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KNEE ALIGNMENT COMPARISON IN SINGLE VS DOUBLE LEG WEIGHT-BEARING X-RAY

Orthopaedics

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ABSTRACT

Background: One of the leading causes of disability in elders is osteoarthritis of knee. The functional outcome of surgical procedures depends on proper alignment assessment. Our study aims to access the knee alignment parameters is x-rays taken in double standing and single standing weight bearing x-rays. **Methods:** One hundred patients who visited Chettinad hospital and research institute, Chennai, with knee pain and knee deformity were selected for the study. All patients were subjected to single and double-leg standing Anteroposterior (AP) full-limb radiographs to access the varus or valgus deformity. Radiology technicians followed a standard protocol to obtain these radiographs. All X-rays were uploaded to the hospital picture archiving and communicating system and Hip-Knee-Ankle Angle (HKAA), Medial-Proximal-Tibial Angle (MPTA), Lateral-Distal-Femoral Angle (LDFA) and Joint-Line-Convergence Angle (JLCA) measured. The data was analysed using, MedCalc v18.2.1 **Results:** The mean age was 56.2 years (range 45- 68 years) mean BMI was 27.1 kg/m2. We were able to find a significant difference in JLCA and HKAA between double and single-leg standing x-rays. **Conclusion:** HKAA and JLCA were affected by the patient's position. In single-leg weight-bearing, the force line shifts medial to the knee joint centre, therefore the compressive stress is increased in the medial aspect. Followed by this change the angles are higher while the patient is standing on a single leg and varus deformity is augmented in this position.

KEYWORDS

Single Leg , Double leg, Knee Alignment

INTRODUCTION

One of the leading causes of disability in elders is osteoarthritis of knee[1]. OA is a multifactorial condition. The progression of osteoarthritis knee is determined in part by mechanical effects on local structures. One of the mechanical influences on cartilage loss is limb alignment. Hip-knee-ankle alignment contributes to load distribution across the articular surface, by proportionately dividing load between the medial and lateral compartments[1]. The load-bearing axis is represented by a line drawn from the mid-femoral head to the mid-ankle. In neutrally aligned limbs, the medial compartment bears 60%–70% of the force across the knee during weight-bearing [2] and in part, because it is subjected to more load than the lateral compartment, OA affects the medial tibiofemoral compartment more often than the lateral [3]. In a varus knee, this line passes medial to the knee and a moment arm is created, which further increases force across the medial compartment. In a valgus knee, the loadbearing axis passes lateral to the knee, and the resulting moment arm increases force across the lateral compartment [4]. Knee malalignment can be modified surgically but a meticulous analysis of the deformity has to be achieved in order to define the type, size and site of deformity for optimized therapeutic planning, surgical technique, and postoperative follow-up.

The frontal plane alignment measurements are the gold standard method to assess knee alignment in patients with OA. Typical clinical tool for this purpose is full limb anteroposterior (AP) radiograph of lower extremities while the patient is standing on both feet [5]. Several different parameters are measured in knee radiographs. One of the most commonly used parameters is the load-bearing axis.

Lower limb alignment depends on two geometries: the long bones and articulating surfaces of femur and tibia[6]. Hip-Knee-Ankle Angle (HKAA) as the most common parameter that is measured by radiographs indicates the size of deformity. It is the angle formed by the intersection of a line from the centre of femoral head to the centre of the tibial spine and a second line from the centre of talus to the centre of the tibial spine. The normal HKAA is 180º, the angle greater than 180º represents a valgus deformity, and less than 180º is a varus deformity. Medial Proximal Tibial Angle (MPTA), Lateral Distal Femoral Angle (LDFA) and Joint Line Convergence Angle (JLCA) determine alignment between tibial and femoral surfaces in weight-bearing position. These angles are defined as follows; MPTA: The angle between the tibial mechanical axis and tibial joint line (line across the medial and lateral tibial plateaus) that is normally 87. LDFA: The angle between the femoral mechanical axis and femoral joint line (line across the distal femoral condyles) is normally 93 . JLCA: The angle between femoral and tibial joint line that is normally 0 - 2, meaning they are almost parallel. The abnormal angle is due to asymmetric wear. The varus femoral condylar orientation, medial joint space narrowing, and tibial plateau compression are the secondary sign of OA progression [6].

During the stance phase of gait which encompasses sixty percent of the gait cycle, body weight is supported by single leg. The mechanical axis angle is different in single-leg standing, double-leg standing, and supine positions [7].

MATERIALS AND METHODS

One hundred patients who visited Chettinad hospital and research institute, Chennai, with knee pain and knee deformity from November 2022 to January. 2023 were selected for the study. This study was approved by Chettinad hospital and research institute Committee of Ethics.

Patients who are above 45 years either had knee OA or were at high risk for developing knee OA were included in the study. Patients who are obese, with current knee pain or with history of knee surgeries or injuries are considered high risk. ankylosing spondylitis, Reiter's syndrome, rheumatoid arthritis, psoriatic arthritis, significant kidney disease, cancer, bilateral knee replacements, history of fracture, and surgical treatment of OA were excluded from the study.

All patients were subjected to the gold standard imaging modality for assessing lower limb alignment, that is Anteroposterior (AP) full-limb radiograph to access the varus or valgus deformity. Radiology technicians followed a standard protocol to obtain these radiographs. For this study, both single and double leg weight bearing x-rays were taken with patients on bare feet with knees in full extension and tibial tubercles facing forwards. 80-90 kV and 100 to 300 mA settings were used while x-ray beams were centred at the knee. Single leg weight bearing x-ray were taken by asking the patient to raise the normal leg. By doing so, the patient will be bearing his full weight on the malaligned knee.

All X-rays were uploaded to the hospital picture archiving and communicating system (PACS). The X-rays were then used to measure 4 parameters. The parameters include HKA angle, MPTA, LDFA,

JLCA. All the parameters were measured by a single observer in blind circumstances with no knowledge of prior results. The data was analyzed using, MedCalc v18.2.1

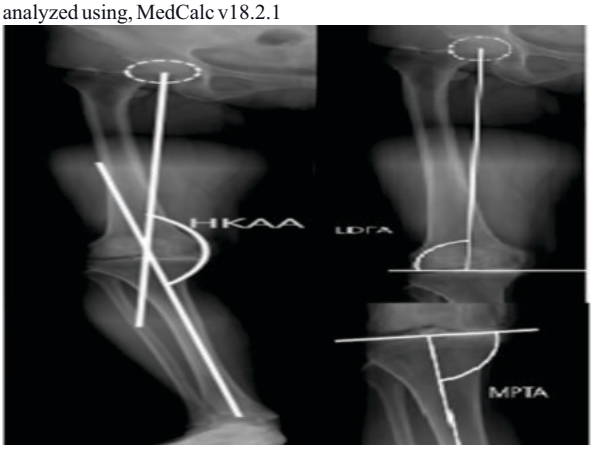

Fig 1: Xray showing how HKAA, LDFA and MPTA is measured.

Parameters	position	Mean
HKAA	Single leg standing	8.7
	Double leg Standing	7.98
MPTA	Single leg standing	89.2
	Double leg Standing	89.1
LDFA	Single leg standing	90.2
	Double leg Standing	89.7
JLCA	Single leg standing	3.43
	Double leg Standing	3.03

RESULTS

Hundred patients who participated in the study include 54 males and 46 females. The mean age was 56.2 years (range 45- 68 years) mean BMI was 27.1 kg/m2. Varus deformity was seen in 91 cases. In our study, we were able to find significant differences in HKAA and JLCA between single leg and double-weight-bearing x-rays. We were not able to find no changes in MPTA and LDFA.

DISCUSSION

Our study aimed to compare knee alignment parameters between single leg and double leg weight bearing x-rays. In our study majority of our participants had high body mass index which was predictable. Gudbergsen et al. concluded that weight loss is effective for symptomatic relief in obese subjects with knee osteoarthritis [8]. In our study the mean age was above 50 years which can be substantiated by the pathophysiology of osteoarthritis. Matsumoto et al. performed a study in 2015 that indicated that ageing was associated with the lateral curvature of the femoral shaft changing in the initiation of varus-type OA of the knee. Following these changes, secondary signs of OA progression including varus femoral condylar orientation, medial joint space narrowing, and tibial plateau compression arises [9]. Advancing age causes reductions in cartilage volume, proteoglycan content, cartilage vascularization, and cartilage perfusion and is the major risk factor for osteoarthritis in association with biochemical factors as mentioned by the American Association of Orthopaedic Surgeons [10].

Accuracy in pre-and post-operative knee alignment radiography is an important factor that must be regarded. The gold standard modality for knee alignment assessment is full limb lower extremity radiography in double leg weight-bearing position. In our study, we compared this with single leg weight bearing x-ray and we found a significant difference in HKAA and JLCA between these 2 methods. Several studies were conducted for assessing the reproducibility of angle measurements in short and full-limb radiographs. In 2009, Colebatch et al. compared and assessed the reproducibility of knee axial alignment (HKA and FTA), on conventional AP knee and full-limb radiographs in healthy people. They suggested standard AP knee radiographs with proper reproducibility as a useful method for measuring knee alignment [11].

In the current study, we demonstrated that HKAA and JLCA were significantly different between double and single-leg weight-bearing positions. The linear regression analysis confirmed the effectiveness of the patient's position on these angles (*P=0.000*). HKAA and JLCA were higher in single leg weight-bearing position which was similar to findings in the study of Specogna et al [12]. They found that HKAA measured on single-leg weight-bearing radiography is more representative of dynamic joint load and further highlights the difference between dynamic and static measures.

CONCLUSION

The gold standard imaging modality for assessing lower limb alignment is an Anteroposterior (AP) full-limb radiograph taken in double-leg standing. There is a significant difference in HKAA and JLCA measured in double-leg standing and single-leg standing. This change is due to during dynamic activities, such as gait, or single-leg weight-bearing, the force line shifts medial to the knee joint centre, therefore the compressive stress is increased in the medial aspect. Followed by this change the angles are higher while the patient is standing on a single leg and varus deformity is augmented in this position

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