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CORRELATION BETWEEN PATELLA TENDON LENGTH AND WOMAC SCORE IN OSTEOARTHRITIS KNEE.

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ABSTRACT

Background with Objectives: Knee osteoarthritis (OA) is a common degenerative disorder leading to pain, stiffness and functional limitation. Radiological severity often does not correlate well with clinical symptoms. Anatomical factors such as patella tendon length (PTL) may influence functional outcomes. The present study was conducted to determine the correlation between patella tendon length and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score in patients with osteoarthritis knee.

Methodology: This cross-sectional study was conducted in the Department of Orthopaedics, National Institute of Medical Science and Research, Jaipur over a period of 18 months. A total of 62 patients aged ≥40 years were included. Mean age of participants was 58.23±11.21 years, with female predominance (58.1%). Most patients had moderate to severe osteoarthritis with Kellgren–Lawrence Grade 3 (45.2%) and Grade 4 (37.1%). Patella tendon length was measured on lateral knee radiographs at 30° flexion. Functional assessment was performed using the WOMAC index. Statistical analysis included Pearson correlation with $p<0.05$ considered significant.

Results: The mean WOMAC scores were: pain 5.14±2.41, stiffness 1.82±0.96, physical function 16.73±7.11 and total score 23.71±10.17, indicating moderate symptom severity.

Correlation analysis showed a weak negative association between patella tendon length and WOMAC scores: pain (r = -0.206, p=0.107), stiffness (r = -0.145, p=0.261), function (r = -0.227, p=0.076), and total WOMAC score (r = -0.266, p=0.036), with only total score showing statistical significance. There was a weak positive but non-significant correlation between PTL and KL grading (r = 0.202, p=0.115). Comparison across PTL groups revealed that patients with short tendon length had highest WOMAC score (27.33±11.53), followed by medium (23.05±10.09) and lowest in long tendon group (20.60±7.72), indicating worse functional outcomes with shorter tendon length.

Conclusion: The study demonstrates that patella tendon length has a weak but clinically relevant association with functional outcomes in knee osteoarthritis. Longer tendon length is associated with lower WOMAC scores and better functional status, while shorter tendon length is linked to greater pain and disability. However, patella tendon length does not show a significant correlation with radiological severity, indicating that functional impairment in osteoarthritis is multifactorial.

Keywords: Knee osteoarthritis, Patella tendon length, WOMAC score, Kellgren-Lawrence grading, Functional outcome, Correlation study

INTRODUCTION

Osteoarthritis of the knee represents one of the most prevalent degenerative joint disorders globally, affecting millions of individuals across all demographic groups and significantly impairing their quality of life through progressive cartilage degeneration, chronic pain, joint stiffness and substantial functional limitations.[1] As populations continue to age and life expectancy increases, particularly in developing countries, the prevalence of knee osteoarthritis is rising dramatically, making it a substantial public health burden that necessitates comprehensive investigation into its complex pathophysiology, contributing anatomical and biomechanical factors and reliable clinical assessment methods.[2,3] The disease process involves intricate interactions between mechanical loading patterns, anatomical variations, cartilage metabolism, inflammatory mediators and biomechanical alterations that collectively influence disease progression, symptom severity and clinical outcomes in affected individuals.[4]

The patellar tendon, also referred to as the patellar ligament, extends from the inferior pole of the patella to the tibial tuberosity with a typical length ranging from 3.5 to 5.5 centimeters, serving as a crucial component of the knee extensor mechanism by transmitting forces from the quadriceps muscle to the tibia during knee extension and functional activities.[5] Variations in patellar tendon length have been increasingly recognized as important factors influencing patellofemoral biomechanics and joint kinematics with altered tendon dimensions potentially affecting force distribution across the knee joint, modifying contact pressures on articular cartilage and contributing to abnormal joint loading patterns that may accelerate degenerative changes.[2,6] Recent evidence suggests that patellar height abnormalities, typically assessed through standardized radiographic ratios such as the Insall-Salvati index (which calculates the ratio of patellar tendon length to patellar length) are significantly associated with structural damage in the patellofemoral joint, including cartilage loss, subchondral bone changes and bone marrow lesions in patients with osteoarthritis. The position, morphology and alignment of the patella have been shown to play critical roles in maintaining normal biomechanical function of the knee joint with numerous studies demonstrating that both patella alta (high-riding patella with elongated patellar tendon) and patella baja (low-riding patella with shortened patellar tendon) may predispose individuals to patellofemoral complications, altered joint mechanics, abnormal cartilage contact patterns and accelerated degenerative changes.[3,7,8]

The Western Ontario and McMaster Universities Osteoarthritis Index, universally known as the WOMAC score, represents a widely validated, reliable and responsive patient-reported outcome measure specifically designed to comprehensively assess pain, stiffness and physical function in individuals with knee and hip osteoarthritis across diverse populations and clinical settings.[9,10] This standardized self-administered questionnaire comprises 24 items systematically divided into three distinct subscales: pain (5 items evaluating pain intensity during various activities with scores ranging from 0-20), stiffness (2 items assessing joint stiffness with scores ranging from 0-8) and physical function (17 items evaluating difficulty performing daily activities with scores ranging from 0-68) with higher cumulative scores indicating worse symptoms, greater functional impairment and reduced quality of life.[10,11]

The WOMAC has demonstrated excellent test-retest reliability, construct validity, criterion validity and responsiveness to clinically meaningful changes across multiple language versions, cultural adaptations and patient populations, firmly establishing it as a gold standard tool for evaluating disease severity, monitoring treatment outcomes and assessing therapeutic interventions in osteoarthritis patients. Its ability to capture patient-perceived functional limitations, symptom burden and disease impact on daily activities provides crucial clinical information that complements objective radiographic assessments, physical examination findings and biomechanical measurements in the comprehensive evaluation of knee osteoarthritis.[12,13]

Despite growing recognition of the importance of biomechanical factors in knee osteoarthritis pathogenesis and the established role of patellar anatomy in joint mechanics, limited research has specifically investigated the relationship between patellar tendon length and functional outcomes measured by the WOMAC score in patients with knee osteoarthritis. Understanding this correlation could provide valuable insights into how anatomical variations contribute to symptom severity and functional disability, potentially identifying patients at higher risk for poor outcomes and informing targeted therapeutic interventions.[2,3,14] Furthermore, establishing such associations may enhance clinical decision-making regarding conservative management strategies versus surgical interventions, particularly in cases where anatomical correction could potentially improve biomechanical alignment and reduce symptom burden. Therefore, investigating the correlation between patellar tendon length and WOMAC score in osteoarthritis knee represents an important step toward comprehensive understanding of the multifactorial nature of this debilitating condition and may contribute to more personalized and effective treatment approaches for affected individuals.[4,15,16]

NEED OF THE STUDY

The need to investigate the correlation between patellar tendon length and WOMAC score in knee osteoarthritis arises from critical knowledge gaps regarding how anatomical variations influence patient-reported functional outcomes. While radiographic severity often fails to predict symptom burden, establishing this correlation could bridge the gap between objective anatomical measurements and subjective functional disability. Recent evidence shows that higher patellar tendon length ratios correlate with more severe osteoarthritis, suggesting altered biomechanics and increased cartilage stress. However, how these anatomical changes translate into WOMAC-measured functional impairment remains poorly understood.

Clinically, this knowledge would enable early identification of patients at risk for severe functional limitation, guiding targeted interventions including physiotherapy, bracing and timely surgical referrals. Most existing studies focus on post-surgical scenarios rather than native osteoarthritic knees, creating a significant research gap. Understanding this correlation would support personalized treatment approaches, allowing clinicians to tailor interventions based on individual anatomical characteristics and better predict treatment outcomes. Ultimately, establishing the relationship between patellar tendon length and WOMAC scores would enhance comprehensive understanding of knee osteoarthritis's multifactorial nature and enable evidence-based, individualized management strategies.

AIM AND OBJECTIVES

AIM:

To determine the Correlation between patella tendon length and Western Ontario and McMaster Universities osteoarthritis index (WOMAC) score in osteoarthritis knee.

OBJECTIVES:

1. To measure the variation in patella tendon length in patients with Osteoarthritis Knee.
2. To compare the WOMAC scores of patients with Osteoarthritis Knee with varying patella tendon lengths.
3. To determine the relationship between patella tendon length and the severity of Osteoarthritis Knee.

REVIEW OF LITERATURE

SURGICAL ANATOMY

KNEE JOINT

The knee joint is classified as a modified hinge joint, designed to permit flexion and extension while allowing slight rotational and translational movements. It is composed of three primary bones - the femur, tibia and patella - which together form three partially independent compartments: the medial tibiofemoral, lateral tibiofemoral and patellofemoral compartments. These components work in coordination to provide stability, strength and smooth articulation during weight-bearing and motion activities such as walking, running and climbing. The structural configuration of the knee enables it to sustain substantial mechanical loads while maintaining flexibility and functional mobility.[17,18]

FEMUR

The distal portion of the femur demonstrates a highly specialized architecture that contributes significantly to knee mechanics. The femoral condyles are asymmetrical in both shape and alignment; the medial condyle is larger and exhibits a more regular curvature, while the lateral condyle is slightly shorter and broader. The long axis of the lateral condyle lies closer to the sagittal plane, whereas the medial condyle is angled obliquely-typically opening posteriorly at an angle of approximately 22 degrees. This difference in alignment ensures proper load distribution during knee movement.[19] At the anterior aspect, the condyles are divided by a shallow groove called the femoral trochlea, which provides a smooth track for patellar movement during flexion and extension. The lateral condyle's broader contour within the intercondylar notch contributes to patellar stability and assists in guiding knee motion during dynamic activity.

Figure 1: Knee Joint

Source: https://www.physio-pedia.com/images/d/d6/Ligaments-of-the-knee.jpg

TIBIA

The tibia, the major weight-bearing bone of the lower leg, forms the lower portion of the knee joint. The medial tibial plateau is larger, flatter and has a squared-off posterior margin, a feature clearly visible on lateral radiographs. In contrast, the lateral tibial plateau is smaller and displays a slightly convex surface. The presence of the menisci - crescent-shaped fibrocartilaginous structures greatly enhances joint congruence by deepening the articular surfaces and distributing the load evenly across the tibial plateaus. Between these plateaus lies the intercondylar eminence or tibial spine, which serves as an important attachment area for ligaments and menisci. The anterior intercondylar fossa, located anterior to this eminence, provides anchoring points for several critical structures: the anterior horn of the medial meniscus, the anterior cruciate ligament (ACL) and the anterior horn of the lateral meniscus. Posteriorly, the attachments include the posterior horns of both menisci and the posterior cruciate ligament (PCL). This intricate arrangement of structures allows the knee to balance flexibility with stability, preventing excessive motion while permitting smooth articulation.[18,19]

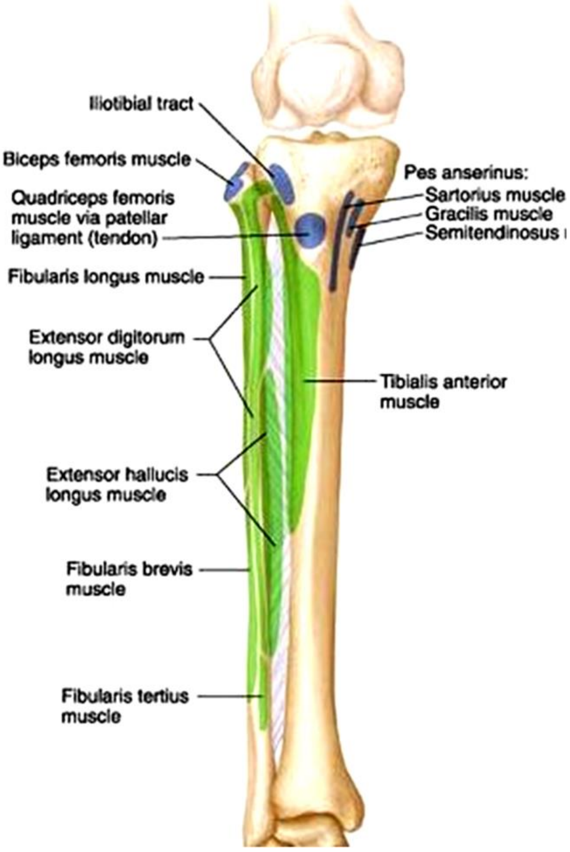


Figure 2: Tibia and its attachments

Source: m.instantanatomy.net/diagrams/leg036a.png

ARTICULAR CARTILAGE

Articular cartilage is a specialized, resilient connective tissue that covers the surfaces of bones within synovial joints, including the femoral condyles, tibial plateaus and posterior aspect of the patella. It consists of a dense extracellular matrix composed of collagen fibers mainly type II and hydrated proteoglycans, which together provide both elasticity and resistance to compressive forces. Proteoglycans, made up of a core protein attached to glycosaminoglycan chains help retain water and maintain the cartilage's load-bearing capacity. Structurally, hyaline cartilage is divided into four distinct zones: the superficial (tangential), middle (transitional), deep (radial) and calcified zones. These layers vary in collagen fiber orientation and chondrocyte arrangement, optimizing the tissue's mechanical strength and shock absorption. The highest density of chondrocytes is located near the subchondral bone and progressively decreases toward the surface. Because cartilage lacks its own blood supply, it relies on diffusion from synovial fluid for nourishment in its superficial regions and on the subchondral bone for deeper layers. This unique structure ensures low-friction joint movement and helps protect underlying bone from stress and damage.[20,21]

LIGAMENTS

The knee joint is reinforced and stabilized by an extensive network of ligaments and meniscal structures that regulate motion, prevent dislocation and maintain alignment.[22] These include:

1. **Fibrous capsule:** A dense connective tissue sheath enclosing the joint, providing general stability and containing synovial fluid.
2. **Ligamentum patellae:** A continuation of the quadriceps tendon, extending from the patella to the tibial tuberosity, aiding in knee extension.
3. **Tibial collateral ligament (medial collateral ligament):** Located on the medial side of the knee, it connects the femur to the tibia, resisting valgus stress and stabilizing the inner knee.
4. **Fibular collateral ligament (lateral collateral ligament):** A cord-like structure on the lateral side that prevents varus stress and supports the outer aspect of the knee.
5. **Oblique popliteal ligament:** Extends from the semimembranosus tendon across the posterior knee, reinforcing the capsule and resisting hyperextension.
6. **Arcuate popliteal ligament:** Strengthens the posterolateral corner of the knee and assists in stabilizing the posterior capsule.
7. **Anterior cruciate ligament (ACL):** Extends from the anterior tibial plateau to the posterior femoral condyle, controlling anterior translation of the tibia and rotational stability.
8. **Posterior cruciate ligament (PCL):** Runs from the posterior tibial plateau to the anterior femoral condyle, preventing posterior displacement of the tibia.
9. **Medial meniscus:** A C-shaped fibrocartilaginous structure that cushions and stabilizes the medial compartment.
10. **Lateral meniscus:** More circular in shape and mobile, it serves to absorb shock and enhance joint congruity in the lateral compartment.
11. **Transverse ligament:** Connects the anterior horns of both menisci, coordinating their movements during flexion and extension.[23,24]

MENISCI

The menisci are two crescent-shaped fibrocartilaginous structures that act as vital components of the knee joint, primarily responsible for enhancing the articulation between the femoral condyles and tibial plateaus. They effectively deepen the tibial articular surfaces, improving joint stability and load distribution. Structurally, they are composed mainly of type I collagen, which accounts for approximately 75% of their dry weight with the remaining 8-13% consisting of non-collagenous proteins. The collagen fibers are arranged predominantly in a circumferential orientation, allowing the menisci to withstand and dissipate compressive forces efficiently.[25] In addition, radial fibers extending across the surface and within the mid-substance contribute to tensile strength and prevent longitudinal tearing. Functionally, the menisci are essential for several biomechanical processes including load transmission across the tibiofemoral joint, improving joint congruence, facilitating even distribution of synovial fluid to nourish articular cartilage and preventing impingement of soft tissues during knee movement.[26]

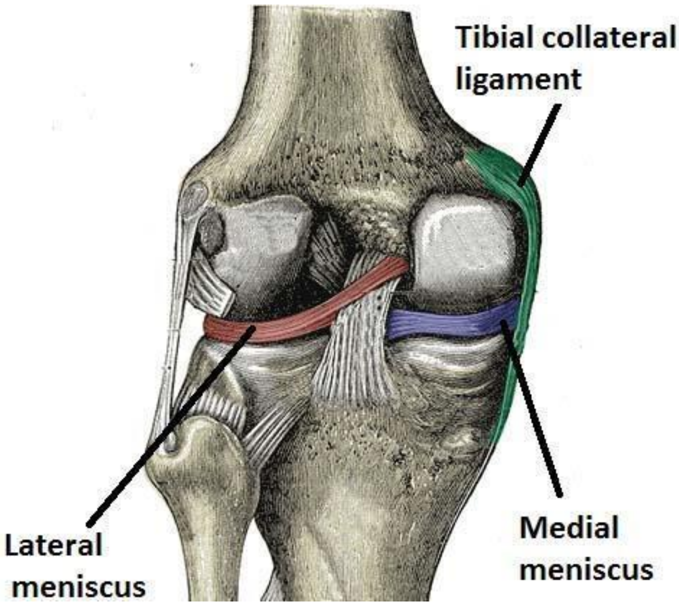


Figure 3: Ligaments around the knee joint

Source: https://teachmeanatomy.info/wp-content/uploads/The-Menisci-of-the-Knee-Joint-Posterior-View.jpg

MUSCLES

The primary movements of the knee joint include flexion, extension and limited rotation, all of which are coordinated by surrounding muscles. Flexion is mainly achieved through the action of the hamstrings comprising the biceps femoris, semitendinosus and semimembranosus assisted by the gastrocnemius and popliteus muscles. Extension is primarily performed by the quadriceps femoris group, which consists of the rectus femoris, vastus medialis, vastus lateralis and vastus intermedius. During terminal extension, due to the unique shape of the femoral condyles and ligamentous constraints, the femur exhibits a slight medial rotation on the tibia known as the “screw-home” mechanism, which locks the knee for stability. The sartorius, gracilis and semitendinosus muscles on the medial side, along with the iliotibial tract on the lateral side, act as stabilizing “guy ropes” maintaining pelvic and knee alignment during movement.[27]

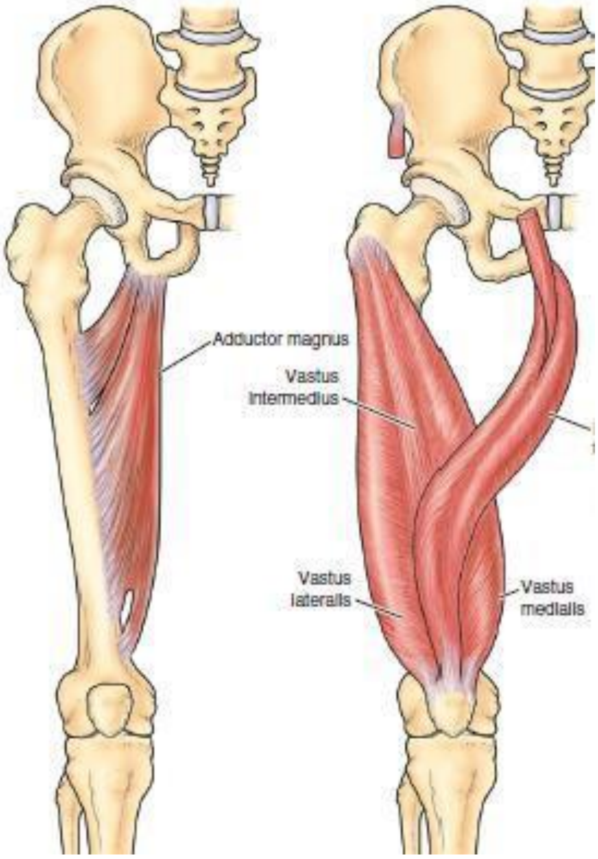


Figure 4: Muscles causing knee extension

Source: https://www.instagram.com/p/DLmzD3Ax0v2/

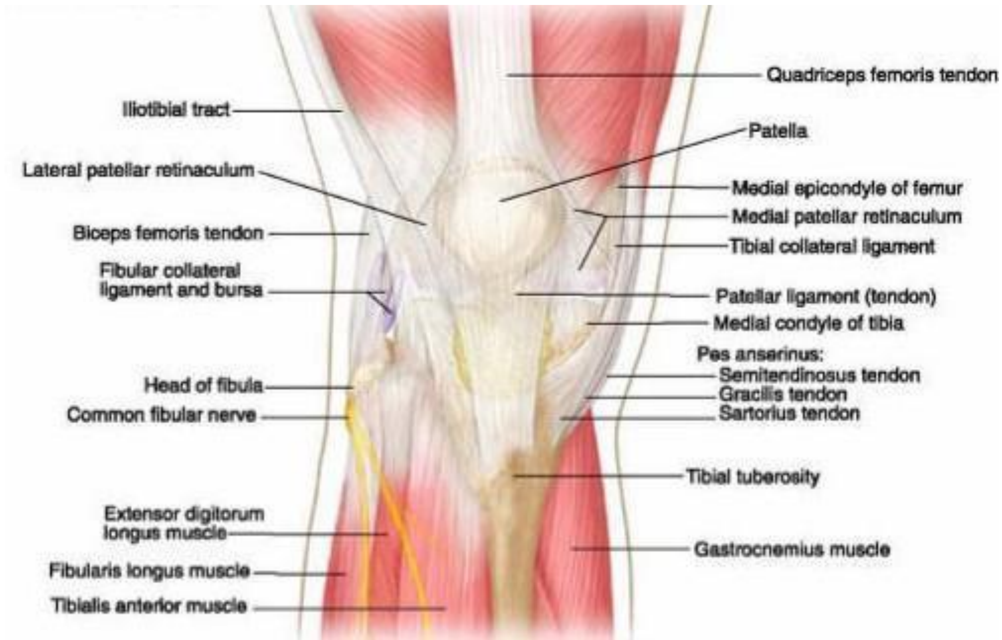


Figure 5: Muscles in anterior aspect of knee joint

Source: https://www.aafp.org/content/dam/brand/aafp/pubs/afp/issues/2007/0115/p194-f1.jpg

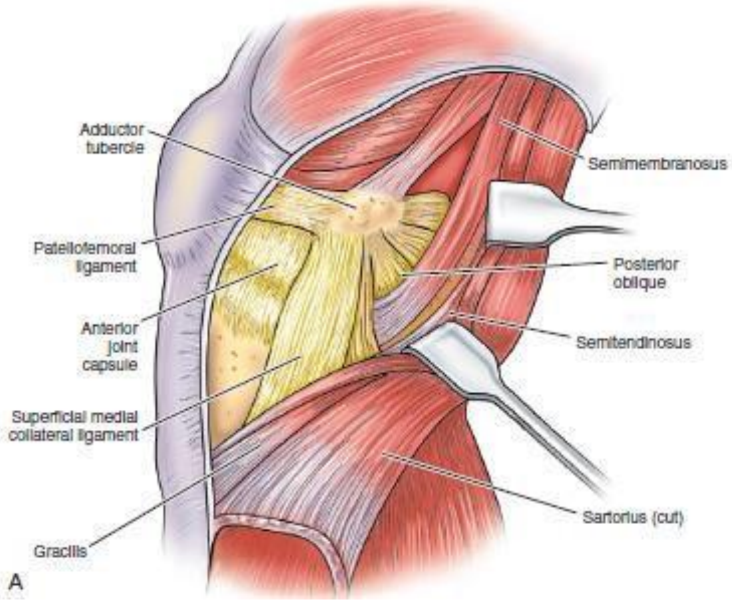


Figure 6: Medial aspect of knee joint

Source: https://musculoskeletalkey.com/wp-content/uploads/2016/08/B9781437715033000913_f091-005-9781437715033.jpg

BLOOD SUPPLY

The knee joint receives a rich and intricate blood supply through an extensive anastomotic network that ensures consistent perfusion during flexion and extension. This vascular network is formed by five main sources: (1) the five genicular branches of the popliteal artery, (2) the descending genicular branch of the femoral artery, (3) the descending branch of the lateral circumflex femoral artery, (4) two recurrent branches of the anterior tibial artery and (5) the circumflex fibular branch of the posterior tibial artery. Together, these arteries create a periarticular arterial ring that sustains the joint’s metabolic demands and facilitates healing following injury.[28]

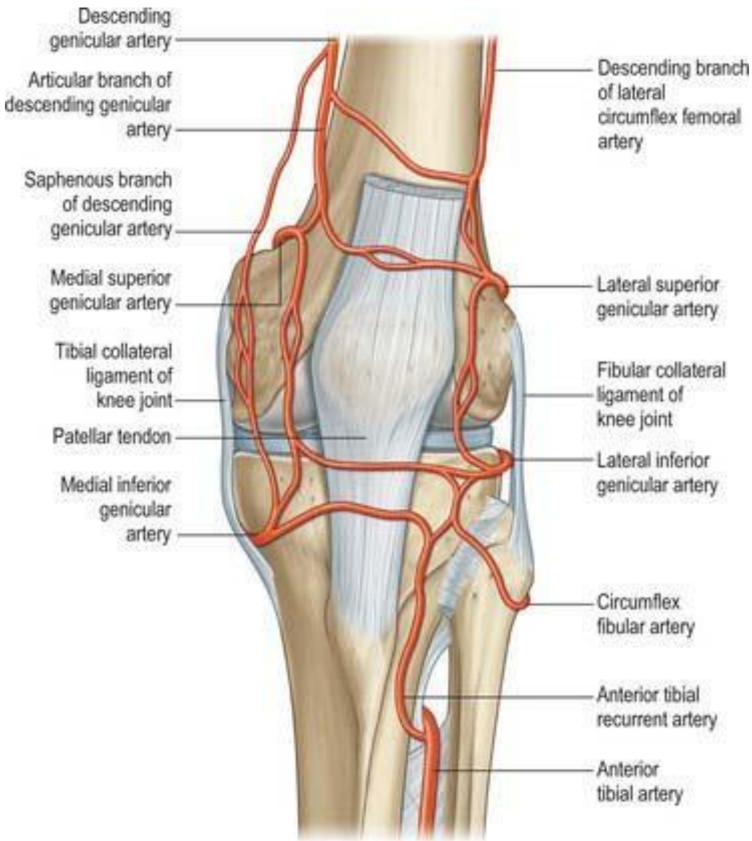


Figure 7: Arterial supply around knee joint

Source: https://basicmedicalkey.com/wp-content/uploads/2016/06/B9780443066849500901_gr1.jpg

Nerve Supply

The innervation of the knee joint is derived from several major nerves contributing articular branches. The femoral nerve supplies the anterior aspect of the joint through branches to the quadriceps, particularly the vastus medialis. The sciatic nerve contributes via its tibial and common peroneal (fibular) branches, which provide genicular twigs to the posterior and lateral portions of the capsule. Additionally, the obturator nerve, through its posterior division, innervates the medial aspect of the joint. This composite innervation ensures proprioceptive feedback and pain sensation, aiding in reflexive stabilization during movement.[29]

Movements of knee joint

Sagittal Plane movements-

- Flexion - 0-125 degrees
- Extension - 0-10 degrees

Rotational movements-

- Internal rotation /external rotation- 6 degrees.[30]

Mechanical alignment of Knee joint

The alignment of the lower limb is determined by the relationship between the anatomical and mechanical axes. The anatomical axis refers to the diaphyseal midline of the femur and tibia, which forms a natural valgus angle of about 6° ± 2°.[30] The mechanical axis, defined as a straight line from the center of the femoral head to the center of the talar dome on a standing long-leg anteroposterior radiograph, should ideally pass through the center of the knee joint, representing a neutral alignment. In cases of genu varus (bow-legged) deformity, the mechanical axis shifts medially, while in genu valgus (knock-knee) deformity, it deviates laterally.[31]

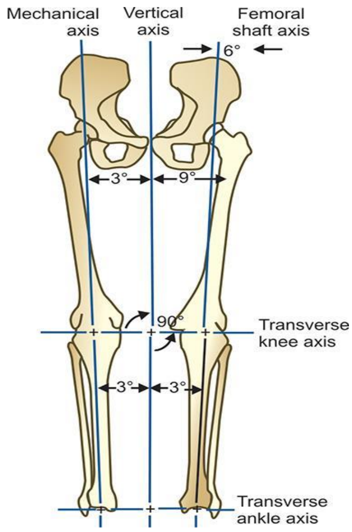


Figure 8: Mechanical axis and anatomical axis

Source: https://d45jl3w9libvn.cloudfront.net/jaypee/
static/books/9789350251683/Chapters/images/12-1.jpg

To correct coronal plane deformities, surgeons rely on weight-bearing axis correction methods, most notably the Dugdale technique, which recommends lateralizing the mechanical axis to 62-66% of the tibial plateau width from the medial edge with 65% commonly considered optimal.

Fujisawa point

Figure 12: Fujisawa point

Source: https://www.researchgate.net/figure/Radiological-image-showing-Fujisawa-point_fig1_338186500

The Fujisawa point is a landmark used in corrective osteotomy planning to restore proper mechanical alignment. It divides the tibial plateau into 0-100% from medial to lateral, serving as a reference for determining the ideal intersection point of the mechanical axis through the knee. The correction angle is established by drawing lines from this target point to the centers of the femoral head and talar dome, accounting for ligamentous laxity that affects tibiofemoral joint distraction. The wedge height needed for correction is traced on the radiograph corresponding to the desired angular adjustment and is standardized to account for radiographic magnification. This precise technique ensures optimal load distribution across the joint post-correction, minimizing stress on the articular cartilage and improving long-term joint function.[31]

KNEE OSTEOARTHRITIS:

Epidemiology:

Knee osteoarthritis (KOA) represents a substantial global health burden, affecting approximately 374.7 million individuals worldwide in 2021 with an age-standardized prevalence of 4,711.84 per 100,000 population (4.90%) for both sexes.[32,33] The global prevalence varies significantly by age group with studies indicating that 16.0% of individuals aged 15 years and over and 22.9% of individuals aged 40 years and over are affected by KOA.[32] In 2019, there were approximately 364.58 million prevalent cases globally, including 29.51 million incident cases and 11.53 million disability-adjusted life years (DALYs) attributed to KOA.[34] The disease burden has increased substantially since 1990 with age-standardized rates for prevalence, incidence and DALYs increasing by 8.3%, 7.1% and 8.2% respectively with projections suggesting a 74.9% increase in KOA cases by 2035.[35]

Knee osteoarthritis represents a significant public health challenge in India with an overall prevalence of 28.7% in the general population based on community-based studies. In a comprehensive cross-sectional study conducted across five geographic sites in India, including North, Central, Western, Southern and Eastern regions, radiographic diagnosis using the Kellgren and Lawrence grading scale revealed substantial disease burden among individuals aged 40 years and above. The prevalence demonstrates considerable geographic variation with higher rates observed in rural areas (31.1%) and metropolitan cities (33.1%) compared to small cities (17.2%) and towns (17.1%).[36] A systematic review and meta-analysis of elderly Indians reported a pooled prevalence of 47% (95% CI: 38.4% to 55.8%), indicating that nearly half of the elderly population in India suffers from knee osteoarthritis.[37] Recent population studies have shown that the burden of osteoarthritis in India increased from 23.46 million cases in 1990 to 62.35 million cases in 2019, representing a substantial epidemiological transition.[38]

Gender disparities are prominently observed in the Indian context with females demonstrating a significantly higher prevalence of 31.6% compared to males at 28.1% (P = 0.007).[36] Regional studies from rural South India reported a community prevalence of knee osteoarthritis among adults aged 40 years and above with female gender identified as a significant risk factor.[39] In rural Jammu, the overall prevalence was 35.7% with females showing substantially higher rates at 44.5% compared to males at 23.1%.[40] Studies from rural areas of Karnataka reported a prevalence of 42% among elderly individuals aged 60 years and above with female preponderance noted consistently across different geographic locations.[37] The age-related progression is marked with prevalence increasing from lower rates in the 40-50 year age group to the highest burden observed in individuals aged 60 years and above (P = 0.001).[36] In a study from rural South India using American College of Rheumatology criteria, adults aged 40 and above demonstrated significant age-related increases in disease prevalence.[39]

Etiology & Pathogenesis:

Knee osteoarthritis is a multifactorial and heterogeneous condition influenced by several independent risk factors, including aging, previous joint trauma, obesity and female sex. These factors collectively contribute to the disruption of the normal biomechanical and biochemical integrity of the joint. The disease is characterized by progressive structural alterations such as articular cartilage loss, osteophyte formation, subchondral sclerosis and synovial changes. Microscopically, OA cartilage demonstrates fibrillation, fissuring and focal necrosis, alongside neovascularization. Chondrocytes, which are responsible for maintaining and repairing cartilage, undergo increased metabolic activity in an attempt to counteract matrix degradation. However, when reparative processes fail to keep pace with degeneration, OA develops. A key biochemical marker of this process is the upregulation of ADAMTS (a disintegrin and metalloproteinase with thrombospondin motifs), an aggrecan-degrading enzyme found both in affected cartilage and in circulation.[21] Radiographically, the hallmark features described by Kellgren et al. include joint space narrowing, indicative of cartilage loss and the presence of marginal osteophytes.[41]

Burr et al. suggested that early OA involves subchondral bone sclerosis and microfracture formation, which may accelerate cartilage degeneration.[21] Clinically, patients commonly experience knee pain, often accompanied by stiffness, swelling and deformity. Symptoms vary in severity, from mild discomfort to debilitating pain. Early management includes conservative options such as physiotherapy, orthotic bracing, weight reduction, lifestyle modification and pharmacological therapy namely nonsteroidal anti-inflammatory drugs (NSAIDs), analgesics, glucosamine, chondroitin sulfate and intra-articular injections of corticosteroids or hyaluronic acid.[42] As OA progresses, surgical options become necessary. Depending on patient age, activity level, disease extent and compartmental involvement, procedures such as arthroscopic debridement, osteochondral grafting, autologous chondrocyte implantation, high tibial or distal femoral osteotomy, partial or total knee arthroplasty and arthrodesis may be performed.[43]

Genu varum:

In genu varum, the femoral and tibial diaphyseal axes diverge laterally, creating an angle exceeding 173-175 degrees. The weight-bearing line drawn from the femoral head to the midpoint of the ankle joint shifts medially by more than 4 ± 2 mm relative to the center of the knee. In severe deformities, the mechanical axis deviation (MAD) exceeds 15 mm medially and the intercondylar distance (ICD) between the femoral condyles increases significantly.[42] This misalignment intensifies the load on the medial compartment, promoting cartilage wear and advancing degenerative changes.

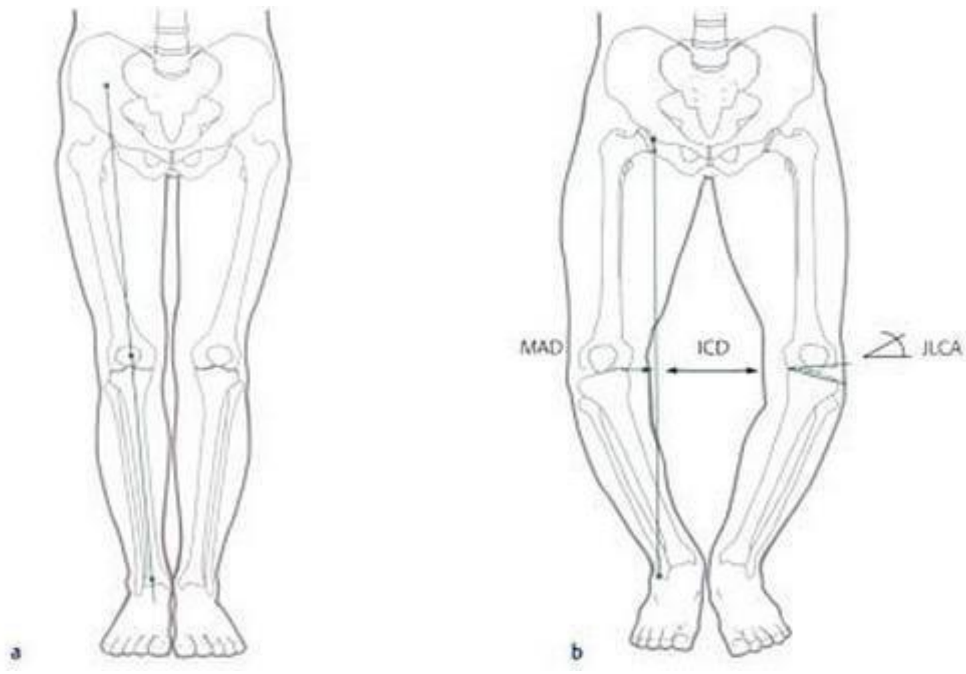


Diagram showing normal lower limb(a) and varus deformity of the lower limb(b) (AO - Osteotomies around the knee)

Figure 13: Normal and varus deformity of knee

Source: https://i0.wp.com/musculoskeletalkey.com/wp-content/uploads/2020/06/10-1055-b-002-10327_c01_f006.jpg?fit=764,377&ssl=1

Consequences of the lower limb deformities:

When frontal plane deformities of the femur or tibia alter normal knee alignment, load distribution across the joint becomes uneven.[44] This abnormal mechanical stress accelerates cartilage degradation, resulting in the progression of degenerative joint disease. Corrective osteotomy, a surgical procedure involving bone cutting and realignment, is designed to shift the weight-bearing axis from the affected region to a healthier portion of the knee. By redistributing mechanical load, the surgery relieves pain, enhances joint function and slows the degenerative process, potentially delaying the need for total or partial knee replacement. Both open-wedge and closed-wedge osteotomy techniques are well-established and are selected based on the specific nature and degree of varus or valgus deformity.[45]

Clinical Examination:

1. **Patient Assessment:** Before determining the appropriate surgical or nonsurgical management, factors such as the patient's age, occupation, body mass index (BMI), symptom duration, prior surgeries and postoperative expectations must be carefully reviewed. A comprehensive nutritional, neurological and vascular examination helps identify underlying conditions that could compromise postoperative recovery or surgical success.

2. **Physical Examination:** A detailed examination begins with inspection for swelling, scars, sinuses or deformities. The range of motion is assessed in various positions - extension, mid-flexion and full flexion to evaluate joint stability and alignment. Observation during standing helps assess the severity of varus or valgus deformities. Examination of the patellar tracking mechanism is crucial to identify malalignment or clunk syndromes. The integrity of the extensor mechanism is verified and neurological, vascular and gait assessments are performed. The hip and spine are also examined to rule out referred pain sources.

Uni compartmental Osteoarthritis:

Medial unicompartmental femorotibial OA is the most common presentation of localized knee degeneration. Patients typically report pain localized to the medial joint line during walking or standing. When discomfort is diffuse or extends beyond a single compartment, the indication for osteotomy should be reconsidered, as other pathologies may be contributing to symptoms.[46]

Radiographic Views:

Preoperative radiographic evaluation is vital for accurate diagnosis and surgical planning. Standard anteroposterior (AP) and lateral knee radiographs, along with a full-length weight-bearing scanogram of both lower limbs, provide critical information about the mechanical axis and the extent of deformity. A weight-bearing AP radiograph helps determine the degree of malalignment and guides osteotomy planning. To ensure precision, the patella must face directly forward over the femoral condyles to prevent rotational errors that could distort measurements.[41]

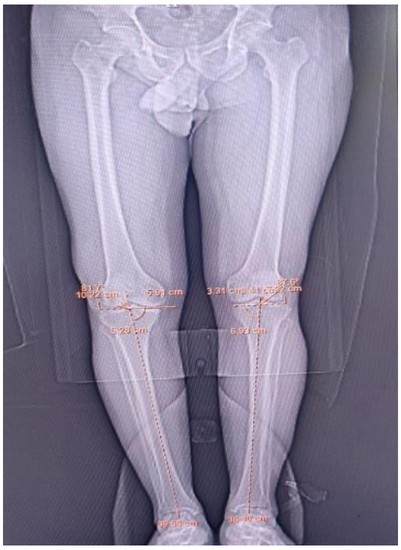


Figure 14: lower limb scanogram

Source: https://www.shutterstock.com/shutterstock/photos/16298 57320/display_1500/stock-photo-scanogram-of-lower-limb-or-x-ray-image-of-total-lower-extremity-medical-background-concept-1629857320.jpg

Grade of Osteoarthritis:

Several radiological classification systems have been established to describe the progressive stages of osteoarthritis (OA) based on structural and morphological changes visible on imaging. These grading systems help clinicians assess disease severity, monitor progression and guide treatment decisions. The two most widely used classifications are the Kellgren and Lawrence classification and the Ahlbäck classification.

1. Kellgren and Lawrence Radiological Classification of Osteoarthritis[41]

This system is one of the most commonly used grading methods for OA and is based on plain radiographic findings. It evaluates the presence of osteophytes, joint space narrowing, subchondral sclerosis and bone deformity.

- Grade 0: No visible radiographic signs of osteoarthritis.
- Grade I: Doubtful or minimal joint space narrowing with possible early osteophytic lipping.
- Grade II: Definite osteophyte formation accompanied by possible narrowing of the joint space on weight-bearing radiographs.
- Grade III: Multiple osteophytes, definite joint space narrowing, subchondral sclerosis and early bony contour deformities.
- Grade IV: Extensive osteophyte formation, severe joint space narrowing, marked subchondral sclerosis and evident bony deformity indicating advanced disease.

This grading scale provides a standardized framework for evaluating radiographic OA severity, allowing for comparison across clinical studies and aiding in determining appropriate management strategies.

Figure 15: Kellgren and Lawrence Classification -Osteoarthritis of knee

Source: https://www.researchgate.net/figure/Radiographic-grading-of-osteoarthritis-in-knee-joint-using-Kellgren-Lawrence-score_fig1_347074739

2. Ahlbäck Radiological Classification of Osteoarthritis of the Knee

The Ahlbäck classification is specifically applied to knee osteoarthritis and focuses on the degree of joint space loss, tibial plateau attrition and tibiofemoral subluxation. It is particularly useful in assessing advanced stages of disease and planning surgical interventions such as osteotomy or arthroplasty.

- **Grade I:** Mild reduction of joint space compared to normal.
- **Grade II:** Complete obliteration of the joint space, indicating full cartilage loss.
- **Grade III:** Tibial plateau attrition of less than 5 mm, signifying early subchondral bone wear.
- **Grade IV:** Tibial plateau attrition between 5-10 mm, reflecting more extensive bone erosion and deformity.
- **Grade V:** Severe deformity with marked tibial subluxation or displacement.

The Ahlbäck classification is especially valuable for orthopedic surgical planning, as it correlates closely with the extent of bone destruction and deformity observed intraoperatively.[47,48]

MANAGEMENT OF OSTEOARTHRITIS OF KNEE

Osteoarthritis (OA) of the knee can be addressed through either non-operative (conservative) measures or surgical interventions, depending on the stage of disease, severity of symptoms and patient-specific needs. The main goals of treatment are to reduce pain, improve joint function, correct deformity and enhance overall quality of life.[49]

CONSERVATIVE (NON-OPERATIVE) MODALITIES OF TREATMENT MANAGEMENT:

Knee osteoarthritis is a chronic, multifactorial and progressive disorder that significantly impairs mobility and daily functioning. Conservative management is typically the first line of therapy, aiming to alleviate pain, restore strength and maintain joint stability before surgical treatment becomes necessary. Key non-operative approaches include therapeutic exercise, weight management, orthotic support and pharmacologic therapy.[50]

Exercise Therapy:

Exercise plays a crucial role in managing knee OA by enhancing muscle strength, improving joint stability and reducing stiffness. Both land-based and aquatic exercise programs have been shown to improve physical function and alleviate pain. Aerobic and resistance training, particularly when combined with weight reduction in overweight or obese individuals, produces significant clinical benefits. Isometric quadriceps strengthening is especially effective; when performed three times per week for six weeks with the knee flexed to 60 degrees, it significantly improves quadriceps torque, pain scores and overall function.[49,50]

Orthotic and Supportive Interventions:

Several mechanical aids and supportive devices are recommended to improve lower limb alignment and reduce joint stress. These include medially wedged insoles for valgus deformities, lateral heel wedges or subtalar strapped insoles for varus knees and medially directed patellar taping to improve patellar tracking.[51] Walking aids, such as canes, braces and knee sleeves, can help reduce joint loading and improve stability. Participation in self-management and psychosocial programs, manual therapy combined with supervised exercises and the application of heat or cold therapy are also beneficial for symptom control and maintaining mobility.[52]

Pharmacological Management:

Drug therapy focuses on pain relief and inflammation control. First-line medications include nonsteroidal anti-inflammatory drugs (NSAIDs), particularly for patients under 75 years of age, to manage mild-to-moderate pain. Intra-articular corticosteroid injections are recommended for acute flare-ups with effusion.[43,48] For patients unresponsive to NSAIDs, tramadol and other opioid analgesics may be prescribed cautiously. Intra-articular hyaluronic acid injections can improve lubrication and delay disease progression, while glucosamine and chondroitin sulfate supplements may support cartilage metabolism and repair by replenishing essential glycoproteins.

Surgical Management

Surgical intervention is reserved for patients with persistent, disabling pain or deformity that fails to respond to conservative measures, or for those with recurrent locking, effusion or severe joint degeneration. Common indications include functional limitation, structural instability and end-stage OA.[43,44,49] The choice of surgical procedure depends on multiple factors such as patient age, activity level, disease stage, number of compartments affected and overall health status. Surgical options include:

- Arthroscopic debridement for removal of loose cartilage or osteophytes.
- Osteotomy (tibial or femoral) for realignment of weight-bearing axes in cases of varus or valgus deformity.
- Unicompartmental, total or patellofemoral arthroplasty for advanced cases involving one or more compartments.

OSTEOTOMY

Successful osteotomy requires meticulous preoperative planning and thorough clinical evaluation. The procedure should be performed precisely at the apex of the deformity to achieve optimal correction. Performing osteotomy away from this point risks creating secondary deformities instead of restoring normal alignment.[41] The metaphyseal region of long bones is preferred for osteotomy due to its superior regenerative capacity compared to the diaphysis, where bone healing is slower.

Among osteotomy types, open-wedge procedures are technically simpler and more accurate than closed-wedge techniques. The open-wedge method allows intraoperative fine-tuning using a spreader and when stable fixation devices are applied, bone grafting is often unnecessary. To ensure a favorable outcome, restoration of a horizontal joint line is essential.[42]

Calculation of Wedge Size (Correction Angle):

The femoro-tibial angle determines the extent of varus or valgus deformity. A line is drawn from the center of the femoral head to the Fujisawa point approximately 62.5% across the width of the tibial plateau. A second line is drawn from the center of the talar dome to the same coordinate. The angle formed between these lines represents the required correction angle, ensuring that the postoperative mechanical axis passes through the Fujisawa point, redistributing load evenly across the knee.[53]

HIGH TIBIAL OPENING WEDGE OSTEOTOMY:

Surgical Principles:

High tibial osteotomy (HTO) aims to unload the degenerated medial compartment in patients with varus deformity by shifting the mechanical axis laterally toward the Mikulicz line, thereby transferring weight-bearing forces to the healthier lateral compartment. This approach is especially suitable for younger, active patients as it preserves the native joint and can delay the need for knee replacement.[42,44]

Advantages of the Medial Open-Wedge Technique:

Compared to the lateral closed-wedge method, the medial open-wedge osteotomy offers several key benefits:

- Requires only a single osteotomy.
- Avoids fibular osteotomy, peroneal nerve dissection and detachment of extensor muscles.
- Prevents limb shortening, preserving leg length symmetry.
- Simplifies future total knee arthroplasty if required.

IMPLANTS USED FOR FIXATION

TomoFix Plate:

The TomoFix system, a rigid, T-shaped titanium internal fixator with a uniaxial locking mechanism, is considered the gold standard for stabilizing osteotomy sites. It offers biomechanical advantages that facilitate rapid bone healing through:

1. High primary fixation stability.
2. A compliant bone-implant interface allowing micro-movement within the osteotomy gap to promote callus formation.[54]

TomoFix plates come in two versions - standard **and** small stature (sm) to accommodate different patient builds. The proximal design supports biplanar osteotomy, increasing surface contact for faster bone healing. Fixation is achieved with three 5 mm bicortical locking screws and one 4.5 mm cortical screw proximally and two 5 mm unicortical locking screws distally.[55]

Figure 18: Tomofix plate

Source: https://media.aofoundation.org/approved/-/media/project/aocd/migrated-images/aoas/_img/inn/aps/2009/slides/tomofixmedialhightibia_2.jpg?h=384&iar=0&w=512 &rev=a842a2fb0c6d464db708cc2e18bc9770

Puddu Plate:

Developed by Giancarlo Puddu in the 1990s, the Puddu plate popularized the medial open-wedge osteotomy technique and remains a recognized implant in knee realignment surgery.[43] The plate includes a built-in spacer and is available in two main designs: one with a longer stem (approximately 3 inches long and 1.25 inches wide) and spacers of 10 mm or 12 mm in height, each 5 mm thick. While effective for moderate deformity correction, the Puddu plate has limited utility in cases requiring large angular corrections.[56,57]

Figure 19: Puddu plate

ASSESSMENT OF KNEE OSTEOARTHRITIS

Knee osteoarthritis is a chronic degenerative joint disease characterized by progressive cartilage loss, subchondral bone changes and osteophyte formation, representing one of the leading causes of pain and functional disability worldwide. Comprehensive assessment of knee osteoarthritis is essential for accurate diagnosis, severity grading, treatment planning and monitoring disease progression and therapeutic outcomes. Assessment strategies encompass clinical evaluation, patient-reported outcome measures, radiological imaging and functional performance testing to provide a holistic understanding of disease impact.[58,59] The following sections summarize the key assessment tools and scoring systems used in clinical practice and research.

Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

The WOMAC is the most widely used disease-specific patient-reported outcome measure for assessing pain, stiffness and physical function in knee osteoarthritis. It consists of 24 items divided into three subscales: pain (5 items), stiffness (2 items) and physical function (17 items). Each item is scored on either a five-point Likert scale (0=none to 4=extreme) or a 100mm visual analog scale with higher scores indicating worse symptoms. The maximum total score is 96 points with individual subscale ranges being 0-20 for pain, 0-8 for stiffness and 0-68 for physical function. WOMAC demonstrates excellent test-retest reliability (ICC>0.9) and good concurrent validity with other outcome measures. The minimal clinically important change ranges from 8-10 points for pain, 6-10 points for function and 0.84-1.3 points for stiffness on a 0-100 scale. WOMAC is recommended as the gold standard instrument for evaluating physical function in knee osteoarthritis in both clinical practice and research settings.[60,61]

Knee Injury and Osteoarthritis Outcome Score (KOOS)

The KOOS is a comprehensive, self-administered questionnaire that extends the WOMAC to assess both short-term and long-term outcomes in patients with knee injuries and osteoarthritis.[62] It consists of 42 items across five subscales: pain (9 items), symptoms including stiffness (7 items), activities of daily living (17 items), sport and recreation function (5 items) and knee-related quality of life (4 items). Each subscale is scored separately on a 0-100 scale, where 0 represents extreme knee problems and 100 represents no problems. KOOS takes approximately 10 minutes to complete and has acceptable test-retest reliability (ICC = 0.75-0.93) across subscales, except for sport and recreation which shows ICCs between 0.45-0.65. The minimal clinically important difference ranges from 12-13.5 points for pain, 10-11 points for ADL and 12-16 points for quality of life. KOOS is particularly valuable for younger, more active patients with varying physical activity expectations and is widely validated across multiple populations and languages.[63,64]

Oxford Knee Score (OKS)

The Oxford Knee Score is a 12-item patient-reported questionnaire specifically designed to assess pain and function in patients with knee osteoarthritis. Each item is scored on a five-point scale (0-4) with the total score ranging from 0 to 48 points, where higher scores indicate better outcomes. The OKS demonstrates excellent test-retest reliability (ICC>0.9) and good concurrent validity, correlating strongly with other knee assessment tools including WOMAC and KOOS. The questionnaire is brief, easy to complete and has been extensively validated for use in assessing outcomes following total knee arthroplasty and conservative management of knee osteoarthritis.[65,66]

Kellgren-Lawrence (KL) Grading System

The Kellgren-Lawrence classification is the most widely used radiographic grading system for assessing knee osteoarthritis severity based on plain radiographs. It categorizes disease into five grades: Grade 0 (normal, no radiographic features), Grade 1 (doubtful, possible osteophytic lipping and questionable joint space narrowing), Grade 2 (minimal, definite osteophytes with possible joint space narrowing), Grade 3 (moderate, multiple osteophytes, definite joint space narrowing, some sclerosis and possible deformity) and Grade 4 (severe, large osteophytes, marked joint space narrowing, severe sclerosis and definite bony deformity). The KL grading system demonstrates interobserver reliability ranging from 0.51-0.89. KL grading shows moderate positive correlation with WOMAC pain and function scores, particularly at higher grades and remains the standard for radiographic assessment in clinical trials and epidemiological studies.[67]

MRI Osteoarthritis Knee Score (MOAKS)

The MRI Osteoarthritis Knee Score is a comprehensive semi-quantitative scoring system for assessing multiple joint structures using magnetic resonance imaging. MOAKS evaluates bone marrow lesions, cartilage morphology (partial and full-thickness loss), osteophytes, synovitis-effusion, meniscal damage and extrusion, ligaments, periarticular features and subchondral cysts across 14 articular subregions of the knee. Cartilage loss is scored on a 0-3 scale based on the percentage of surface area affected (0=none, 1=<10%, 2=10-75%, 3=>75%) with separate assessment for any thickness loss and full-thickness loss. MOAKS demonstrates moderate correlation with clinical symptoms, particularly for full-thickness cartilage loss at the medial femorotibial joint which correlates with WOMAC pain scores. MOAKS is considered a reliable, comprehensive tool for detecting early structural changes before they become visible on plain radiographs and for monitoring disease progression in research studies.[68]

Knee Society Scoring System (KSSS)

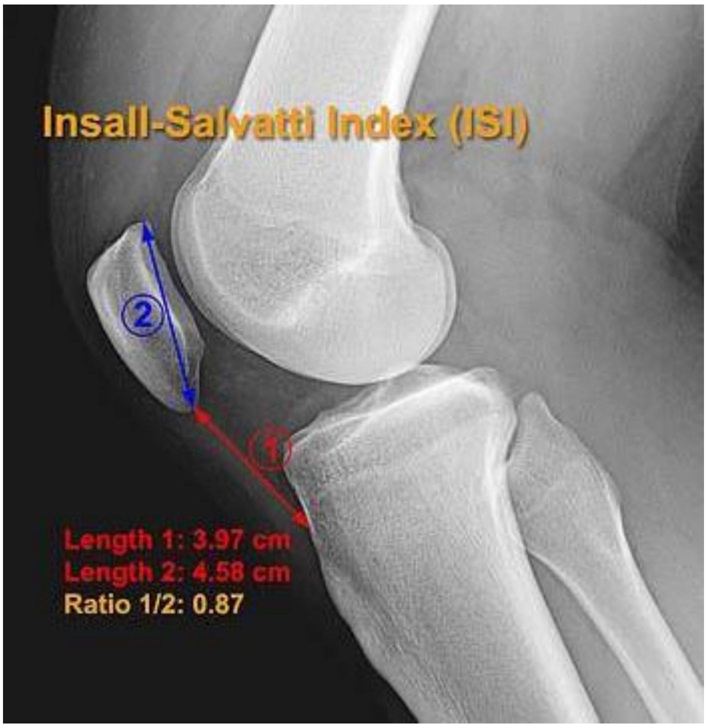
The Knee Society Scoring System is an objective assessment tool developed to evaluate knee and patient functional abilities before and after total knee arthroplasty in osteoarthritis patients. It consists of two portions, each scored from 0-100 points: (1) the clinician-rated Knee Score evaluating pain, range of motion, flexion deformities, contractures, alignment and stability in anteroposterior and mediolateral planes and (2) the patient-reported Function Score assessing mobility (walking distance and stair climbing) and use of walking aids. Higher scores indicate better outcomes and the dual-component structure allows separate assessment of the surgical procedure's technical success (Knee Score) and the patient's functional capabilities (Function Score). The KSSS is widely used in orthopedic practice for standardized documentation and comparison of knee arthroplasty outcomes.[69]

Insall-Salvati Ratio

The Insall-Salvati Ratio (ISR) is the most widely used radiological index for assessing patellar height, calculated by dividing the patellar tendon length by the maximum patellar length.[70,71]

$$\text{ISR} = \frac{\text{Patellar Tendon Length (TL)}}{\text{Patellar Length (PL)}}$$

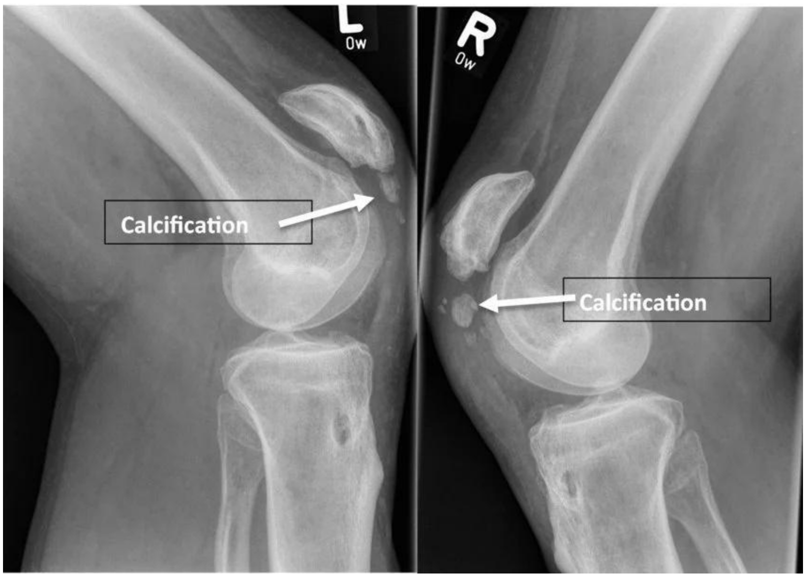
- TL = length of the posterior surface of the patellar tendon from the inferior pole of the patella to its insertion on the tibial tuberosity
- PL = maximum diagonal distance between the superior and inferior poles of the patella



Source: https://radsource.us/wp-content/uploads/2010/08/3a.jpg

Measurement Technique

The ISR is measured on a lateral knee X-ray or sagittal MRI with the knee flexed at 30°, as this provides the appropriate patellar tendon tension for an accurate reading. It is the most reliable patellar height method on both conventional radiographs and CT with good intra- and inter-observer reliability across all imaging modalities.



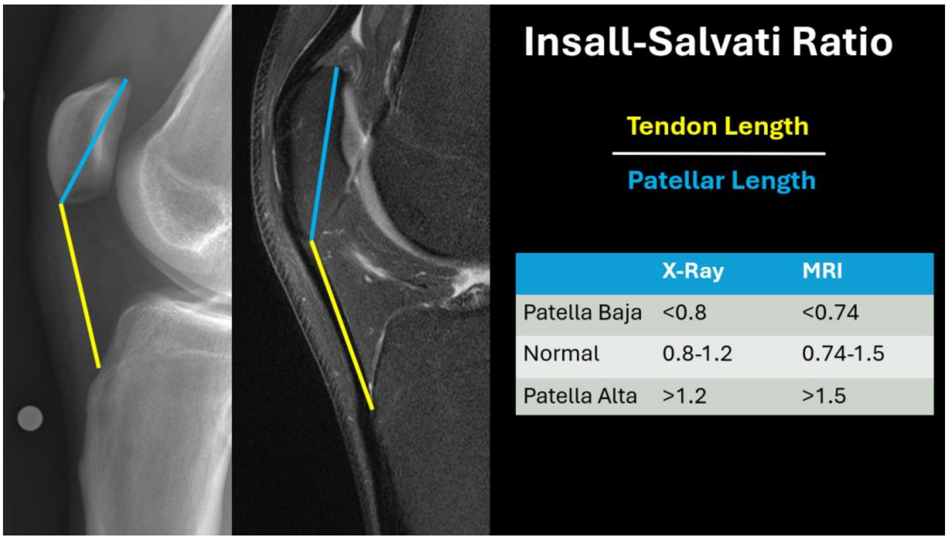
Source: https://www.researchgate.net/publication/331941198/figure/fig1/AS:960296487243809@1605963932384/Lateral-X-ray-in-30-degrees-flexion-on-the-left-knee-and-right-knee-showing-subpatellar.jpg

Interpretation

Finding	ISR Value	Interpretation
Patella Baja	< 0.8	Low-riding patella
Normal	0.8 - 1.2	Normal patellar height
Patella Alta	> 1.2	High-riding patella

Clinical Significance

- Patella alta is associated with patellar instability, chondromalacia and increased ACL tear risk - one study found the ISR was significantly higher (1.16 ± 0.16) in children with ACL tears versus controls (0.99 ± 0.14)
- Patella baja is commonly seen post-total knee arthroplasty or following patellar tendon shortening and can cause anterior knee pain and restricted flexion
- Patella alta and baja together affect an estimated 1-2% of the world population, but are often underreported.[72]



Source: https://radshare.net/storage/1942/image.png

Modified ISR

The Modified Insall-Salvati Ratio (MISR) was proposed to reduce errors arising from unusual patellar shapes - it uses the articular surface length of the patella (rather than total patellar length) in the denominator. However, studies confirm the original ISR has better intra- and inter-observer reliability than the modified version.[71]

RELATED LITERATURE

Kalichman et al. (2007) investigated the relationship between patellofemoral (PF) alignment and knee pain and function using standard magnetic resonance imaging (MRI) scans of extended knees from participants in the Boston Osteoarthritis of the Knee Study (BOKS), a longitudinal study on symptomatic knee osteoarthritis. Patellar alignment parameters in both sagittal and transverse planes were analyzed in relation to pain and function scores from the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Linear regression models were applied, adjusting for potential confounders including age, sex, body mass index (BMI), depression scores from the Center for Epidemiologic Studies Depression Scale (CES-D) and Kellgren-Lawrence radiographic grading. The results indicated that an increased trochlear angle (TA) was associated with higher WOMAC pain scores (P = 0.06) and greater functional impairment (WOMAC function subscale, P = 0.04). Furthermore, higher lateral patellar tilt angle (LPTA) and reduced bisect offset indicating greater lateral patellar subluxation showed trends toward associations with increased pain, though these did not reach strong statistical significance. No significant associations were identified between other alignment parameters and either pain or function. The study concluded that greater trochlear angle correlates with functional decline in patients with knee osteoarthritis, while other measures of PF malalignment were not strongly linked to pain or disability.[73]

Becker R et al. (2008) evaluated the outcomes of combined partial lateral facetectomy, lateral release and tibial tubercle medialization in 51 knees from 50 patients diagnosed with isolated patellofemoral osteoarthritis. The patients, aged between 46 and 81 years with a mean age of 60.1 years, were followed for a minimum of 7 months (mean 20.2 months). Preoperative radiographs indicated Ahlbäck Grade III or IV lateral patellofemoral joint space narrowing. Clinical assessment was conducted using the WOMAC and McCarroll scores, while radiographic evaluation included posteroanterior flexion weightbearing, lateral and 45° axial views. The WOMAC results demonstrated significant improvement with pain scores increasing by 2.34 points and functional scores by 1.63 points postoperatively. Additionally, the Insall-Salvati index showed a notable decrease, although it remained within the normal range. Most patients reported symptomatic relief in the patellofemoral joint; however, overall clinical outcomes were not superior to other surgical options. Given the limited follow-up duration, the authors concluded that this combined surgical approach should be used cautiously and not routinely recommended until long-term results confirm its efficacy.[74]

Tanamas et al. (2010) conducted a cross-sectional study to explore how patellofemoral geometry specifically patella inclination, sulcus angle and patella height relates to knee pain and patellar cartilage volume. The study involved 240 community-based adults aged 25-60 years who were part of a larger investigation into obesity and musculoskeletal health. Magnetic resonance imaging (MRI) of each participant's dominant knee was used to measure the lateral condyle-patella angle, sulcus angle and Insall-Salvati ratio, along with patellar cartilage and bone volumes. Pain levels were evaluated using the WOMAC Visual Analogue (VA) pain subscale. Findings indicated that a greater lateral condyle-patella angle, reflecting increased medial patellar inclination, was linked to reduced WOMAC pain scores (regression coefficient −1.57, 95% CI −3.05 to −0.09) and increased medial patellar cartilage volume (regression coefficient 51.38 mm^3, 95% CI 1.68 to 101.08 mm^3). Conversely, a higher-riding patella, shown by a higher Insall-Salvati ratio, corresponded with decreased medial patellar cartilage volume (regression coefficient −3187 mm^3, 95% CI −5510 to −864 mm^3). There was also a trend suggesting that a shallower sulcus angle might be associated with increased lateral cartilage volume (regression coefficient 43.27 mm^3, 95% CI −2.43 to 88.98 mm^3). Overall, the study concluded that a more medially inclined patella is associated with both structural and symptomatic benefits, whereas a high-riding patella may contribute to cartilage deterioration, reinforcing the rationale for corrective interventions promoting medial patella alignment.[75]

Tsavalas et al. (2012) conducted a retrospective study involving 650 knee MRI scans from 622 patients to assess patellofemoral congruency measurements and their relationship with the severity of ipsilateral osteoarthritis (OA). Participants were categorized into two age groups: 50 years or younger and over 50 years. The study revealed significant differences in several MRI-based parameters-sulcus angle (SA), sulcus depth (SD), lateral patellar displacement (LPD) and lateral patellofemoral angle (LPFA) between normal knees and those affected by patellofemoral OA in both age categories (p-values ranging from 0.0002 to <0.0001). Furthermore, the severity of cartilage defects showed significant correlations with these same measures: SA (rho = 0.21, p = 0.0001; rho = 0.443, p < 0.0001), SD (rho = −0.198, p = 0.0003; rho = −0.418, p<0.0001), LPD (rho = 0.176, p = 0.0013; rho = 0.251, p = 0.0002) and LPFA (rho = −0.204, p = 0.0002; rho = −0.239, p = 0.0005) across both age groups. The findings demonstrated that anterior malalignment of the knee joint, reflected in abnormal patellofemoral congruence parameters, is significantly associated with the presence and severity of patellofemoral osteoarthritis.[76]

Kiswati et al. (2016) conducted an observational analytic study using a cross-sectional and consecutive sampling design to explore the relationship between osteoarthritis (OA) grading in the femoropatellar joint, patellar malalignment and their association with pain and disability assessed through the WOMAC score. The analysis involved correlating the WOMAC score with Kellgren-Lawrence OA grading and joint space narrowing using Spearman's rank correlation, while differences in WOMAC scores related to patellar malalignment were examined using a t-test. The results indicated significant positive correlations between OA grading and WOMAC scores in various radiographic views: AP/LAT/Skyline (r = 0.488, p = 0.003), AP/LAT (r = 0.452, p = 0.006) and AP/Skyline (r = 0.362, p = 0.033). A significant correlation was also found between WOMAC scores and femoropatellar joint space narrowing (r = 0.370, p = 0.026). However, the t-test showed no significant difference in WOMAC scores between individuals with and without patellar malalignment (p = 0.711 and p = 0.751, respectively). The study concluded that OA severity in different radiographic positions and femoropatellar joint space narrowing were significantly associated with pain and disability, while patellar malalignment did not significantly affect WOMAC outcomes.[77]

Haj-Mirzaian et al. (2019) investigated the relationship between the Insall-Salvati ratio (ISR), an indicator of patella alta and the progression of MRI-detected osteoarthritis (OA)-related structural damage in the patellofemoral joint over a 24-month period using data from the Osteoarthritis Initiative (OAI). Through weighted random sampling, 500 knees were selected from an initial pool of 1,677. The longitudinal analysis revealed that a higher baseline ISR was significantly associated with worsening of bone marrow lesions (BML) (odds ratio [OR] 11.18, 95% CI 3.35-39.6, adjusted p < 0.001) and cartilage damage (OR 7.39, 95% CI 1.62-34.71, adjusted p = 0.042) in the lateral patella over 24 months. However, no significant associations were found between ISR and the progression of BML or cartilage damage in the medial patella or the medial and lateral trochlea. The study identified an optimal ISR cutoff value of ≥1.14 (95% CI 1.083-1.284) for predicting worsening lateral patellofemoral structural damage with a sensitivity of 73.73% and specificity of 66.67%. Despite some uncertainty in the findings, the results suggest that ISR may serve as a useful predictive marker for progressive lateral patellofemoral OA-related structural deterioration based on sagittal knee MRI assessments.[78]

Yuan et al. (2019) conducted a double-blind, prospective study to compare patellofemoral function, clinical outcomes and radiographic parameters between freehand and cutting guide patellar resection techniques in patients undergoing total knee arthroplasty (TKA). The study included 100 patients, each receiving a single TKA and they were randomly assigned to either technique group. The participants were followed for an average of 28 months (range 18-38 months) with 14% lost to follow-up. The findings revealed no significant differences between the two groups in the incidence of anterior knee pain, need for revision surgery, or key functional and clinical outcomes measured by the Knee Society clinical rating system, the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), patient satisfaction, physical examination results, or performance on the 30-second stair-climbing test. Radiographic assessments also showed no differences in the hip-knee-ankle angle, lateral patellar displacement, or Insall-Salvati ratio. However, a significantly greater number of outliers with lateral patellar tilt exceeding 10° was observed in the freehand group compared to the cutting guide group (p = 0.036), though mean tilt values were not significantly different. Additionally, demographic and preoperative factors such as age, sex, body mass index, preoperative Knee Society scores and range of motion were not linked to postoperative anterior knee pain. Overall, the study concluded that both resection techniques produced equivalent outcomes in terms of patellofemoral function, clinical performance and radiographic measures, although the cutting guide technique demonstrated fewer cases of excessive lateral patellar tilt.[79]

Verhulst et al. (2020) conducted a study to assess the intra- and interrater reliability of various patellar height measurement techniques across conventional radiography (CR), computed tomography (CT) and magnetic resonance imaging (MRI) and to evaluate whether methods originally developed for CR could be effectively applied to CT and MRI. The research included 48 patients treated for patellar instability. Among the evaluated methods, the Insall-Salvati (IS) ratio demonstrated consistently good intra- and inter-observer reliability across all imaging modalities-CR, CT and MRI. The patellotrochlear index (PTI) also showed good to excellent reliability on MRI for all observers. When comparing results across modalities, the IS ratio displayed moderate to good reliability with the strongest agreement between radiography and MRI. In contrast, other methods, such as the Blackburne-Peel ratio, Caton-Deschamps ratio and modified Insall-Salvati ratio showed only poor to moderate inter-method consistency. The study concluded that the IS ratio is the most reliable approach for determining patellar height across imaging techniques, particularly on CR and CT, while the PTI is the most dependable measurement on MRI. Importantly, the findings indicated that normal IS ratio reference values established for radiography can also be appropriately applied to MRI evaluations.[80]

Aguirre-Pastor et al. (2020) conducted a prospective study to examine the incidence and clinical impact of postoperative patella baja (PPB) following primary total knee arthroplasty (TKA) in a large patient cohort with at least two years of follow-up. The study included 354 patients with a mean age of 71.7 years (range 52-87), assessed using the Knee Society Scores (KSS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the 12-item Short Form Health Survey (SF-12) and range of motion (ROM) evaluations. Patellar height was measured using the Insall-Salvati and Blackburne-Peel ratios. After an average follow-up of 3.6 years (range 2.0-6.6), 286 patients (80.7%) exhibited normal patellar height, 51 (14.4%) had PPB and 17 (4.8%) had true patella baja (TPB). Comparative analysis showed no significant differences among the three groups in KSS-function (P = .107), ROM (P = .408), WOMAC-pain (P = .095), WOMAC-stiffness (P = .279), or SF12-mental (P = .363). Similarly, no significant differences were observed between the normal and PPB groups for KSS-knee (P = .903), WOMAC-function (P = .294), or SF12-physical (P = .940). However, patients with TPB had significantly lower KSS-knee (P = .031), WOMAC-function (P

= .018) and SF12-physical (P = .005) scores compared to the other groups. The study concluded that while PPB commonly occurs after TKA, it does not significantly affect clinical outcomes, whereas true patella baja, though rare is associated with notably poorer postoperative function and physical health scores.[81]

Analan et al. (2021) investigated how the Insall-Salvati Index (ISI) relates to pain, physical performance, muscle strength, fall risk and postural stability in patients with primary knee osteoarthritis (OA). The retrospective study included 62 symptomatic knees from 45 patients aged 40-75 years who met the American College of Rheumatology criteria for primary knee OA with radiographic stages II and III according to the Kellgren-Lawrence classification. ISI was measured on lateral knee radiographs taken in 30° flexion. Pain and function were assessed using the Visual Analogue Scale (VAS), WOMAC and Lequesne indices, while fall risk and postural stability were evaluated through the Tetrax Interactive Balance System. Quadriceps and hamstring strength were measured isokinetically at angular velocities of 60°/s and 180°/s. The participants had a mean age of 58.52 ± 8.01 years with patellar positions distributed as 24.2% patella alta, 3.2% patella baja and 72.6% normal height. The average ISI was 1.19 ± 0.17 on the right and 1.18 ± 0.16 on the left. No significant correlations were found between ISI and VAS, WOMAC, Lequesne scores, postural stability, or muscle strength ($r < 0.3$, $p > 0.05$). The study concluded that ISI does not appear to influence pain levels, physical functioning, fall risk, postural balance, or muscle strength in individuals with primary knee OA.[82]

Yoon et al. (2022) investigated whether the quadriceps muscle area influenced patellofemoral (PF) cartilage condition and clinical outcomes in patients undergoing total knee arthroplasty (TKA). The study included 204 patients whose PF cartilage status was assessed intraoperatively, while quadriceps muscle thickness and area were measured preoperatively using knee computed tomography (CT). Additional radiographic evaluations included the Q-angle, hip-knee-ankle (HKA) angle, limb alignment and Insall-Salvati ratio. Logistic regression analysis identified factors related to PF cartilage lesions with the overall model reaching statistical significance (Hosmer-Lemeshow $\chi^2 = 0.493$). Results revealed that a smaller HKA angle was significantly associated with a higher incidence of PF cartilage damage (p = 0.033), while alignment was the only factor influencing these lesions. However, PF cartilage condition showed no correlation with clinical outcome scores. Notably, a thicker medial quadriceps muscle was significantly associated with higher Knee Society Knee Scores (KSKS) (p = 0.028), suggesting better knee function. The study concluded that while quadriceps thickness, Q-angle and patellar height were not linked to PF cartilage lesions, reduced HKA angles were associated with their occurrence. Moreover, PF cartilage damage did not affect clinical symptoms, but greater medial quadriceps muscle thickness corresponded with improved functional outcomes.[83]

Zhou et al. (2023) conducted a retrospective study to evaluate how varying degrees of valgus deformity correction influence patellar position and postoperative outcomes in patients with valgus knees undergoing total knee arthroplasty (TKA). The study followed 118 patients who were categorized into three groups based on postoperative hip-knee-ankle (HKA) alignment: neutral (±3°), mild (3-6°) and severe (>6°) valgus. Postoperative clinical efficacy was assessed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), range of motion (ROM) and Knee Society Score (KSS), while patellar positioning was evaluated through the patellar tilt angle (ε-angle), congruence angle (θ-angle) and Insall-

Salvati index (ISI). Results showed significant postoperative improvements in HKA, ROM, WOMAC and KSS across all groups (P<0.001). The ISI values decreased modestly after surgery (P<0.05), indicating slight changes in patellar height. However, the patellar tilt angle was notably higher in the severe valgus group than in the mild and neutral groups (P < 0.001), suggesting impaired patellar alignment. Univariate analysis further revealed that residual valgus deformity significantly influenced WOMAC, KSS and patellar alignment parameters (α-, ε- and θ-angles). The study concluded that mild undercorrection of valgus deformity does not adversely affect short-term functional outcomes after TKA, but excessive residual valgus (>6°) is associated with reduced clinical scores and increased risk of abnormal patellar tracking, even though patellar height remains largely unaffected.[84]

Lingaraju K et al. (2024) conducted a prospective observational study to assess the functional outcomes of posterior stabilised total knee arthroplasty using the WOMAC index in patients aged 30-70 years with severe osteoarthritis or rheumatoid arthritis. The study included 14 patients (5 males and 9 females) treated over a period of two years (2022-2024) with follow-up evaluations at 1, 3, 6 and 12 months. Functional outcomes were measured using the WOMAC index, which showed a marked improvement after surgery with the mean score increasing from 54.00±7.67 preoperatively to 89.65±0.95 at 6 weeks, 91.56±1.03 at 3 months, 94.36±1.03 at 6 months and 95.70±0.95 at later follow-up and this improvement was statistically significant compared to baseline values. All patients demonstrated excellent outcomes based on WOMAC scoring, indicating substantial improvement in pain relief, joint function and activities of daily living. The study concluded that posterior stabilised total knee arthroplasty is highly effective in improving functional status and overall quality of life, making it a valuable treatment option for patients suffering from knee pain and disability.[85]

Barahona M et al. (2024) aimed to determine specific cutoff values for clinical scoring systems including the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Kujala score and Knee Injury and Osteoarthritis Outcome Score-Quality of Life (KOOS-QL) that could predict the likelihood of treatment success or failure in improving patient-reported quality of life following cruciate-retaining total knee arthroplasty without patellar replacement. The study analyzed 161 successful evaluations and identified threshold values indicating improvement success as <4 for WOMAC-Pain, <1 for WOMAC-Stiffness, <15 for WOMAC-Function, >70 for Kujala score and >62 for KOOS-QL, whereas higher chances of failure were associated with values >7 for WOMAC-Pain, >3 for WOMAC-Stiffness, >26 for WOMAC-Function, <55 for Kujala score and <41 for KOOS-QL. The findings demonstrated that these cutoff points have good to excellent discriminatory ability in distinguishing successful from unsuccessful outcomes. Overall, the study concluded that these validated thresholds can be effectively used for estimating sample sizes in research and for comparing postoperative quality of life outcomes in patients undergoing total knee arthroplast.[86]

Yang Z et al. (2025) conducted a study to evaluate the relationship between the severity of knee osteoarthritis and patellofemoral alignment along with patellar height using radiographic parameters in 534 adult outpatients, including 339 (63%) females with a total of 586 knees analyzed. The findings demonstrated that increasing age had a significant positive correlation with the severity of knee osteoarthritis (r = 0.516, P

<0.01), while lateral patellar tilt angle (LPTA) showed a strong negative correlation (r = -0.662, P <0.01). In contrast, sulcus angle (SA) (r = 0.616, P <0.05) and tibial tuberosity-trochlear groove (TT-TG) distance (r = 0.770, P <0.01) were positively correlated with the severity of tibiofemoral osteoarthritis. Further multiple linear regression analysis revealed that osteoarthritis severity (β = -2.946, P <0.001) and side (β = -0.839, P = 0.001) were significantly associated with LPTA; osteoarthritis severity (β = 5.032, P <0.001) and age (β = -0.095, P <0.001) were associated with SA; and osteoarthritis severity (β = 2.445, P <0.001), sex (β = -0.326, P = 0.041), body mass index (β = -0.061, P = 0.017) and age (β = -0.025, P <0.001) were associated with TT-TG. Overall, the study concluded that the radiological severity of knee osteoarthritis increases with age, sulcus angle and TT-TG distance, while it decreases with increasing LPTA, indicating a significant association between patellofemoral alignment parameters and disease severity.[87]

Halmandge AM et al. (2025) conducted a hospital-based cross-sectional study to evaluate MRI findings using MOAKS scoring in knee osteoarthritis and to correlate these findings with WOMAC scores and Kellgren-Lawrence grading system. A total of 40 patients with knee osteoarthritis underwent MRI evaluation and MOAKS scoring was compared with radiographic grading and clinical assessment. The results showed that the mean total WOMAC score was 9 with K-L grade 2 being the most commonly observed radiographic grade. Bone marrow lesions and cartilage loss were more prominent in the medial femorotibial compartment. There was a moderate positive correlation between WOMAC score and K-L grade, as well as between WOMAC score and full-thickness cartilage loss at the medial femorotibial joint and between WOMAC pain score and partial-thickness cartilage loss at the lateral femorotibial joint. However, no significant correlation was found between bone marrow lesions and pain severity. Overall, the study concluded that higher WOMAC scores were associated with higher K-L grades and greater cartilage loss on MOAKS scoring, whereas other MOAKS parameters such as bone marrow lesions, osteophytes and synovitis did not show a significant association with pain severity or radiographic grading.[88]

MATERIALS AND METHODS

STUDY DESIGN: It is a cross-sectional study.

STUDY AREA: The study was conducted in the Department of Orthopaedics, National Institute of Medical Science and Research, Jaipur.

STUDY PERIOD: 18 months

SAMPLE SIZE: Sample size was calculated using following formula -

$$\eta = \frac{z^2{}_{\alpha/2} * p * (1-p)}{d^2}$$

$$= \frac{1.96^2 * (0.2) \quad * (1-0.2)}{(0.1)^2}$$

= 61.5 ≅ 62 Samples.

Where,

$z_{\alpha/2}$: inverse probability of normal distance at 95% confidence interval

p : prevalence rate 22% to 39%.

d :Margin of error (10% considered)

SAMPLING TECHNIQUE: Purposive sampling technique

SELECTION CRITERIA:

INCLUSION CRITERIA:

1. Patients aged 40 years and above of either sex.
2. Established diagnosis of patellofemoral pain based on physical examination and history.
3. Patient willing to participate in study.

EXCLUSION CRITERIA:

1. Previous knee injury or surgery.
2. History of rheumatoid arthritis or any other autoimmune disorder.
3. Participants with other types of arthritis (e.g., gout, psoriatic arthritis).
4. Neurological conditions that affect the lower extremities.

METHODOLOGY AND TECHNIQUE

The present study was conducted among patients diagnosed with knee osteoarthritis who were recruited from orthopaedic outpatient clinics and associated hospitals. The diagnosis of knee osteoarthritis was established based on clinical findings and relevant radiological evidence. All participants were included according to predefined inclusion and exclusion criteria after obtaining informed consent. A detailed clinical evaluation was performed for each patient, which included comprehensive history taking regarding pain duration, severity, functional limitation and associated comorbidities, followed by a thorough physical examination of the knee joint. The study was designed to systematically evaluate the relationship between patellar tendon length and the clinical severity of knee osteoarthritis.

Radiological assessment was carried out using standard lateral radiographs of the knee joint taken at 30° of flexion for all participants. This standardized positioning was maintained to ensure consistency and reproducibility of measurements across all subjects. The imaging focused on identifying specific anatomical landmarks, including the lower pole of the patella and the tibial tuberosity. The patellar tendon length was measured as the linear distance between these two landmarks. All measurements were obtained using calibrated radiographic tools and standardized techniques to minimize inter-observer and intra-observer variability. Care was taken to ensure proper patient positioning and image clarity to enhance the accuracy of measurements and reliability of results.

WOMAC SCORE ASSESSMENT

Functional assessment of disease severity was performed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) questionnaire, a validated and widely accepted tool for evaluating knee osteoarthritis. The questionnaire was administered to all participants in a structured manner. It assessed three major domains: pain, stiffness and physical function. The pain component evaluated the intensity of discomfort during various activities, stiffness assessed joint rigidity particularly after periods of inactivity and functional assessment focused on the ability to perform daily activities such as walking, climbing stairs and sitting. Each response was scored according to the standardized WOMAC scale and the total score as well as individual subscale scores were calculated. Higher scores indicated greater severity of symptoms and functional impairment.

STATISTICAL ANALYSIS

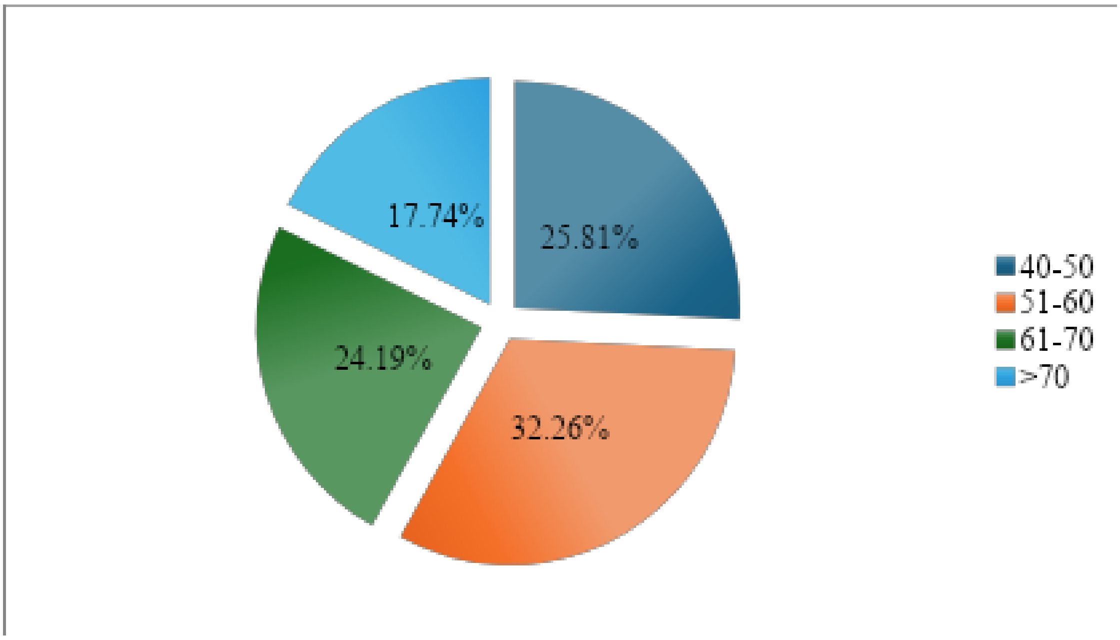
Statistical analysis was performed to determine the relationship between patellar tendon length variation and the severity of knee osteoarthritis. The collected data were compiled, coded and analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Pearson's correlation coefficient was applied to assess the strength and direction of the relationship between patellar tendon length and overall WOMAC scores. Additionally, subgroup analysis was carried out to evaluate the association between patellar tendon length variation and individual WOMAC subscales, including pain, stiffness and functional limitation. These analyses provided a detailed understanding of whether structural variations in the patellar tendon were significantly associated with specific clinical features and overall disease severity in patients with knee osteoarthritis.

RESULTS

Table 1: Age-wise distribution

Age Group	No.	Percentage
40-50	16	25.81%
51-60	20	32.26%
61-70	15	24.19%
>70	11	17.74%
Total	**62**	**100.00%**
Mean±SD	**58.23±11.218**	

The age-wise distribution of study participants showed that the majority of patients belonged to the 51–60 years age group, accounting for 32.26% (n=20), followed by the 40–50 years group at 25.81% (n=16) and 61–70 years at 24.19% (n=15). Patients aged more than 70 years constituted 17.74% (n=11) of the study population. The mean age of participants was 58.23±11.218 years, indicating that osteoarthritis of the knee was more prevalent among middle-aged and elderly individuals with a peak incidence in the sixth decade of life.

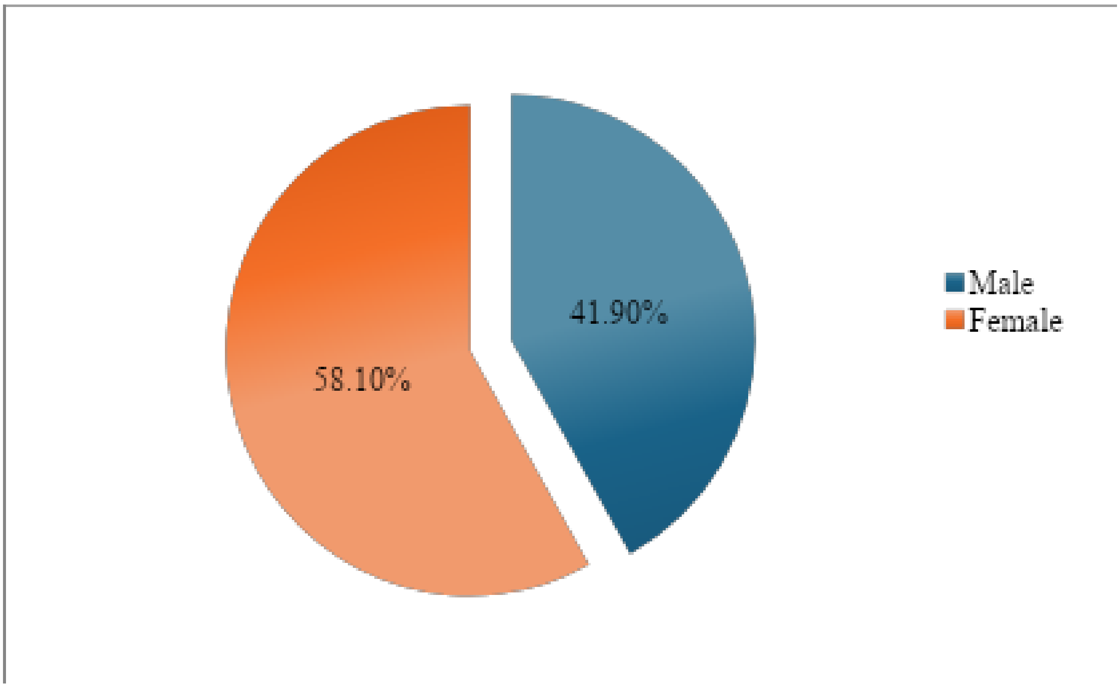


Graph 1: Age-wise distribution

Table 2: Gender-wise distribution

Gender	No.	Percentage
Male	28	41.9%
Female	36	58.1%
Total	**62**	**100.0%**

The gender distribution revealed a higher proportion of females compared to males in the study population. Females constituted 58.1% (n=36), while males accounted for 41.9% (n=28). This indicates a female predominance in osteoarthritis knee cases, suggesting that women are more commonly affected than men in this study cohort.

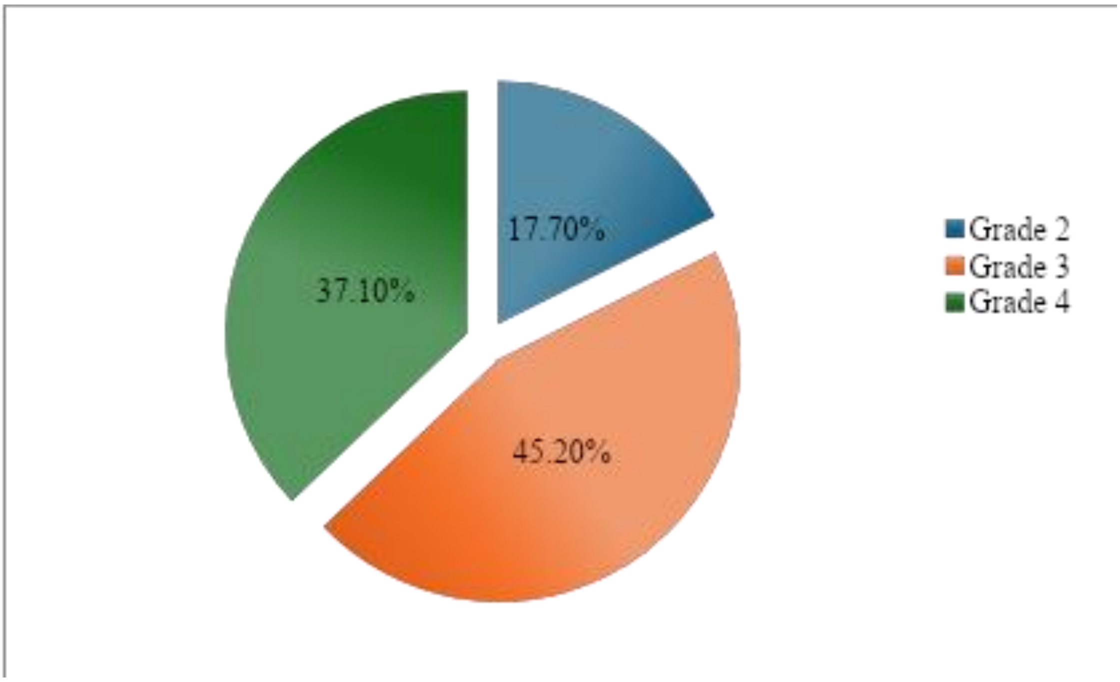


Graph 2: Gender-wise distribution

Table 3: Kellgren-Lawrence Grading

KL Grading	No.	Percentage
Grade 2	11	17.7%
Grade 3	28	45.2%
Grade 4	23	37.1%
Total	**62**	**100.0%**

The distribution of Kellgren-Lawrence (KL) grading showed that the majority of patients had Grade 3 osteoarthritis, comprising 45.2% (n=28), followed by Grade 4 at 37.1% (n=23) and Grade 2 at 17.7% (n=11). This indicates that most patients presented with moderate to severe osteoarthritis with a significant proportion already in advanced stages of disease at the time of evaluation.

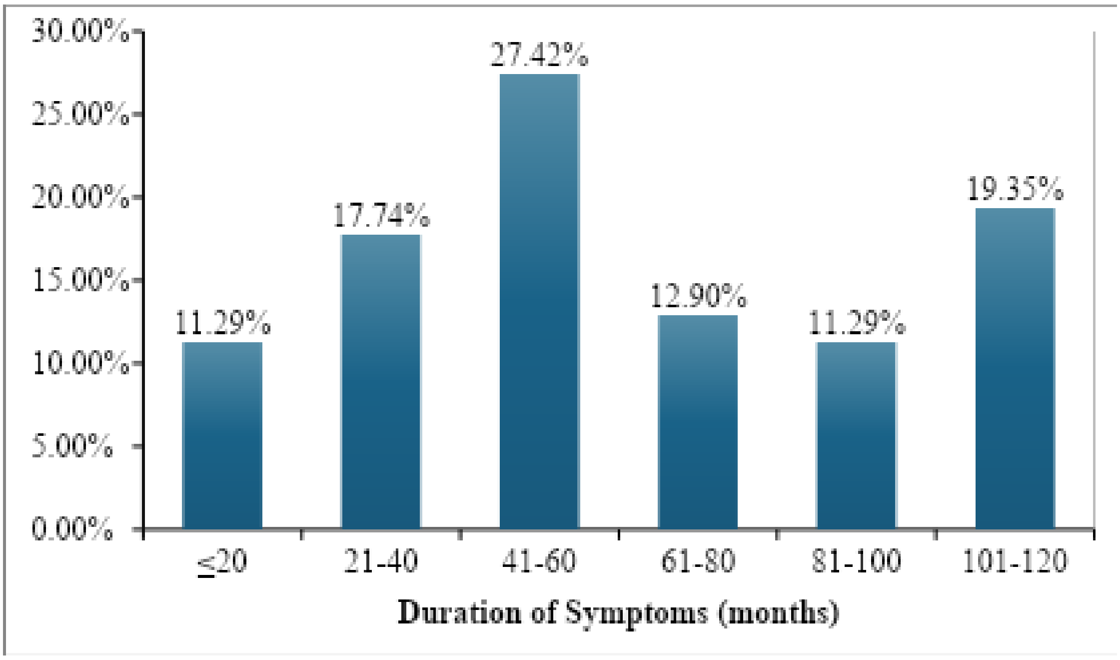


Graph 3: Kellgren-Lawrence Grading

Table 4: Duration of Symptoms

Duration of Symptoms (months)	No.	Percentage
≤20	7	11.29%
21-40	11	17.74%
41-60	17	27.42%
61-80	8	12.90%
81-100	7	11.29%
101-120	12	19.35%
Total	**62**	**100.00%**
Mean±SD	**62.00±32.044**	

The distribution of duration of symptoms showed that the largest proportion of patients had symptoms for 41–60 months, accounting for 27.42% (n=17), followed by 101–120 months at 19.35% (n=12) and 21–40 months at 17.74% (n=11). A smaller proportion of patients had shorter duration ≤20 months and 81–100 months, each comprising 11.29% (n=7), while 61–80 months accounted for 12.90% (n=8). The mean duration of symptoms was 62.00±32.044 months, indicating that most patients had long-standing disease before presentation, reflecting the chronic and progressive nature of osteoarthritis.

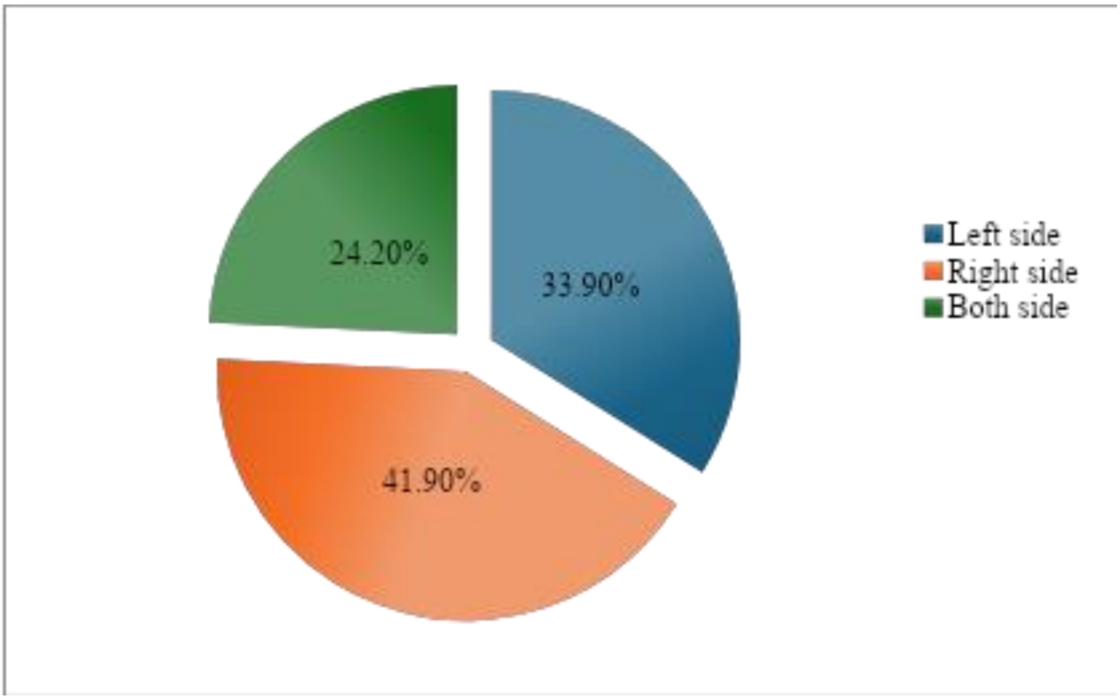


Graph 4: Duration of Symptoms

Table 5: Side of Affected Knee

Side of Affected Knee	No.	Percentage
Left side	21	33.9%
Right side	26	41.9%
Both side	15	24.2%
Total	**62**	**100.0%**

The distribution of the side of the affected knee revealed that the right knee was more commonly involved, seen in 41.9% (n=26) of patients, followed by left knee involvement in 33.9% (n=21). Bilateral involvement was observed in 24.2% (n=15) of cases. This suggests that unilateral involvement, particularly of the right knee, was more frequent, although a considerable proportion of patients had disease affecting both knees.

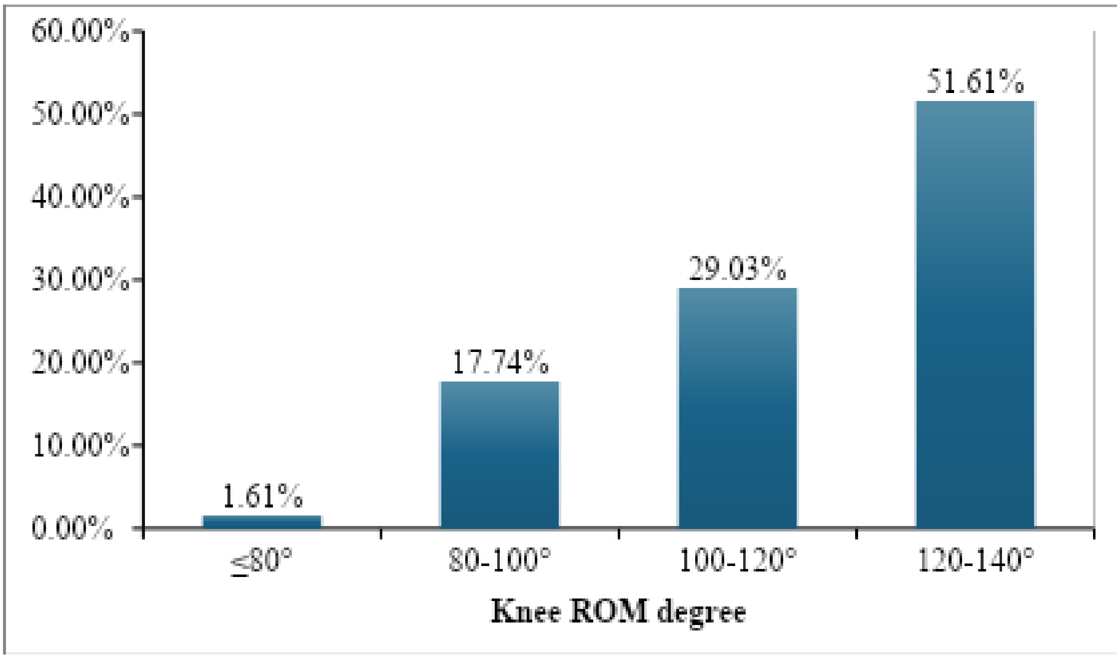


Graph 5: Side of Affected Knee

Table 6: Knee ROM degree

Knee ROM degree	No.	Percentage
≤80°	1	1.61%
80-100°	11	17.74%
100-120°	18	29.03%
120-140°	32	51.61%
Total	**62**	**100.00%**
Mean±SD	**118.345±19.534**	

The assessment of knee range of motion demonstrated that more than half of the patients (51.61%, n=32) had a ROM between 120–140°, followed by 29.03% (n=18) with ROM between 100–120°. A smaller proportion had reduced ROM of 80–100° (17.74%, n=11), while only 1.61% (n=1) had severely restricted ROM ≤80°. The mean ROM was 118.345±19.534 degrees, indicating that although many patients retained relatively good joint mobility, a subset exhibited moderate to severe restriction, consistent with varying severity of osteoarthritis.

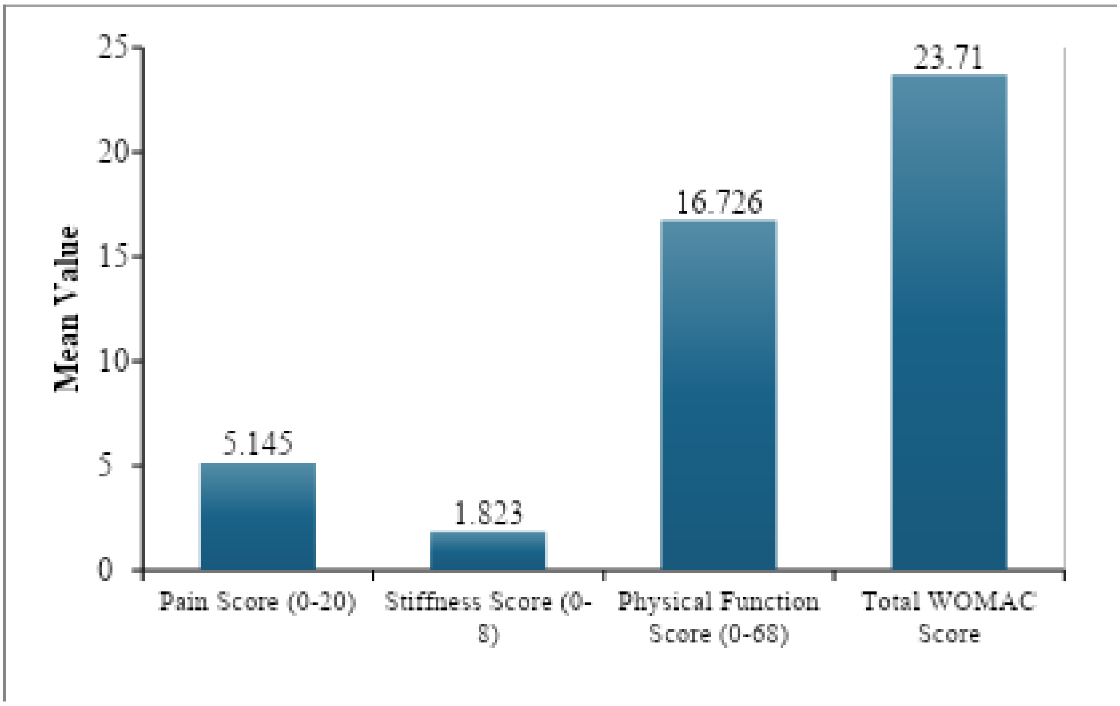


Graph 6: Knee ROM degree

Table 7: Mean WOMAC Score

WOMAC Score	Mean	Std. Deviation	p-value
Pain Score (0-20)	5.145	2.4148	<0.001
Stiffness Score (0-8)	1.823	.9671	
Physical Function Score (0-68)	16.726	7.1131	
Total WOMAC Score	23.710	10.1665	

The mean WOMAC scores indicated that the average pain score was 5.145±2.4148 (out of 20), suggesting mild to moderate pain among the study participants and this was statistically highly significant ($p<0.001$). The mean stiffness score was 1.823±0.9671 (out of 8), indicating relatively low levels of stiffness. The mean physical function score was 16.726±7.1131 (out of 68), reflecting a moderate degree of functional limitation in daily activities. The overall mean total WOMAC score was 23.710±10.1665, demonstrating a moderate burden of symptoms and disability among patients with osteoarthritis knee.



Graph 7: Mean WOMAC Score

Table 8: Correlation between Patella Tendon Length with WOMAC Scores

	Pearson Correlation (r)	p-value
WOMAC Pain score	-0.206	0.107
WOMAN Stiffness	-0.145	0.261
WOMAC Physical function score	-0.227	0.076
Total WOMAC Score	-0.266	0.036*

* Significant (p<0.05)

The correlation analysis between patella tendon length and WOMAC scores showed a weak negative correlation with all components of the WOMAC index. The correlation with pain score was r = -0.206 (p=0.107), stiffness score was r = -0.145 (p=0.261) and physical function score was r = -0.227 (p=0.076), all of which were not statistically significant. However, the total WOMAC score showed a weak negative but statistically significant correlation (r = -0.266, p=0.036), indicating that as patella tendon length increased, the overall WOMAC score tended to decrease slightly, suggesting a modest association between longer tendon length and better clinical outcomes.

Table 9: Correlation between Patella Tendon Length with KL Grading

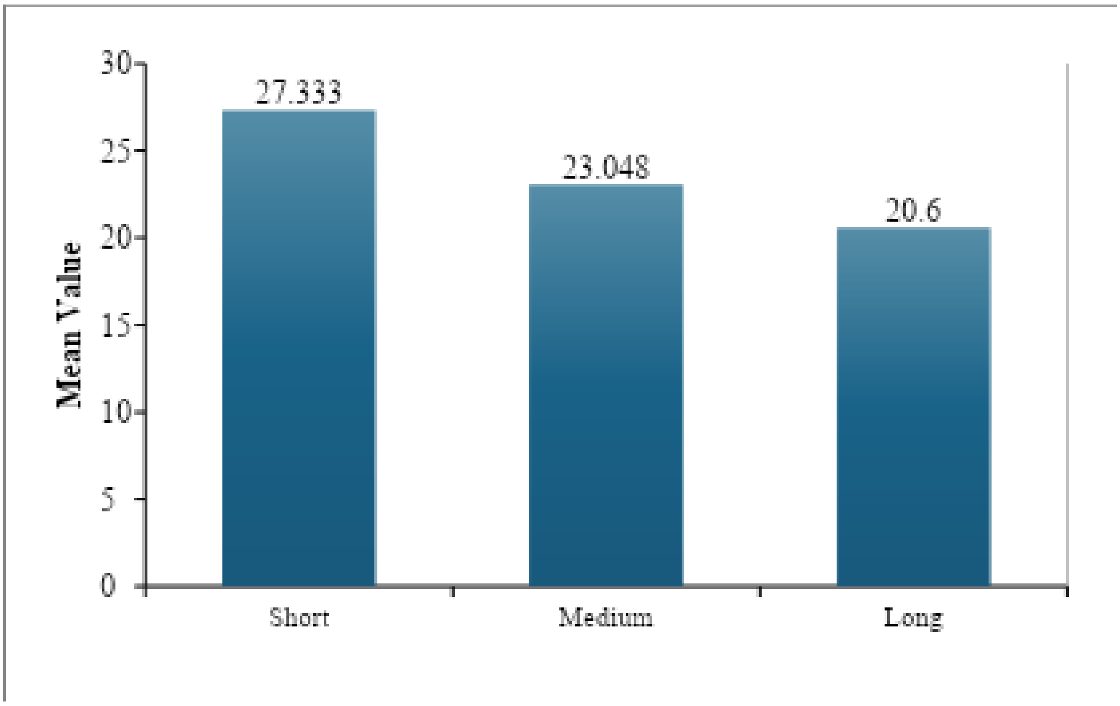
		Patella Tendon Length (mm)	Knee OA Grade (KL Grading)
Patella Tendon Length (mm)	Pearson Correlation	1	.202
	Sig. (2-tailed)		.115
	N	62	62
Knee OA Grade (KL Grading)	Pearson Correlation	.202	1
	Sig. (2-tailed)	.115	
	N	62	62

The correlation analysis between patella tendon length and Kellgren-Lawrence (KL) grading demonstrated a weak positive correlation (r = 0.202), indicating a slight tendency for patella tendon length to increase with higher grades of osteoarthritis. However, this association was not statistically significant (p = 0.115), suggesting that patella tendon length did not have a meaningful relationship with radiological severity of knee osteoarthritis in this study population. The findings imply that tendon length may not be a reliable indicator of disease severity as assessed by KL grading.

Table 10: WOMAC by Patella Tendon Length Groups

PTL group	n	Mean WOMAC	SD	Median	Min	Max
Short	21	27.333	11.53	29.00	5.00	47.00
Medium	21	23.048	10.09	27.00	3.00	36.00
Long	20	20.600	7.72	20.50	6.00	35.00

The comparison of WOMAC scores across patella tendon length groups showed that patients with short tendon length had the highest mean WOMAC score (27.33±11.53), indicating greater pain, stiffness and functional limitation. This was followed by the medium tendon length group with a mean score of 23.05±10.09, while the long tendon length group had the lowest mean WOMAC score (20.60±7.72). The median values also followed a similar trend. These findings suggest that shorter patella tendon length is associated with worse clinical outcomes, whereas longer tendon length is linked to relatively better functional status and lower symptom severity among patients with osteoarthritis knee.



Graph 8: WOMAC by Patella Tendon Length Groups

DISCUSSION

Osteoarthritis of the knee is a chronic, progressive degenerative disorder that predominantly affects the middle-aged and elderly population, leading to pain, stiffness and functional limitation. The patellofemoral joint plays a crucial role in knee biomechanics and variations in patellar alignment, tendon length and joint morphology have been suggested to influence both structural severity and clinical outcomes. The present study was conducted to evaluate the clinico-radiological profile of knee osteoarthritis with special emphasis on patella tendon length and its correlation with functional status and disease severity. The findings of this study are discussed in light of existing literature to understand the relationship between anatomical factors and patient-reported outcomes such as WOMAC score, as well as radiological grading using the Kellgren–Lawrence system.

In the present study, most patients were in the 51–60 years age group 32.26% (n=20), followed by 40–50 years 25.81% (n=16), 61–70 years 24.19% (n=15) and >70 years 17.74% (n=11) with a mean age of 58.23±11.218 years. This shows that osteoarthritis knee was mainly seen in middle-aged and elderly patients, particularly around the sixth decade of life. This finding was closely comparable with **Becker et al. (2008)**[74], who studied 50 patients/51 knees with isolated patellofemoral osteoarthritis and reported a mean age of 60.1 years with an age range of 46–81 years, which is very near to the mean age of the present study. Similarly, **Kalichman et al. (2007)**[73] included 213 patients with symptomatic knee osteoarthritis and reported a higher mean age of 66.7 years with a range of 47–93 years, suggesting that symptomatic knee OA is more frequent in an older population compared with the present study. **Tsavalas et al. (2012)**[76] divided patients into age groups of ≤50 years and >50 years and found patellofemoral OA prevalence was much higher in the older group, 41.3% in >50 years compared with 8.6% in ≤50 years, supporting the present study where most cases were above 50 years. The present mean age was slightly higher than **Tanamas et al. (2010)**[75], who studied

240 adults aged 25–60 years and reported a mean age of 45.7±9.4 years; this difference may be due to their community-based adult population, whereas the present study focused on osteoarthritis knee patients. In contrast, studies involving total knee arthroplasty patients showed older age groups: **Zhou et al. (2023)**[84] reported mean ages of 64.24±8.33 years, 63.26±8.17 years and 63.63±8.72 years across neutral, mild and severe valgus groups, respectively. **Yang et al. (2025)**[87] also supported the age-related nature of knee OA, showing that age had a strong positive correlation with KOA severity (r=0.516, p<0.01).

In the present study, females constituted a higher proportion of cases 58.1% (n=36) compared to males 41.9% (n=28), indicating a clear female predominance in osteoarthritis knee. This finding is consistent with **Yang et al. (2025)**[87] reported that out of 534 patients, 63% were females, showing a similar female predominance and supporting the present study results. Likewise, **Tsavalas et al. (2012)**[76] observed that 36.1% of women older than 60 years had cartilage lesions and patellofemoral osteoarthritis, which was higher compared to men, further reinforcing that females are more commonly affected. Similarly, **Becker et al. (2008)**[74] and other patellofemoral osteoarthritis studies also reported a higher prevalence among females, particularly in middle-aged and elderly populations, which aligns with the current study trend. In contrast, some studies such as **Yuan et al. (2019)**[79] found that gender was not significantly associated with anterior knee pain or outcomes, indicating that while prevalence may be higher in females, gender may not always influence clinical outcomes.

In the present study, the majority of patients had Grade 3 osteoarthritis (45.2%, n=28), followed by Grade 4 (37.1%, n=23) and Grade 2 (17.7%, n=11), indicating that most patients presented with moderate to severe radiological osteoarthritis at the time of evaluation. These findings are comparable with **Halmandge et al. (2025)**[88] reported that Kellgren–Lawrence Grade 2 was the most prevalent grade in their study population, although they also demonstrated that higher KL grades were associated with higher WOMAC scores and cartilage loss, suggesting progression toward more severe disease stages, which aligns with the higher proportion of Grade 3 and 4 cases in the present study. Similarly, **Becker et al. (2008)**[74] studied patients with patellofemoral osteoarthritis and reported that most cases had advanced radiological disease (equivalent to Grade III and IV changes), which is in close agreement with the present study where over 80% of patients were in Grade 3 and 4. In addition, **Yang et al. (2025)**[87] demonstrated that increasing severity of osteoarthritis (higher KL grade) was significantly associated with worsening structural parameters, supporting the concept that patients presenting to tertiary care centers often have more advanced disease, as observed in the current study. Furthermore, MRI-based studies such as **Tsavalas et al. (2012)**[76] also showed that structural cartilage damage and osteoarthritic changes increase with disease severity, indirectly supporting the higher proportion of advanced grades in symptomatic patients.

In the present study, most patients had long-standing symptoms with the highest proportion having symptoms for 41–60 months (27.42%, n=17), followed by 101–120 months (19.35%, n=12) and 21–40 months (17.74%, n=11). The mean duration of symptoms was 62.00±32.044 months, showing that knee osteoarthritis patients commonly presented after a prolonged symptomatic period of nearly 5 years. **Halmandge et al. (2025)**[88] described knee osteoarthritis as a long-standing chronic joint disease and found that higher WOMAC scores were associated with higher K-L grades and cartilage loss. **Haj-Mirzaian et al. (2019)**[78] followed structural worsening of patellofemoral OA over 24 months and reported that higher baseline Insall-Salvati ratio was associated with worsening lateral patellar BMLs OR 11.18, p<0.001 and cartilage scores OR 7.39, p=0.042. **Becker et al. (2008)**[74] included patients with isolated patellofemoral osteoarthritis showing advanced radiographic changes with Ahlbäck Grade III and IV lateral patellofemoral joint space narrowing, indicating established long-term disease.

In the present study, the right knee was most commonly affected (41.9%, n=26), followed by the left knee (33.9%, n=21), while bilateral involvement was seen in 24.2% (n=15) of patients. This indicates that unilateral involvement was more frequent with a slight predominance of the right side, although a considerable proportion had bilateral disease. **Yang et al. (2025)**[87] evaluated 586 knees in 534 patients, clearly indicating that multiple patients had involvement of both knees, supporting the presence of bilateral disease in osteoarthritis, as also observed in 24.2% of cases in the present study. Similarly, **Tsavalas et al. (2012)**[76] studied 650 knee MRI examinations from 622 patients, implying that several patients had involvement of more than one knee, again supporting the concept that osteoarthritis can be bilateral or affect both joints over time. **Becker et al. (2008)**[74] reported analysis of 51 knees in 50 patients, also indicating occasional bilateral involvement, although the study primarily focused on patellofemoral osteoarthritis rather than side distribution

The majority of patients had relatively preserved knee motion with 51.61% (n=32) having ROM 120–140°, followed by 29.03% (n=18) with 100–120°, 17.74% (n=11) with 80–100° and only 1.61% (n=1) having severely restricted ROM ≤80°. The mean ROM was 118.34±19.53°, indicating that most patients retained near-functional mobility despite osteoarthritis. These findings are comparable with **Aguirre-Pastor et al. (2020)**[81] evaluated patients after total knee arthroplasty and found no significant difference in range of motion between groups (p=0.408), suggesting that functional ROM is often maintained or restored around acceptable levels. Similarly, **Zhou et al. (2023)**[84] reported that patients undergoing treatment for valgus knee deformity showed significant improvement in ROM postoperatively (p<0.001), indicating that knee osteoarthritis patients can achieve or maintain functional ROM values close to normal ranges (~110–130°), which aligns with the present study mean of 118.34°. **Yuan et al. (2019)**[79] observed that pre-operative and post-operative ROM did not significantly differ between groups, indicating that ROM remains within a functional range even in patients with patellofemoral pathology.

In the present study, the mean WOMAC pain score was 5.145±2.4148 (out of 20), stiffness score 1.823±0.9671 (out of 8) and physical function score 16.726±7.1131 (out of 68). The total WOMAC score was 23.710±10.1665, indicating an overall moderate level of pain, stiffness and functional limitation and the pain score was statistically significant (p<0.001). These findings are comparable with **Halmandge et al. (2025)**[88] reported a mean total WOMAC score of 9, which was lower than the present study; however, they also demonstrated that higher WOMAC scores were associated with higher Kellgren–Lawrence grades and cartilage loss, supporting the moderate WOMAC values observed in the present study where most patients had Grade 3 and 4 osteoarthritis. Similarly, **Becker et al. (2008)**[74] reported improvement in WOMAC scores after surgical intervention with pain improving by 2.34 points and function by 1.63 points, indicating that

WOMAC scores are sensitive indicators of clinical severity and functional limitation, consistent with the moderate baseline WOMAC scores observed in the present study. **Tanamas et al. (2010)**[75] found that patellofemoral geometric changes were associated with reduction in WOMAC pain scores (regression coefficient -1.57), indicating that WOMAC pain reflects underlying structural and biomechanical factors, which supports the moderate pain score (5.145) observed in the present study. Furthermore, **Kalichman et al. (2007)**[73] reported that certain patellofemoral alignment parameters were associated with increased WOMAC pain and functional impairment, reinforcing that WOMAC scores are closely linked to clinical severity in knee osteoarthritis.

In the present study, patella tendon length showed a weak negative correlation with all WOMAC components: pain (r = -0.206, p = 0.107), stiffness (r = -0.145, p = 0.261) and physical function (r = -0.227, p = 0.076), none of which were statistically significant. However, the total WOMAC score showed a weak but statistically significant negative correlation (r = -0.266, p = 0.036), indicating that increasing patella tendon length was associated with a slight reduction in overall symptom severity. These findings are supported by **Tanamas et al. (2010)**[75] reported that patellofemoral geometry parameters were associated with WOMAC pain scores, where increased medial patella inclination was linked with a reduction in WOMAC pain (regression coefficient -1.57). Similarly, **Kalichman et al. (2007)**[73] found that patellofemoral alignment parameters such as trochlear angle and lateral patellar tilt were associated with WOMAC pain and functional impairment. In contrast, **Yoon et al. (2022)**[83] reported that patellar height and alignment parameters were not significantly associated with clinical scores. Additionally, **Haj-Mirzaian et al. (2019)**[78] demonstrated that increased Insall–Salvati ratio (indicative of patellar height) was associated with worsening structural changes such as cartilage damage and bone marrow lesions.

In the present study, patella tendon length showed a weak positive correlation with Kellgren–Lawrence (KL) grading (r = 0.202, p = 0.115), which was not statistically significant, indicating that patella tendon length did not have a meaningful association with radiological severity of osteoarthritis. **Yoon et al. (2022)**[83] reported that patellar height (Insall–Salvati ratio), Q-angle and quadriceps parameters were not associated with patellofemoral cartilage lesions. Similarly, **Kalichman et al. (2007)**[73] found that although some alignment parameters were associated with symptoms, many patellofemoral alignment measures were not significantly associated with disease severity or functional impairment. In contrast, **Yang et al. (2025)**[87] demonstrated that certain patellofemoral parameters such as sulcus angle (r = 0.616, $p<0.05$) and TT–TG distance (r = 0.770, $p<0.01$) showed a strong positive correlation with osteoarthritis severity, indicating that while some anatomical factors significantly influence KL grading, patellar length-related parameters may not be among the strong predictors. Furthermore, **Haj-Mirzaian et al. (2019)**[78] found that increased Insall–Salvati ratio (patella alta) was associated with worsening structural changes over time (OR 11.18 for BML, $p<0.001$; OR 7.39 for cartilage damage, p=0.042).

In the present study, patients with short patella tendon length had the highest mean WOMAC score (27.33±11.53), followed by the medium group (23.05±10.09), while the long tendon length group had the lowest WOMAC score (20.60±7.72). This indicates that shorter patella tendon length is associated with greater pain, stiffness and functional limitation, whereas longer tendon length is linked with relatively better clinical outcomes. **Tanamas et al. (2010)**[75] demonstrated that favorable patellofemoral geometry, such as increased medial patella inclination, was associated with a reduction in WOMAC pain score (β = -1.57), suggesting that better anatomical alignment leads to improved clinical outcomes. Similarly, **Aguirre-Pastor et al. (2020)**[81] observed no significant difference in WOMAC pain, stiffness, or function scores across different patellar height groups (p>0.05).

SUMMARY

- Majority of patients were in 51–60 years age group (32.26%, n=20) with mean age 58.23±11.21 years, followed by 40–50 years (25.81%) and 61–70 years (24.19%), indicating peak incidence in sixth decade.
- Female predominance was observed with 58.1% (n=36) females compared to 41.9% (n=28) males.
- Most patients had moderate to severe osteoarthritis with Grade 3 (45.2%) being most common followed by Grade 4 (37.1%) and Grade 2 (17.7%).
- Majority had long-standing symptoms, most commonly 41–60 months (27.42%) with mean duration 62.00±32.04 months, indicating chronic disease presentation.
- Right knee involvement (41.9%) was more common than left (33.9%) with bilateral involvement in 24.2% cases.
- Most patients had good knee mobility with 51.61% having ROM 120–140° and mean ROM 118.34±19.53°, while only 1.61% had severe restriction ≤80°.
- Mean WOMAC scores indicated moderate symptom severity with pain 5.14±2.41, stiffness 1.82±0.96, function 16.72±7.11 and total score 23.71±10.16.
- Patella tendon length showed weak negative correlation with WOMAC components (pain r=-0.206, stiffness r=-0.145, function r=-0.227) with only total WOMAC showing significant correlation (r=-0.266, p=0.036).
- There was weak positive, non-significant correlation between patella tendon length and KL grading (r=0.202, p=0.115), indicating no strong association with radiological severity.

- Patients with short tendon length had highest WOMAC score (27.33±11.53), followed by medium (23.05±10.09) and lowest in long tendon group (20.60±7.72), showing worse outcomes with shorter tendon length.

CONCLUSION

The present study demonstrated that knee osteoarthritis predominantly affects middle-aged and elderly individuals with a higher prevalence among females. Most patients presented with moderate to severe disease (Kellgren–Lawrence Grade 3 and 4) and long-standing symptoms, highlighting the chronic and progressive nature of the condition. Despite the advanced disease stage, a majority of patients retained relatively good knee range of motion, although they experienced moderate levels of pain, stiffness and functional limitation as reflected by WOMAC scores.

The study further revealed that patella tendon length has a limited but notable association with clinical outcomes. While no significant correlation was found between patella tendon length and radiological severity, a weak negative correlation was observed with overall WOMAC score, suggesting that longer tendon length may be associated with slightly better functional status. Additionally, patients with shorter patella tendon length exhibited higher WOMAC scores, indicating greater symptom severity and functional impairment. Overall, the findings suggest that although patella tendon length may not be a strong predictor of radiological severity, it has a clinically relevant relationship with functional outcomes. These results emphasize the multifactorial nature of knee osteoarthritis, where anatomical, biomechanical and clinical factors collectively influence disease severity and patient quality of life.

LIMITATIONS OF THE STUDY

- The study had a relatively small sample size (n=62), which may limit the generalizability of the findings.
- Being a single-center study, the results may not represent the broader population.
- The cross-sectional design limits the ability to establish causal relationships or assess disease progression over time.
- Patella tendon length was measured using radiographs only, which may be subject to measurement bias and less accurate compared to advanced imaging like MRI.
- The study relied on WOMAC score as a subjective assessment tool, which may be influenced by patient perception and reporting bias.
- Potential confounding factors such as BMI, physical activity level, occupation and comorbidities were not fully controlled.

- The study did not include a control group (non-OA patients) for comparison.
- Inter-observer and intra-observer variability in radiographic measurements were not assessed.
- The distribution of patients across tendon length groups may not be equal, which could affect statistical comparisons.
- The study did not evaluate long-term outcomes or follow-up data, limiting understanding of progression and prognosis.

RECOMMENDATIONS

- Larger multi-center studies with bigger sample size should be conducted to improve generalizability of findings.
- Longitudinal (follow-up) studies are recommended to assess progression of osteoarthritis and causal relationship with patella tendon length.
- Use of advanced imaging modalities (MRI/CT) is suggested for more accurate assessment of patellar tendon length and joint structures.
- Future studies should include control groups (normal individuals) for better comparison and validation of results.
- Adjustment of confounding factors such as BMI, physical activity, occupation and comorbidities should be incorporated in analysis.
- Detailed evaluation of patellofemoral alignment parameters (ISR, Q-angle, TT-TG distance) should be included for comprehensive assessment.
- Incorporation of objective functional assessment tools (e.g., gait analysis, muscle strength testing) along with WOMAC score is recommended.
- Early screening and identification of high-risk patients based on anatomical variations should be encouraged.
- Physiotherapy and biomechanical correction strategies targeting patellofemoral alignment should be emphasized in management.
- Further research should explore the role of surgical correction of patellar alignment in improving functional outcomes in osteoarthritis knee.

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APPENDICES

Appendix 1: Patient Information Sheet

Study Title: Correlation between patella tendon length and WOMAC score in osteoarthritis knee.

Dear Patient,
You are invited to participate in a research study. Before you decide whether to participate, please read this information sheet carefully and feel free to ask any questions you may have.
Purpose of the Study: the purpose of the study is to evaluate the relation between patellar tendon length and functional severity of knee osteoarthritis, as measured by the WOMEC score.

What Will Happen If You Take Part: If you agree to participate, you will be asked some questions about your knee pain, stiffness, and daily activities using the WOMAC Score questionnaire.

- A clinical examination of your knee will be performed.
- Your knee X-ray will be taken or reviewed (if already available) to measure patellar tendon length.
- No additional invasive procedures will be done.
- The total time required will be approximately 15–20 minutes.

Risks and Discomforts: This study involves minimal risk.

- You may feel mild discomfort while answering questions related to pain and daily activities.
- If an X-ray is required, there is minimal radiation exposure, which is routinely used in standard clinical care.
- No injections, medications, or surgical procedures are involved in this study

Benefits: There may be no direct medical benefit to you from participating in this study.

- However, your condition will be carefully evaluated, which may help in better understanding your knee problem

Confidentiality: All information collected during this study will be kept strictly confidential. Your identity will not be disclosed in any publication or presentation of the study results. Data will be stored securely and will be accessible only to the research team.

Voluntary Participation: Your participation in this study is entirely voluntary. You are free to withdraw at any time without giving a reason, and your decision will not affect the quality of care you receive in any way.

Contact Information: If you have any questions or concerns about this study, please contact: Dr. Avadh Amarshibhai Ranipa, ph-no.7878266299; Department of Orthopaedics, NIMS University, Jaipur, Rajasthan, India.

Appendix 2: Case Record Form / Proforma

CASE RECORD FORM

SCREENING & ELIGIBILITY

Inclusion Criteria	Yes	No	Exclusion Criteria	Yes	No
1. Age between 40-75 years	☐	☐	1. Secondary OA (Rheumatoid, Post-traumatic)	☐	☐
2. Radiological evidence of OA	☐	☐	2. Previous knee surgery (TKR/HTO)	☐	☐
3. Willing to give informed consent	☐	☐	3. History of patellar tendon rupture	☐	☐
			4. Active knee infection	☐	☐

Is the patient eligible? ☐ Yes ☐ No

Date of Consent: ___/___/______

Patient Initials: _______

DEMOGRAPHICS & ANTHROPOMETRY

Name:		**OPD/IPD No:**	
Age:	_______ years	**Date of Assessment:**	___/___/_______
Sex:	☐ Male ☐ Female	**Occupation:**	☐ Sedentary ☐ Moderate ☐ Heavy
Contact No:		**Dominant Limb:**	☐ Right ☐ Left
Height:	_______ cm	**Weight:**	_______ kg
BMI:	_______ kg/m^2	**Side Involved:**	☐ Right ☐ Left ☐ Bilateral

CLINICAL HISTORY & EXAMINATION

Duration of Symptoms:	_______ months	**Onset:**	☐ Insidious ☐ Sudden
Previous Treatments:	☐ NSAIDs ☐ Physiotherapy ☐ Injections ☐ None		
Deformity:	☐ Nil ☐ Varus ☐ Valgus	**Crepitus:**	☐ Nil ☐ Mild ☐ Moderate ☐ Severe
Tenderness:	☐ Joint line ☐ PT ☐ None	**Range of Motion:**	Ext: _______° (Deficit:_____°) Flex: _______°

RADIOLOGICAL ASSESSMENT

Date of X-Ray: ___/___/______ **View:** Standard Lateral View (30° flexion)

1. Osteoarthritis Grading (Kellgren-Lawrence)		
☐ Grade 0 (Normal) ☐ Grade I (Doubtful) ☐ Grade II (Minimal) ☐ Grade III (Moderate) ☐ Grade IV (Severe)		
2. Patellar Tendon Length Measurements		
Patellar Length (PL):	______ mm	
Patellar Tendon Length (PTL):	______ mm	
Insall-Salvati Ratio (PTL/PL):	______	
Other X-ray Findings:	☐ Osteophytes ☐ Subchondral sclerosis ☐ Joint space narrowing ☐ None	

WOMAC OSTEOARTHRITIS INDEX

(0=None, 1=Slight, 2=Moderate, 3=Severe, 4=Extreme)

Domain / Question	0	1	2	3	4
A. PAIN					
A1. Walking	☐	☐	☐	☐	☐
A2. Climbing stairs	☐	☐	☐	☐	☐
A3. Night pain	☐	☐	☐	☐	☐
A4. Resting	☐	☐	☐	☐	☐
A5. Weight bearing	☐	☐	☐	☐	☐
B. STIFFNESS					
B1. Morning stiffness	☐	☐	☐	☐	☐
B2. Stiffness later in day	☐	☐	☐	☐	☐
C. PHYSICAL FUNCTION					
C1. Descending stairs	☐	☐	☐	☐	☐
C2. Ascending stairs	☐	☐	☐	☐	☐

Domain / Question	0	1	2	3	4
C3. Rising from sitting	☐	☐	☐	☐	☐
C4. Standing	☐	☐	☐	☐	☐
C5. Bending to floor	☐	☐	☐	☐	☐
C6. Walking on flat surface	☐	☐	☐	☐	☐
C7. Getting in/out of car	☐	☐	☐	☐	☐
C8. Going shopping	☐	☐	☐	☐	☐
C9. Putting on socks	☐	☐	☐	☐	☐
C10. Rising from bed	☐	☐	☐	☐	☐
C11. Taking off socks	☐	☐	☐	☐	☐
C12. Lying in bed	☐	☐	☐	☐	☐
C13. Getting in/out of bath	☐	☐	☐	☐	☐
C14. Sitting	☐	☐	☐	☐	☐
C15. Getting on/off toilet	☐	☐	☐	☐	☐
C16. Light domestic duties	☐	☐	☐	☐	☐
C17. Heavy domestic duties	☐	☐	☐	☐	☐

SECTION 6: SCORE CALCULATION

SECTION 7: DECLARATION

Examiner Name: ______________________ **Examiner Signature:** ____________________ **Date:** ___/___/______	**Patient Signature / Thumb Impression:** _______________ **Witness Name:** ______________________

Appendix 3: Informed Consent Form (English)

Study Title: Correlation between patella tendon length and WOMAC score in osteoarthritis knee

The contents of the information sheet dated that was provided have been read carefully by me/explained in detail to me, in a language that I comprehend and I have fully understood the contents. I confirm that I have had the opportunity to ask questions. The nature and purpose of the study and its potential risks/ benefits and expected duration of the study and other relevant details of the study have been explained to me in detail. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal right being affected.

I understand that the information collected about me from my participation in this research and sections of any of my medical notes may be looked at by responsible individuals from NIMS Ethics Committee Members/ Regulatory Authorities. I give permission for these individuals to have access to my records.

I agree to allow the research team to collect and use my medical data for the purposes of this study, with the understanding that my identity will remain confidential. I consent to participate in this study of my own free will.

Patient Name:	Witness Name:	Investigator Name:
__________________	__________________	__________________
Signature:	Signature:	Signature:
__________________	__________________	__________________
Date:	Date:	Date:
__________________	__________________	__________________

Appendix 4: Informed Consent Form (Hindi)

अध्ययन शीर्षक:घुटने के ऑस्टियोआर्थराइटिस में पटेला टेंडन की लंबाई और WOMAC स्कोर के बीच संबंध

मुझे प्रदान की गई सूचना पत्रक की सामग्री को मैंने स्वयं ध्यानपूर्वक पढ़ लिया है / मुझे मेरी समझ की भाषा में विस्तार से समझाया गया है, और मैंने इसकी सभी बातों को पूरी तरह समझ लिया है। मैं पुष्टि करता/करती हूँ कि मुझे प्रश्न पूछने का अवसर दिया गया था।

मुझे इस अध्ययन की प्रकृति और उद्देश्य, संभावित जोखिम एवं लाभ, अध्ययन की अपेक्षित अवधि तथा अन्य संबंधित जानकारी विस्तार से समझाई गई है। मैं यह समझता/समझती हूँ कि इस अध्ययन में मेरी भागीदारी पूरी तरह स्वैच्छिक है और मैं किसी भी समय बिना कोई कारण बताए इससे बाहर हो सकता/सकती हूँ, जिससे मेरे उपचार या कानूनी अधिकारों पर कोई प्रभाव नहीं पड़ेगा।

मैं यह समझता/समझती हूँ कि इस शोध में मेरी भागीदारी से संबंधित जानकारी तथा मेरे चिकित्सा अभिलेखों के कुछ भागों को NIMS एथिक्स कमेटी के सदस्य / नियामक प्राधिकरणों द्वारा देखा जा सकता है। मैं ऐसे व्यक्तियों को मेरे अभिलेखों तक पहुंच की अनुमति देता/देती हूँ।

मैं सहमति देता/देती हूँ कि शोध दल इस अध्ययन के उद्देश्य से मेरे चिकित्सा डेटा को एकत्र और उपयोग कर सकता है, इस समझ के साथ कि मेरी पहचान गोपनीय रखी जाएगी। मैं अपनी स्वतंत्र इच्छा से इस अध्ययन में भाग लेने के लिए सहमत हूँ।

रोगी का नाम:	गवाह का नाम:	अनुसंधानकर्ता का नाम:
________________	________________	________________
हस्ताक्षर:	हस्ताक्षर:	हस्ताक्षर:
________________	________________	________________
तारीख:	तारीख:	तारीख:
________________	________________	________________

Appendix 5: Institutional Ethics Committee Approval

NIMS UNIVERSITY RAJASTHAN, JAIPUR

Fully empowered & incorporated as a regular & full-fledged University under **NIMS UNIVERSITY ACT, 2008 duly recognized by Government of India under the provisions of the Sections 2(f) and 22 of the UGC Act, 1956.**

OFFICE OF THE INSTITUTIONAL ETHICS COMMITTEE

NECRBHR, DHR File No.-EC/NEW/INST/2022/RJ/0118

Ref. No.: NIMSUR/IEC/2024/1018

Date: 11/05/2024

From

Office of the Institutional Ethics Committee
Nims University Rajasthan, Jaipur
NH- 11 C, Jaipur-Delhi Highway, Jaipur

To,

The Principal Investigator
Dr. Avadh Ranipa
Department of Orthopedics
Proposal No. IEC/P-636/2024

Dear Dr. Avadh Ranipa

Institutional Ethics Committee Nims University Rajasthan, Jaipur had received & reviewed your application to conduct the research study titled "Correlation between patella tendon length and WOMAC score in osteoarthritis knee" on 11/05/2024.

The following documents were reviewed:

a. Protocol
b. Patient Information Sheet and Informed Consent Form in English and vernacular language
c. Proposed methods for subject accrual to be used for the purpose
d. Principal Investigator's current CV

Appendix 6: Institutional Ethics Committee Approval

NIMS UNIVERSITY RAJASTHAN, JAIPUR

Fully empowered & incorporated as a regular & full-fledged University under **NIMS UNIVERSITY ACT, 2008 duly recognized by Government of India under the provisions of the Sections 2(f) and 22 of the UGC Act, 1956.**

NIMS UNIVERSITY

OFFICE OF THE INSTITUTIONAL ETHICS COMMITTEE

The following members of the ethics committee were present at the meeting held on 11/05/2024 at 11:00 AM in Board room, Hotam administration block, Nims University Rajasthan, Jaipur.

S. No	Name	Designation
1.	Dr. Kunal Kothari	Chairman
2.	Dr. Mahaveer Singh	Member Secretary
3.	Dr. Seema Chouhan	Clinician
4.	Dr. Vineet Choudhary	Clinician
5.	Dr. Anumeha Jain	Clinician
6.	Dr. Sushma BJ	Clinician
7.	Dr. Hemant Garg	Basic Medical Scientist
8.	Mrs. Mridula Chandra	Social Scientist
9.	Mr. Sunil Kumar Sharma	Legal Expert
10.	Mrs. Kusum Sharma	Lay Person

We approve the study to be conducted in its presented form in your Department, at Nims University Rajasthan, Jaipur. This approval is valid till the completion of the study.

Please note that the committee is constituted as per ICH-GCP, Schedule-Y and ICMR guidelines and follows them.

It is confirmed that neither you nor any of the study team members have participated in the decision-making procedures of the Committee.

You are required to submit the following reports to the EC.

- 6 monthly/annual study reports about the progress of the study.
- A copy of the final study report at the completion of the study.
- You need to inform & resubmit your protocol in case of any addition or deletion in your objectives or methods of approved protocol.

The Ethics Committee expects to be informed immediately about:

- All serious adverse events (SAE) occurring at the site within 24 hours to IEC.
- Any change to or deviation to the protocol approved by this Ethics Committee that you implement to eliminate hazards to the study subjects.
- New information that may affect adversely the safety of the subjects or the conduct of the study.

Yours truly

Member Secretary
Institutional Ethics Committee
Nims University Rajasthan, Jaipur

MEMBER SECRETARY
Institutional Ethics Committee,
NIMS University Rajasthan, Jaipur

Appendix 7: Plagiarism certificate

NIMS UNIVERSITY RAJASTHAN, JAIPUR

Fully empowered & incorporated as a regular & full-fledged University under NIMS UNIVERSITY ACT, 2008 duly recognized by Government of India under the provisions of the Sections 2(f) and 22 of the UGC Act, 1956.

OFFICE OF RESEARCH AND INNOVATION CELL

CERTIFICATE OF PLAGIARISM CHECK FOR THESIS

Author Name	DR. AVADH AMARSHIBHAI RANIPA	
Department	MS ORTHOPAEDICS	
Batch	2023-2026	
Guide (Designation)	DR. MAHAVEER PRASAD GOYAL (Professor, Department of Orthopaedics)	
Co-guides	*Name*	*Designation and Department*
	-	-
Topic	CORRELATION BETWEEN PATELLA TENDON LENGTH AND WESTERN ONTARIO AND MCMASTER UNIVERSITIES OSTEOARTHRITIS INDEX (WOMAC) SCORE IN OSTEOARTHRITIS KNEE	
Total Similarity/Plagiarism (%)	**09%**	
Submission Date	**27/04/2026**	

Checked by: **- Dr. Sourav Debnath**

Dr. Sumit Rajotiya

Clinical Research Associate – RAIC

Assistant Professor – Department of Pharmacy

Nims University Rajasthan, Jaipur

NIMS UNIVERSITY RAJASTHAN JAIPUR (INDIA)

THIS REPORT HAS BEEN GENERATED BY TURNITIN ANTI PLAGIARISM SOFTWARE

Appendix 8: Master Chart

S No.	Name	Age	Gender	Knee OA Grade (Kellgren-Lawrence Grading)	Knee ROM (degrees)	Duration of Symptoms (Months)	Affected Knee (Right/Left/Both)	Patella Tendon Length (mm)	WOMAC Pain Score (0-20)	WOMAC Stiffness Score (0-8)	WOMAC Physical Function Score (0-68)	Total WOMAC Score (0-96)
1	Mrs.kashmiri	52	Female	Grade 3	99.3	34	Right	49.3	5	4	26	35
2	Mrs.Ghota	64	Female	Grade 3	89.4	113	Left	47.7	5	2	21	29
3	Mr.hanuman singh	73	Female	Grade 4	136.5	70	Both	46	9	3	29	41
4	Mr.Hemant Singh	41	Male	Grade 3	130.2	15	Right	43.2	1	0	4	5
5	Mr.Chandra Kala	70	Female	Grade 2	105.4	49	Left	46	5	1	13	19
6	Mr.Mahmoodi	45	Female	Grade 3	97.3	108	Both	46.7	9	2	30	41
7	Mrs. Radha Sharma	42	Female	Grade 3	95.5	16	Right	52.7	2	0	4	6
8	Mr.Bhairuram Jat	78	Male	Grade 4	108.8	76	Left	48.1	5	1	13	19
9	Mrs.Urmila Sharma	53	Female	Grade 3	147.5	54	Both	49.4	3	1	10	14
10	Mr.Mahendra Kumar Gupta	61	Male	Grade 4	133.6	27	Right	61.1	3	1	7	11
11	Mr.Kanwaljeet Singh Walia	65	Male	Grade 3	84.8	109	Right	52.1	3	1	13	17
12	Mrs.Munni Devi	54	Female	Grade 2	151.1	52	Left	52	1	0	3	4
13	Mr.Santram	50	Male	Grade 4	88.3	30	Both	54	5	2	18	25
14	Mr.Harishankar Sharma	70	Male	Grade 4	114.1	50	Both	63.7	7	3	17	27
15	Mr. Haribilash	65	Male	Grade 3	107.8	111	Right	48.6	5	2	22	29
16	Mrs. Radha Devi	52	Female	Grade 4	148.2	92	Left	47.1	3	1	9	13
17	Mr.Rajendra Singh Choudhary	65	Male	Grade 3	126.1	57	Right	47.3	8	2	26	36
18	Mr.Janak	66	Male	Grade 4	150.1	64	Left	54.2	0	2	11	13
19	Mrs. Dipa Bai	59	Female	Grade 3	115.4	42	Left	40.4	8	3	23	34
20	Mr.Sayalu Ram	78	Male	Grade 4	102.5	29	Right	47.4	7	2	18	27
21	Mrs.Batul	69	Female	Grade 3	129.3	61	Right	38	7	2	22	31
22	Mr.Ramchandra Kumawat	67	Male	Grade 4	116.2	30	Right	51.1	3	1	8	12
23	Mr.Manish Pandey	48	Male	Grade 3	124.7	94	Left	39.4	7	3	25	35
24	Mrs. Ram Singh	45	Male	Grade 2	142.7	50	Right	55.5	4	2	15	21
25	Mrs.Sushma Nain	74	Female	Grade 4	139.9	46	Both	47	7	2	23	32
26	Mrs.Sabnum	52	Female	Grade 3	128.2	55	Right	50	6	3	20	29
27	Mrs.Chauthmali Devi	45	Female	Grade 2	131.2	54	Left	44.1	4	2	12	18
28	Mr.Shakoor	75	Male	Grade 4	120.9	19	Right	53.7	6	2	19	27
29	Mrs. Mamta Devi	48	Female	Grade 2	122.4	59	Both	42.7	4	1	11	16
30	Mr.Ramchandra Balai	66	Male	Grade 4	81.4	116	Both	50.2	7	2	24	33
31	Mrs. Kanta Devi	64	Female	Grade 3	136.6	17	Right	57.1	5	2	14	21
32	Mr.Kanaram Gurjar	77	Male	Grade 3	109.6	81	Right	60.3	3	1	11	15
33	Mrs.Meera Devi	52	Female	Grade 4	110.1	53	Left	60.9	8	2	25	35
34	Mrs. Poonam Jindal	44	Female	Grade 4	137.3	115	Both	46.7	6	2	20	28
35	Mrs.Savitri Devi	53	Female	Grade 2	138.5	109	Both	55.4	4	1	9	14
36	Mrs.Santosh	54	Female	Grade 3	129.3	11	Left	48.7	5	2	22	29
37	Mr.Pritam Singh	48	Male	Grade 4	121.4	40	Both	55.9	4	2	14	20
38	Mrs.Naseem Bano	46	Female	Grade 2	126.5	30	Left	48.4	4	1	16	21
39	Mrs.Gayatri Soni	54	Female	Grade 3	130.7	98	Left	36	4	2	17	23
40	Mrs.Fulwati Devi	49	Female	Grade 2	134.1	45	Right	62	6	3	19	28
41	Mr.Umar Khan	71	Male	Grade 3	112.4	30	Right	51.4	7	3	22	32
42	Mrs.Champa Ojha	58	Female	Grade 3	147.5	56	Both	56.3	4	1	14	19
43	Mr.Ratiram	60	Male	Grade 2	112.4	44	Left	45.6	2	1	9	12
44	Mrs.Sudama Devi	75	Female	Grade 3	128.3	117	Right	44.4	7	2	20	29
45	Mrs.Santosh	54	Female	Grade 3	93.6	110	Left	48.3	4	2	14	20
46	Mr.Sube Singh	72	Male	Grade 4	112.9	52	Left	48.6	2	1	6	9
47	Mr.Hanif Khan	59	Male	Grade 3	118.4	113	Right	44.7	9	3	24	36
48	Mrs.Mohar Bai	52	Female	Grade 3	98.1	114	Right	48.2	1	0	2	3
49	Mrs.Suman Kanwar	50	Female	Grade 4	114	16	Right	53	3	1	11	15
50	Mrs.Kamlesh Devi	44	Female	Grade 2	105.5	17	Left	47.1	4	1	11	16
51	Mr.Kamal Singh	65	Male	Grade 4	133.6	40	Left	44.1	10	3	31	44
52	Mrs. Kailash Chand Meena	58	Male	Grade 3	107.3	36	Both	52.7	4	1	15	20
53	Mrs.Kiran Devi	61	Female	Grade 3	122.8	69	Right	52.1	4	1	18	23
54	Mrs.Chandrawati Devi	63	Female	Grade 4	128.7	63	Left	56.6	2	1	7	10
55	Mrs. Rahisa Bano	48	Female	Grade 3	151.3	72	Both	38.4	8	2	21	31
56	Mrs.Juveda	60	Female	Grade 3	108.7	47	Right	48.9	7	3	24	34
57	Mr.Kalu Ram Dhobi	71	Male	Grade 2	67.2	39	Left	43.2	5	2	16	23
58	Mrs.Bhanwati	67	Female	Grade 4	86.6	62	Both	56.6	7	2	21	30
59	Mrs. Hakiman	51	Male	Grade 4	126.9	114	Right	45.4	12	5	30	47
60	Mrs.Saroj	52	Female	Grade 3	95	85	Right	60.8	7	2	19	28
61	Mr.Lachchhu Ram	74	Male	Grade 4	104.8	88	Left	48.3	6	3	20	29
62	Mrs.Naarangi Devi	56	Female	Grade 4	133.5	84	Right	54.7	6	2	19	27

Appendix 9: Declaration

DECLARATIONS

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflicts of Interest: The authors declare no conflicts of interest.

Data Availability: The raw study data are available from the corresponding author upon reasonable request.

Ethics Approval: The study protocol was approved by the Institutional Ethics Committee of NIMS University, Jaipur.

IEC Approval Number: IEC/P-636/2024

Date of Approval: 21/05/2024