DIPLOMARBEIT

Gender-specific outcome differences after primary total knee arthroplasty

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PREFACE

In November 2011 I gathered some practical experience at the department of orthopedics and orthopedic surgery at Medical University of Graz. There, I coincidentally met Dr. Christine Wibmer, and asked her if there was any possibility for me to join some research projects.
She advised me to visit Professor Dr. Leithner's lecture on case reports and introduced me to PD Dr. Patrick Sadoghi for topics on knee surgery.

During Professor Dr. Leithner's lecture, I was given the opportunity to acquire the basic knowledge on how to undertake a scientific project, and how to perform accurate research and I learned the fundamental rules of writing a scientific paper.

This thesis is my first experience in the scientific world, and mostly thanks to PD Dr. Patrick Sadoghi, PD Dr. Mathias Glehr, and OA Dr. Norbert Kastner I have learned a lot during that period.

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ABBREVIATIONS

ACL....................................... Anterior cruciate ligament
ACR .... American congress of rheumatology
AIIS………………………………...Anterior inferior iliac spine
ANOVA…………………………Analysis of variance
AP .... Anteroposterior
ASIS……………………………..Anterior superior iliac spine
CRR .... Cumulative revision rate
GF .... Growth-factor
IGF .... Insuline-like growth-factor
IL... Interleukin
KSS....................................... Knee society score
LCL .... Lateral collateral ligament
LCS……………………………..Low contact stress
M... Musculus
MCL .... Medial collateral ligament
ML... Mediolateral
MMP .... Matrix metalloproteinase
OA... Osteoarthritis
PCL....................................... Posterior cruciate ligament
PDGF .... Platelet derived growth-factor
PFC……………………………..Press fit condylar
PIIS……………………………...Posterior inferior iliac spine
PMMA………………………….. Polymethylmethacrylate
PRP……………………………..Platelet rich plasma
PSIS…………………………….Posterior superior iliac spine
RA... Rheumatoid arthritis
ROM .... Range of motion
SIRS .... Systemic inflammatory response syndrome
TGF....................................... Transforming growth-factor
TKA....................................... Total knee arthroplasty
TNF-α.................................... Tumor necrosis factor alpha

VAS....................................... Visual analogue scale

VS……………………….. .... Versus

VEGF…………………………...Vascular Endothelial Growth Factor

WOMAC................................. Western Ontario and McMaster Universities Osteoarthritis Index

ABSTRACT

ENGLISH

INTRODUCTION

The scientific community has faced much debate on the topic of gender and different outcomes between female and male patients after implantation of low-contact-stress (LCS) total knee arthroplasty (TKA).

OBJECTIVES

The objective of this study was to investigate outcome differences between female and male patients after implantation of low-contact-stress (LCS) mobile-bearing total knee prostheses (TKA) at a minimum follow-up of ten years with respect to clinical and radiological parameters.

METHODS

All patients undergone implantation of LCS TKA in our department with a minimum follow-up of 10 years were invited retrospectively, using our hospital database. Data was extracted with respect to range of motion (ROM), the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score, the Knee Society Score (KSS), the visual analogue scale (VAS), and radiological signs of loosening on conventional X-rays. We used SPSS 20 for statistical analysis and a p-value <0.05 was set for significance.

RESULTS

The database search revealed 467 Patients with 546 TKAs in total. After exclusion of the deceased, 236 patients remained for analysis. Eighty-four prostheses out of 66 patients could be clinically examined. At follow-up, we observed no significant

differences between female and male patients in terms of the above-mentioned parameters. Further 42 patients were additionally interviewed by telephone interview.

CONCLUSION

Clinical or radiological outcomes do not significantly differ between female and male patients after implantation of LCS total knee prostheses at ten years of minimum follow-up. We therefore found no factors in favor of gender-specific total knee prostheses.

GERMAN

EINLEITUNG

Die Frage, ob geschlechtsspezifische Unterschiede das Outcome nach einer Implantation einer low-contact-stress (LCS) Knietotalendoprothese (K-TEP) beeinflussen ist von hoher Relevanz.

ZIELSETZUNG

Für diese Studie wurde das Outcome von weiblichen und männlichen PatientInnen nach Implantation einer LCS mobile-bearing K-TEP mit einem minimalen Follow-up von 10 Jahren anhand klinischer und radiologischer Parameter getrennt untersucht und verglichen.

METHODEN

Anhand der Klinikdatenbank Medocs wurden alle PatientInnen, welche mit einer LCS-Prothese versorgt wurden und ein Follow-up von mindestens 10 Jahren aufwiesen, eingeladen an der Studie teilzunehmen. Der Bewegungsumfang (ROM), der Western Ontario und McMaster Universities Osteoarthritis Index (WOMAC-score), sowie der Knee Society Score (KSS), die Visual Analogue Scale (VAS) und radiologische Zeichen der Prothesenlockerung wurden erhoben. Für die statistische Auswertung wurde SPSS 20 verwendet. Als Signifikanzgrenze wurde ein P-Wert von <0.05 festgelegt.

ERGEBNISSE

In der Datenbank konnten 467 Patienten mit insgesamt 546 K-TEPs gefunden werden. 236 Patienten blieben für die Untersuchung nach Ausschluss verstorbener Patienten. 66 Patienten mit 84 Prothesen konnten klinisch untersucht werden und restliche PatientInnen wurden telefonisch kontaktiert. Letztendlich konnte kein signifikanter Unterschied im Outcome zwischen weiblichen und männlichen PatientInnen festgestellt werden.

Diskussion

Es gibt keinen signifikanten Unterschied im Outcome zwischen Frauen und Männern nach Implantation einer LCS Knietotalendoprothese bei einem minimalen Follow-up von 10 Jahren. Es konnten keine Faktoren gefunden werden, die für die Verwendung einer geschlechtsspezifischen K-TEP sprechen würden.

General Part

Anatomy of the knee joint

General aspects

The knee is the largest joint in the human body as a compound double condylar articulation. Although the whole joint lies within one single cavity, it is usually divided into two parts. The first one is the articulation between femur and tibia, which is again parted into a lateral and a medial compartment. The second is a sellar joint, formed by the patella articulating with the femur.(10,11)

The knee joint is very carefully balanced by a variety of ligaments, muscles, the articular capsule, and the menisci. These components care for the steady and even distribution of the forces working on the knee. In the following, all important structures affecting the knee joint mobility are described.

Bony structures

The human knee joint consists of three bony parts which form two different joints. The tibiofemoral joint is put together by the femoral condyles and the tibial plateau, while the femoroptellar joint is composed of the femoral condyles and the patella.(12)

The tibial plateau offers two articular surfaces, a lateral and a medial one, which are divided by the intercondylar region. The lateral articular surface is smaller and more circular, while the medial one is larger and more oval. The distal outlines of the femoral condyles are shaped to match this design, the lateral one being almost circular and smaller, and the medial one appearing more oval. The lateral profile of the femoral condyles shows a convexity with a curvature that increases posteriorly.(10)

The patella is a flat bone with a proximal base and a distal apex. In the lateral cut it is somewhat wedge-shaped. It is embedded in the quadriceps tendon, and therefore, the patella is classified as a sesamoid bone. The anterior side of the patella has a rough surface, while the posterior surface, which is the articulating part, is covered with elastic cartilage. A larger lateral area of the patella is separated from the medial area by the vertical ridge.(10)

ARTICULAR CAPSULE

The capsule of the human knee consists of the fibrous capsule and the synovial membrane.(10,13)

The distal attachment of the fibrous capsule is placed 1 cm distally of the condylar margins of the tibial head. The lateral and medial attachment on the proximal end follows the outlines of the femoral condyles. Posteriorly, it reaches the intercondylar area, and anteriorly, it blends with the tendon of the quadriceps muscle and the patella. The posterior fibers run vertically and are strengthened by the oblique popliteal ligament. Medially, the capsule is merged with the tibial collateral ligament. The lateral capsular fibers however are separated from the fibular collateral ligament by a fat pad.(10,13)

The posterior distal attachment of the synovial membrane lies between the lateral and medial condyle of the superior articular surface of the tibia and encloses the anterior interconylar area. Lateral, medial, and anterior attachment follows the margins of the articular cartilage. The proximal attachment starts posteriorly at the intercondylar fossa and goes along with the margins of the articular cartilage of the lateral and medial femoral condyle. On the anterior side it is attached to the margin of the patellar surface of the femur.(13)

At the proximal patellar border, the synovial membrane continues to form the suprapatellar bursa, which lies between the quadriceps muscle and distal femoral shaft. The distal anterior part of the synovial membrane is parted from the patellar tendon by the infrapatellar pad of fat (the Hoffa´s fat pad).(10,13)

The synovial membrane has various functions, the most important of which being the cleaning of the articular cavity by phagocytosis and the synthesis of synovial fluid. This synovial fluid is most important for smooth gliding between the articular surfaces and the nutrition of the cartilage.(2)

LIGAMENTS

The patellar ligament reaches from the apex of the patella to the tibial tuberosity. It is the continuation of the quadriceps tendon. Medial and lateral superficial parts of the patellar ligament insert on the side of the tibial tuberosity, to form the medial and lateral patellar retinacula, which blend into the fibrous capsule.(10,13)

The oblique popliteal ligament stretches across the popliteal fossa, from the tendon of the semimembranosus muscle to the lateral part of the intercondylar line of the femur.(10)

The Y-shaped arcuate popliteal ligament has fibers coming from the tendon of the popliteus muscle and from the lateral femoral epicondyle which converge at the head of the fibula. (10)

The tibial collateral ligament comes from the medial epicondyle of the femur and inserts at the medial tibial condyle. It is connected to the medial meniscus. The tibial collateral ligament is divided into two parts. The anterior part is flat, and it descends to meet the posterior medial surface of the tibial shaft. Mm. sartorius, gracilis, and semitendinosus are stretching right across it. The shorter posterior part goes directly down to the medial tibial condyle, and is connected to the fibrous capsule.(10,12)

The profile of the fibular collateral ligament is more oval. It reaches from the lateral femoral epicondyle to the fibular head. It is covered by and partly connected with the tendon of the musculus biceps femoris. In contrast to the medial collateral ligament it is not blended with the meniscus beneath it.(10,12)

The anterior and posterior cruciate ligaments are found close to the articular center, shifted a little posteriorly. The anterior cruciate ligament (ACL) goes from the anterior intercondylar area of the tibia to the posteromedial surface of the lateral condyle of the femur. It is connected to the anterior cornu of the medial meniscus and divided into an anteromedial bundle and a posterolateral bundle. The stronger posterior cruciate ligament (PCL), which is attached to the posterior cornu of the lateral meniscus, goes from the posterior intercondylar region to the lateral surface of the medial condyle of the femur.(10,13)
The position of the ACL in relation to the PCL can be described as anterolateral.
Two ligaments, the anterior and the posterior menicofemoral ligament, are attached to the posterior cornu of the lateral meniscus and join the PCL to insert on the lateral side of the medial femoral condyle. Both the ACL and the PCL consist of two different functional bundles. (10,13)

The tansverse genual ligament is stretched between the anterior cornu of the medial meniscus and the anterior margin of the lateral meniscus.(13)

The transverse retinaculum, which strengthens the capsule, consists of fibers that run from the lateral margin of the patella to the iliotibial tract. In 30% of the cases a medial transverse retinaculum is present. It connects the medial margin of the patella to the medial femoral epicondyle.(10,13)

Figure 1: Picture of a right knee joint; anterior view. From: Sobotta, Atlas der Anatomie des Menschen, Band 2 (14)

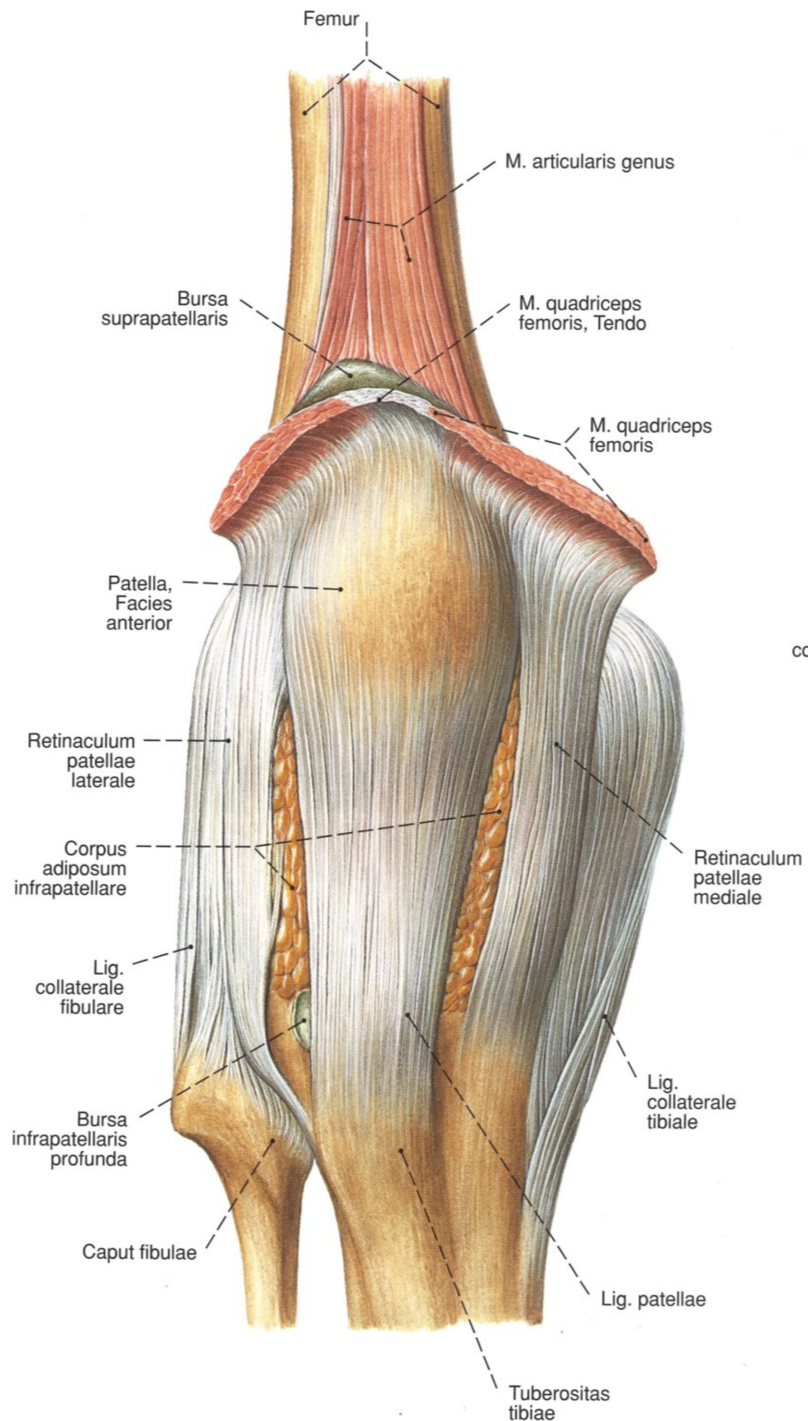
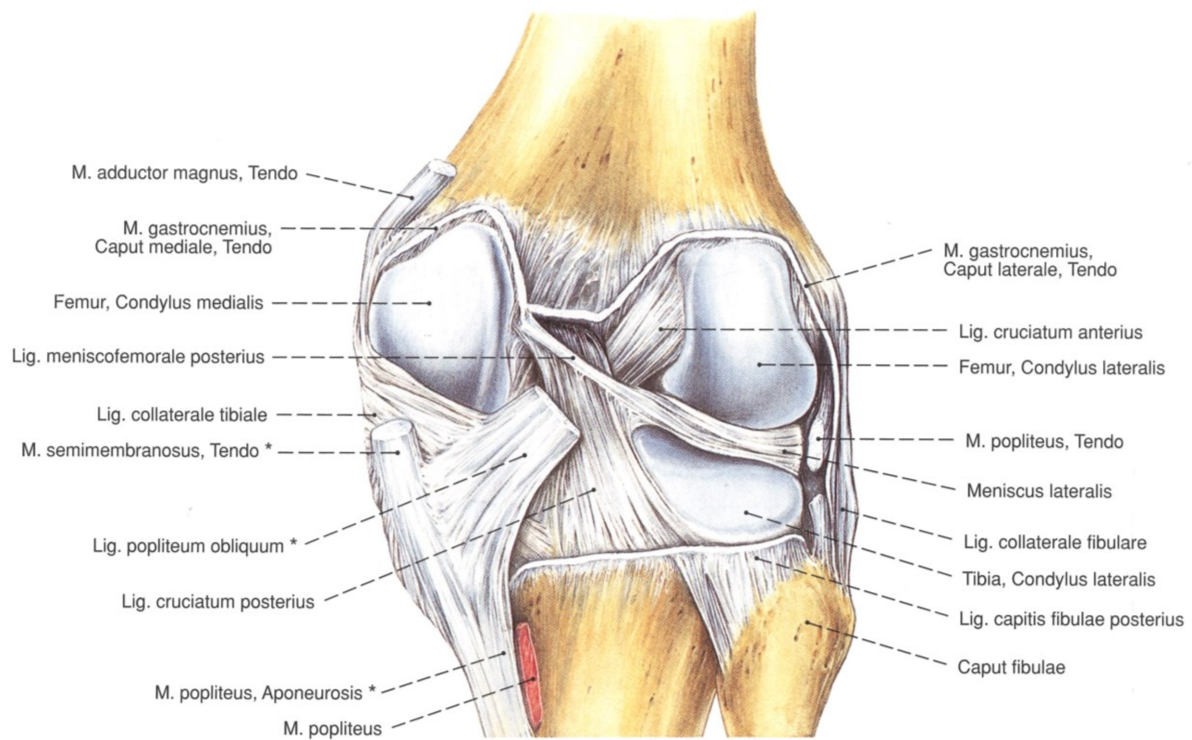


Figure 1 shows a portrait of the front of a human knee. The extracapsular ligaments, the infrapatellar pad of fat and the retinacula are illustrated. The cruciate ligaments as well as the menisci are hidden behind the patellar ligament and the articular capsule.

Figure 2: Picture of a right knee joint; posterior view. From: Sobotta, Atlas der Anatomie des Menschen, Band 2 (14)



In this illustration, the human knee is shown from behind, so the ligaments in the popliteal area and its surroundings can be seen.

FUNCTIONAL ANATOMY

The knee joint is the largest and most complex joint (besides the shoulder joint) of the human body; therefore, there are many functional aspects that need to be discussed.

The human knee is the connection between the hip and the ankle. On the one hand it has to offer a stable stance, and on the other hand it has to be flexible and allow movements and rotations in several directions.

When extended, the femoral condyles have a very large area of contact with the tibial plateau and the menisci. When bended, however, the area gets smaller due to the posteriorly decreasing radius of the femoral condyles. This enables the flexed knee to move more freely and makes it even possible to rotate it, but it also requires additional ligaments for protection. As the collateral ligaments are relaxed when the knee is bent, the cruciate ligaments have to stabilize the movements in that position. When the lower leg is internally rotated, the cruciate ligaments are intertwined and therefore limit the internal rotation to approximately 10°. In external rotation the space between the cruciate ligaments increases, so the range of motion is larger at about 30-40°.(6,15)
To enable a stable stance, the knee has a special mechanism. Mediated by the ligaments, the lower leg performs an external rotation of 5° when the knee is fully extended. After that rotation a further extension of about 10° is possible. In that final position the knee is able to bear the weight of the whole body without the use of muscles. All this happens more or less automatically. In full extension the anterior cruciate ligament is tense and so it rotates the tibia externally (or the femur internally).(6)

The human knee joint is moves around two axes. It can flex, extend, and it rotate internally and externally in flexion. However, in full extension, no rotation movements are possible in the physiological knee joint. The following table is a brief summary of the movements of the knee joint and the participating muscles.(6)

Table 1: Function of the muscles moving the knee, From: Rohen, Funktionelle Anatomie des Menschen(6)

Axis	Movement	ROM	Muscles
Transversal	Flexion	active 130° passive 158°	M. biceps femoris M. sartorius M. gracilis M. semitendinosus M. semimembranosus M. gastrocnemius M. popliteus
	Extension	0-10°	M. quadriceps femoris M. tensor fasciae latae
Longitudinal	Internal rotation	10° (when knee is in 90° flexion)	M. semitendinosus M. semimembranosus M. popliteus M. sartorius M. gracilis
	External rotation	40° (when knee is in 90° flexion)	M. biceps femoris

The muscles performing internal rotation insert on the medial condyle of the tibia, the external rotators on the fibular head.(6,13)

When flexing the knee, internal and external rotators work together as synergists, while the extension is mainly managed by one single muscle, the M. quadriceps femoris. However, the quadriceps femoris is much stronger than the flexors. While walking, it has to bring the flexed supporting leg back to an upright position and therefore, it has to work against the full bodyweight. Meanwhile, the flexors only have to flex the free leg.(6)

GENDER-SPECIFIC DIFFERENCES

There are several differences between the female and the male knee with respect to its anatomy that are discussed in literature. Many study groups have given this topic a lot of attention. Primarily, they want to find out whether or not the female knee differs significantly from a male knee in any proportion or angle. It has to be noted that the results of the performed studies differ enormously.(16–20)

The underlying interest was, beside of anatomic curiosity, to proof the necessity of gender specific knee prostheses or on the other hand to invalidate such proof.

Q-Angle

To measure the Q-Angle, an imaginary line is drawn from the anterior superior iliac spine to the center of the patella. The angle between the patellar tendon and this imaginary line is the Q-Angle.(17) Normally, Q-angles less than 18 degrees for females and less than 15 degrees for males are physiological.

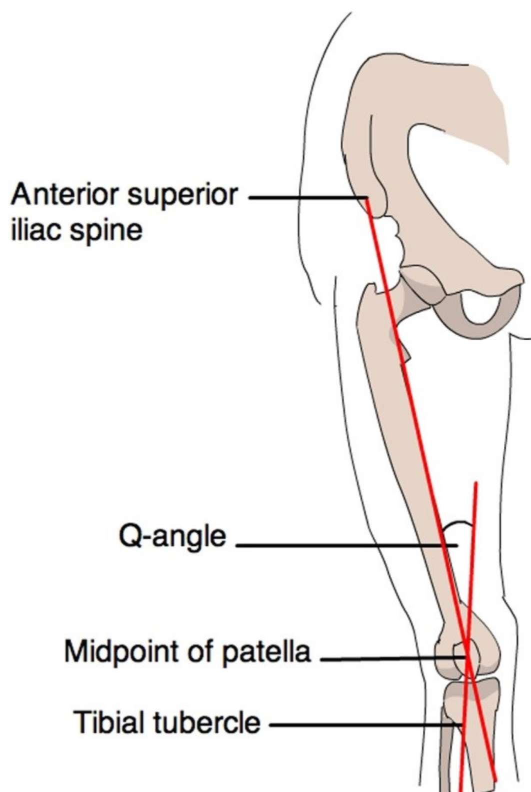


Figure 3: Determination of the Q-Angle.(1)

In their paper, Conley et al. published that there is a significant difference in Q-Angles.(18) The mean female Q-Angle is supposed to be greater than the average Q-Angle of a male knee. However, there is also evidence for the contrary. In their systematic review, Merchant et al. were able to show that the Q angle in men and women is very similar. It just has to be corrected for the difference in average height.(17,18)

Anterior condylar height

The anterior condyle height is larger in men than in women. The average value for the lateral condyle in females is 10.1 mm compared to 10.9 mm in male knees. The difference in medial condyles is even larger, reaching from 5.1 mm in female knees to 6.4 mm in males.(18)

According to Merchant et al., this difference disappears after consideration of the difference in height.(17)

Aspect ratio of the femoral condyles

The aspect ratio is the medial-lateral to anterior-posterior dimension (ML: AP).
Conley et al. collected data that shows that regardless of the AP dimension women have smaller ML dimensions. In addition, they found evidence that the average female distal femur has a more trapezoidal shape than the more rectangular distal femur in male patients. Some systems for total knee arthroplasty address this anatomical variance by femoral shields which are variable in width. (18–20)

HISTOLOGY

BONES

Bone tissue consists of two main components, namely cells of different types, and mineralized extracellular matrix (ECM). The ECM is put together by hydroxyapatite and collagenous fibers. The above mentioned cells are osteoblasts, osteocytes, and osteoclasts. Osteoblasts are the cells that build new bone tissue, while osteoclasts diminish old bony structure. Osteocytes are former osteoblasts and are usually fully surrounded by mineralized ECM.(2)

Human bone tissue is diminished by phagocytosis and rebuilt every day for as long as we live. That mechanism has different reasons. It is mandatory to prevent weakening of the tissue, it repairs small damages in the bones, it ensures a continuous functional adaption, and provides available calcium to the body very quickly.(2)

Bone tissue can be divided into two different types. One is the spongy bone, which is less dense, the other one the much denser compact bone. Spongy and compact bone tissue can be macroscopically distinguished one from another. While the compact bone appears very homogenously, the spongy bone is formed by trabeculi, creating a grid of some kind, and often contains red bone marrow.(2)

All the interior surfaces of the bone are covered with the endosteum, a thin layer consisting of osteoblasts and osteoclasts as well as preliminary osteoblasts. The correspondent membrane covering the exterior surface, except for articular surfaces, is the periosteum.(2)

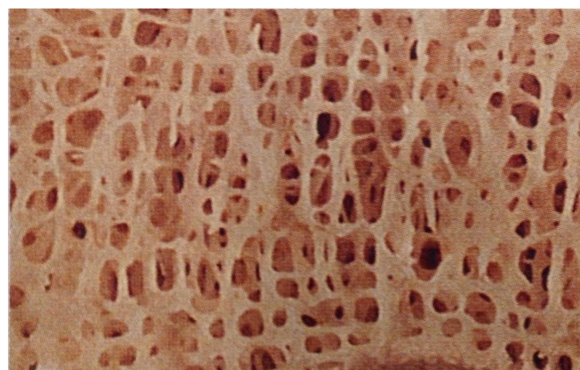


Figure 4: Microscopic picture of the spongy part of a human thoracic vertebra. From: Lüllmann-Rauch, Taschenlehrbuch Histologie(2)

CARTILAGE

Cartilage tissue consists of chondrocytes and ECM. In this case the ECM is made from proteoglycans and collagenous fibers, giving the cartilage its elastic characteristics.(2)

There are three different types of cartilage. Hyaline cartilage is the most common form in the human body. Elastic cartilage and fibrocartilage are built the same way as hyaline cartilage, but they each have an additional component in their ECM. Elastic cartilage is equipped with elastic fibers, making it less stable but very elastic to pressure and bending. Fibrocartilage is the most resistant type of cartilage, thanks to its very thick collagenous fibers.(2)

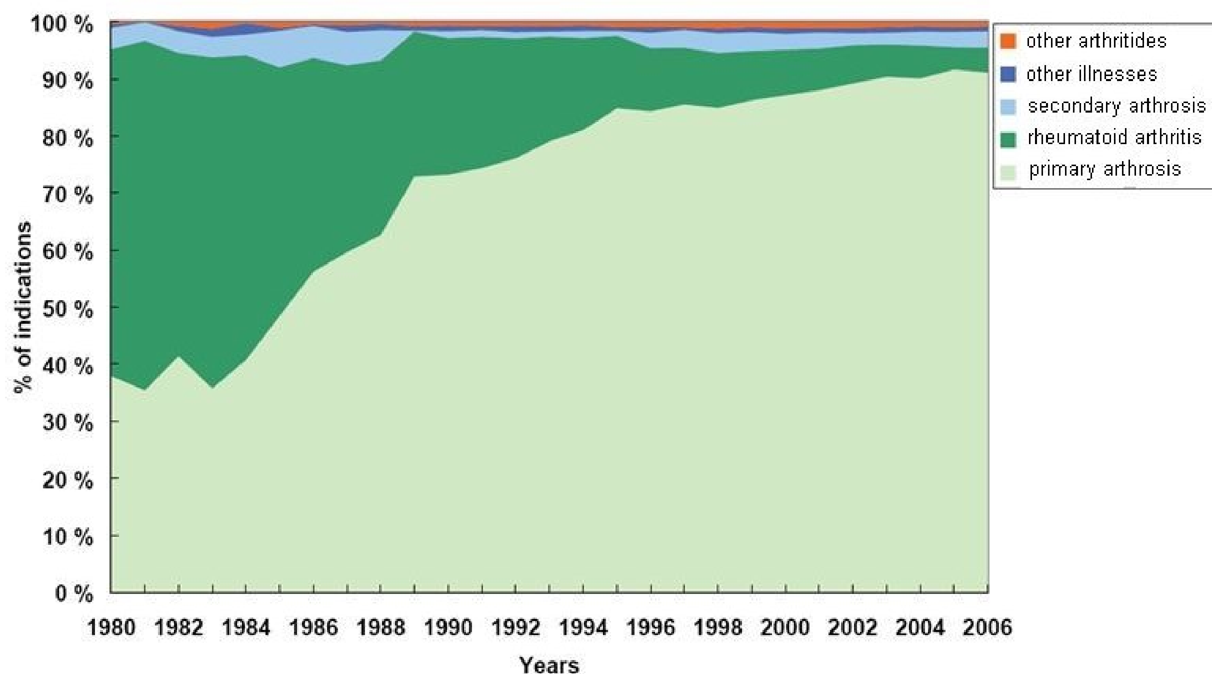
Hyaline cartilage is stable, but also has distinct elastic properties, and covers the articular surfaces of our bones. Elastic cartilage can be found in the ear, where stability is not so much required as excellent elastic features. Our spinal disks on the other hand, have to withstand enormous forces throughout the day. They are an example for the resistant fibrocartilage.(2)

INDICATIONS FOR TOTAL KNEE ARTHROPLASTY

There are several conservative options of treating knee pain due to osteoarthritis, both pharmacologic and non-pharmacologic. However, when those modalities do not lead to an acceptable pain relief and/or improvement of the function, surgical options should be discussed.(21–24)

The main indications for total knee arthroplasty (TKA) are end-stage osteoarthritis of the knee, rheumatoid arthritis, and persistent knee pain, which is particularly a problem known by older people. Usually, radiographic changes can be detected in a patient undergoing knee replacement surgery and at least in one compartment of the joint there is some exposed bone to be found. But all in all, the indication for total knee replacement should mainly depend on the patients´ symptoms in combination with the radiological setting. Those can reach from massive knee pain, especially at night, to severe disabilities affecting the patient's mobility or even her or his ability to work.(22–25)

Figure 5: Primary indications for TKA from 1980 to 2006. This figure is from the Finnish Arthroplasty Register. (3)



OSTEOARTHRITIS (OA)

Definition and Classification

Osteoarthritis (OA) is a progressive disease that can technically affect any joint in the human body. While it can have multiple causes, it always leads to a consistent biological, morphological, and clinical progression. The main characteristic of OA is the degeneration of cartilage, which can lead to complete destruction of the articular surface and affect the function of bones, ligaments, capsular structures, and muscles.(8)

OA can be classified according to Kellgren et al. who divided the disease into five grades (Kellgren 0-4) depending on the severity of radiographic changes, although grade 0 indicates that no radiographic changes can be found.
Using this scale, a significant sex-related difference could be detected, with women having more Kellgren 3-4 changes in a common X-ray than men.(4,26)

Table 2: Radiographic changes in osteoarthritic joints according to Kellgren and Lawrence. (4) **This is further illustrated in figures 6 to 9.**

Grade	Radiographic changes
Kellgren 0	No changes
Kellgren 1	Doubtful findings
Kellgren 2	Minimal changes
Kellgren 3	Moderate changes
Kellgren 4	Extensive changes

Etiology and Risk Factors

The cause for OA is usually a mismatch of the stress a joint is confronted with and the amount of stress it is able to cope with. Etiologically, OA can be divided in primary and secondary OA. The initial problem of primary OA is the cartilage, which is of poor quality and in so far not cut out for the burden it has to carry. Secondary OA is of completely different genesis. It can develop on the ground of metabolic diseases, traumata, inflammation, or malalignment.(27)

A variety of risk factors can be involved in the genesis of OA. Some of them, such as age, gender, or congenital deformities are connate and as such cannot be influenced. However, they have a significant influence and impact. Women after their menopause are more frequently affected by OA then men, and with increasing age, the number of OA patients also rises.(8)

To name some more aspects, there are also mechanical risk factors like acute trauma of the joint (with consecutive loss of stability / alignment), chronic overuse, or acquired skeletal diseases, or dysplasia. All those potentially lead to increased stress on the involved joint.(8,27)

Metabolic diseases can also have an impact on the genesis of OA. The most important ones are diabetes mellitus, hyperuricemia, hypercholesteremia, and obesity; yet, it is noteworthy that the latter can influence the genesis and progression of the disease on a metabolic as well as on a mechanical level.(8)

Epidemiology

OA is one of the most common diseases in the industrialized world. The knee and the hip joints are burdened with a strong predisposition for OA due to the functional exposure of our erect walking and standing position. Internationally, incidence and prevalence of OA vary strongly. Numbers reach from 10 to 2230 and for prevalence the spectrum reaches from 0.5 to 36 %.(8)

Age seems to be a very important risk factor for OA. While only 15 % of 50-year-olds are affected by OA of the knee, the percentage of 80-year-olds reaches up to 50 %.(8)

Pathogenesis

The articular cartilage is formed by chondrocytes (2-6 %), extracellular matrix (ECM), which is produced by the chondrocytes, and water (65-80 %), bound by proteoglycans. All this is held together by elastic fibers. Those are responsible for the viscoelasticity of the cartilage. But it is necessary to renew all those components on a continuous basis so the cartilage does not lose its elastic characteristics. Very slowly, the components of the matrix are removed and at the same time are newly synthetized. This happens with the help of cytokines, certain growth factors (GFs), and matrix metalloproteinases (MMPs).(8)

When this fragile process gets out of balance so that the destruction of matrix components predominates, it can come to OA. It seems that IL-1 and TNF-α are very important for the pathogenesis of OA. On the one hand they reduce the synthesis of collagens and proteoglycans, which are both vital for the integrity of the articular cartilage; on the other hand, they can stimulate the synthesis of proteolytic enzymes (MMPs).(8)

The natural antagonists of those enzymes are GFs (TGF – β, PDGF and IGF). However, with growing age, the concentration of those GFs in the cartilage decreases. If the balance between the anabolic and the katabolic processes gets lost, the cartilage takes structural damage.(8)

In an advanced stage, this structural damage can be observed in an X-ray. The loss of cartilage leads to a narrowing of the joint space and the loss of elasticity and absorbing characteristics leads to subchondral sclerosis. Additionally, the malfunction of the chondrocytes anabolic qualities can result in the formation of osteophytes.(8)

RHEUMATOID ARTHRITIS

Introduction

Rheumatoid arthritis (RA) is also referred to as chronic polyarthritis or, in case of the knee, as rheumatoid gonitis. When talking about rheumatoid gonitis it has to be clear that this is just one aspect of a complex systemic inflammatory disease, as it only describes the infestation in the knee joint.(8)

Definition and Classification

Rheumatoid arthritis (RA) is a systemic inflammatory disease. It mainly affects the joints, but can also attack tendons, bursae, serous cavities, blood vessels, the eyes, and further organs. It usually is classified according to the American College of Rheumatology. (ACR) (7,8)

Table 3: Classification of RA according to the American Congress of Rheumatology (7,8)

Grade	Symptoms	Description
1	Morning stiffness	At least 1 hour
2	Soft swelling	Arthritis of at least 3 joints
3	Arthritis of the hand	MCP, PIP, DIP
4	Systemic arthritis	Simultaneous affection of the according joint regions
5	Rheumatoid nodule	Subcutaneous nodules near a joint
6	Rheumatoid factor positive	Detected in serum
7	Radiographic change	Joint-near osteoporosis and / or erosion

Etiology and Risk Factor

The discussion of the genesis of this disease includes exogenous as well as endogenous factors. Exogenous factors could be bacterial or viral infections. On the endogenous side, genetic predisposition and immunological as well as endocrinological mechanisms have to be considered.(8)

Epidemiology

RA is a disease that affects people of all races and social levels and spreads without any geographic boundaries. The incidence of 500 for females and 200 for males accounts for the importance of adequate treatment modalities. Prevalence lies between 0.2 and 1.4 %. The peak of disease onset is between 40 and 50 years of age. Women are affected 2 to 3 times more often than men.(8,27)

Pathogenesis

Despite of huge efforts in research, science has not succeeded in completely unraveling the pathogenesis of RA yet. The current hypothesis is that viral and bacterial antigens, supported by a certain genetic predisposition, lead to a chronic, recurrent immune response. Apart from that, other factors like diet, mental pressure, and social stress seem to play a role in the process. Whatever the exact pathway may be, it always leads to severe synovialitis. This induces certain enzymatic and proliferative processes, resulting in complete destruction of the joint.(27) However, due to the onset of new biological (TNF-alpha, e.g.) the incidence of massive osteoarthritis of the knee joint, caused by RA decreased within the last decades.

OTHER INDICATIONS

After those main indications for TKA, there are some further ones which have to be mentioned. Those however only account for a small part of this procedure, because TKA is not the first line treatment in these cases. It can however be superior to other treatment options in some cases, and for that has to be considered as a possible alternative.(28)

If roentgenographic findings correlate clearly with the clinical impression of arthritis, significant deformities, connate or acquired, can be an indication for TKA. It has to be kept in mind that it is not a primary indication for this kind of surgery. Especially when there is no loss of joint space to be detected it is most undesirable to perform TKA, because in that case patients tend to be very unsatisfied with the clinical outcome.
In special circumstances, if the deformity causes a flexion contracture or varus or valgus laxity, TKA is absolutely the first choice. It should be evaluated if a more constrained prosthesis is needed in order to compensate the lack of stability.(28)

The next indication, also very rare, is an actual indication for TKA. It is severe patellofemoral arthritis. If conservative treatment options are exhausted, it can be the best way of regaining quality of life, as isolated patellofemoral replacement is still under clinical investigation and TKA can be expected to have a by far better outcome than patellectomy.(28) However, the issue of patellofemoral replacement is still not resolved.

CONTRAINDICATIONS FOR TKA

A contraindication is a circumstance that forbids the practice of a certain diagnostic or therapeutic intervention. There are basically two groups of contraindications; an absolute contraindication, as the name already gives away, excludes the intervention. Meanwhile, relative contraindications leave some room for the evaluation of risks and benefits.(29)

Absolute contraindications for TKA are amongst others are sepsis, local infection of the knee, systemic infection (SIRS), or a chronic infection from a source other than the knee.(8)

There is a large variety of relative contraindications for TKA and for surgery per se. Those include circumstances that complicate or even rule out save anesthesia (e.g. age, weight etc.) and previous osteomyelitis near the area of the surgery. Furthermore, the insufficiency of the extensor muscles, severe vascular disease, and a genu recurvatum add in. TKA should further not be performed if the patient is adequately supplied with an arthrodesis.(8,28) It is possible to perform TKA on patients with those conditions, but the ratio between risk and benefit for the patient has to be considered very carefully. Obesity also is a relative contraindication for TKA. First of all, the rate of complications after surgery is significantly higher in morbidly obese patients. This alone is enough to reconsider surgery. Secondly, the mean post-operative outcome scores are lower in morbidly obese patients compared to a non-obese group. Radiolucent lines, which represent poor implant seat and are associated with post-operative knee pain are also more often observed in obese patients.(28,30–32)

DIAGNOSIS AND IMAGING

In order to diagnose osteoarthritis (OA) of the knee, a variety of tests (e.g. clinical tests, imaging, laboratory tests) can be used. In their study, a group from the European league against rheumatism published a list of recommendations.(33)

They found three symptoms and three signs to be the most useful tools for the diagnosis of OA of the knee.

Symptoms:

- Persistent knee pain
- Limited morning stiffness
- Reduced function

Signs:

- Crepitus
- Restricted movement
- Bony enlargement

Zhang et al. assume a background prevalence of 12.5% of knee OA in over 45-year-olds.(33) This percentage grew up to 99% in patients with all six symptoms and signs.

They concluded that although there is no international gold standard for the diagnosis of OA of the knee, rigorous clinical examination is the only way to confirm a definite, save diagnosis.(33)

When it comes to imaging, the easiest way of gaining information on the condition of the affected joint is to get an X-ray. It is a rather cheap examination with relatively low radiation exposure.

Simple demographic and clinical data of patients having knee pain, such as age, BMI, and sex can give some information about the status of the patient’s knee with regard to osteoarthritis. It is however not a very reliable tool, and may only be used in addition to more certain diagnostic modalities.(34)

A conventional X-ray is always done in two axes (anterior / posterior; medial / lateral). Otherwise, it would not be possible to interpret it adequately. Several parameters have to be considered. First, the anatomic structure is of importance. The outlines of the bones, the position of the joint members to each other, the integrity of the bones and the articular surface, osteophytes, and the width of the joint space have to be examined.(27,35,36)

Second, it is necessary to assess the bone density in order to detect osteoporosis, osteolytic processes or bone densification or sclerosis.(27,35)
Finally, soft tissue, potential free foreign bodies, and implanted prostheses are given some attention. When interpreting X-rays, it is very important to always keep the clinical appearance of the patient in mind.(27,35)

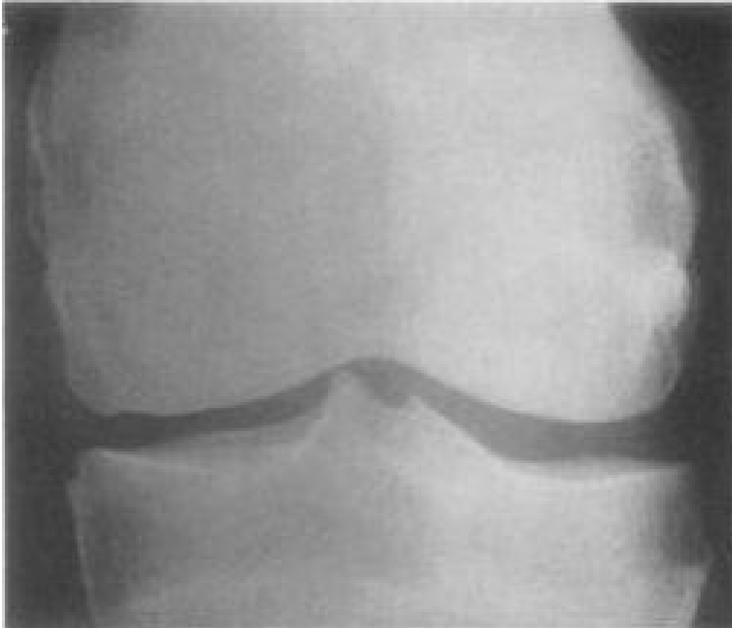
Regarding the degeneration of the knee joint, there are four main indicators in an X-ray. Those are

- Reduction of the joint space,
- Osteophytes,
- Subchondral sclerosis, and
- Pseudocysts.

The reduction of joint space can be interpreted as an indirect sign of cartilaginous degeneration, and is a very important finding for the diagnosis of osteoarthritis.(4,27,35)

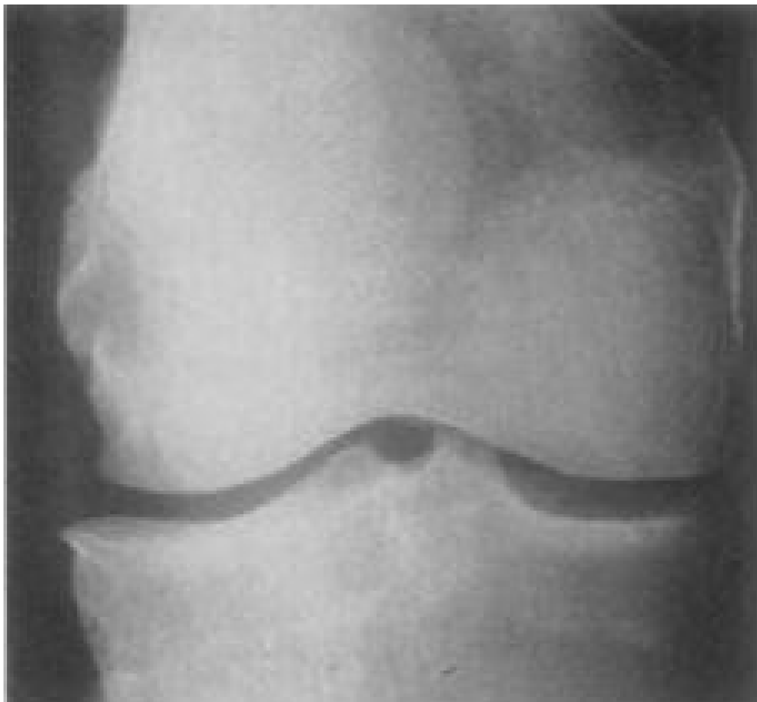
As described above, the radiographic changes in an osteoarthritic joint can be graded according to Kellgren et. al.(4). The following X-rays show the radiographic changes dependent on the grading (0-4).

Figure 6: X-ray of a knee joint (anterior/posterior) Kellgren Grade 0-1 (4)



This antero-posterior (ap) X-ray shows a knee with no clear signs of degeneration. The joint space may be a bit to narrow, but that seems to be because the X-ray is not strictly a/p. According to Kellgren and Lawrence, it would be graded as 0-1, which means that there are no or only doubtful radiographic changes to be found.

Figure 7: X-ray of a right knee (anterior/posterior) Kellgren Grade 2 (4)



In this ap X-ray, only minimal changes can be detected. Those consist in beginning subchondral sclerosis, starting formation of osteophytes on the lateral margin of the tibial plateau, and reduction of the joint space.

Figure 8: X-ray of a right knee (anterior/posterior) Kellgren Grade 3 (4)

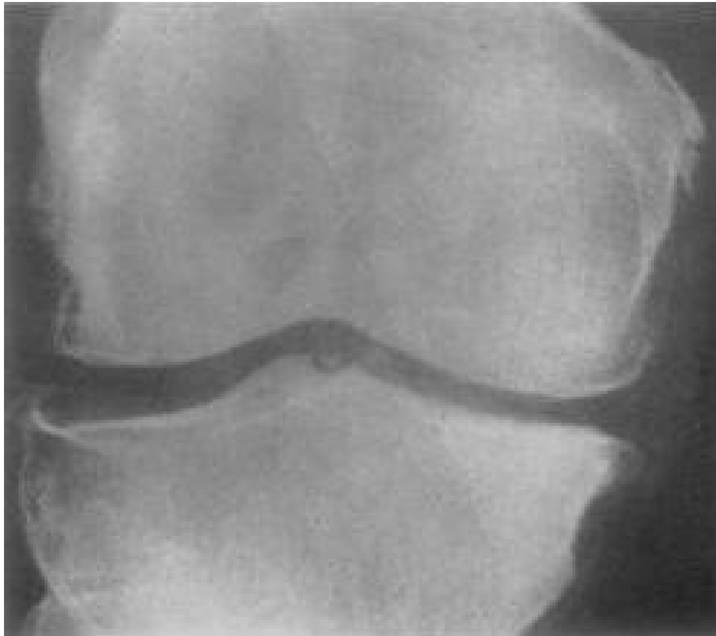
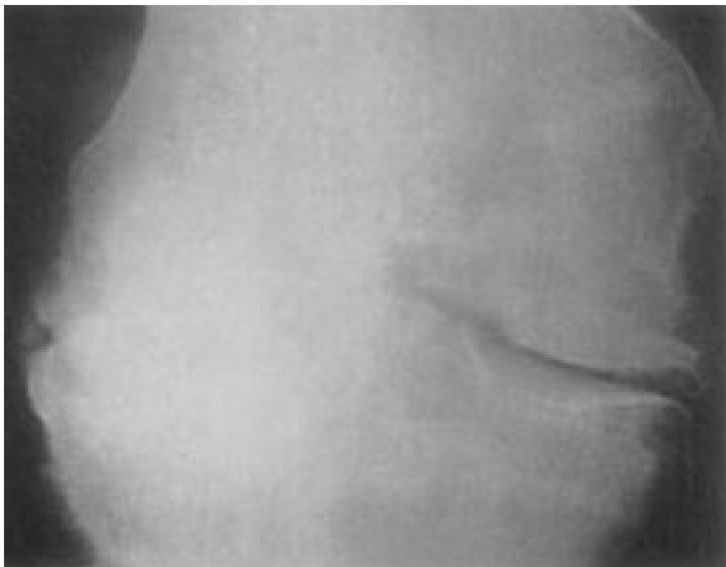


Figure 4 shows a ap X-ray with a knee with radiographic changes grade 3 after Kellgren and Lawrence. Osteophytes, sclerosis of tendons and ligaments as well as subchondral sclerosis and diminishing joint space are found.

Figure 9: X-ray of a knee joint (anterior/posterior) Kellgren Grade 4 (4)



This ap X-ray shows typical changes of a knee with severe Osteoarthritis (Kellgren 4). The joint space is completely used up, sclerosis and formation of osteophytes progresses. These changes usually correlate with massive pain and severely limited function of the joint.

PROSTHETIC DESIGNS

When a total knee arthroplasty is planned, there are different prosthetic designs that can be used. However, there is usually only one design that fits the patient's needs best.
It must be considered whether the capsule and ligament system is intact and able to provide stability to the knee joint and lead its movements. Also it is necessary to look at the alignment of the joint to detect varus or valgus malalignment.

UNCONSTRAINED

The unconstrained design can be further subcategorized into

- Posterior-cruciate retaining and
- Posterior-cruciate substituting

The unconstrained knee prosthesis, especially the posterior cruciate retaining, is the one that is most commonly used for primary TKA. These prostheses rely on the patient's native posterior cruciate ligament (PCL) to stabilize the knee during flexion. The preservation of the PCL is important because it improves flexion by allowing femoral rollback, which is however not anatomic because of the loss of ACL. The disadvantages of this design are firstly that the components need to be flat and a bit less congruent in order to allow rollback, which leads to higher contact stress and increased wear. Secondly, it has to be mentioned that loss of the PCL will lead to flexion instability.(37)

The posterior-cruciate substituting design needs to replace the PCL. This is achieved by a tibial post and a femoral cam, producing a mechanical rollback movement. The downside of the prosthesis is that if the flexion gap is loose or if the knee hyperextends, the femoral part can jump over the tibial post, which means that the knee is completely dislocated. This event is referred to as a cam jump. The reduction of this dislocation requires sedation.(37)

The indications for this kind of prosthesis are mainly inflammatory arthritis, which often leads to late PCL rupture, previous patellectomy, and deficiency of PCL.(37)

An unconstrained prosthetic design may only be used if the capsule- and ligament system still gives enough stability to the joint. As for the alignment, it should not differ to varus or valgus by more than 20° as well as an eventual flexion contracture should not exceed 20°.(8,37)

Contraindications for this prosthetic design are given when the patient suffers from high-grade insufficiency of the collateral ligaments, genu recurvatum, or neuromuscular instability of the knee joint.(8)

As the following two figures show, the mean five year implant survival of a PCL retaining prosthesis is superior compared to a posterior stabilized design.
However, both designs have great outcomes over time.

Figure 10: Survival of primary posterior-cruciate retaining prosthesis over five years. This figure is from the Danish Arthroplasty Register.(3)

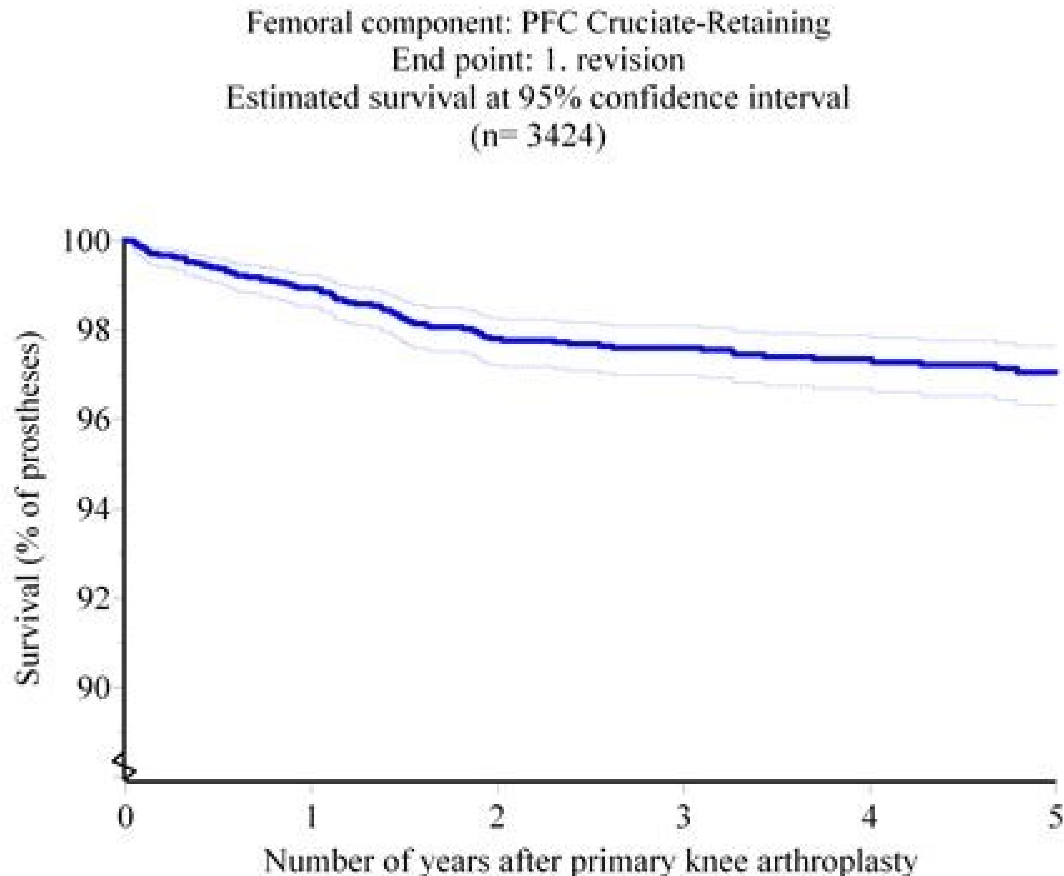
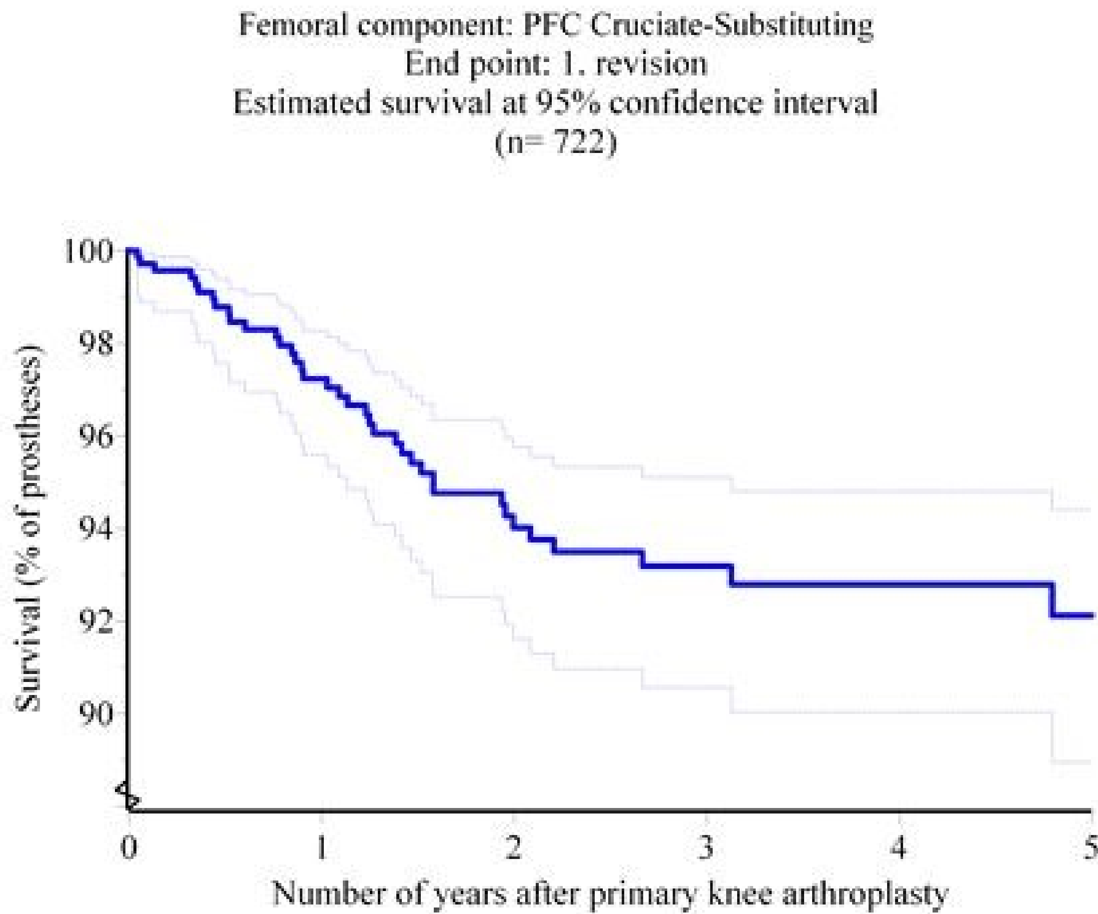


Figure 11: Survival of primary posterior-cruciate substituting prostheses over five years. This figure is from the Danish Arthroplasty Register (3)



As illustrated in figure 6, approximately 98 % of the PCL-retaining knee prostheses were still intact after a period of five years, whereas figure 7, representing the PCL-substituting design, shows a five year survival of around 92 %. That means that 8 % of the posterior-stabilized prostheses had to be revised during that period of time. Most of those revisions even had to be performed after two years (approximately 6 %).

CONSTRAINED

There are three different types of constrained prostheses:

- Non hinged,
- Constrained hinged and
- Mobile bearing prosthesis

When the patient's ligaments do not give sufficient stability to the joint, a constrained prosthesis has to be used.

In that case, all the varus and valgus stress has to be handled by the prosthesis in order to enable the patient to make secure movements. The problem with these prostheses is the additional stress the prosthesis has to endure. This of course leads to increased wear of the prosthesis and consecutive aseptic loosening. To meet these requirements a constrained prosthesis with rotating platform is available, so the rotational forces don't have to be absorbed by the prosthesis itself.(8,37)

The constrained non hinged prosthesis provides a large central post on the tibial component. This post has to compensate varus and valgus forces, so the LCL and MCL are substituted. It is used in patients with LCL or MCL deficiency.(37)

In the constrained hinged prosthesis, the tibial and the femoral component are fixed to each other by a metal bar, which is inserted into a polyethylene bearing. Older prostheses of this design were not yet equipped with a rotating platform. This resulted in a high loosening rate due to the rotational forces. Global ligament deficiency is the main indication for this prosthesis.(37,38)

The third constrained prosthesis design is the mobile bearing prosthesis. The difference to the constrained hinged prosthesis is that the polyethylene bearing is not fixed to the tibial component. That way, the bearing can provide two articular surfaces (tibial component – bearing – femoral component). This is supposed to reduce implant wear and decrease contact stress.(37,38)

SURGICAL TECHNIQUE

GENERAL ASPECTS

As in every surgical procedure, one of the most important conditions for a save intervention is an aseptic environment to prevent contamination of the wound. Before the incision, a tourniquet is applied to minimize blood loss and to ease surgical exposure.(28)

In our case, a low contact stress mobile-bearing prosthesis with rotating platform was used, usually showing excellent outcome and good durability.(39)

In all cases, the medial paraptellar approach was used. An alternative would be the the lateral and the subvastus or midvastus approach. Lateral approaches might by applied in cases with more than 12 degrees of valgus. For the medial parapatellar approach, a midline incision, beginning about 5 cm above the superior pole of the patella and reaching the tibial tubercle is made. The dissection continues between vastus medialis and the tendon of the quadriceps muscle. The joint is opened up from the medial side.(28,37)

As soon as the joint is exposed, osteophytes and intraarticular soft tissue is removed. The proximal tibia and the distal femur are cut in a correct angle to the functional axis. In order to achieve that, an extramedullary alignment device has to be installed. There are options for a tibia first as well as a femur first technique in total knee arthroplasty. In addition, surgeons might implant the prosthesis according to the ligament balancing technique or according to the native anatomical setting. Scientific literature has not demonstrated a clearly superior outcome of these different options yet.(28,37)

Before inserting the actual components of the prosthesis, patellofemoral tracking has to be assessed using trial components. Patellofemoral tracking can be corrected by a lateral retinacular release or medial reefing. If necessary, patellar resurfacing can be performed. This means attaching a small polyethylene button to the posterior side of the patella, which from then on articulates with the femoral component of the prosthesis.(28,37)
The proper components of the prosthesis can be inserted using a cemented or non-cemented system. Cemented systems use a polymethyl methacrylate cement to fix the prosthesis to the bone. In non-cemented prostheses short-term fixation is achieved by a press-fit system and with time bony ingrowth ensures long-term fixation. However, cementing of the tibial plateau has revealed superior results and less aseptic loosening of TKA and is gold standard nowadays.(28,37)
Most recently, there have been trials with platelet-rich plasma (PRP), in order to improve wound healing. However, a clear advantage using PRP has not yet been proven.

Before suturing up the wound, a redon drainage is inserted and the wound is dressed and drained.(28,37)

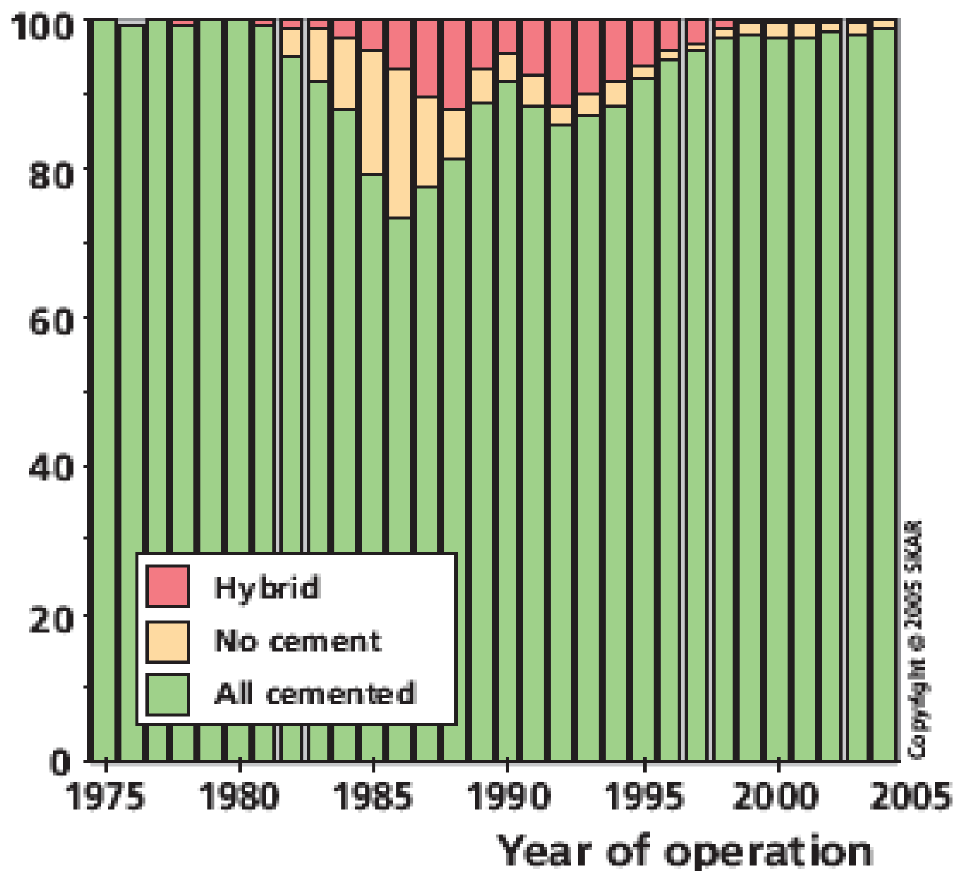
CEMENTED VS. NON-CEMENTED TECHNIQUE

There are two ways of fixing the prosthesis to the surrounding bone. The first option is to use special bone cement (polymethylmethacrylate) which cures in a matter of minutes and then holds the femoral and the tibial component in place. The other option is not to use such cement and rely on fixation due to the bone growing into the prostheses surface. (40)

Anyway, there is no such thing as a standardized guideline for using either the one or the other technique. It is not yet clear if one of the both techniques is superior compared to the other. Also, the debate about long-term survivorship is not yet completely resolved.

However, as figure 12 shows, the cemented technique is used more often than non-cemented fixation with respect to the femoral shield.

Figure 12: Relative distribution of fixation methods in primary total knee arthroplasty in percent. This figure is from the Swedish arthroplasty register (3)



Some of the studies are in line with that decision, such as a the publication of Ranawat et al. (41), indicating a clear superiority of cemented fixation regarding durability and survivorship.

This is in contrast to the findings of other study groups, who could not find a significant difference in long-term survival comparing cemented to non-cemented prostheses.(42,43)

Figure 13: Cumulative revision rate (CRR) of TKA compared between cemented and non-cemented tibial component. This figure is from the Swedish arthroplasty register. (3)

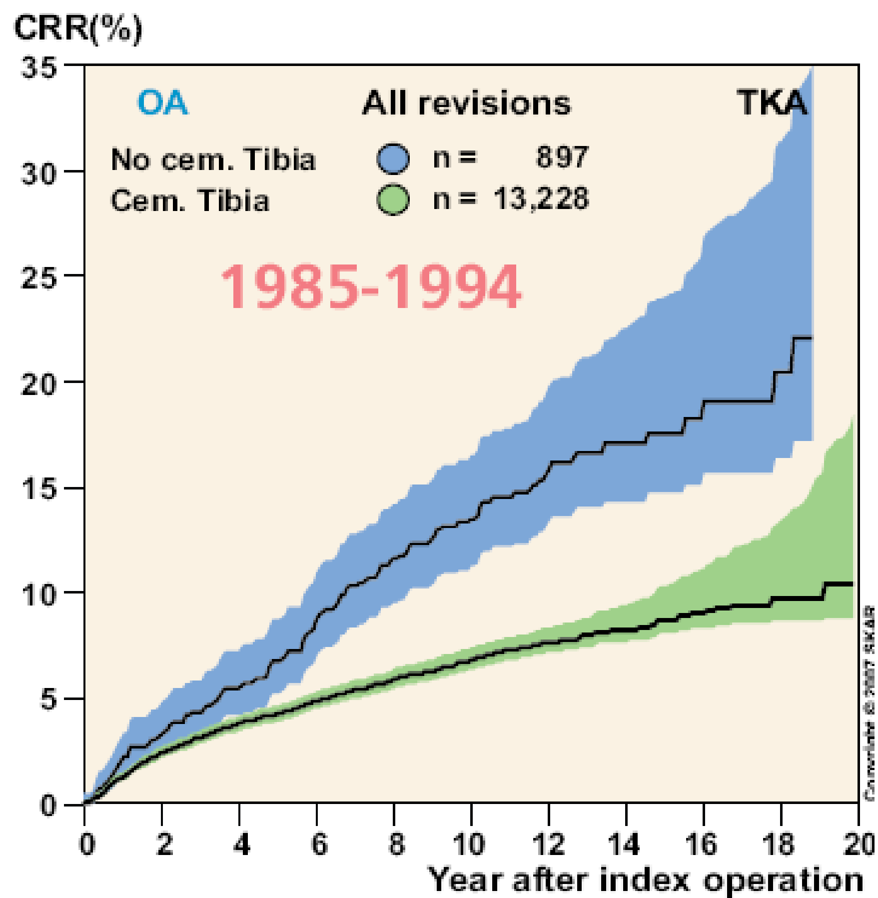
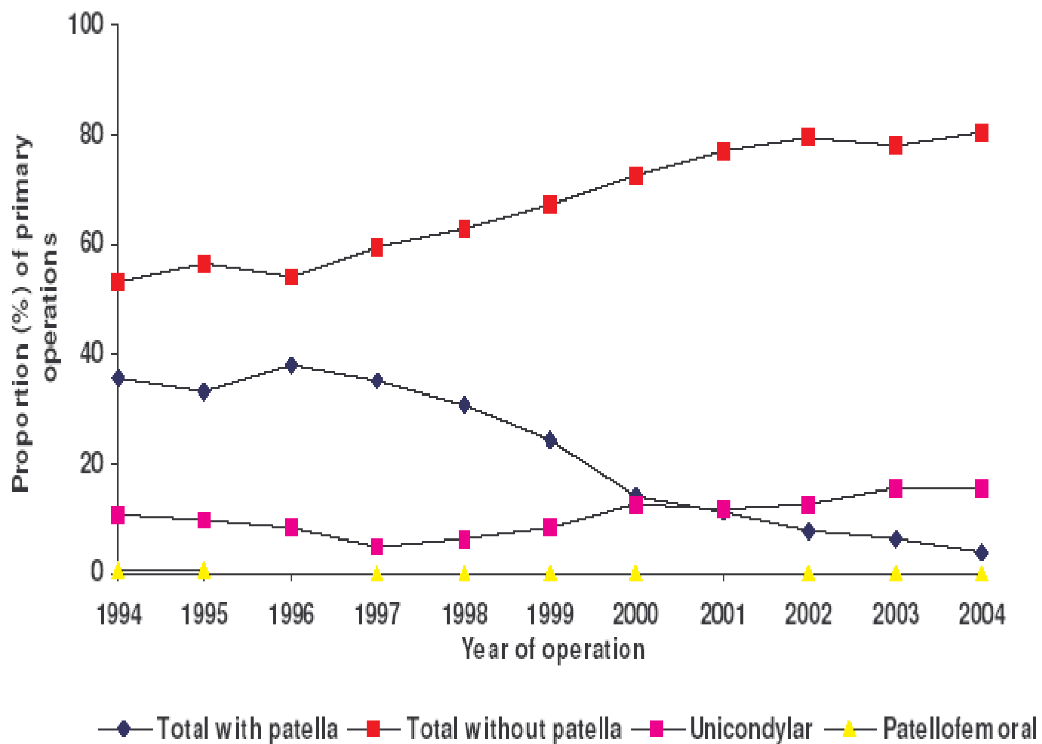


Figure 13 shows a clear difference in the cumulative revision rate between the cemented and the non-cemented group. Anyway, it has to be respected that this is a very unbalanced comparison regarding the number of included patients. The group with cemented tibial component is almost fifteen times as large as the group with the non-cemented tibial component. This may be biasing the results.
There are also numerous studies and meta-analyses claiming a clear supremacy of cemented prostheses, showing better durability of fixation and superior long-term survival with less mechanical failure.
However, it always has to be considered that there is no correct technique per se. It has to be respected that there are many different factors, influencing the survival of the prosthesis, such as the patient’s age, activity level and bodyweight. (41) At the authors´ department, we cement the tibial plateau in all cases and the femoral shield in most of the cases. Uncemented femoral shields may be however used in case of young patients with excellent bone stocks.

PATELLAR RESURFACING

Patellar resurfacing can be performed in any patient receiving a total knee prosthesis. If the surgeon decides to resurface the patella, a polyethylene button is fixed on the patient's patella, which then articulates with the femoral component of the prosthesis. Whether or not patellar resurfacing should be performed in total knee arthroplasty is a controversially discussed topic in literature. It is supposed to reduce postoperative anterior knee pain, improve the knee function and lower the risk of revision surgery. However, while these are desirable aims, further evidence is needed in order to decide the effectiveness of patellar resurfacing in meeting those demands. (44,45)

Figure 14: Use of patellar component in primary TKA from 1994 to 2004 in %. This figure is from the Norwegian arthroplasty register.(3)



At present, studies show no improved outcome regarding anterior knee pain if a patellar component is implanted. Regarding the argument of increased infection risk due to longer operative time, there is no evidence to hold on to. Operative time does not differ significantly between the group with patellar resurfacing and the one without resurfacing, and neither does the infection rate.(44,45)
There is a significant difference, however, concerning the risk of reoperation. Implanting a patellar component seems to reduce the risk of revision surgery in total knee arthroplasty.(44,45)

In the absence of clear evidence, the surgeon has to assess the individual situation and then decide whether to resurface the patella or not. At the authors´ institution, we normally do not replace the patella in total knee arthroplasty.

COMPLICATIONS

In order to write about surgical complications, there has to be a clear definition of what is regarded as a complication. I chose to use the following definition for my study.

''A complication is an unintended and undesirable event or condition following medical treatment, that is harmful for the patient and necessitates adjustment of medical treatment, or that leads to permanent harm.''(9)

Of course, it is not enough just to assess whether a patient did or did not have a complication. A huge amount of information can be gained when complications are also graded for severity. The following table describes the grades of severity of a complication according to Goslings and Gouma.(9)

Table 4: Grading of surgical complications according to Goslings and Gouma(9)

Grade	**Severity / Treatment**
Grade 0	No harm
Grade 1	Temporary disadvantage, no (re-)operation needed
Grade 2	Recovery after (re-)operation
Grade 3	Permanent damage/disability
Grade 4	Death
Grade 5	Unclear due to untimely death

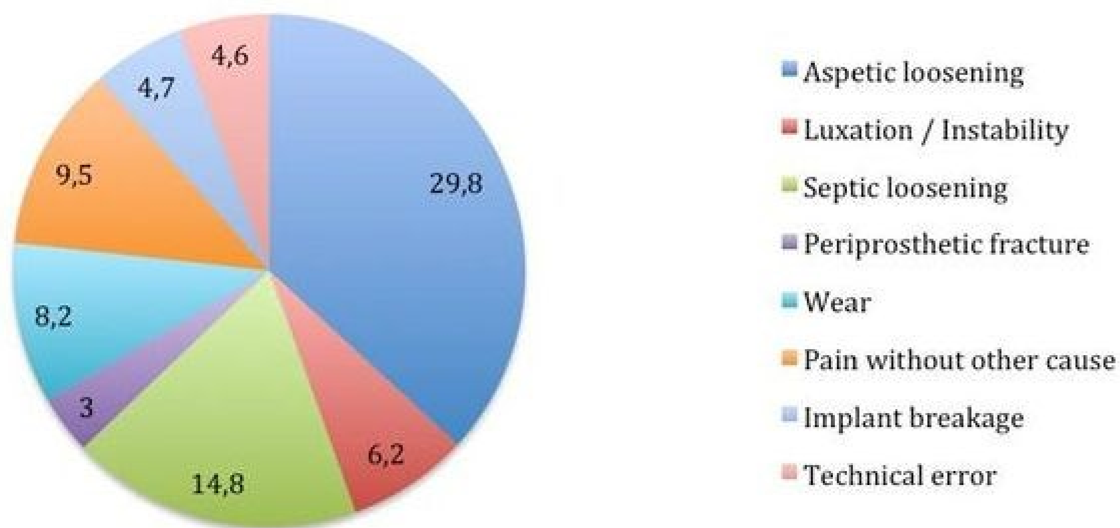
REVISION

Revision surgery can be needed after primary total knee replacement in case of a complication, such as infection or aseptic loosening.

The most common reason for revision is aseptic loosening, which accounts for around 30% of all cases and is mostly due to implant wear.(25)

Another quite common reason for revision surgery (up to 15% of primary revisions) is infection. This is a very serious problem, which is usually treated in a two-staged revision. Unfortunately, the outcomes of revision surgery due to infection are not favorable.(25)
Other problems that can potentially lead to revision surgery include patellofemoral pain, instability, and stiffness of the knee, and implant breakage. Altogether, the above named complications are the reason for 80-90% of all revisions.(5,25,46)

Figure 15: Cause for revision surgery in total knee arthroplasty From: Sadoghi P. et al. Revision Surgery after Total Joint Arthroplasty: A Complication-based Analysis using Worldwide Arthroplasty Registers(5)



As figure 10 shows, there are various other causes for revision surgery after TKA that have to be considered. All those factors can lead to an impact on the patient's quality of life, their satisfaction with the prosthesis, and ultimately on the outcome of the surgery. So, in order to reveal satisfactory outcome, it is crucial to investigate potential causes for revision. Yet, most patients, even if they have undergone revision surgery, are satisfied with their total knee prosthesis.(47)

Special Part

Introduction and Background

In the past few years, gender-specific outcome differences have become a very interesting and much discussed topic in the field of total knee arthroplasty. The high interest in this matter can easily be proven by the 961 results when searching in PubMed for the terms “gender” and “total knee arthroplasty”.

One of the reasons for this increased interest is the introduction of female-specific knee-prostheses. The problem is that there is a lack of evidence for females having worse outcome than men when using a standard unisex prosthesis, which would be necessary to justify the need of a gender-specific prosthetic design.(18) Despite the high number of published papers concerning this problem, findings strongly differ from one another. In the hope of clearing this topic, we took effort to perform this retrospective outcome study with a minimum follow-up of 10 years.

The underlying hypothesis of this study was that there is in fact a difference in outcome between female and male patients after primary total knee arthroplasty at 10 years of follow-up.

METHODS

STUDY DESIGN AND PATIENT RECRUITMENT

The design of this study is a retrospective level III cohort study. (48)
We searched our hospital database for patients having received a Low-contact-stress (LCS) mobile-bearing total knee prosthesis with a minimum follow-up of 10 years. This search revealed 467 patients with 546 TKAs. Two-hundred-and-thirty-one patients have already died, and so 236 remaining patients (189 women and 47 men) were invited to our clinic for clinical assessment. After first invitation, 66 patients (50 women and 16 men) with 84 prostheses showed up and were examined with respect to pain levels, mobility, ROM, and patient satisfaction.
We acquired further data from another 42 patients by interviewing them on the telephone or by searching the reports of their last visits at our outpatient clinic with a minimum follow-up of 10 years, revealing a number of 108 patients and 138 prosthesis in total.
All the patients included gave informed consent in the knowledge that anonymous data will be used for research and can be published. Clinical data and x-rays were gained from our clinic database. The replacements were performed at a single institution. The study was approved by the local Institutional Review Board.

SURGICAL TECHNIQUE AND REHABILITATION

The prostheses were implanted under general or epidural anesthesia. A medial parapatellar approach was used. The tibial cut was performed with a posterior slope of 5°. For the femoral cut an intramedullary guide system was used with 3° of external rotation according to the flexion gap balancing technique. Following the manufacturer's instructions, both the tibial and the femoral part were implanted using a cemented technique. Patellar resurfacing was not performed on any of the patients.
All the patients received the same prosthesis, namely the low-contact-stress (LCS) mobile-bearing total knee prosthesis (Johnson & Johnson, New Brunswick, NJ, USA; previously DePuy, Warsaw, IN, USA).

The patients were allowed full weight bearing postoperatively. Two days after surgery continuous passive motion was used. Between ten and fourteen days after surgery, all the patients were discharged. For further rehabilitation, the patients were referred to an outpatient rehabilitation program until their sixth postoperative week.
Pain management was performed using a mixture of 75 mg diclofenac and 30 mg orphenadrine iV combined with 40 mg pantoprazole orally or 1 g metamizole iV combined with 40 mg pantoprazole orally and 7.5 mg piritramide by intramuscular injection.

OUTCOME ASSESSMENT

All the patients have a minimum follow-up of ten years.
For clinical evaluation we used the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the Knee Society Score (KSS), and the visual analogue scale (VAS).(49,50) Furthermore, the patients were scanned for postoperative complications according to Goslings and Gouma.(9)

RESULTS

DEMOGRAPHIC DATA

The patients' mean age at the time of surgery was 62 years (range 21-78). When they were examined, the mean age was 76 years (range 37-95). Minimum follow-up was set at ten years (mean 14, range 11-23). At this stage and the end of my thesis, 66 patients were investigated in total, compromising for 50 female (75.8%) and 16 male (24.2%) patients, who were included in our study. Further 42 patients were interviewed by phone calls and additional patients and follow up examinations will follow after publication of this diploma thesis. All the implantations were performed using a totally cemented technique (tibial plateau and femoral shield).

OUTCOME ASSESSMENT

There was no significant difference to be observed between female and male patients after ten years of follow-up regarding KSS, WOMAC, or active and passive ROM.

The mean KSS funcion score was 68.55 (±30.209） for female patients and 79.25 (±24.017) for male patients with no significant difference between the groups (p=0.172). KSS pain score averaged 69.13 (±20.908) in women and 76.25 (±24.447) in men also with an insignificant difference (p=0.442).

The mean active ROM for the female patients was 96° (±19.67°) and 94.62° (±17.26°) for the male patients. Passive ROM was 99.1° (±20.27°) in females, while male patients reached 100.77° (±17.93°). WOMAC score revealed no significant difference between patients either.

However, we found a significant difference in pain levels, using the VAS reaching from 1.03 points for male to 1.56 points for female patients.

There were six complications (7%) in 84 prosthesis to be reported: One case of a ruptured patella tendon which had to be treated surgically (grade 2), one case of aseptic loosening requiring revision surgery (grade 2), two cases of infection treated with two-stage revision surgery (grade 2) and two cases of inlay wear followed by

surgical exchange of the polyethylene inlay. Three of the above named complications were in female patients (50%), the other three in males (50%).

Table 5: Statistical analysis of active range of motion (ROM) between female and male patients, ten years after implantation of low-contact stress total knee prosthesis. No significant difference between female and male patients could be observed.

	Sex	N	Mean	SD	p-value
Active ROM	female	100	96,0000	19,66898	0,860
	male	26	94,6154	17,25822	

Table 6: Statistical analysis of passive range of motion (ROM) between female and male patients, ten years after implantation of low-contact stress total knee prosthesis. No significant difference between female and male patients could be observed.

	Sex	N	Mean	SD	p-value
Passive ROM	female	100	99,1000	20,26815	0,962
	male	26	100,7692	17,92720	

Tables 5 and 6 show the statistical analysis of active and passive range of motion (ROM) divided by gender. As the p-values of 0,860 for active ROM and accordingly 0,962 for passive ROM indicate, no significant difference could be detected.

Table 7: Statistical analysis of the knee society score (KSS) indicating no significant difference between female and male patietns ten years after implantation of the low-contact stress total knee prosthesis.

	Sex	N	Mean	SD	p-value
KSS (function)	female	64	68,55	30,209	0,172
	male	20	79,25	24,017	
KSS (pain)	female	64	69,13	20,908	0,442
	male	20	76,25	24,447	

Table 7 shows the analysis of the two domains of the Knee Society Score.
The p-values of 0,172 for knee function and 0,442 for knee pain tell us that according to the KSS, there is no statistical significant difference between men and women.

DISCUSSION

In this study we evaluated the outcome after implantation of primary LCS total knee prosthesis with a minimum follow-up of ten years, in order to make out possible differences between men and women. The hypothesis was that there are in fact significant differences in the outcome after total knee arthroplasty between men and women at minimum follow-up of ten years.

Our findings indicate no significant differences between female and male patients after ten years of follow-up concerning active and passive ROM, clinical outcome, or knee function using the KSS and the WOMAC score. We did however find a difference in pain levels, with female patients indicating significantly higher scores on the VAS compared to male patients. This difference of 1,03 points compared to 1,56 points may be of statistical significance. Yet it has to be considered that it is a rather small difference regarding the fact that the VAS is a 10-leveled scale, and so the clinical importance of those findings has to be questioned.

The frequently stated problem concerning gender-specific anatomical differences, such as mediolateral to anteroposterior dimension or the Q-angle, causing problems when using a unisex prosthesis could not be verified in our study.(18)

The limitations to this study are as follows: The ten-year period was set as minimum follow-up. However, follow-up is inconsistent in our patients and varies from 10 to 33 years, which might result in a bias. Furthermore, the sex ratio is shifted to the female side with 100 female patients and 26 male patents. However, this is the typical distribution of gender after TKA cases. Yet, all the prostheses were implanted at a single institution with standardized methods.

Conclusion

Based on our statistical data we infer that there is no significant difference in the outcome after primary TKA at a minimum follow-up of ten years between the genders, regarding active and passive ROM, function, and clinical outcome. This leads us to the conclusion that there is no necessity for a gender-specific prosthetic design.

A previous publication with a minimum follow-up of five years regarding the same topic came to similar results, with the conclusion that a gender-specific prosthesis is not needed.(16)

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