Focus On

Navigation for TKR

Computer navigation in total knee replacement (TKR) has been widely available since 2002. Since then, two key debates have emerged. First, does computer navigation improve accuracy of implant positioning and alignment? and secondly, does any such improvement result in enhanced longevity of the prosthesis?

Accuracy of alignment

Restoring normal mechanical axis of the limb in the coronal plane has always been one of the main goals for knee arthroplasty surgeons in order to reduce the risk of early implant failure as a result of accelerated wear and aseptic loosening. Early single-centre studies of computer-navigated TKR showed superior alignment in the coronal, sagittal and rotational planes. Since these early studies, which had relatively small sample sizes, more data have been published to support better alignment with navigation. However, the difference between navigated and conventional TKR is perhaps smaller than was first expected.

Coronal malalignment of more than 3° has been shown to cause premature implant failure. A large meta-analysis of randomised controlled trials showed that navigation reduces the number of patients with post-operative malalignment of more than 3°, although the mean alignment and mechanical axis do not differ between navigated and conventional TKR groups. The relative risk of a deviation of more than 3° from the straight mechanical axis by using navigation was 0.76 compared with conventional TKR. Another comprehensive meta-analysis estimated this risk to be 31.8% for conventional TKR but 9% for navigated TKR. Kim et al demonstrated that there was no difference in alignment and orientation between navigated and traditional TKRs at bilateral TKR, with one side being navigated and the other side not.

Predictive finite element analysis on real patient data has shown that contact stresses on the polyethylene tibial insert were reduced by 12% in a series of navigated TKRs compared with conventional TKR. Another comprehensive meta-analysis estimated this risk to be 31.8% for conventional TKR but 9% for navigated TKR. Meanwhile Kim et al demonstrated that there was no difference in alignment and orientation between navigated and traditional TKRs at bilateral TKR, with one side being navigated and the other side not.

Additional benefits of navigation

To achieve balance in TKR, careful bone resection and soft-tissue release must be performed. Failure to release contracted collateral ligaments can lead to accelerated implant wear, especially when treating severe deformity, although excessive collateral ligament release can lead to instability. Using real-time navigation measurement and two intra-operative tests, Hakki et al were able to predict the need for collateral release with high sensitivity and specificity. Release was necessary in only ten of 93 patients (10.8%), significantly fewer than the 50% to 76% that have been reported elsewhere. Similar results have been demonstrated by other groups, suggesting that navigation may allow a more quantifiable approach to soft-tissue balance and lead to fewer patients needing a collateral ligament release.

Clinical outcome

Clinical outcome can only truly be assessed by properly conducted, randomised controlled trials. These would require at least five years' follow-up and large numbers of patients to give adequate power to a study, in order to identify a modest reduction in revision rates, or an improvement in knee scores. As yet, no studies meet these criteria and, therefore, there are currently no clinical data to show improved long-term outcomes with navigated TKR. There is some limited evidence of improved function and quality of life within the first post-operative year for patients with a navigated TKR; short-term function also appears to be improved by better coronal alignment of the limb after TKR. However, Spencer et al reported no difference in clinical outcome at two years despite superior alignment in their navigated TKR group. As a result of the improved lifespan of modern implants, it may be that many more years of follow-up will be needed in order to demonstrate a difference between the techniques.

Learning curve

There is a learning curve associated with adopting any new technique. Jenny, Miehlke and Giurea showed in a multicentre trial that there were no differences in implant position, clinical out-

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come and complications between beginner and established centres. Operative time was longer for beginner centres but this difference disappeared after 30 procedures.

**Complications**

Navigation increases the duration of surgery by 23% or 17 minutes; however, there is no increase in the rate of infection. There have been cases of femoral fracture secondary to drill holes used in the placement of infra-red trackers. Consequently, many would recommend unicortical fixation of trackers to prevent this complication.

**Cost**

As there are no long-term outcome data for the procedure, it is presently impossible to determine whether computer navigation is cost effective. Novak, Silverstein and Bozic performed a cost analysis based on current data and found that if equipment is purchased, computer navigation in the USA adds $1500 to the cost of an operation. However, in the UK most centres lease equipment; this results in a smaller cost increase of approximately £150 per operation. As fewer instrument sets must be sterilised for a navigated procedure, much of this additional outlay is recouped by the hospital. Computer navigation is most likely to be cost effective in high volume centres. Slover et al. estimated that an annual reduction in revision rates of 2% would be required over 20 years in a centre which performed 250 navigated TKRs per year in order to be cost effective.

**Future technologies**

The majority of computer navigation systems currently available rely on infra-red emitting or reflecting trackers; these are fixed to the bones of the patient or to instruments. A frustrating, technical aspect of navigated TKR is loss of the line of sight between trackers and the computer because of intervening theatre personnel and equipment, or contamination of the trackers by blood. Electromagnetic and radiofrequency tracking systems do not require line of sight between the computer and the trackers. These have been shown to be as accurate as infra-red systems in clinical trials. Specially-designed instruments such as drills, saw blades and cutting blocks are now available for use with navigation systems. These can reduce the operating time and may also improve accuracy.

**Other applications**

Navigation is perfectly suited for use in other areas of knee surgery. Peri-articular osteotomies for osteoarthritis and the correction of deformity can be guided by the real-time measurement of angles determined during pre-operative planning and may be more accurate and reproducible. Navigation is also suitable for both minimally invasive TKR and unicompartamental knee replacement, where restricted access to anatomical landmarks can cause difficulty with implant positioning and the referencing of bone cuts. In addition, navigation may have a role to play in establishing the best location for bone tunnels during anterior cruciate ligament reconstruction.

**Summary**

Computer-navigated TKR is well established in many centres and appears safe and relatively easy to learn. Its main benefit is a reduction in the number of TKRs that have a coronal malalignment of more than 3. In the long-term, this may result in fewer revision procedures for early implant failure. However, as yet there are no data to support this claim. In addition, there is some evidence that blood loss and systemic emboli are reduced using navigation as opposed to intramedullary jigs. Navigation may assist the surgeon to achieve a proper soft-tissue balance, thereby reducing the number of patients who require collateral ligament release and the subsequent risk of post-operative instability. Operative time is slightly longer when using navigation but this does not appear to cause additional morbidity. As yet, there is no convincing economic argument favouring computer navigation. However, in high-volume centres, a small reduction in the early revision rate can justify the additional cost. Overall, computer navigation is a useful additional tool for the orthopaedic surgeon who seeks to perform a total knee replacement and to achieve accuracy of alignment.

**References**


