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EDITORIAL

Alignment in TKA: what has been clear is not anymore!

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The optimal implant orientation when performing a total knee arthroplasty (TKA) remains a timely, pertinent, and unanswered question. For many years, the alignment debate has filled journals and congresses, and monopolised discussions among knee surgeons all around the globe. In the development of TKA surgery, Michael Freeman introduced the concept of right-angled femoral and tibial bone cuts (mechanical alignment) and the idea of parallel and equal flexion and extension spaces. Using the mechanical alignment target, the knee surgeon strived to create a neutral lower limb alignment represented by a hip-knee-ankle angle target of $180° \pm 3°$ [4, 12]. Although the mean hip-knee-ankle angle (HKA) of patients scheduled for TKA is near neutral, there is a wide variation and only 0.1% have neutral femoral and tibial mechanical axes [1]. With a systematic approach, mechanical alignment introduces anatomic modifications for many individuals and results in unequal medial–lateral or flexion–extension bone resections. Multiple ligament release techniques and algorithms have been proposed to re-balance the unbalanced gaps created.

In the past years we have seen increased questioning of the concept of mechanical alignment, which has been considered the gold standard for decades. Historically, the alignment philosophy for TKA was driven by the desire to maximize durability and relieve pain with less regard for restoring normal knee kinematics and function. However, several landmark studies have shown the concept of neutrally aligning every TKA is dogma and not true anymore [23].

Questioning such a dogma leads to a certain amount of uncertainty among knee surgeons and opens the door to non-scientific subjective definitions and personal opinions of what alignment targets are preferred and which ones to safely recommend. Hence, it is important to unambiguously describe and define the current implant orientation and alignment options [18]. Only when knee surgeons use the same definitions to discuss alignment progress can be made and misinterpretation be limited.

Anatomical alignment was introduced in the 1980s by Hungerford and Krackow with the goal to improve functionality by closer mimicking the native knee alignment [18]. With a systematic approach, anatomical alignment still aims for a neutral HKA, but the bones are cut 3° oblique to their mechanical axes to reflect the population's mean native joint line orientation (3° femoral valgus and 3° tibial varus) [18].

Kinematic alignment, first proposed in 2006 by Howell et al., is an 'individualised' or patient-specific technique, aiming to restore the pre-arthritic or native limb and joint line alignment of each patient [3, 8, 9, 11]. By resurfacing the knee joint, kinematic alignment technique aims to co-align the axes and joint lines of the components with the three 'kinematic' axes and joint lines of the pre-arthritic or native knee. Femoral and tibial bone resection thicknesses checked with caliper measurements should match the thickness of the components after compensating for wear and the kerf of the saw cut. Intrinsically, it preserves/restores native ligament laxities, does not create gap imbalance and thus minimises the need for ligament release [14]. In his protocol, Howell does not place restrictions on the patient's anatomy and post-operative correction. Kinematic alignment requires a precise surgical technique which can be performed by different techniques: manual instruments, computer navigation, personalised instruments, and computer guidance,

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with caliper verification that the executed resections are correct [10, 14].

Some knee anatomies may be inherently biomechanically inferior, or may have been altered by metabolic bone disease, childhood deformity, etc. Concerns remain about restoring severe patho-anatomies, which may not be compatible with current TKA prostheses and fixation methods [9, 22]. Keeping in mind these uncertainties, Vendittoli et al. recommended "safe zones" for TKA alignment and suggested the use of a restricted kinematic alignment protocol [1]. The algorithm involves modifications of bony cuts within a "safe range" defined by the following criteria: independent tibial and femoral cuts must be within $\pm 5°$ of the mechanical axis of the respective bone and the overall resulting hip-knee-ankle angle (HKA) must fall within $\pm 3°$ of neutral.

However, these concerns about the need to restrict the degree of preoperative deformity and post-operative correction when performing kinematically aligned TKA are not supported by available knowledge. In a mid-term study, of unrestricted kinematic alignment the 10-year implant survival (i.e., 1.5% revised for aseptic reasons) and yearly revision rate (i.e., 0.3%) met the expected gold standard of mechanically aligned TKA, and the 2 to 9-year incidence of tibial component failure was negligible [9, 13]. Despite restoring a more varus limb alignment, kinematic alignment, in gait analyses, produced a lower knee adduction moment and medial tibial compartment load and more normal gait than mechanical alignment [2, 15]. The intra-operative forces in the medial and lateral compartments of patients with outlier alignment of the limb, knee, and tibia are comparable with those with in-range alignment, with no evidence of overload of the tibial compartments [19, 20, 22]. Accurate restoration of the distal femoral, posterior femoral, and tibial joint lines within ± 1 mm is needed as deviations as small as 2 mm and 2° increase tibial compartment forces beyond those of the native knee, which patients may perceive as stiffness or limited motion [16, 17, 21].

The latest and most compelling support for use of kinematic or an 'individualised' alignment philosophy in place of mechanical alignment is from the systematic classification of the phenotype of the native limb and knee joint line by Hirschmann et al. [5–7]. Guided by the individual phenotype identified the optimal alignment for each knee is found. It is about a more meticulous planning in 3D and the decision if an off the shelf knee could do it or if the knee needs a customised TKA.

Due to the significant deficiencies in both our knowledge and technology in the past, we were far from replicating normal knee kinematics with TKA. Current limitations in TKA function and patient satisfaction should stimulate us to question our practice. Implant design and surgical techniques need to be advanced to better reproduce the anatomy and kinematics of native knees and ultimately provide a forgotten joint. As with many things in life there are different phases of adoption of a newer alignment philosophy such as kinematic or individualised alignment. The surgeons that are early adopters are on the forefront of change and their concepts need examination and vetting. The late adopters are conservative and remain critical until the newer alignment philosophy is proven superior to mechanical alignment. The mass in between, the middle adopters, remain rather indecisive and somewhat confused about the definition and benefits and short-comings of available alignment philosophies. In one of our previously published papers the authors stated they used kinematic alignment; however, their surgical method was challenged as not meeting the definition of kinematic alignment in a letter to the editor by Riviere et al. The correction will be published in this issue.

It appears that what was clear for decades is not so clear anymore. The discussion needs to go on and will go on. Our understanding will be enhanced by the use of an unambiguous definition of alignment by those that report outcomes of TKA.

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