Kang et al\(^1\) have ably demonstrated the role of finite element analysis (FEA) in deciphering the complex interplay between component positioning of the implanted total knee arthroplasty (TKA) and the kinetics of key soft-tissue structures. This work extends our knowledge of the role of the central posterior restraint (posterior cruciate ligament (PCL)) and the impact of varying posterior condylar offset (PCO) and posterior tibial slope upon final tibiofemoral flexion, muscle load, and by inference, final construct stability. Using an established computer model of TKA, the fine balancing of the knee after arthroplasty has been keenly exposed. The extension of this modelling work to examine muscle load in the quadriceps and patellofemoral articulation is of particular interest, and supports previous \textit{in vitro} cadaveric work.\(^2,3\) It would appear that there is, in effect, a form of length tension effect when determining optimal offset and tibial slope. Perhaps the addition of the flexor hamstring in a future computer mixed-modelling analysis could delineate the true force couple effect at any instantaneous point of motion. Purists may argue that translation of such hypothetical FEA theory into clinical practice is hampered by the significant assumptions inherent in such work. However, this work does allow for reliable computation of how small changes that often occur during a manually performed TKA can have a significant impact upon the biomechanics of the prosthetic joint. Building upon these findings through \textit{in vitro} work will direct our study hypotheses to delineate the role of other factors such as preoperative deformity, soft-tissue envelope behaviour and femoral component geometry upon final construct performance.

PCO allows for improved clearance of the tibial component in deep flexion, and through resolution of forces, will act with the anterior patellofemoral offset to optimise the lever arm in flexion. PCO has been shown to correlate with functional outcome after revision TKA, with decreasing offset associated with a worse outcome.\(^4\) The effect of PCO should be maximal in mid to late flexion and Kang et al\(^1\) are to be congratulated on comprehensively defining the patterns of load across the patellofemoral joint in their model. There would intuitively appear to be a perfect balance for controlled load through both the tibiofemoral and patellofemoral articulations at each point of flexion which maintain correct tension in the anterior (e.g. quadriceps, patellar retinaculae) restraints. This work stresses the importance of maintaining normal anatomy, and indeed, such a philosophy could be extended to the role of accurate restoration of soft-tissue constraint through intraoperative tension and load measurement systems. There is a move away from the simplistic two-point measurement of gap geometry at full extension and 90 degrees of flexion, and this work highlights the value of examining the behaviour of the knee during this functionally important phase of knee flexion. The importance of PCO in determining ultimate knee flexion was recognised by Bellemans\(^5\) and others.\(^6\) However, others have failed to find such a relationship.\(^7\) It is known that the PCL acts as a restraint to posterior tibial subluxation and is at risk of avulsion, with increased tibial slope angle.\(^8\) This relationship is further complicated by the knowledge that \textit{in vivo}, the PCL is often diseased and may not exhibit true elastic behaviour.\(^9\) The PCL may also be deficient, be it inherent or traumatic, and when this is the case there is increased force transmitted to the patellofemoral joint that may lead to increase cartilage wear and degeneration.\(^10\)

It is difficult to input such confounding variables into the current FEA models, limiting their applicability. This confusion is
The effects of posterior cruciate ligament sacrifice in total knee arthroplasty remain unknown. The potential influence of implant position on the outcome of TKA.

Component alignment is a critical aspect of TKA. Coronal alignment of the TKA has been shown to influence the load in the medial compartment, which may affect the wear of the polyethylene, and ligamentous stability, laterally. Femoral rotation has been demonstrated to have a direct effect on the force transmitted through the medial tibiofemoral compartment and patellofemoral joint, with internal rotation increasing the force through these compartments. The majority of TKA designs sacrifice the anterior cruciate ligament, and others also sacrifice the PCL, which changes the joint kinematics. To address this, some surgeons have employed a bi-cruciate retaining TKA, which restores the normal joint kinematics on FEA. However, even if a bi-cruciate TKA is used and placed in the correct alignment and rotation it is often not replicating the patients pre-operative anatomy. In an effort to replicate the patients knee kinematics, the implant can be aligned according to their own specific mechanics, and this is defined as kinematic alignment. Kinematic alignment has been shown to replicate the normal biomechanics of the knee joint in FEA. There have been contrasting clinical results of kinematic alignment compared with conventional mechanically-aligned TKA. The most recent randomised controlled trial concluded significantly improved functional outcomes in the kinematic group, but this was at the expense of more outliers with a poor outcome, which were thought to have been due to malalignment of the prosthesis.

A major limitation during TKA is the variability of implant positioning. One in ten patients are outliers with an implant that is more than 3° from planned alignment. This variability will most likely result in abnormal joint kinematics. Robotic-assisted surgery is significantly more accurate at achieving correct implant alignment, which has the potential to reproduce native joint kinematics more reliably. Whether the kinematics vary according to anatomy, or if they influence outcome after TKA remains unknown.

References

Funding Statement
None declared

Author Contributions
N. D. Clement, Writing the paper.
D. J. Deehan, Writing the paper.

Conflicts of Interest Statement
None declared

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