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Original Research

Retrospective Analysis of Femoral Rotational Asymmetry at a Tertiary Care Hospital

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ABSTRACT
Background: The femur represents the longest, heaviest, and most robust bone in the human skeletal system. Femoral rotational asymmetry (FRA) refers to an anatomical discrepancy where the posterior condyles and the trochlear groove lack perpendicular alignment. Hence, the present retrospective study was conducted for evaluation of the femoral rotational asymmetry
Materials &Methods:50 patients were scanned resulting in 100 knee scans. The deepest locations within the trochlear groove, indicative of the sulcus line, were designated as regions of interest (ROIs) on the surface rendering and validated through orthogonal views in a multiplanar reconstruction format. The sulcus line (SL) was then quantified in relation to the surface area of the epiphysis (SEA) and the posterior condyle (PC) employing the "angle" tool, with the resulting data recorded in a Microsoft Excel spreadsheet. The ROI points were inserted. All the results were recorded and analyzed using SPSS software.
Results: The mean WL and SL were +2.7° and +1.1° respectively. The mean PC was -1.9°.In 58 percent of the cases, the rotational landmark was WL while it was SL in 25 percent of the cases.The Average SL and PC + 3° and PCL (Kinematic alignment)was present in 18 percent and 35 percent respectively.
Conclusion: Both the SL technique and the WL technique can be employed to assess the rotational alignment of the trochlear groove with SL showing slightly better results.
Key words: Femoral, Rotation, Asymmetry.

INTRODUCTION

The femur represents the longest, heaviest, and most robust bone in the human skeletal system. At its proximal end, a pyramid-shaped neck connects to a spherical head at its apex and a cylindrical shaft at its base. Additionally, two notable bony projections, known as the greater and lesser trochanters, serve as attachment points for muscles responsible for the movement of the hip and knee joints.[1,2] Other significant anatomical features include the adductor tubercle, which facilitates the attachment of the posterior segment of the adductor magnus muscle, and the linea aspera. The hip joint is classified as a ball-and-socket joint, formed by the acetabulum of the pelvis that encases the femoral head. The orientation of the head is directed medially, superiorly, and slightly anteriorly. Furthermore, the ligamentum teres femoris establishes a connection between the acetabulum and the fovea capitis femoris, a small pit located on the head of the femur.[3,4]The sulcus line (SL) serves as a three-dimensional reference point those accounts for individual differences in the coronal orientation of the trochlear groove, distinguishing it from the conventional Whiteside's line (WL). Femoral rotational asymmetry (FRA) refers to an anatomical discrepancy where the posterior condyles and the trochlear groove lack perpendicular alignment.[5]Hence; the present retrospective study was conducted for evaluation of the femoral rotational asymmetry

MATERIALS & METHODS

The present retrospective study was conducted for evaluation of femoral rotational asymmetry. A retrospective review of a consecutive series of pre-operative knee CT scans of patients requiring hip replacement was performed. In total, 50 patients were scanned resulting in 100 knee scans. Reference points were established at key anatomical landmarks, specifically the lateral epicondyle, the medial epicondylar sulcus, and the posterior condyles, on the axial two-dimensional (2D) slice where these features were most distinct. Subsequently, a three-dimensional (3D) reconstruction was executed utilizing specialized software. The deepest locations within the trochlear groove, indicative of the sulcus line, were designated as regions of interest (ROIs) on the surface rendering and validated through orthogonal views in a multiplanar reconstruction format. The sulcus line (SL) was then quantified in relation to the surface area of the epiphysis (SEA) and the posterior condyle (PC) employing the "angle" tool, with the resulting data recorded in a Microsoft Excel spreadsheet. The ROI points were inserted. All the results were recorded and analyzed using SPSS software.

RESULTS

The mean WL and SL were +2.7° and +1.1° respectively. The mean PC was -1.9°.In 58 percent of the cases, the rotational landmark was WL while it was SL in 25 percent of the cases.The Average SL and PC + 3° and PCL (Kinematic alignment)were present in 18 percent and 35 percent respectively.

Table 1: Rotational landmark angels measured in degrees relative to the surgical epicondylar axis

Landmark	Mean	SD
WL	+2.7°	2.3°
SL	+1.1°	2.1°
PC (posterior condylar line)	-1.9°	1.8°
Average SL and PC	-0.3°	1.1°

Table 2: Outline rate for each rotational landmark

Landmark	Percentage outliners
WL	58 %
SL	25 %
PC + 3°	12 %
Average SL and PC + 3°	18 %
PCL (Kinematic alignment)	35 %

DISCUSSION

The femoral region, commonly referred to as the thigh, is delineated proximally by the hip joint and distally by the knee joint. This area is partitioned into three distinct muscle compartments—anterior, posterior, and medial—by connective tissue septae. The muscles located in the femoral region play a significant role in facilitating movement at both the hip and knee joints. Additionally, the principal neurovascular structures of the lower limb traverse these femoral compartments prior to their entry into or exit from the pelvic cavity.[6,7]The rotation of the femoral component plays a crucial role in achieving favorable results following Total Knee Arthroplasty (TKA). The alignment of internal or external rotation of the femur component in TKA significantly influences sustained clinical outcomes. Malrotation or improper alignment of the femur component can potentially lead to complications like patellofemoral maltracking and instability, post TKA stiffness. It can also lead to anterior knee pain and instability during mid-flexion. Malrotated femur component can lead to abnormal tortional loading on the tibia component, impingement of the cam post in posterior stabilized (PS) cruciate sacrificing designs causing premature wear and loosening of the components.[8]The rotational alignment of the trochlear groove can also be referenced to determine femoral component rotation. The APA, also known as Whiteside's Line (WL) is used to determine the rotational alignment of the trochlear groove. It is formed by a line between two points, the deepest part of the trochlear groove anteriorly and the centre of the intercondylar notch posteriorly. Measurement of this line is unreliable and this stems from utilizing a two-dimensional (2D) line to measure a three-dimensional (3D) curve. A more accurate 3D technique known as the sulcus line (SL) was developed correcting for variations in the coronal alignment of the curve of the trochlear groove to isolate its rotational alignment.[9]

The mean WL and SL were +2.7° and +1.1° respectively. The mean PC was -1.9°.In 58 percent of the cases, the rotational landmark was WL while it was SL in 25 percent of the cases.The Average SL and PC + 3° and PCL (Kinematic alignment)were present in 18 percent and 35 percent respectively. Victor J et al presented literature review of previously published

papers describing rotational alignment of the distal femur and discussing different techniques in obtaining correct rotational alignment of the femoral component in TKA. Utilizing the available data, one can derive the mean angular relationships concerning the rotation axes of the distal femur within the axial plane. Notably, the trochlear anteroposterior axis demonstrates the highest degree of interindividual variability.[10]In another study conducted by Newman CR et al, authors measured the SL. A retrospective analysis of a series of 191 CT scans of nonarthritic knees was performed. Measurements were taken of rotational landmarks in three-dimensional reconstructions. The variability and incidence of outliers in the surgical landmark (SL) were found to be lower than those associated with the white line (WL), yet higher than the posterior condylar line (PC). When averaging the PC + 3° with the SL, there was no alteration in the rate of femoral malrotation concerning the surgical epicondylar axis (SEA); however, this approach significantly reduced the change in the rotational alignment of the trochlear groove between the native and prosthetic knees, decreasing it from 31% to 5%. Furthermore, femoral rotational asymmetry (FRA) was identified in 56 out of 191 cases (29%), with measurements exceeding 5°. The SL technique demonstrated superior accuracy compared to WL in establishing the rotational alignment of the trochlear groove. Nonarthritic femora exhibits a considerable prevalence of rotational asymmetry. By recognizing and categorizing FRA in individual instances, it becomes possible to position the femoral component optimally, ensuring the best alignment with both the native posterior condyles and the trochlear groove.[10]

Hayasaka S et al hypothesized that FRA increases as the tibial plateau becomes more varus due to internal rotation of the posterior condyles and external rotation of the trochlear groove to ensure a vertical trochlear groove at 90° knee flexion.A total of seventy lower limb Computed Tomography (CT) scans were analyzed by two evaluators. The study involved comparisons of both the sulcus line (SL) and the posterior condylar line (PCL) in relation to the surgical epicondylar axis (SEA). Measurements of femoral and tibial coronal alignment were conducted using CT scanograms and three-dimensional reconstructions. Correlation analyses were executed to explore the relationships between femoral rotational alignment (FRA), SL, PCL, and the coronal alignment of both the tibia and femur. The average FRA was determined to be +2.9° (with SL externally rotated relative to PCL). Notably, an FRA exceeding four degrees was observed in 24% of the knees (17 out of 70). A statistically significant correlation was identified between the FRA and the medial proximal tibial angle (MPTA). Additionally, significant correlations were established between both the SL and MPTA, as well as the PCL and MPTA. It is noteworthy that native femora often exhibit rotational asymmetry.[11]

CONCLUSION

Both the SL technique and the WL technique can be employed to assess the rotational alignment of the trochlear groove with SL showing slightly better results.

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