

Component Alignment in Total knee Replacement



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Introduction

Total knee replacement (TKR) is one of the most commonly performed surgical intervention providing substantial relief from pain and improvement in functional disability in patients with knee arthritis [1]. Although the survival of primary TKR is excellent with 95% of survival at 10 years for most implants [2], approximately 20% of those who undergo TKR are not satisfied with the outcome at the end of one year assessment [3]. Restoration of knee alignment is one of the main determinants of successful outcomes after TKR [4]. Implant malalignment following primary TKA has been reported to be the primary reason for revision in 7% of revised TKR [5].

Discussion

Alignment axes

Vertical Axis is defined as a vertical line that extends distally from the center of the pubic symphysis on a normal weight bearing antero posterior radiograph. This vertical axis is used as a reference axis/line from which the other axes are determined [5].

The mechanical axis of the lower extremity is determined by drawing a line from the centre of the femoral head to the centre of the ankle joint, which corresponds to an approximately 3° slope compared with that of the vertical axis. The anatomic axis of the lower extremity is an axis in relation to the intra medullary canals. The femur anatomical axis (FAA) is determined by a line drawn proximal to distal in the intra medullary canal bisecting the femur in one-half. Tibia anatomical axis (TAA) is created by a line drawn proximal to distal in the intra medullary canal bisecting the tibial in half [4].

On antero posterior evaluation, the anatomic axis and mechanical axis of femur has 5° to 7° of inclination difference between them, however anatomic and mechanical axis of the tibia correspond with each other (Figure 1). Hip knee axis (HKA) also known as mechanical axis of lower limb is commonly defined as the angle between the mechanical axis of the femur and the mechanical axis of the tibia [6].

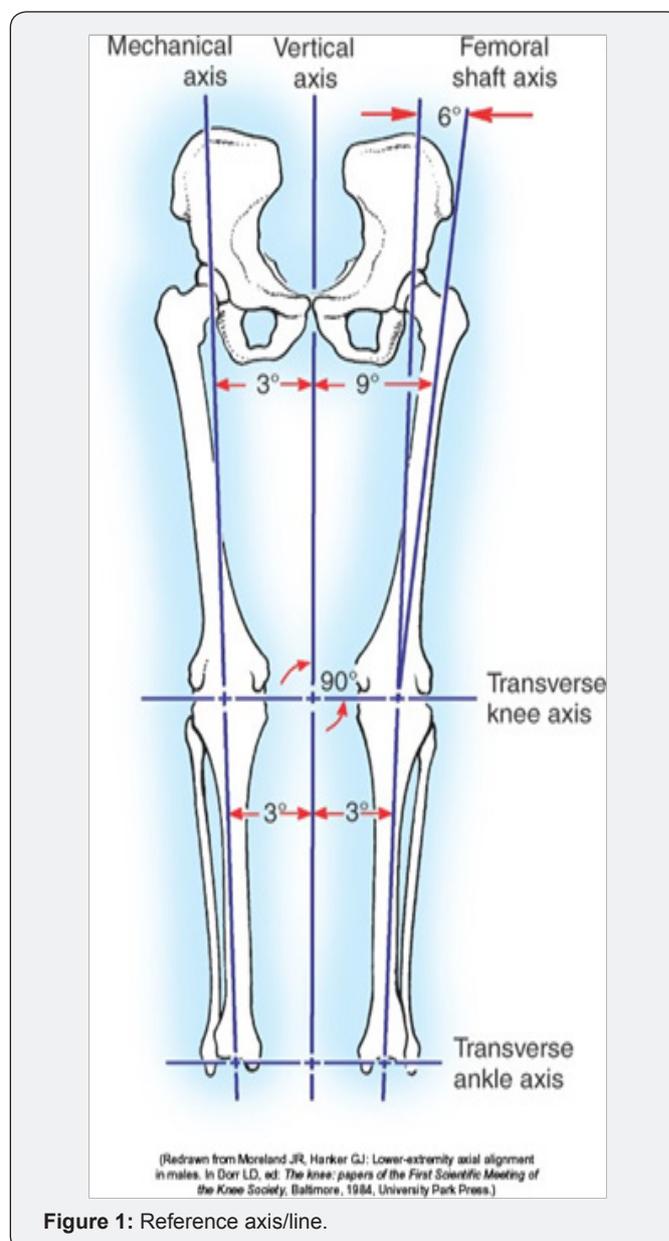


Figure 1: Reference axis/line.

Coronal alignment

One of the goals of TKR is restoration of overall mechanical axis of the lower limb also known as HKA angle. Tibiofemoral axis (TFA) can be determined on short anteroposterior radiographs of the knee when full length weight bearing views are not available. The acceptable alignment is between 7° and 9° of valgus. [7]. According to Fang et al increased failure rates were noted in TKR with varus malalignment (TFA < 2.5°) and valgus malalignment (TFA > 7.5°) [7]. It was found that knee aligned +/- 3° of neutral mechanical axis had better international knee society scores (KSS) and short form 12 (SF 12) scores at 6 weeks, 3 months, 6 months, and 12 months after surgery [8].

The optimal distal femoral cut is made at 2°-7° of valgus to the FAA to achieve optimal mechanical alignment. Femoral component placement > 8° of valgus in relation to FAA has resulted in 5 times higher rates of failure. [9]. Coronal alignment of femoral component > 8° and < 2° of valgus with respect to the FMA were associated with implant failure [10]. The tibia component should be placed at neutral alignment (90°) in coronal plane with maximum bone coverage and this is achieved by proximal tibial cut at 90° to the mechanical axis of tibia [9,11]. Tibial component > 30 of varus had increased risk of medial bone collapse [12]. According to Kim et al. [11]. No knees in the neutrally aligned group required revision of the components, and 3.4% of the varus malaligned tibia component required revision at 15.8 years of average follow up.

Sagittal Alignment

The ideal femoral component positioning in sagittal plane is considered to be 0-3 degrees of flexion [10]. Hyperextension of the femoral component apparently increases the risk of osteolysis [13] and also it may create a notch in the anterior femoral cortex, which can increase the potential risk of a supracondylar fracture [14]. The study by Lustig et al. [15] in 95 patients found that Sagittal alignment of femoral component greater than 3.5° from the mechanical axis was found to increase the relative risk of mild flexion contracture at one-year follow-up by 2.9 times.

The desired tibial sagittal alignment for most prosthesis types is a posterior slope between 0° to 7° [10]. Tibial malalignment in the sagittal plane (< 0° or > 7°) had a failure rate of 4.5%, as compared to a failure rate of 0.2% in the neutrally aligned group [11]. In sagittal alignment the proximal tibia should never be resected in an anterior slope, as it would lead to impaired posterior flexion space and possible instability [16].

Rotational Alignment

There are many anatomical landmarks used to determine rotational alignment for femur. The trans epicondylar axis (TEA) of the femur is regarded as the gold standard axis for establishing the rotational alignment of the femoral component during TKR [8,17,18], other methods are trans-sulcus axis (TSA) also known as Whiteside's line [19], gap balancing (GB) and

posterior condylar axis (PCA). Femoral component should not be implanted in internal rotation with respect to TEA as the femoral component should be placed in 2-5° of external rotation in relation to TEA [11,20].

It is accepted that placement of femoral component in approximately 3° to 5° of external rotation, relative to the posterior condylar axis, improves patellar tracking. Externally rotating the femur 3-4° may be accurate with most patients; however in valgus knee with hypoplastic lateral femoral condyles every 1mm of asymmetrical cartilage erosion can change the femoral rotation by approximately 1° if rotational alignment is guided by PCA [20]. Femoral component .in excessive external rotation increases the medial flexion gap and may lead to symptomatic flexion instability; external rotation of this component by as little as 5° from the TEA increases shear forces on the patellar component [17,18]. Bell et al. [20] reported internal rotation of femoral component (>3° internal rotation in relation to TEA) was one of the significant etiological factors for pain after TKR. (24) Femoral component in flexion creates lift off of the anterior flange and patellar impingement and excessive extension of the femoral implant will displace the extensor mechanism anteriorly, increasing retinacular tension and patella femoral compressive force [21].

There are many anatomical landmarks used for the tibial component placement for rotational alignment which includes medial border of the tibial tubercle axis (TTA) [22,23], transverse axis of the tibia, medial 1/3 of the tibial tubercle [22,24] and malleolar axis [23]. There is no gold standard landmark for rotational alignment of the tibial component. Relying only on the TTA has been associated with mal positioning of tibial component [25] so combination of reference points may reduce errors in component position [17]. Tibial component malrotation is more common and typically more severe than femoral component malrotation [26]. It was found that internal rotation of tibia component > 9° in relation to TTA caused pain and functional deficit but there was no pain in patient with external rotational errors [18] and similar results were found by Bell et al. [20].

Conclusion

The goal of successful TKR is to achieve accurate alignment of components. Malaligned components may lead to pain, poor functional outcome and impair stability of the joint [20,26-29]. The acceptable parameters for accurate alignment are knee aligned +/- 3° of neutral mechanical axis [8] Coronal alignment of femoral component > 8° and < 2° of valgus with respect to the FMA [10]. The tibia component should be placed at neutral alignment (90°) in coronal plane with maximum bone coverage [9,11]. The ideal femoral component positioning in sagittal plane is considered to be 0-3 degrees of flexion and the desired tibial sagittal alignment for most prosthesis types is a posterior slope between 0° to 7° [10]. Femoral component should not be implanted in internal rotation with respect to TEA

as the femoral component should be placed in 2–5° of external rotation in relation to TEA [11,20]. There is no gold standard for measurement of tibial component rotation Excessive internal rotation of tibia component when measured in relation to the tibial tubercle can lead to knee pain [10].

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