CONTROVERSIES IN KNEE ARTHROPLASTY

Neutral mechanical alignment
IS IT NECESSARY?

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The cause of dissatisfaction following total knee arthroplasty (TKA) remains elusive. Much attention has been focused on static mechanical alignment as a basis for surgical success and optimising outcomes. More recently, research on both normal and osteoarthritic knees, as well as kinematically aligned TKAs, has suggested that other specific and dynamic factors may be more important than a generic target of 0 ± 3° of a neutral axis. Consideration of these other variables is necessary to understand ideal targets and move beyond generic results.

Historically, the orthopaedic community has looked at alignment in total knee arthroplasty (TKA) as a dichotomous variable that is either aligned within 0 ± 3° of a neutral axis or mal-aligned. As a consequence of this focus on mal-alignment our knowledge about the ideal alignment is little better today than it was in the 1970s when knee arthroplasties were first introduced. The question remains whether the ideal target is really broad and generic such as 0 ± 3° range or might actually be narrow and specific for each patient, with a penalty to pay with deviations of even one degree. It is important to choose the right target in order to maximise both durability of the implant and function of the TKA in the patient. While one target value might maximise both durability and function, it might be that there are two different targets, for example one that maximises durability, recognising the biomaterial limitations of metal, plastic and bone cement, and another target that maximises function, recognising the biological limitations of ligaments and soft tissues. Furthermore, it is debatable whether a single two-dimensional value such as varus or valgus on a plain radiograph can describe the ideal alignment.1,2

In contrast to the high patient satisfaction rate following total hip arthroplasty, up to 20% of patients remain dissatisfied after TKA for reasons that are not clear.3 The current accepted practice of achieving post-operative mechanical neutral alignment is based largely on studies with some fundamental flaws. Two of the more problematic flaws are the reliance on post-operative short knee radiographs, which do not allow for accurate calculation of the mechanical axis, and that the original more elementary TKA designs that have been studied which have few similarities to modern condylar TKA.5

The reason for reconsidering the principle of neutral mechanical alignment is based on both the gap between current methodology and patient satisfaction, as well as evidence regarding normal and osteoarthritic joint anatomy and mechanics. In addition, the inconsistent correlation between achieving mechanical alignment needs examining, especially the key outcomes such as implant survival and optimal function and then these need to be compared with the favourable outcomes in the literature of kinematically aligned TKA.

Substantial resources have been dedicated to the use of computer-assisted navigation, robotics and patient specific instrumentation under the hypothesis that achieving precisely the generic target of a mechanical axis will promote durability or improve function. In a randomised controlled trial (RCT), Gothen et al6 found that computer-assisted surgery was more predictable than conventional surgery for achieving mechanical alignment but functional results were marginally improved. Kim et al7 similarly found that there was little
We have reviewed modern cemented TKA in 398 patients in order to evaluate whether achieving a mechanical axis of 0 ± 3° conferred a 15-year survivorship advantage when looking at revision for all causes and revision for mechanical failure.9 This group of patients had implants that are similar to contemporary knee arthroplasties and were all performed by one experienced surgeon (JR). The results showed a revision rate of 45 in 292 knees (15.4%) in the mechanically aligned group versus 14 in 106 knees (13%) for all causes. Thus, attaining the mechanical axis is not a ‘safe harbour’ when it comes to implant durability and high patient satisfaction.

In primary osteoarthritis research, the factors other than alignment that may be important have been studied extensively. These include gait dynamics10 and the influence of neurological, muscular, or skeletal issues,11 and the dynamic loading that goes across the knee joint.12 The conclusions from these studies are that two patients with very different body shapes or comorbidities should not be expected to achieve the same result from one generic target. However, little research has addressed these same issues following TKA. In our own gait laboratory, we studied the relationship between mechanical alignment and dynamic loading after modern knee arthroplasties.13 In total 15 patients went through the gait laboratory pre-operatively and again after two years. Despite 13 of 15 patients (87%) having static mechanical alignment of 0 ± 3°, only seven of the 15 patients (47%) had balanced dynamic loading of their knee joint. The substantial variation found between static and dynamic alignment showed that mechanical alignment does not predict dynamic loading after modern knee arthroplasty. This data may provide insight as to why some well-aligned knees fail and some outliers prove durable at 15 and 20 years. Similar inconsistencies between static mechanical alignment and dynamic kinematics have also been identified.14,15

In parallel to the research demonstrating some of mechanical alignment’s shortcomings, there has been evidence in support of so-called kinematic alignment. The principle of this technique is to restore the patient’s own pre-arthritic anatomy and maintain the normal axes of rotation about the knee.16 The traditional mechanical alignment protocol is to cut the tibia at 0° and minimise the thickness of cuts. After cutting the tibia at 0° in the typical varus knee, the lateral side is relatively over resected. The femur must then be over-resected medially with possible functional benefit to computer-assisted navigation versus conventional TKA, although the alignment and survivorship were not statistically different. In conventional TKA studies, small deviations from 0 ± 3° also have had a small effect on durability.8

Several clinical studies have recently been published in support of kinematically aligned TKA. In a RCT, Dossett et al20 compared the outcomes of patients undergoing either kinematically or mechanically aligned TKA. In this study of 88 patients, those allocated to the kinematically aligned cohort had better improvement in Western Ontario and McMaster Universities Arthritis Index (WOMAC), Oxford, and Knee Society scores as well as higher mean flexion and superior pain relief at two years. Howell et al21 reported on the function of 198 patients (214 knees) with kinematically aligned knees during a minimum follow-up of 31 months in order to assess the relationship with alignment and mechanical failure. Patients with alignment classified as either in range or a varus/valgus outlier according to their tibial component, knee and limb, all had similar Oxford knee and WOMAC scores and no patient went on to be revised for loosening, instability, or wear. In a separate study, Howell et al22 investigated contact kinematics in kinematically aligned TKA and were able to demonstrate a reduction in detrimental contact forces during both standing and kneeling. Finally, in the questionnaire administered by Nam et al,4 patients who had a kinematically aligned TKA were three-times more likely than those with a mechanically aligned TKA to report that their knee felt normal.

A final question that arises is whether it is safe to explore alternatives to the mechanical axis. Certainly, the mechanically aligned TKA has a history of safety and should be the basis of comparison. In our study we showed no difference at 15 years in survivorship and no predictive ability for dynamic loading with a static mechanical axis target and hence along with reports from other institutions, it does seem reasonable to explore an alternative strategy.9 However, until more data is available, staying within the boundaries of an overall alignment 2° to 7° valgus23 and tibial component alignment less than 3° varus14,24 remains a useful target range.

Most surgeons today would agree that alignment plays an important role in TKA function and survival, but certainly factors other than alignment are also important in determining the survival of modern TKAs.25,26 The evidence suggests that ideal alignment after knee arthroplasty...
is probably very specific for any given patient and influenced by individual differences. There is a complex interplay between limb alignment, component rotation, sizing, ligament balance and gait dynamics. Moving forward, more attention needs to be devoted to function in knee arthroplasty in order to improve patient satisfaction. While the mechanical axis has been useful, future improvements are dependent on achieving better targets. The historical focus on radiographical outliers to explain total knee failures has been shown to be inadequate and has possibly constrained our intellectual curiosity.

**Author contributions:**
M. M. Allen: Background research, Writing the paper.
M. W. Pagnano: Primary content, concepts, opinion, edited paper.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

This article was primary edited by S. P. F. Hughes.

This paper is based on a study which was presented at the 31st Annual Winter 2014 Current Concepts in Joint Replacement® meeting held in Orlando, Florida, 10th-13th December.

**References**
