Michael T. Hirschmann
Roland Becker *Editors*

The Unhappy Total Knee Replacement

A Comprehensive Review and Management Guide

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Foreword I

The paradox that the knee is a poor construct and ingenious edifice had long been recognized. It has evolved over millions of years, a marvellous system connecting the long levers of both femur and tibia, absorbing and cushioning the locomotory forces generated in the lower limb while maintaining movement in six degrees of freedom.

The knee, subject to growth disturbances with consequent deformity, inflammatory and degenerate diseases, injuries, and sport leading to secondary osteoarthritis, presents a great challenge to both clinician and patient alike for its reconstruction, rehabilitation, and return to full function.

Great strides have been made in many modes of treatment including the major advances of knee arthroplasty. However, the gains made here do not match those attained with total hip replacement (THR).

The hip joint with its three degrees of freedom and ball joint mechanics presented a smaller design problem, albeit great strides were needed to address the mechanical fixation of the cup and in particular the stem, including an appreciation of Pauwel`s law on the morphology of the proximal femur.

On the other hand, the development of the total knee replacement (TKR) presented greater challenges. The trade-off between allowing six degrees of freedom and the task of maintaining stability by retaining the native ligaments to optimize knee kinematics continues.

How should the artificial knee joint be configured? A pure hinge was not the solution. As the early TKR results were not convincing, the profession relied heavily on the high tibial osteotomy. Many patients aware of the at this time still inherent problems of the early artificial knee joints continued to postpone the TKR “solution” for as long as possible.

Bringing together our new understanding of materials, tribology, and biology with state-of-the-art design technology offers the potential for real advancement in TKR. Thirty years ago, the Deane prosthesis delivered promising early results, allowing very good mobility, an excellent gait pattern with normal rotation, and hence very little patellar problems. Its tibial saddle and ball design allowed rotation in progressive flexion and stopped rotation whenever the knee came to extension like automatic rotation. It was ingenious for its time. Unfortunately, the implant materials failed; the femoral polyethylene cup receiving the ball on this saddle was too thin and too weak to withstand the forces beyond 8 to 10 years.

Nowadays, we are still fighting for more durable, long-lasting, pain- and problem-free TKR implants. The current 80 % success rate is not good enough.

Novel work on understanding knee joint anatomy, kinematics, biomechanics, tissue biology, and perhaps additional yet unknown discoveries may result in the development of well-equilibrated artificial joint systems.

The following analysis of the "unhappy knee replacement" gives real insight into why and where the mechanical and tissue physiology collide and why pain-free function so needed has not yet been achieved. The diagnostic and treatment recommendations given here are the state of the art of a renowned international expert faculty dealing with unhappy TKR.

Professor em. Dr. med. Werner Müller

Foreword II

Dear reader,
Total knee replacement has been one of the most thankful inventions in orthopedics of the last century. The mobility of patients can be preserved. Mobility is very important in order to participate actively in social life. Despite all novel technologies, such as computer assisted surgery and patient-specific instrumentation, we will never be able to achieve 100 % success rate. Therefore, the indication for total knee replacement should always be at the end of the road of our treatment options.

The majority of patients are very happy after joint replacement; however, there is a group of patients who complain about poor function, pain, limited range of motion, contraction, or instability. These are the patients who require special attention and care by the surgeons. In many cases it is not easy to identify the causes of the patient's complaint. Most of the time there is a combination of several factors that is the reason for the patient's unsatisfaction.

There are not many comprehensive books about revision total knee replacement on the market. This book fills the gap and provides detailed information about the diagnostic algorithm for indentifying the patient's problem.

The two editors of this excellent book about the "unhappy total knee arthroplasty" focus on a very difficult group of patients to treat. They have written a very special book in collaboration with many well known experts throughout the world. All of them are dedicated to revision total knee replacement and are aware of the difficulty of the treatment of these patients. I am very impressed about the number of authors and the countries there are from.

Roland Becker worked for many years in my department at the Otto-von-Guericke University in Magdeburg and he started his research and clinical work very early in the large field of knee pathologies. He is a dedicated knee surgeon with great experience in joint preserving surgery and knee arthroplasty. He is the head of the Department of Orthopedic Surgery and Traumatology in Brandenburg.

Michael Hirschmann has taken over the Department of Knee Surgery at the Bruderholz Hospital, in the place of Prof. Werner Müller, one of the most famous orthopedic surgeon of the knee.

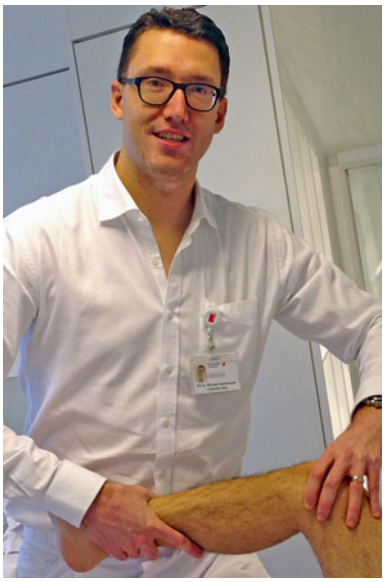
The editors have written numerous chapters themselves and worked as co-authors in others. The book provides detailed information about basic

science, clinical aspects, and treatment options of patients who are unhappy after their total knee replacement. They have added interesting case reports, sharing their experience with many surgeons.

Congratulations for such an impressive book.

Prof. em. Dr. med. W Neumann

Preface



PD Dr. med. Michael T. Hirschmann

Prof. Dr. med. Roland Becker

Total knee replacement (TKR) is considered to be a very successful treatment in osteoarthritic knees leading to mostly satisfied and pain-free patients. Due to advancements in implant design, surgical technique, and better understanding of biomechanics and tribology, the survival rates of TKR have been improved to at least 15 years in 85–95 % of patients. Moreover, sports activity after TKR is not the exception anymore.

However, when looking more closely into orthopaedic literature, approximately 20–30 % of patients are not happy after TKR, complaining about pain, instability, swelling, or reduced range of motion. In a considerable number of patients, their need, demands, and expectations are not fully met. Considering rheumatology journals, only 40 % are pain free after TKR.

There are various reasons for unhappy knees after TKR. As causes, we differentiate implant- or surgery-related problems such as malpositioning, under- or oversizing, instability, stiffness, patellofemoral problems such as patellar maltracking, or infection from patient-related problems such as depression, anxiety, unrealistic expectations, low self-efficacy, and metal allergy or hypersensitivity.

Despite major advancements of clinical and radiological diagnostics over the last 20 years, the identification of the cause of the patient`s problems remains challenging and not successful in every case.

There are patients in which the knee *looks good but feels bad*. There are others in which the knee *looks bad but feels good*. This paradox remains yet unsolved. The current clinical and radiological diagnostics very often do not unambiguously guide further treatment. In these cases, the choice of treatment is more influenced by the surgeon`s gut feeling (experience and preference) than clear clinical evidence.

Only if the orthopedic surgeon has correctly identified the cause(s) of the patient`s problems, the subsequent treatment will lead to ease of the patient`s problems. It should be kept in mind that there is no revision surgery, which could not make it worse for the patient. Hence, we gathered expert knowledge contributed by renowned international knee surgeons with profound experience in revision TKR.

With this book, we strive to address the increasing need of improved diagnostic and treatment guidelines for the challenging and growing group of patients with an unhappy knee after TKR.

It also covers the basics of TKR and describes the causes of failure, giving practical hints on how to avoid those. Renowned international experts, who have extensively published in peer-reviewed journals, provide you with an evidence-based, clinically focused guidance on the causes of unhappy TKR, surgical approaches and techniques, state-of-the-art diagnostic algorithms, specific pathology-related treatment options such as salvage and revision TKR strategies.

With the clinical case scenarios, we assembled typical cases, which you will encounter in your life as orthopedic surgeons. This book should serve you as a practical management guide for your clinical practice. Furthermore, we have included a wide variety of illustrations explaining the key points made.

It is our hope that reading this book will allow you to know more and as a result contribute meaningfully to the care of your patients.

Finally, the editors would like to thank all the contributing authors in putting together their expertise and time to make this publication possible.

The Editors

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Part I

Basics Science and Principles in Total Knee Replacement

Anatomy and Biomechanics of the Natural Knee and After TKR

1

Richard T. Keller and Andrew A. Amis

Contents

Keynotes

1. Kinematics is controlled by both the remaining soft tissues in the knee and articular surface geometries of the implant.
2. Knee kinematics can be characterised by a coupled internal rotation and role gliding during flexion. The tibia performs a coupled internal rotation during knee flexion.
3. TKR component designs can be differentiated in posterior cruciate retaining, posterior stabilised, total stabilised and rotating hinged TKR.
4. Axial knee loading can reach up to 8 times body weight.
5. Design factors in TKR include femoral condyle radii, tibial insert frontal plane conformity and mediolateral offset of the trochlear groove.

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1.1 Natural Knee Kinematics

One of the major challenges in total knee replacement (TKR) is to restore knee biomechanics as close as possible to the natural knee. The complex kinematics of the knee can be fully described by a 'six-degrees-of-freedom' movement, with three rotations and three linear translations along a set of perpendicular axes.

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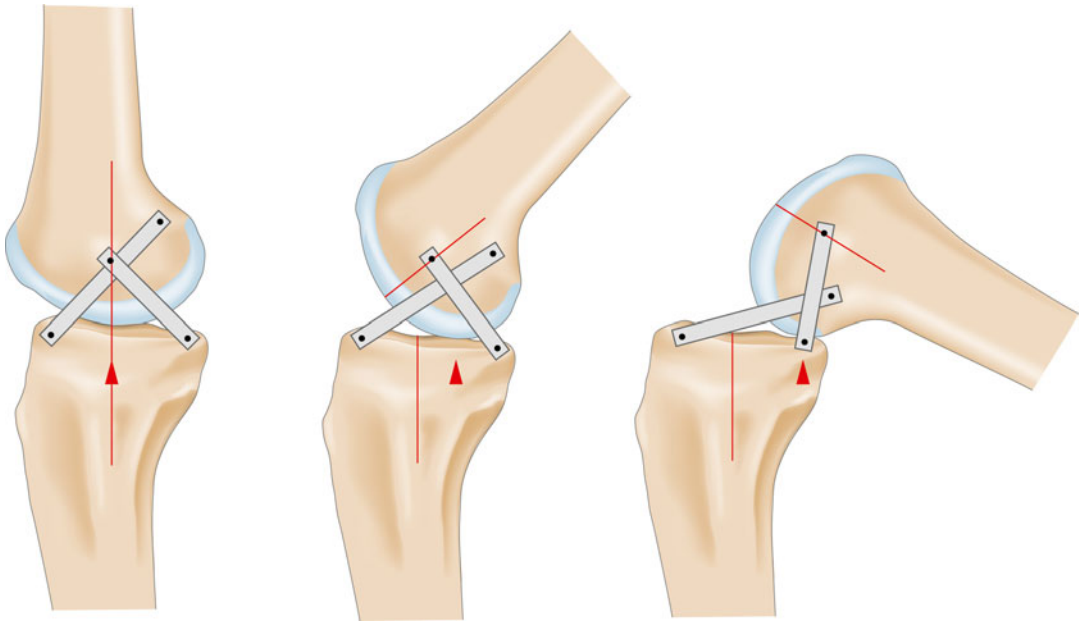

Fig. 1.1 The femoral rollback can be simplified and described in a two-dimensional (2D) four-bar linkage system

The rotations are internal and external (IE) rotation in the transverse plane, varus–valgus (VV) in the coronal plane and flexion and extension (FE) in the sagittal plane. Translations along those axes give displacement in proximal and distal (superior and inferior), anteroposterior and mediolateral directions, respectively.

In a simplified first step, the femoral rollback was described in a two-dimensional (2D) four-bar linkage system [1, 2] (Fig. 1.1). This provided a mechanical explanation of the relative motion of the femur on the tibia with increasing flexion. The ratio of rolling and gliding of the femur on the tibial plateau increases during flexion from 1:2 at the early stage of flexion, to 1:4 in deep flexion. There is no fixed axis to describe knee motion, like a simple hinge joint, secondary translations and rotations are involved throughout. Among those is the coupled internal rotation of the tibia about its long axis, which occurs automatically in response to the articular geometries of the medial and lateral compartments engaging during flexion. Additionally, the ligamentous restraints vary throughout the full range of motion.

Knee kinematics can be characterised by a coupled internal rotation and roll-gliding motion during flexion.

More recent studies have shown a significant difference between the knee kinematics of the medial and lateral compartment [3] (Fig. 1.2).

The medial femoral condyle predominantly rotates and demonstrates minor translation during flexion. In contrast, the lateral condyle rolls and glides posteriorly on the tibial plateau. The different kinematic behaviour in the medial and lateral compartments lead to coupled internal rotation of the tibia in relation to the femur during flexion.

The tibia performs a coupled internal rotation during knee flexion.

The condyles are almost spherical during the range of motion between 20° and 120° of knee