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What does alignment mean in total knee arthroplasty?

When studying alignment after total knee arthroplasty (TKA) many concerns exist. This term may be confusing, because it can refer both to lower limb attitude compared to the mechanical axis, and to components' positioning compared to the joint line orientation. For this reason, before speaking about alignment, it is crucial to understand the axis of the lower limb and the different TKA alignment techniques.

Global lower limb mechanical axis refers to the connecting line (also called Maquet's line) from the center of the femoral head to the center of the ankle joint. Usually this line passes through the center of the knee and has an inclination of 3° from distal to proximal compared to the vertical midline (Figure 1).

The anatomical axes of the femur and the tibia refer to the mid-shaft lines. The femoral mechanical axis is the line connecting the center of the femoral head to the deepest part of the femoral notch. Those axes form an angle of 6°, also called anatomical-mechanical angle (AMA). The tibial mechanical axis is the line passing from the center of the tibial plateau to the center of the talus and its parallel to the anatomical axes. The mechanical axes of femur and tibia form at the level of knee joint the hip-knee-ankle angle (HKA angle), that is usually 180±3° (Figure 2).[1]

With this in mind, the anatomical alignment of the femoral joint surface is about 9° of valgus referred to the anatomical axis, whereas the inclination of the joint surface compared to the mechanical axis is 3° (*i.e.* 9° joint line inclination referred to anatomical axis – 6° AMA=3°). As regards the alignment of the tibial plateau, since the anatomical and mechanical axes are equivalent, this is about 3° of varus (Figure 3).[2]

Considering these definitions, overall alignment can be described in two ways, either by the anatomical femoral-tibial angle (AFT angle) or the mechanical femoral-tibial angle (MFT angle). The AFT angle is simply the difference between the anatomical alignment of the femoral joint surface (9° of valgus) and tibia (3° of varus) and is usually about 6° of valgus. Likewise, the MFT angle is the difference between the mechanical alignment of the femoral joint surface (3° of valgus) and tibia (3° of varus), resulting in 0° or neutral mechanical alignment.[3]

Therefore, component positioning in TKA is crucial to obtain a correct lower limb axis. Different alignment techniques were described. For decades the neutral mechanical alignment popularized by Insall was consid-

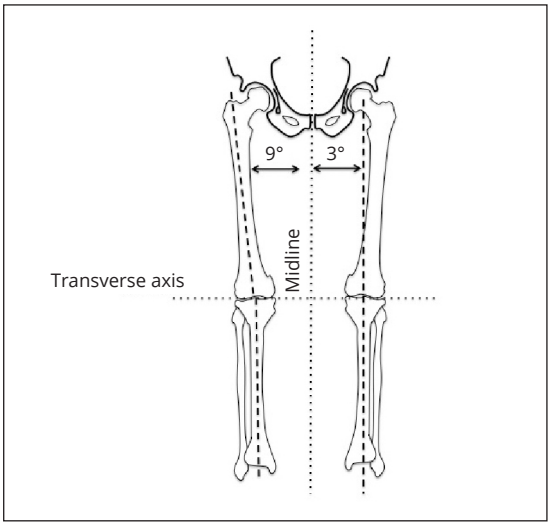

Figure 1.—Lower limb mechanical alignment (on the right) and femoral anatomical axis (on the left) referred to the midline.

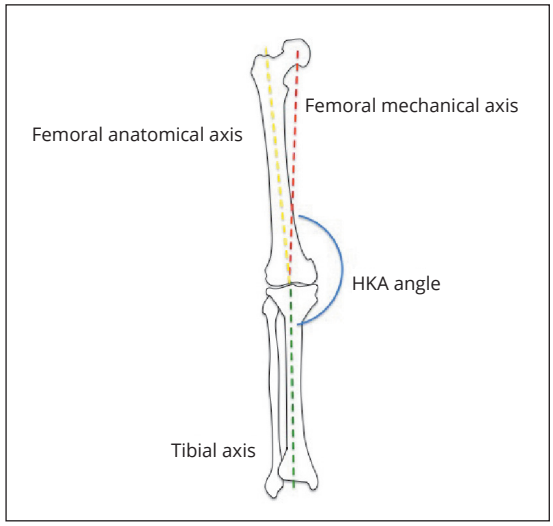

Figure 2.—Axes of femur and tibia.

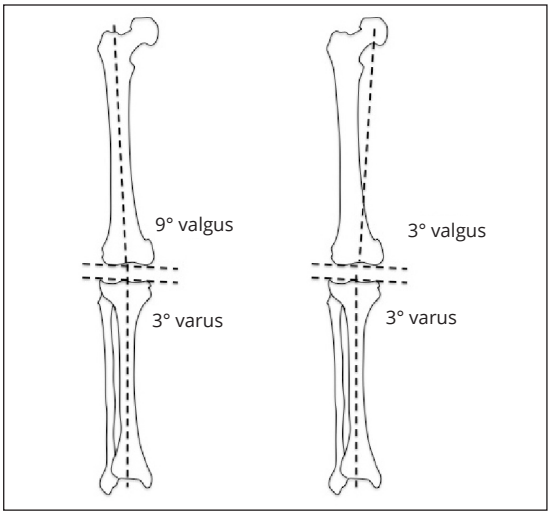

Figure 3.—Knee joint lines referred to the anatomical (on the left) and mechanical axis (on the right) of the femur.

ered the gold standard in TKA, but a great interest in a more "anatomical" approach has recently re-emerged.[4]

Insall's concept was that knee osteoarthritis is an asymmetrical disease with asymmetrical load distribution; therefore, the goal of joint replacement is to achieve a symmetrical joint surface and a symmetrical load distribution. The surgical technique consists in a 0° tibial cut perpendicular to mechanical axis, ligament balancing in flexion and extension, and a distal femoral cut ranging from 2 to 5 degrees in order to correct the preoperative deformity and achieve a neutral mechanical alignment. Moreover, the femoral component is externally rotated to achieve the correct balance. It is clear that Insall technique tends to modify the native knee.

Anatomically aligned TKA was first descripted by Hungeford *et al*. in 1982.[5] The aim was to achieve a joint line obliquity of 2-3 degrees of varus as the natural proximal tibial obliquity, as a more anatomical reconstruction. This technique should promote a more physiological load distribution on tibial component and reducing lateral retinaculum stretching during flexion.

Kinematically aligned (KA) TKA have recently emerged as an alternative to the systematic alignment. Starting from the principles of unicompartmental knee arthroplasty and the concept of constitutional varus introduced by Bellemans *et al*.,[6] KA TKA provides a patient-specific and ligament sparing technique, where the natural inclination of knee joint line is restored.

Vanlommel *et al*. introduced in 2015 the adjusted mechanical alignment (aMA) consisting in an adaptation of conventional mechanical alignment.[7] The goal of aMA is to undercorrect the global alignment within 3°, adjusting the femur and maintaining the tibia mechanically aligned. The authors found that patients with preoperative constitutional varus seem to achieve better functional outcomes.

Restricted kinematic alignment (rKA) is a recent technique where a computational algorithm help to study the preoperative HKA, femoral and tibial orientation joint line, and plan the adjustments on both side to achieve an HKA angle within 3° and an inclination of the joint surfaces within 5°.

Depending on the chosen alignment technique, component positioning will vary, but this does not go beyond a strict surgical technique. Correct alignment in TKA is one of the major objectives in replacement surgery, a correct component positioning lead to long-term survivorship and better functional outcomes.

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