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EDITORIAL

Any technology assisting total knee arthroplasty (TKA) will fail without the correct 3D alignment and balancing target

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Technological advancement of total knee arthroplasty (TKA) such as navigation or PSI is a history of unachieved promises and failures. Why is that? For us, it should not be about just avoiding theses mistakes from the past, it should be about learning from them. According to the Gartner hype cycle, an introduction of new technology (or prosthesis) always follows a similar pattern and one can differentiate certain periods. You probably still remember the time when navigation was introduced and put forward as the final solution to all problems and challenges in TKA. In the introduction period, early users started to evaluate the possible benefits of navigation in TKA. A tremendous number of scientific articles reported promising early results. The short learning curve or the high accuracy and reliability of the navigation system was highlighted [7, 8]. Fostered by these promising early results navigation systems were installed in many hospitals all around the world and the use of it for TKA increased accordingly over the next years. After this first enthusiasm, the radiological and then clinical outcomes were investigated. A high system accuracy and less outliers in positioning the TKA components were found [1]. However, over the years, an increasing number of studies reported no clinical differences for navigated TKA when compared to conventional or patient-specific instrumented (PSI) TKA [11]. In contrast, the Australian registry is showing a reduced revision rate in particular for young and active patients. What can we learn from this historical journey for our current trip with regards to robotics?

Again, new promises are made, reaching from better reliability in achieving the alignment goals to improved outcomes. Why should robotic assisted TKA be better than navigated TKA? At the end, robotic is navigation and execution. Does the guided saw really make a huge difference? These pertinent questions are still unanswered.

The difference between navigation and robotics is not the accuracy itself. The difference is that we meanwhile have learned that even a perfect mechanically aligned and stable knee is changing the individual bony anatomy (e.g., joint line) in a lot of patients so much that these unphysiological resections are leading to stresses in the ligamentous frame of the knee [3]. Additionally, various studies have demonstrated that bony and ligamentous phenotypes exist and that aiming for a constant goal is probably not enough [4, 10]. Precisely, targeting the wrong goal is still not achieving better results. This is leading to much more important questions than the question which technical tool shall I use. The questions are: What is the perfect knee? Is a perfect knee the same in different individuals? To answer these questions we need to fulfil 2 preconditions: 1. Definition of 3D alignment and balancing targets and 2. Quantitative measurement of these parameters. And, therefore, technical tools can be helpful. Therefore, where are we now with both questions?

Regarding the 3D targets we are all focussing a lot on coronal alignment. Individual reconstruction of MPTA/LDFA and HKA for example and multiple workflows recreating these parameters have been published. The reason for this coronal bony focus is, that it can be easily measured. Stability is another important parameter, although we do not know exactly whether all gaps equal is the correct goal for all knees. In particular, when we recognise that more than 80% of natural knees have a lateral flexion gap that is more lax than the medial one [2]. For these

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parameters, our measurement options in robotics are reproducible, however, still not reflecting the active in vivo situation as the data is obtained in a supine position and passively [9].

Another important, but underemphasised aspect for bony and ligament goals is the sagittal plane. The reason, we do not know exactly what we are aiming for. Some are trying to reconstruct the individual (medial) slope, others are respecting the influence of the implant. What about femoral flexion? What about the interaction between posterior offset and flexion gap size? Is it more important to balance the knee in flexion or is it more important to anatomically resect the posterior condyles? What role does the implant conformity in anterior–posterior direction play for this question?

The most difficult plane is the horizontal plane where we do not know what we are aiming for, except the general goal of a balanced patella-femoral joint with a centered patella. While we have quantitative parameters for the femorotibial joint at least in the coronal plane, we do not have such parameters for the patella-femoral joint. Even worse, none of the robotic systems is capable to deliver quantitative data of this compartment.

What is the consequence on this? Where are we now? With technical tools we are able to collect data for some important parameters of the complex knee joint, which is a lot more than what we have with conventional surgery. However, we do not know what are the correct targets for the 3D alignment measured. For example, a valgus knee with a reduced LDFA: Shall we reconstruct the pathology or shall we correct it to "normal". What is normal and how much abnormality is accepted? Beside the problem of data interpretation, we still miss a lot of data to describe the knee in 3D precisely, and this dilemma is neither solved by navigation nor by robotics. Therefore, the potential to fail with robotics again is not low.

However, the only way to understand more about the interaction between all these parameters is data driven surgery. The data will be the basis for a better understanding of the complex knee joint, and therefore, we need to include robotics in our daily workflow and even more important analyse the different aspects of individual reconstruction constantly. Whether, us surgeons in the end are smart enough to understand this interaction and find the best individual solution for each patient by ourselves or whether AI and ML will help us to find it, will be the future question [5, 6, 12].

The current robotic systems will not solve all problems, but it is the only tool to collect relevant data to answer at least some of these questions, by that robotic systems are the precondition to gain the relevant data. As the data of actual robots is limited we need to work on smarter tools to gain more and more insight. This means that the journey of robotic systems has just started and we will discuss the benefit at different time points again. In this issue, we have put together remarkable articles investigating the value of navigation or robotics for knee arthroplasty.

Data availability This is an editorial-there is no data.

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