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New possible pathways in improving outcome and patient satisfaction after TKA

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Patient dissatisfaction after TKA has not been improved dramatically since the introduction of new alignment (navigation, custom guides) and balancing techniques. Orthopaedic surgeons consider the ligaments as essentially passive stabilizing structures. However, during the activities of daily living, the joints are stabilized primarily by our muscle actions that both move and stabilize the joints. Isometric motion of the joint does not cause the distance separating the bone attachments to change. The practical importance of isometry is confirmed by the fact that ligaments are elongated irreversibly if the strain exceeds a given level (5%). In ligament surgery as well as in TKA, the concept of isometry is highly important. In this paper we wish to highlight the fact that the role of the soft tissue envelope goes beyond structural and mechanical support. The presence of mechano-c.q. nocireceptors in the structures around the human knee joint has long been reported but is underrecognised by TKA surgeons.

Keywords : TKA ; patient satisfaction ; ligament strain ; mechanoreceptor.

Outcomes of knee replacement are traditionally assessed by survival analysis with revision as an endpoint. More than half of Total Knee Arthroplasty (TKA) revisions are performed less than two years after the index operation and are related to instability, malalignment or malpositioning and failure of fixation. Long-term "technical failures" requiring revision of the prosthesis such as loosening, fracture, or infection are relatively few.

Survival analysis underestimates the problem, as pain or poor function do not necessarily lead to revision. Although improvement following TKA can be dramatic, the gains are typically less than the changes reported by patients who have had a total hip arthroplasty (*14*). Numerous studies report that only 70% to 89% of patients are satisfied after their primary TKA, and as many as 20%-30% of patients continue to endure knee pain or have problems after TKA (*6,8,7,12*).

In the past 40 years, the number of implant designs available on the marketplace has increased enormously, usually with little evidence of improved effectiveness (*9*). Despite the fact that more

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than 100 different designs are now available on the marketplace, none of these seems to be associated with a patient satisfaction rate higher than 80%. The proportion of outliers has decreased recently with surgical technique improvements, better and more accurate alignment instruments, navigation and patient specific guides (*1,21*). Improved ligament balancing techniques using different tensioner designs have not provided reproducible results in the hands of the average orthopaedic surgeon (*2*).

Worldwide each year an increasing number of TKA's are performed : in 2009 more than 600.000 primary TKA's in the USA alone. This means that over 100.000 people who undergo TKA experience suboptimal outcomes every year, which is roughly equal to the annual incidence of RA in the USA (*17*).

We suggest that by now the pioneering days of TKA should have ended. We should no longer tolerate a 20% patient dissatisfaction rate. It is therefore imperative that we identify the pre-, per- and post-operative risk factors in an attempt to reduce our number of patients with poor results. Possible predictive factors such as age, gender, pre-operative functional and psychological status have been studied extensively but have shown modest predictive power (*3,16*).

Why is it that some patients remain unhappy with their function, despite TKA‘s high long-term reliability ?

We believe that the interaction with the peri-articular soft tissues plays an important role.

The collateral ligaments are an important factor in maintaining knee stability and avoiding abnormal motion. We believe that we need to look beyond traditional ways of thinking and accept the general principle that every patient has his own specific knee with its own patient specific soft tissue sleeve.

The concept of isometry of the collateral ligaments is important to describe this soft tissue sleeve (*5*). It has been shown by Victor *et al* that the MCL and LCL in the intact knee joint remain isometric during several motor tasks (*24*). It seems worthwhile to investigate the feasibility of safeguarding the patient's own specific soft tissue sleeve during knee joint replacement.

At the same time, it therefore may appear wise to considerably restrict or even avoid ligament release procedures in balancing the knee, providing the deformity can be corrected adequately without jeopardizing the implant's fixation or durability.

Currently no consensus exists regarding the best way to achieve a balanced TKA. Many differing techniques and sequences for ligament release have been reported over the years since Freeman and Insall first highlighted the importance of ligament balancing in the late seventies. New tools have been introduced to help the surgeon. However, randomized controlled trials comparing different techniques, sequences, and tools are scarce. The best method of achieving a balanced knee is yet to be determined.

Ligaments of the knee joint traditionally are seen as mechanical and structural joint stabilizers, but an abundant body of evidence indicates that the ligaments also have a sensory (essentially proprioceptive) role (*22*). O'Connor *et al* made an interesting observation by combining joint instability with denervation, which resulted in accelerated joint degeneration (*18,20*). A study by O'Brien *et al* also indicated that following nearly anatomic ACL reconstruction, morphological changes consistent with the development of mild OA do develop, suggesting a neurosensory mechanism (*19*). Avoiding neuroreceptor disturbance during ligament releases might therefore be important.

The ligaments are minimally deformed by joint rotations and develop stresses opposing further rotation. Mechanically sensitive afferent nerve fibers (mechanoreceptors) have been observed in ligaments. These afferents are activated by tensile stresses. These ligamentous mechanoreceptors may participate in the regulation of the knee joint stability. Other sensory fibers in the soft tissue envelopE of joints are nociceptors. When activated, these structures mediate the sense of pain.

In the soft tissue envelope of the knee, four types of receptors exist (*13,27*) :

– Type I Ruffini type receptors consist of a number of nerve processes that envelop and contact bundles of collagen fibers with a particular orientation. They can be thought of as load cells that detect tensile loads or stresses. They are mechanoreceptors with a very low threshold and

high sensitivity. Ruffini type receptors are driven by very small tensile stresses of about 15-20 kPa (*15*). They also act as limit-detectors.They are slowly adapting static and dynamic mechanoreceptors.
– Type II Pacini afferents are located around the patellar tendon and are activated by compression stimuli. They have a low threshold, and adapt rapidly as dynamic mechanoreceptors.
– Type III or Golgi-Mazzoni endings are high-threshold and very slowly adapting mechanoreceptors
– Type IV receptors are fine afferents with free nerve endings as terminals. They have a high threshold for mechanical activation and are nociceptors or non-adapting pain receptors.

The system of very sensitive, both rapidly and slowly adapting sensors in the soft tissue envelope sends impulses that contribute to the regulation or preparatory adjustment of the stiffness (tonus) and activity of the muscles around the knee joint (hamstrings and quadriceps) and thereby regulate stability (*23*). The sensory system within the knee ligaments provides the central nervous system with information about speed, acceleration, position and direction of movement.

The idea that the knee ligaments have a neurosensory function has implications on the surgical balancing during TKA. The classic way of releasing the ligaments to balance a TKP is based on the notion that the ligaments are only passive structural elements. When for example during ligament release of the LCL small but discrete nerve endings are transected, conceivably this could partly de-afferent this area of the soft tissue envelope, thereby diminishing the effectiveness of the locally initiated Protective Muscular Reflexes (PMR) (*11*) including an important part of the proprioception.

The presence of mechanoreceptors in the collateral ligaments means, by definition, that the mechanical status of these ligaments is monitored by the central nervous system (CNS). Therefore, it should be clear that the collateral ligaments are not merely passive rope-like structures with only biomechanical functions. We believe that even slight damage to the innervated region of the ligaments, with damage to its contained neural elements, could have important effects. Even with careful observation during orthopaedic surgery, clear structural damage to the collateral ligaments and their circumferential structures containing nerve endings is difficult to observe (*25*).

Since we know that ligament injury (regardless of the degree of structural instability) disrupts the neural apparatus, the clinical consequence could be variable. However, most patients will have a postoperative function which is altered by this neural injury. Luckily, adaptation occurs over time in 75% of the patients by mechanisms of re-innervation of the scar tissue, modulation of the spinal reflexes and cerebral reprogramming. In 25% of patients this “neural adaptation” does however not occur, potentially causing this group of patients to remain symptomatic.

Ligamentous and capsular releases, malpositioning or malalignment of the artificial joint can disturb the neurosensory protective system of the knee during TKA : afferent nerves may subsequently send “wrong” information from the knee joint to the CNS.

Functional joint stability is determined by the passive restraints caused by the soft tissue envelope, the joint geometry, the friction between the surfaces and the load on the joint by compression forces from gravity and muscles. The contribution of the load imposed on the joint by contraction of the surrounding muscles is considerable (*4*). When this is impaired, failure is pending.

Based upon the above mentioned rationale, we advocate to study collateral ligament strains in the native knee and compare these with the measurements in the replaced knee.

We believe that a previously not really recognized but important aspect in the evaluation of implant success, is the “surgical tolerance factor” of the knee joint. We wish to introduce this concept In order to examine and determine the permissiveness of a certain implant in the hands of a certain surgeon.

This “surgical tolerance factor” evaluates the tolerance or amount of play towards technical implantation, without compromising the end result.

To conclude, although registries are of undeniable value, there are inherent limitations in the data they provide. They provide a valuable addition to clinical studies, including randomized clinical trials, but cannot replace the additional information provided by studies based on patient satisfaction (*5,10*). Awareness of these limitations is crucial when assessing registry data.

In this paper we wish to highlight the fact that the role of the soft tissue envelope goes beyond structural and mechanical support. The presence of mechano-c.q. nocireceptors in the structures around the human knee joint has long been reported but is underrecognised by TKA surgeons.

Furthermore, preservation and isometric reconstruction of the soft tissue envelope might be a potential way to decrease the failure rate of TKA.

Finally, we also believe that the boundaries of variability in surgical implantation have to be defined.

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