Is the primary goal of total knee arthroplasty soft tissue balancing or alignment correction?

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Recommendation: The main objective of total knee arthroplasty (TKA) is to ensure the best possible outcome for the patient. The review of literature reveals that both alignment correction and soft tissue balancing are crucial for optimal outcome of TKA.

Strength of Recommendation: Moderate

Rationale: Total knee arthroplasty (TKA) is an extremely successful operation, with satisfaction rates over 80%[1]. However, a small fraction of the patients express dissatisfaction due to residual symptoms or lack of adequate improvement. Considering the high survivorship of modern TKA implants, the best way to assess success is through the use of patient-reported outcomes (PROMS). For many years, surgeons have used mechanical alignment as their goal to restore normal knee biomechanics and achieve equal load distribution in both medial and lateral compartments [2]. With the advent of robotic-assisted surgery, more accurate implant positioning and alignment restoration can be attained. However, other surgeons focus on achieving equal flexion and extension gaps through manual laxity tests or spacer blocks, which are not objective measurements of knee balance. New technologies enable surgeons to accurately balance the knee joint through tension measuring devices that give live feedback of the tension under each knee compartment to guide the bone recuts, implant positioning, and soft tissue releases[3]. Notwithstanding, whether a well-aligned or well-balanced knee translates into better postoperative outcomes is still a matter of debate.

Alignment and PROMs

Coronal Alignment – Mechanical Axis

The mechanical axis is usually assessed through the use of the Hip-Knee-Ankle angle in leg-length radiographic views or via computed tomography scan. Out of 25 studies evaluating the relationship of the mechanical axis with PROMs[4–23], 5 (20%) showed an improvement in PROMs when adequate alignment parameters were achieved. Four studies showed that patients with a HKA within 3° of the mechanical axis had improved Knee Society Scores (KSS)[24], SF-12, Oxford knee score (OKS), and international knee score (IKS)[25–27] compared to knees outside this range. One study showed a linear correlation between varus alignment and worse KSS [28]. Interestingly, the study by Schiffner et al., analyzing mechanical axis restoration in preoperative varus knees, showed that knees with slight postoperative varus alignment exhibited better Knee injury and Osteoarthritis Outcome Score (KOOS) compared to knees with a neutral alignment [21]. Improving quality metrics in patients with adequate mechanical axis restoration might be conditioned on preoperative coronal plane deformities.

Coronal Tibiofemoral Alignment

The knee anatomical axis, which is also a target for alignment during TKA, is often measured by the tibiofemoral angle (TFA), or its individual lateral distal femoral (LDFA) and medial proximal tibial angles (MPTA). From 8 articles evaluating the postoperative TFA, no article showed a relationship between this angle and PROMs [14,15,20,29–33]. The femoral coronal angle was associated with improved KSS and WOMAC in 3/15 (20%) articles [4–6,8,9,14,15,20,29–31,33–36]. Of note, the study by Hooper et al. found a significant but weak association (Pearson's correlation: -0.162, $p=0.006$) with the WOMAC score [35]. Similarly, the study by Chen et al. describes a positive weak correlation (Pearson's: 0.344, $p<0.001$), between the mechanical LDFA and the KSS, instead of the anatomical LDFA [14]. Although positive, the results of these studies are of low clinical relevance. Tibial coronal alignment was associated with PROMs only in 1/12 studies (8.3%) [5,6,8,14,15,20,29–31,33,36,37]. Rassir et al. found that the degrees of tibial coronal alignment malalignment were an independent risk factor for worse KSS functional score ($\beta=-3.43$, $p<0.001$) [37].

Tibial and femoral Sagittal Alignment

The femoral sagittal angle and tibial sagittal angle or tibial slope are the most common measurements used to evaluate alignment in the sagittal plane. We found 11 studies evaluating these measurements and their relationship with the KSS, WOMAC, SF-12, OKS, and visual analog scale of pain [7,14,15,20,22,29,30,33,34,36,37]. In none of these studies was sagittal alignment associated with PROMs. An additional measurement that can be assessed in the sagittal plane is the posterior femoral condylar offset (PFCO), which can be a determinant of alignment and biomechanics during knee flexion. Of 3 studies reporting PFCO, none found a significant association with PROMs [36,38,39].

Axial alignment

Axial alignments are measured by the amount of internal or external rotation of the femoral and tibial components noted in a CT scan. This is calculated by the relation of the posterior aspect of the femoral and tibial component with the transepicondylar axis and the tibial tubercule. 6/13 studies (46.1%) showed an association between axial alignment and PROMs [4,9,15,22,31,34,40–44]. In the only prospective study by Lutzner et al., they found that patients with a rotational mismatch greater than 10° had worse postoperative KSS functional scores[45]. Moreover, the study by Nicoll et al. showed that a worse KSS is associated with femoral component internal rotation >6°, tibial component internal rotation >9°, and tibial component internal rotational mismatch >11° [31]. Additional PROMs linked with axial alignment in these studies were OKS, SF-12, WOMAC, and VAS.

Balancing and PROMs

Using digital tensioners allowed for an accurate estimation of medial and lateral compartment pressures throughout the range of motion. From 13 studies evaluating the influence of balance in PROMs[46–53], 5 (38.5%) studies showed a better performance in PROMs when specific balance thresholds were achieved [54–58]. Most studies investigating this technology define knee balance as an intercompartmental pressure not greater than 15 lb at 10°, 40°, and 90° of knee flexion. Better KSS, WOMAC, OKS, and forgotten joint score (FJS) were achieved when intercompartmental pressure was below the aforementioned cutoff [54–56]. Wakelin et al. used a robotic tensioner with a Simulated Annealing (SANN) optimization algorithm to determine global optimum laxity and balance windows at different flexion angles [57]. They describe an improvement in the KOOS pain subscale at two years when all the balance windows were satisfied. Using the same robotic system, Lee et al. found a similar improvement in the KOOS pain subscale when the mediolateral compartment difference was <1 mm [58]. The development of patient-specific cutoff values for balance is a promising tool for further improving patient satisfaction. However, all the level-1 studies included in this review showed comparable results with the use of a tensioning device and a freehand gap-balancing technique [46–48,50].

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