The role of ligament tension and sensomotoric system in total knee arthroplasty

Roland Becker¹ · Michael Tobias Hirschmann² · Jon Karlsson³

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Roland Becker

Michael Tobias Hirschmann

Jon Karlsson

Implant design, bony morphology and soft tissue balancing are the major issues in total knee arthroplasty (TKA). Looking at the implant design, it has not been changed significantly over the last four decades. Knee kinematic and soft tissue behaviour during motion is very complex and may show a significant impact in clinical outcome after TKA. Flexion and extension of the knee are guided by the

soft tissues. Menschik already reported in detail about the interplay between the cruciate and collateral ligaments [17]. The attachments of the cruciate and collateral ligaments follow circular paths, and there are minor changes in ligament tension only during flexion and extension.

A lot of research focuses on the improvement in knee function after TKA. The impact of proprioception and nociception on knee function after TKA is, however, not well understood. The knee is surrounded by a complex envelope of soft tissue, the site of the mechanoreceptors and nociceptors. Mechanoreceptors in the muscles, tendon and ligaments are responsible for the proprioception. The capsuloligamentous system is comprised of the joint capsule, medial and lateral collateral ligaments, anterior and posterior cruciate ligaments, popliteus tendon, hamstrings tendons and the menisci. Mechanoreceptors and nociceptors are embedded in the collagen of the ligaments and joint capsule transmitting neurosensory information to the spinal cord [10, 25]. Free nerve endings and Ruffini corpuscles are most frequently found in the knee [7]. Mechanoreceptors

✉ Roland Becker
roland_becker@yahoo.de

Michael Tobias Hirschmann
<http://www.kneedoctor.ch/>

¹ Department of Orthopaedics and Traumatology, Hospital Brandenburg, Brandenburg Medical School “Theodor Fontane”, Hochstrasse 26, 14776 Brandenburg, Germany

² Department of Orthopaedic Surgery and Traumatology, Kantonsspital Baselland (Bruderholz, Liestal, Laufen), 4101 Bruderholz, Switzerland

³ Department of Orthopaedics, Sahlgrenska University, Hospital, Sahlgrenska Academy, Gothenburg, Sweden

are identified close to the bone insertion. Free nerve endings and Golgi-like endings are predominantly identified in the PCL and Ruffini corpuscles in the popliteus tendon. Different articular sensory neurons innervate different tissues and may reflect different functions [9]. Proprioception is essential for joint protection, and it is known that proprioception is impaired in patients suffering osteoarthritis [2]. Many intraarticular structures contribute to the proprioception but are damaged during TKA.

This raises the question about the impact of the damage neurosensory system during TKA on final clinical outcome. How important is the sensorimotor system for good clinical function after TKA? There is some controversy in terms of the changes in joint position sense after TKA. While some researchers report a partial reversible effect of the neuromuscular deficits after total knee arthroplasty [5], others report the opposite and a further decrease in muscle strength and activation [6, 18, 22, 23]. No correlation has been reported so far between proprioceptive acuity, pain and limitation in physical function in osteoarthritic knees [12]. In conclusion, poor proprioceptive activity does not appear to correlate with impaired knee function after TKA. For example, many mechanoreceptors are embedded in the posterior cruciate ligament, and one may presume that the preservation of the PCL will cause superior proprioceptive activity after TKA. A recent study compared CR and PS designs in total knee arthroplasty, and no differences in terms of proprioception and muscle strength were reported [24]. In contrast, preserving both of the ligaments during TKA, proprioception was similar to unicondylar knee arthroplasty as shown in another study (UKA) [3].

Tension of the soft tissue envelope of the knee shows direct impact on knee function after TKA. Inappropriate soft tissue tension may cause increased laxity from the biomechanical point of view, which will lead to knee instability and poor function. Knee instability after TKA is the cause of revision surgery in up to 25% and knee stiffness in 10–15% [8, 16, 21]. The impact of changes in soft tissue tension pattern of the knee during motion is not well understood. Different strain behaviours have been reported between the medial and lateral collateral ligaments during knee motion [13]. Preservation of the correct soft tissue tension during TKA is very demanding. Moreover, the impact on soft tissue laxity or tension on the neurosensory system is not well understood. Increase in soft tissue tension will alter the stiffness of the soft tissue complex and may lead to pain [14]. Increase in tension of the soft tissue complex has shown alteration in voluntary quadriceps muscle activation and changes in muscle strength and gait [19]. It has been shown that pain predominantly occurs at the medial and lateral retinaculum and might be the cause for increase in pain, when the implantation of a total joint causes tightness of the soft tissue structures [11]. The

stiffness of the soft tissue complex in osteoarthritic knees was studied in extension and flexion [1]. The stiffness in extension and flexion was 8.9 and 8.5 N/mm, respectively, with a soft tissue tension of 60 N and increased to 26.6 and 21.4 N/mm with a tension of 180 N. The authors concluded that soft tissue tension during surgery of 80–160 N appears to be appropriate from the clinical point of view as it does not affect post-operative range of motion. That study also shows that the stiffness of the tissue differs in extension and flexion [1]. Manual stress testing, spacer blocks, tensiometers and navigation are all used in TKA to preserve static and dynamic soft tissue constraints.

In one of the studies of the current issue of the journal, the accurate soft tissue balance was investigated in human cadavers and showed an inverse relationship of laxity and contact force [15]. However, coronal and rotational laxity changes after TKA when compared with the native knee laxity. Laxity in transverse and frontal plane increased significantly upon increased knee flexion [15]. These findings are supported by other studies. Unequal laxity at 0°, 45°, 90° of knee flexion has been reported [20]. Significantly greater laxity in varus and valgus and internal and external rotation has been reported upon increased flexion.

Even when TKA surgery is performed very precisely, differences in kinematics and soft tissue restraints occur. The usage of a tensiometer is helpful to adjust the distraction force when creating the extension and flexion gap during arthroplasty surgery [4].

There is still a significant lack of knowledge in the understanding of the neuromuscular function of the knee and effect of different tension patterns of the soft tissue on the outcome after TKA. Many studies have focused on correct balancing of the knee during TKA, but a balanced knee also can end up in poor function due to significantly abnormal soft tissue tension.

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