleka kwa hospitali kwa matunzo na msaada pale inapobidi. Pia, habari unayotoa itatusaidia kuelewa vizuri ugonjwa wa osteoarthrirtis. Habari hii ni mchango kwa sayansi na mazoezi ya mifupa.

Je, kuwa kwenye utafiti huu una gharama zozote?

Ushiriki katika utafiti huu utachukua dakika chache tu za wakati wako na hautakugharimu chochote katika suala la kifedha.

Je, kutakua na marejesho ya pesa yoyote yaliyotumiwa kwa sehemu ya utafiti huu?

Kwa kuwa hakuna gharama za fedha kwa ushiriki, hakutakuwa na marejesho.

Je kama una maswali baadaye?

Ikiwa una maswali zaidi au wasiwasi juu ya kushiriki kwenye utafiti huu, tafadhali piga simu au tuma ujumbe mfupi kwa wafanyikazi wa utafiti kwa nambari iliyotolewa chini ya ukurasa huu.

Kwa habari zaidi juu ya haki zako kama mshiriki wa utafiti unaweza kuwasiliana na Katibu / Mwenyekiti, Hospitali ya Kitaifa ya Kenyatta-Chuo Kikuu cha Maadili na Kamati ya Utafiti ya Nairobi Nambari ya simu 2726300 Ext. Barua pepe 44102 uonknh_erc@uonbi.ac.ke.

Wafanyakazi wa utafiti watakulipa malipo yako kwa nambari hizi ikiwa simu ni ya mawasiliano yanayohusiana na utafiti.

CHAGUO ZAKO ZINGINE NI NINI?

Uamuzi wako wa kushiriki katika utafiti ni wa hiari. Uko huru kukataa kushiriki katika utafiti na unaweza kujiondoa kutoka kwa utafiti wakati wowote bila udhalimu au kupoteza faida yoyote.

FOMU YA MAJALIZO (TAARIFA YA MAJIBU)

Taarifa ya mshiriki

Nimesoma na kusomewa fomu hii ya idhini. Nimekuwa na nafasi ya kujadili utafiti huu wa utafiti na mshauri wa utafiti. Nimejibiwa maswali yangu kwa lugha ambayo ninaelewa. Hatari na faida zimeelezewa. Ninaelewa kuwa ushiriki wangu katika utafiti huu ni wa hiari na kwamba ninaweza kuchagua kujiondoa wakati wowote. Ninakubali kwa hiari kushiriki katika utafiti huu wa utafiti.

Ninaelewa kuwa juhudi zote zitafanywa kutunza habari kuhusu kitambulisho changu binafsi kuwa siri.

Kwa kusaini fomu hii ya idhini, sijatoa haki yoyote ya kisheria ambayo ninayo kama mshiriki katika utafiti wa utafiti.

Ninakubali kushiriki katika utafiti huu: Ndio /La

Ninakubali kuwa (fafanua kielelezo) kilichohifadhiwa kwa masomo ya baadaye: Ndio /La

Ninakubali kutoa habari ya mawasiliano kwa ufuatiliaji: Ndio /La

Jina la mshiriki aliyechapishwa: ____

Saini ya mshiriki / Stempu ya kidole gumba ______________________ Tarehe ______________

Kauli ya mtafiti

Mimi, aliyesainiwa chini, nimeelezea kabisa maelezo yanayofaa ya utafiti huu kwa mshiriki aliyetajwa hapo juu na ninaamini kwamba mshiriki ameelewa na kwa hiari na kwa hiari ametoa idhini yake.

Jina la Mtafiti: ______________________________ Tarehe: ______________

Sahihi ____

Jukumu katika utafiti: _________________________ [i.e. wafanyikazi wa utafiti ambao walielezea fomu ya idhini ya habari.]

Kwa habari zaidi wasiliana na ______________________ saa ___________________ kutoka

_________________________ hadi ________________________

Jina Lililochapishwa la Shahidi (Ikiwa shahidi ni lazima, Shahidi ni mtu anayekubalika kwa mtafiti na mshiriki wote)

Jina ________________________________ Maelezo ya mawasiliano ____________________

Saini / stempu ya Thumb: _________________ Tarehe; _______________________________

Kushiriki kwako katika utafiti huu ni kwa hiari, na data yoyote iliyokusanywa katika utafiti huu itabaki kuwa siri. Utambulisho wako hautahitajika, na data itakayokusanywa kutoka kwako itaandikishwa kwa jina la kutokujulikana. Faida kwako kwa kushiriki katika utafiti ni pamoja na marekebisho sahihi ya mkao wa miguu. Hakuna hatari kutoka kwako kujihusisha na utafiti huu. Matokeo ya utafiti hayatatumika kwa faida yoyote ya kifedha. Ikiwa utaamua kujiondoa kutoka kwa utafiti wakati wowote, hautafanyiwa matibabu yoyote ya kibaguzi. Ikiwa unahitaji habari yoyote zaidi au ufafanuzi basi mtafiti mkuu anaweza kuwasiliana kwa kutumia anwani hizo:

Dr. Daniel Mochoge

Nambari ya simu: 0729320313

Barua pep: dmochoge@gmail.com

APPENDIX C: DATA COLLECTION SHEET

Medial Compartment Knee OA

Personal Information	
Patient ID:	Age:
Date of data collection:	Gender:
Weight :	Left or Right foot:
Height of patient:	BMI:

Kellgren and Lawrence system Classification – X-RAY GRADING

grade 0: no radiographic features of OA are present

grade 1: doubtful joint space narrowing (JSN) and possible osteophytic lipping

grade 2: definite osteophytes and possible JSN on anteroposterior weight-bearing radiograph

grade 3: multiple osteophytes, definite JSN, sclerosis, possible bony deformity

grade 4: large osteophytes, marked JSN, severe sclerosis and definite bony deformity

GRADE:

Foot posture

Procedure for foot posture index assessment:

Instruction for the patient:

The patient should be standing in a relaxed and static position with double limb support.

Limb	R / L
Criteria	Score
Talar head palpation	

Curves above medial malleoli	
Curves below medial malleoli	
The bulge in the talonavicular joint region	
Congruence in the medial longitudinal arch	
Adduction or abduction of the forefront on the rearfoot	
Total	

Calculation of medial arch index ________________

Navicular height and drop _______________

APPENDIX D: ETHICS APPROVAL

APPENDIX E: PLAGIARISM REPORT

APPENDIX F: NACOSTI APPROVAL