Navigation in TKR: point of view

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It is a well known fact that the success of total knee replacement surgery depends on several factors. Patients related factors, such as, previous trauma or operations, co-morbidities, physical history and also patient expectations all have a vital role in the final outcome. However, appropriate implant design and especially correct surgical technique with proper soft tissue balancing are expected to have even greater impact on the end result.

Various studies have shown that the most common reasons for early revisions are instability, component malalignment, and patellar problems (1). Revisions for these reasons are not unpleasant only because patients and surgeons have expected results far superior, but because they often are avoidable. Most early revisions could be avoided with better preoperative planning and with better surgical technique. Alignment errors greater than 3° are associated with more rapid failure and radiolucent lines occur more frequently in knees with 3° or more of varus axial alignment or more than 4° of varus placement of the tibial component. These errors also change the intra-articular pressure distribution (2–4). In the long run, the incorrect implant positioning, improper limb alignment and soft tissue imbalance can lead to accelerated implant wear and loosening and result in late revision.

During the early days of arthroplastic surgery no guiding device was used. Mechanical alignment guides were developed to improve the accuracy with which implants can be inserted. Although mechanical alignment systems have improved continuously, errors in implant positioning and limb alignment continue to occur. It has been estimated that errors in tibial and femoral alignment greater than 3° occur in more than 10 % of total knee arthroplasties. So far, the focus has been on obtaining the correct limb alignment by correct and standardized bone resections. An equally important factor for success in knee replacement is soft tissue handling. In contrast to the very precise instrument-guided bone resection techniques, there is hardly any instrumentation provided for the soft tissue balancing. Management of capsule and ligaments is still a matter of surgical judgement, careful testing and good surgical technique. Modern computer-assisted navigation systems have been developed to achieve more accurate and more consistent implant alignment and soft tissue balance during total knee arthroplasty.

It is still unknown, if the navigation systems can really improve the accuracy of component position as compared with that achieved with more traditional techniques involving mechanical guides. Navigation is thought to be a safe alternative that is expected to reduce the number of outliers, especially in minimally invasive surgery. The difference in average alignment or rotational angles may not be that significant, but theoretically computer assisted operation is more standardized and the variation of angles should be reduced. Also, it does give definitively more information about the ligament tension during flexion-extension arch. In that sense, it is thought to be cost-effective in a long run. The drawback of the system is that it will, at least in some extent, lengthen the operation time.

In a meta-analysis of 33 studies of varying methodological quality involving 3423 patients Bauwens (5) with his co-workers showed that the alignment of the mechanical axes did not differ between the navigated and conventional surgery group. Although patients managed with navigation had a lower risk of malalignment of more than 3°, no conclusive inferences could be drawn on functional outcomes or complication rates. However, navigation lengthened the mean operation time by 23 %.

Siston et al. (6) tried to characterize the variability associated with femoral rotational alignment tech-

niques and to determine whether the use of a computer-assisted surgical navigation system reduced this variability. They compared different alignment techniques, including the posterior condylar axis, the anteroposterior axis, the transepicondylar axis and the computer-assisted technique. All techniques resulted in highly variable rotational alignment, with no technique being superior. This variability was primarily due to the particular surgeon who was performing the alignment procedure. A navigation system that relies on directly digitizing the femoral epicondyles to establish an alignment axis did not provide a more reliable means of establishing femoral rotational alignment than traditional techniques did. Surprisingly, less than 20 % of the patients had less than 5 degrees of malalignment.

In a prospective randomized three dimensional study Matziolis and his coworkers had similar findings. Computer-assisted implantation improved the frontal and sagittal alignment of the femoral component but not of the tibial component. However, rotational alignment of the component was not improved compared to referencing the epicondylar axis for the femur and the tuberosity for the tibia (7). In a very recent article about computer assisted minimally invasive arthroplasty the percentage of patients with a coronal tibiofemoral angle within ±3° of the ideal was 92 % for the computer-assisted minimally invasive total knee arthroplasty group, compared with 68 % for the conventional total knee arthroplasty group. Patients also had significantly shorter hospital stay and recovered functionally more rapidly in computer assisted group. The only downsize was significantly longer operative time (8).

In theory, computer assistance is most beneficial when anatomical landmarks are absent or not normal. In such cases, the navigation system would give extra options for referencing (9). It would also be very helpful in revision cases where not only the component position but also restoring the joint line can be challenging.

Navigation is an important learning tool. It will make it easier for the surgeon to understand how balancing could be optimized and also what kind of effect each cut and soft tissue release has on stability. This should not be underestimated. It has been shown that computer navigation will help trainees in getting reasonably good results earlier (10). However, it has also been shown that navigation will not help if surgical skills are not adequate. Yau et al showed in their study that computer navigation did not improve alignment in a lower-volume total knee practice. Navigation did not save the patients from major malalignments (11).

Navigation will lengthen the operation time, but otherwise it should be considered safe. However, the longer operation time may increase the risk for infection. There are also studies reporting on periprosthetic fractures as a complication of the use of navigation system (12). Cases are rare. The prevalence of fat and/or bone-marrow-cell embolization seems not to be different between the patients who have undergone total knee arthroplasty with or without navigation (13).

Overall, computer assisted navigation has given us a new tool for improving our results in knee arthroplastic surgery. The navigation systems we are using today are not yet appropriate for every day use in every single center. The systems are expensive, clumsy and the use of navigation lengthens the operative time significantly. There are some major technological differences between different navigation systems, also the software applications vary a lot. Most of these differences are, however, practical and have most likely very little impact on the end result. As long as the referencing is based on surgeons eye-balling and not on real on-line data, the navigation will be very surgeon dependent. However, we have to closely follow the development and take a vital role in designing new systems for future needs. The information obtained with the use of these devices will lead to improvements in the use of current manual instrumentation and will help design implants and instrumentations in future. Navigation has already helped us understand better the consequences of each bony resection and soft tissue release during the whole flexion-extension arch. In experienced hands, navigation may in future help us to improve accuracy of component positioning, limb alignment and soft tissue balancing. It is at this level that the difference between a good and an excellent knee arthroplasty is made. However, it is vitally important to realize that navigation will not help perform an operation if surgical skills are not adequate.

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