



# LUND UNIVERSITY

## Pain, Function, and Dissatisfaction after Total knee Arthroplasty

ALI, ABDULEMIR MUHAMMED NURI

2016

*Document Version:*

Publisher's PDF, also known as Version of record

[Link to publication](#)

*Citation for published version (APA):*

ALI, ABDULEMIR. MUHAMMED. NURI. (2016). *Pain, Function, and Dissatisfaction after Total knee Arthroplasty*. [Doctoral Thesis (compilation), Orthopaedics (Lund)]. Lund University: Faculty of Medicine.

*Total number of authors:*

1

*Creative Commons License:*

Other

**General rights**

Unless other specific re-use rights are stated the following general rights apply:

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: <https://creativecommons.org/licenses/>

**Take down policy**

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LUND UNIVERSITY

PO Box 117  
221 00 Lund  
+46 46-222 00 00

# Pain, Function, and Dissatisfaction after Total Knee Arthroplasty

Abdulemir Ali



**LUND**  
UNIVERSITY

DOCTORAL DISSERTATION

By due permission of the Faculty of Medicine, Lund University, Sweden.  
To be defended at Lecture hall F1 in Blocket, Getingevägen 4, Skåne University  
Hospital, Lund. Friday, November 25, 2016, 9.00 am.

*Faculty opponent*

Professor Per Wretenberg  
Department of Orthopaedic Surgery  
School of Medical Sciences  
Örebro University Hospital

Organization: LUND UNIVERSITY  Department of Orthopaedics, Clinical Sciences, Lund, Lund University, Sweden  Author: Abdulemir Ali	Document name: DOCTORAL DISSERTATION	
	Date of issue: 2016-11-25	
	Sponsoring organization	
Title : Pain, Function and Dissatisfaction after Total Knee Arthroplasty		
<p>Abstract</p> <p>Osteoarthritis (OA) is a progressive degenerative joint disorder, and the prevalence increases with age. In Sweden, about one in 4 people over the age of 45 years has OA in at least one joint. As the population ages and the prevalence of obesity increases, OA is expected to increase even more. The knee joint is one of the most commonly affected joints. Total knee arthroplasty (TKA) is the most common method of major surgical intervention for OA of the knee in Sweden. About 13,000 knee arthroplasty procedures were performed in Sweden in 2015.</p> <p>During the past 4 decades, there have been continuous improvements in prosthesis design, preoperative templating, and surgical technique including navigation, pain management, and infection prophylaxis, but still a relatively large proportion of patients (up to 20%) are not satisfied with the outcome after surgery.</p> <p>All knee arthroplasty procedures in Sweden are reported to the Swedish Knee Arthroplasty Register (SKAR), which started in 1975. The purpose of the SKAR is to monitor early and long-term surgical outcomes and complications, especially revision procedures.</p> <p>Through the SKAR, we identified 114 non revised dissatisfied patients in Skåne County, Sweden, and a matched control group of 113 patients who were very satisfied after TKA. The patients had an average of 10.5 years of follow-up and were matched by age, sex, hospital, and date of surgery. There were similar clinical findings, performance tests, and radiographic findings in both groups. In the dissatisfied group, the proportion of patients with anxiety and/or depression was higher, mean VAS pain score was higher, and mean range of motion (ROM) was less.</p> <p>Local infiltration analgesia is used for early postoperative pain relieve in TKA. To prolong the postoperative analgesic effect, continuous intraarticular analgesia for 48 hours has been used. In a prospective double-blind randomized study, 200 TKA patients were given either ropivacaine or NaCl intraarticularly by pump. There were no significant differences regarding postoperative VAS pain, length of hospital stay, analgesic consumption, or ROM between the groups. There were, however, significantly more superficial and deep surgical wound infections in the ropivacaine group.</p> <p>Patella-related problems are an important reason for pain after TKA. In Sweden, patellar resurfacing in primary TKA has decreased since the 1980s, from more than 70% to about 2,5% today. In a prospective randomized study of 74 patients undergoing TKA, we randomized to either patellar resurfacing or no resurfacing. We found no significant differences between the groups regarding VAS pain, physical performance, patient satisfaction, or KOOS 5 subscale scores. None of the patients were reoperated within 6 years.</p> <p>In a prospective cohort study of 186 TKA patients with 4 years of follow-up, preoperative anxiety/depression was a strong indicator of postoperative dissatisfaction. The risk increment for dissatisfaction was more than 6 fold, twice that in patients who had to undergo further surgical procedures because of deep infection postoperatively.</p> <p>Anxiety/depression is an important reason for dissatisfaction after TKA. Continuous intraarticular analgesia is unnecessary in TKA, and patellar resurfacing does not appear to be beneficial in patients with primary OA.</p>		
Key words: TKA, dissatisfaction, continuous intraarticular analgesia, patella, anxiety/depression, pain, function		
Classification system and/or index terms (if any)		
Supplementary bibliographical information		Language: English
Lund University, Faculty of Medicine Doctoral Dissertation Series 2016:129		
ISSN 1652-8220		ISBN 978-91-7619-355-6
Recipient's notes	Number of pages:	Price
	Security classification	

I, the undersigned, being the copyright owner of the abstract of the above-mentioned dissertation, hereby grant to all reference sources permission to publish and disseminate the abstract of the above-mentioned dissertation.

Signature \_\_\_\_\_ Date \_\_\_\_\_

# Pain, Function, and Dissatisfaction after Total Knee Arthroplasty

Abdulemir Ali



**LUND**  
UNIVERSITY

Copyright Abdulemir Ali

Department of Clinical Sciences, Section of Orthopaedics, Faculty of Medicine,  
Lund University

Doctoral Dissertations Series: 2016:129

ISBN 978-91-7619-355-6

ISSN 1652-8220

Printed in Sweden by Media-Tryck, Lund University  
Lund, 2016



*In memory of my mother and father*

*To my country, Kurdistan*

*and to my family*

# Contents

List of papers	1
Abbreviations/Definitions	2
Summary in English	3
Sammanfattning – Summary in Swedish	5
Introduction	7
Osteoarthritis	7
Total knee arthroplasty	8
The Swedish Knee Arthroplasty Register	8
Pain	9
Physical function	10
Dissatisfaction after total knee arthroplasty	10
Intraarticular analgesia	11
The patella in total knee arthroplasty	12
Patient-reported outcome measures	13
The hospital anxiety and depression scale	14
Radiography	15
Purposes of this thesis	16
General	16
Specific aims, papers I–IV	16
Patients and methods	17
Paper I	17
Paper II	19
Paper III	22
Paper IV	23
Statistics	24
Ethical considerations	25
Results	26
Paper I	26
Paper II	27
Paper III	28
Paper IV	30
Discussion	32
Conclusions	40
The future	41
Acknowledgments	42
References	44

# List of papers

- I. **Dissatisfied patients after total knee arthroplasty. A registry study involving 114 patients with 8–13 years of follow-up.**  
Abdulemir Ali, Martin Sundberg, Otto Robertsson, Leif E Dahlberg, Carina A Thorstensson, Inga Redlund-Johnell, Ingvar Kristiansson, and Anders Lindstrand.  
*Acta Orthopaedica 2014 June; 85 (3): 229–233*
- II. **Doubtful effect of continuous intraarticular analgesia after total knee arthroplasty. A randomized, double-blind study of 200 patients.**  
Abdulemir Ali, Martin Sundberg, Ulrik Hansson, Johan Malmvik, and Gunnar Flivik.  
*Acta Orthopaedica 2015 June; 86 (3): 373–377*
- III. **Similar patient-reported outcomes and performance after total knee arthroplasty with or without patellar resurfacing. A randomized study of 74 patients with 6 years of follow-up.**  
Abdulemir Ali, Anders Lindstrand, Anna Nilsson and Martin Sundberg.  
*Acta Orthopaedica 2016 June; 87 (3): 274–279*
- IV. **Preoperative anxiety and depression correlate with dissatisfaction after total knee arthroplasty. A prospective longitudinal cohort study of 186 patients, with 4 years follow-up.**  
Abdulemir Ali, Anders Lindstrand, Martin Sundberg, and Gunnar Flivik.  
*The Journal of Arthroplasty 2016 (epub ahead of print)*



# Abbreviations/Definitions

6 MW	6-minute walking test (the distance walked in 6 minutes)
CI	Confidence interval
CIAA	Continuous intraarticular analgesia
CR system	Cruciate retaining system of TKA
CS	Chair-stand test (5 repetitions of rising from a chair and sitting down)
CRR	Cumulative revision rate
CWP	Chronic widespread pain
HAD	Hospital anxiety and depression scale
KOOS	Knee injury and osteoarthritis outcome score
LIA	Local infiltration analgesia
LOS	Length of hospital stay
OA	Osteoarthritis
PROM	Patient-reported outcome measure
RCT	Randomized, controlled trial
ROM	Range of motion (degree of extension–flexion)
RR	Relative risk
SKAR	Swedish Knee Arthroplasty Register
TKA	Total knee arthroplasty
VAS pain	Visual analog scale for pain (0–100 mm)

# Summary in English

Osteoarthritis (OA) is a progressive degenerative joint disorder, and the prevalence increases with age. In Sweden, about one in 4 people over the age of 45 years has OA in at least one joint. As the population ages and the prevalence of obesity increases, OA is expected to increase even more. The knee joint is one of the most commonly affected joints. Total knee arthroplasty (TKA) is the most common method of major surgical intervention for OA of the knee in Sweden. About 13,000 knee arthroplasty procedures were performed in Sweden in 2015.

During the past 4 decades, there have been continuous improvements in prosthesis design, preoperative templating, and surgical technique including navigation, pain management, and infection prophylaxis, but still a relatively large proportion of patients (up to 20%) are not satisfied with the outcome after surgery.

All knee arthroplasty procedures in Sweden are reported to the Swedish Knee Arthroplasty Register (SKAR), which started in 1975. The purpose of the SKAR is to monitor early and long-term surgical outcomes and complications, especially revision procedures.

Through the SKAR, we identified 114 non revised dissatisfied patients in Skåne County, Sweden, and a matched control group of 113 patients who were very satisfied after TKA. The patients had an average of 10.5 years of follow-up and were matched by age, sex, hospital, and date of surgery. There were similar clinical findings, performance tests, and radiographic findings in both groups. In the dissatisfied group, the proportion of patients with anxiety and/or depression was higher, mean VAS pain score was higher, and mean range of motion (ROM) was less.

Local infiltration analgesia is used for early postoperative pain relieve in TKA. To prolong the postoperative analgesic effect, continuous intraarticular analgesia for 48 hours has been used. In a prospective double-blind randomized study, 200 TKA patients were given either ropivacaine or NaCl intraarticularly by pump. There were no significant differences regarding postoperative VAS pain, length of hospital stay, analgesic consumption, or ROM between the groups. There were, however, significantly more superficial and deep surgical wound infections in the ropivacaine group.

Patella-related problems are an important reason for pain after TKA. In Sweden, patellar resurfacing in primary TKA has decreased since the 1980s, from more than 70% to about 2.5% today. In a prospective randomized study of 74 patients undergoing TKA, we randomized to either patellar resurfacing or no resurfacing. We found no significant differences between the groups regarding VAS pain, physical

performance, patient satisfaction, or KOOS 5 subscale scores. None of the patients were reoperated within 6 years.

In a prospective cohort study of 186 TKA patients with 4 years of follow-up, preoperative anxiety/depression was a strong indicator of postoperative dissatisfaction. The risk increment for dissatisfaction was more than 6 fold, twice that in patients who had to undergo further surgical procedures because of deep infection postoperatively.

Anxiety/depression is an important reason for dissatisfaction after TKA. Continuous intraarticular analgesia is unnecessary in TKA, and patellar resurfacing does not appear to be beneficial in patients with primary OA.

# Sammanfattning – Summary in Swedish

Artros är en progressiv degenerativ ledsjukdom där prevalensen ökar med åldern. I Sverige har cirka var fjärde person över 45 års ålder symptomgivande eller röntgenverifierad artros i minst en led. Antalet förväntas öka ännu mer i takt med ökande övervikt och den åldrande befolkningen. Knäleden är en av de vanligaste lederna som drabbas och operation med total knäledsprotos är den oftast använda kirurgiska behandlingen av knäledartros i Sverige. 2015 utfördes cirka 13000 knäprotes operationer i Sverige.

Under de senaste fyra decennierna har det skett en ständig förbättring vad gäller knäprotesoperationer från protesdesign, digitala mallningssystem, operationsteknik inklusive användande av datornavigering, smärtbehandling, infektionsförebyggande åtgärder, samt rehabilitering. Trots dessa förbättringar är en relativt stor andel av patienterna (upp till 20 %) inte nöjda med operationsresultatet och får inte sina förväntningar på operationen infriade.

Alla knäprotesoperationer i Sverige rapporteras till Svenska knäprotesregistret (SKAR). Syftet med SKAR är att följa insatta proteser över tiden och registrera om patienterna opereras igen i samma knä.

Genom SKAR identifierades 114 missnöjda knäprotesopererade patienter i Region Skåne och de jämfördes med 113 mycket nöjda knäprotesopererade patienter. Grupperna matchades för ålder, kön, sjukhus och operationsdatum. Det fanns fler patienter med ångest och/eller depression i den missnöjda gruppen. Missnöjda patienter uppgav också mer smärta och de hade något sämre rörlighet i knäleden. Det förelåg ingen skillnad mellan grupperna gällande klinisk undersökning, funktionella tester eller röntgenresultat.

Att opereras med knäprotes är ett smärtsamt ingrepp. Att spruta lokalbedövning i och runt knäleden i samband med operationen är en vanlig metod för smärtlindring. För att förlänga smärtlindringens duration efter operationen har man prövat att ge lokalbedövning fortlöpande under 48 timmar. I en studie av 200 knäprotesopererade patienter lottades de till att antingen få lokalbedövning (ropivacaine) eller koksalt (NaCl) in i leden genom en pump under 48 timmar efter operationen. Varken läkare, övrig personal eller patienten fick veta vilket medel som gavs. Det fanns inga skillnader mellan grupperna gällande smärta, antal dagars sjukhusvistelse, användning av ytterligare smärtstillande läkemedel

eller rörlighet i knäleden. Fler patienter i ropivacaine gruppen fick ytliga eller djupa sårinfektioner.

Knäprotes operation ger inte alltid full smärtlindring och knäskålsrelaterade problem är en orsak till smärta efter knäprotesoperation. I Sverige ersattes även knäskålens baksida med en protes under 80-talet i upp till 70% av fallen. I dag ersätts knäskålen enbart i cirka 2,5 % av fallen. För att se om detta är bra för patienterna så studerades 74 knäprotesopererade patienter som lottades till att få knäskålen ersatt med protes eller inte. Det fanns inga skillnader mellan grupperna gällande smärta, funktionella tester, patienternas nöjdhetsgrad eller patienternas egen skattning av sin funktion via standardiserade frågor. Ingen patient omopererades under 6 års uppföljningstid.

I en studie av 186 knäprotesopererade patienter med 4 års uppföljning hade patienter med ångest och/eller depression före operation mer än 6 gånger högre risk för att bli missnöjda efter operation. Dubbelt så stor risk jämfört med patienter som opererades om på grund av djup infektion.

Visuell analogskala (VAS) smärta är en vanlig metod för smärtskattning. VAS är en 100 mm lång horisontell linje, där patienten markerar på linjen ett streck som motsvarar den aktuella smärtan. Skalan går från 0-100, där 0 är ingen smärta och 100 värsta tänkbara smärtan.

Knee Injury and Osteoarthritis Outcome Score (KOOS) är ett knäspecifikt instrument för utvärdering av patientens uppfattning om sitt knä. KOOS innehåller 5 områden. Smärta, andra symtom, funktion i dagliga livet, sport och fritidsfunktion, samt, knärelaterad livskvalitet. Frågorna har 5 svars alternativ där, poängen summeras och transformeras till en skala från 0-100, för vart och ett av de 5 områdena där 0 betyder extrema knäproblem och 100 inga knäproblem.

Hospital anxiety and depression scale (HAD) är ett självskattningsformulär för bedömning av ångest och depression. HAD består av 7 frågor vardera för ångest och depression med 4 svarsalternativ. Poängen från de sju olika svaren per delskala summeras där, normal (0-7), mild (8-10), moderat (11-14), svår ( $\geq 15$ ) ångest/depression förekommer.

VAS, KOOS och HAD är självskattningsformulär som användes i olika delarbeten.

Patienter som är missnöjda efter knäprotesoperation har samma kliniska resultat, samma aktivitetsnivå och samma röntgenresultat som de som är mycket nöjda efter operationen. Att använda lokalbedövning i leden efter operation innebär en ökad risk för infektion utan någon bättre smärtlindring. Användandet av en konstgjord knäskålsdel förbättrade inte resultatet vid knäprotesoperation hos patienter med primär artros. Ångest och depression före operationen är en vanlig anledning till missnöjdhet efter knäprotesoperation.

# Introduction

## Osteoarthritis

OA is a progressive degenerative joint disorder, and the incidence increases with advancing age. In Sweden, about every fourth person aged 45 years or more has clinical symptoms from—or radiographic evidence of—OA in at least one joint (Turkiewicz et al. 2015). As the population ages and as the incidence of obesity increases, the prevalence of OA of the knee is expected to increase (Kurtz et al. 2011). Estimation of the exact prevalence of OA is difficult because many patients have symptoms without radiographic findings or vice versa, and the symptoms may change during different time periods. There are certain well-known risk factors for OA such as increasing age, overweight, heredity, female gender, previous trauma, overloading, and joint dysplasia (Blagojevic et al. 2010, Fernandez-Moreno et al. 2008, Khan et al. 2015, Pan et al. 2016). OA is a degenerative process of the joint, which affects not only the cartilage but also other structures such as synovium, ligaments, capsule, and bone. The function of articular cartilage is dependent on the integrity of its extracellular matrix; thus, imbalance between degeneration and re-synthesis of the cartilage is characteristic in OA, where degeneration exceeds repair (Aigner and Stove 2003, Dahlberg et al. 2000). OA can lead to physical, psychological, and socioeconomic disability. The burden of OA management on the community is therefore considerable (Litwic et al. 2013). At the end of the 1990s, the WHO judged musculoskeletal disease to be the disease in focus during the coming decade. The idea of the “Bone and Joint Decade” (2000–2010) was to raise awareness of musculoskeletal disorders, including OA, and to achieve effective prevention and treatment programs (Lidgren 2012). There is still no curative medical treatment for OA, and about 80% of patients are treated through the use of patient education, physiotherapy, weight control, knee brace, insoles, and medication. Aerobic and muscle strengthening exercises are cornerstones in the management of OA, and are recommended for all patients (Zhang et al. 2010). Better Management of Osteoarthritis (BOA) is a patient education and training program used in healthcare units in Sweden. This is an essential part of OA treatment, and most patients should start with this management before being referred for surgery (Thorstensson et al. 2015).

## Total knee arthroplasty

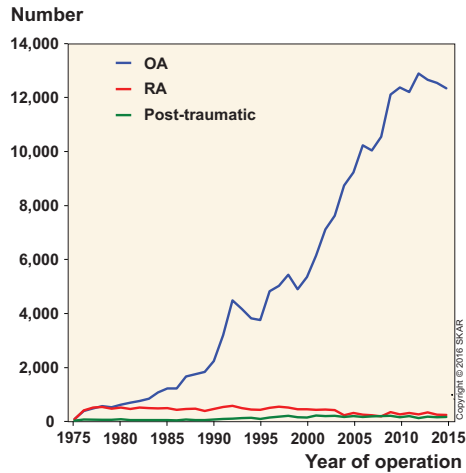
The earliest artificial knee joint operations in humans were carried out by the German surgeon Dr Themistocles Gluck in 1890 (Brand et al. 2011). He inserted a hinged ivory knee joint in 3 patients with a diagnosis of tuberculosis OA. Since that time, trials have been going on to improve knee arthroplasty. In 1953, Dr Walldius, a Swedish orthopedic surgeon, used a hinged prosthesis made of acrylate (Walldius 1953). In 1974, Dr Insall inserted the first total condylar knee replacement. It was the first implant to have a more anatomically shaped design (Insall et al. 1976). Later, even more anatomical and functional approaches led to rapid improvements in similar implants used in TKA operations (Robinson 2005, SKAR 2016).

The use of TKA has been increasing in Sweden since the 1970s (Figure 1). Surgical intervention in knee OA is performed in about one-fifth of patients. The procedure is done in order to reduce pain and improve knee function and quality of life, and the operative results have been regarded as being successful. Internationally, the incidence of primary TKA operations is between 9 and 213 procedures per 100,000 of population (Kurtz et al. 2011). In the USA, the demand for primary TKA has been estimated to grow markedly in the period 2005–2030 (Kurtz et al. 2007). This projected increase in demand for TKA is because of population growth, increase in obesity, and also more TKAs being performed in younger patients. This might be due to a growing number of knee injuries and to expanding indications for TKA (Losina et al. 2012).

In 2015, 94% of the 12,886 primary arthroplasty operations performed in Sweden were TKAs (SKAR 2016).

## The Swedish Knee Arthroplasty Register

The SKAR was the first national quality registry. It was established in Lund, Sweden, in 1975 by late Professor Göran Bauer. All knee arthroplasties, both primary and revision surgeries, in Sweden are registered in the SKAR ([www.myknee.se/en](http://www.myknee.se/en)). The original purpose of the SKAR was to monitor early failures and complications, but later on the registry also focused on the long-term outcome (Robertsson et al. 2014). During the past 4 decades, there has been continuous development in data collection and analysis. The annual report and the website provide feedback to all hospitals and surgeons involved in knee arthroplasty operations. Essential data pertaining to previous surgery on the affected knee, use of tourniquet, drain, minimally invasive surgery, computer-assisted surgery, and prophylaxis (infection, thrombosis) have been registered since 2009. Patient-reported outcome measures (PROMs) were initially collected for special studies, but they have now become a routine for



**Figure 1.** The number of arthroplasties reported to the SKAR since 1974. From the SKAR Annual Report, 2016.

those units that choose to participate in this part of the SKAR. The SKAR audits data quality and accuracy regularly in order to be able to use the data for scientific studies and quality improvement. One advantage of the SKAR is that it has led to certain changes in hospital routines. Previously there was large variation between hospitals regarding implant choices and surgical techniques, but nowadays there has been attempt to standardize as much as possible. Another important benefit of the SKAR is provision of early warnings regarding problems with prostheses and surgical methods.

## Pain

Pain is a subjective feeling of discomfort that is transferred to the brain by sensory neurons. Pain has a huge variation in degree of intensity, with differences between individuals' threshold levels at different times, which make it difficult to measure objectively. Unacceptable pain is the most important indication for TKA in patients with OA of the knee. One of the commonly used pain evaluation instruments is VAS pain, which has been used in all the studies in this thesis. Cartilage damage, new bone formation, changes in subchondral bone, synovitis, and thickening of the joint capsule are all characteristics of OA. Cartilage does not have nerves, which is why it cannot directly generate pain—while the surrounding tissues (such as subchondral bone, periosteum, synovium, ligaments, and joint capsule) are richly innervated and



can be sources of pain (Kidd et al. 2004). Pain in OA of the knee is characterized initially by pain during loading of the joint. This pain may be started by specific activities, and it is usually intermittent in character. At later stages, the pain is more constant—even at rest. Intense early postoperative pain after TKA is common, when two-thirds of TKA patients report having moderate to severe pain (Wang et al. 2002, Wylde et al. 2011). Successive improvement of pain takes place within the first postoperative year. A later painful TKA has several local knee-related and/or extraarticular explanations.

## Physical function

Since an important aim of TKA is improvement in physical function of the knee, pre- and postoperative assessments of knee function are of great value as objective outcome measures. Different knee-related physical performance-based tests are available for evaluation of this improvement. The 6-minute walking, chair-stand, knee bending, knee muscle strength, range of motion (ROM), and straight leg raising tests are some examples of such tests (Andrews et al. 1996, Bremander et al. 2007, Guralnik et al. 1994, Martin et al. 2006, Steffen et al. 2002, Villadsen et al. 2012). These performance-based tests are commonly used as tests of physical function. These tests measure the eccentric and concentric types of muscle contractions, and they are well controlled by patients, as most patients are familiar with such kinds of exercises. These tests are complementary to PROMs and are recommended by Osteoarthritis Research Society International (OARSI) as outcome measures in clinical practice (Dobson et al. 2013). Regardless of their age and activity levels, most patients perform those kinds of activities during daily life.

## Dissatisfaction after total knee arthroplasty

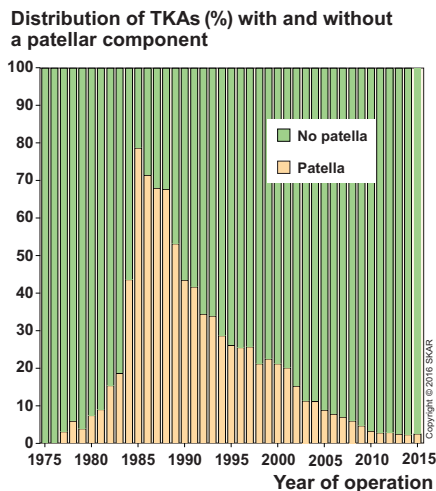
Although TKA is the most effective way of reducing pain and improving knee function and quality of life in patients with knee OA, there are patients who remain dissatisfied with the surgical outcome, and for whom the operation has not matched their expectations. There are several well-documented intrinsic and extrinsic reasons for poor outcome. Common local knee-related reasons are infection, patella-related problems, loosening, stiffness, instability, malalignment, non-optimal component position, component failure, periprosthetic fracture, or inflammation. Extrinsic causes of poor outcome include hip disease, spinal disorder, vascular disease, neurological disease, or complex regional pain syndrome. In the absence of such structural explanations, psychological distress and unmet patient expectations

are possible causes of pain and poor outcome. Historically, the rate of poor outcome (including dissatisfied and uncertain patient groups) after primary TKA has ranged between 7% and 28% (Anderson et al. 1996, Bourne et al. 2010, Brander et al. 2003, Fisher et al. 2007, Hawker et al. 1998, Heck et al. 1998, Khatib et al. 2015, Kim et al. 2009, Noble et al. 2006, Robertsson et al. 2000, Robertsson and Dunbar 2001, Scott et al. 2010, Wylde et al. 2008). In a large registry study from Sweden including 27,372 TKAs with a follow-up time of 2–17 years, approximately 8% of the patients were dissatisfied. Satisfaction was higher in males, in patients with primary OA, and in those with long-standing disease (Robertsson et al. 2000) .

During the past 4 decades, there have been great developments in how to perform TKA regarding prosthesis design, surgical technique, operation time, computer-assisted surgery, pre- and postoperative physiotherapy, LOS, infection prophylaxis, and pain management. Despite this, there still remains a group of patients who are not satisfied with the outcome, despite the absence of any clinical, radiographic, or laboratory explanation for their dissatisfaction. Despite many years of surgical experience of TKA, the proportion of patients who are dissatisfied for unexplainable reasons appears to be approximately the same. This patient group, referred to as the “looks good but feels bad” group (Fisher et al. 2007), remains a mystery to many surgeons.

## Intraarticular analgesia

Local infiltration analgesia (LIA) was introduced in the United Kingdom by Dr Kathleen Reilly in 2005 (Reilly et al. 2005) and developed by Drs Dennis Kerr and Lawrence Kohan in Australia (Kerr and Kohan 2008). The method was introduced for management of early postoperative pain after hip and knee arthroplasty surgery. The medications used included a long-acting local anesthetic (ropivacaine), a non-steroidal anti-inflammatory drug (ketolorac), and a vasoconstrictor (epinephrine). In the TKA, 3 injections totalling 156 ml of infiltrate were administered to the surgical soft tissue including subcutaneous tissue. The method was regarded as effective and safe, and rapidly became popular over the past decade (Andersen et al. 2010, Busch et al. 2006, Essving et al. 2010, Kerr and Kohan 2008, Toftdahl et al. 2007, Vendittoli et al. 2006). The LIA effect persists for about 24 hours post-operatively. In order to prolong the duration of the analgesic effect, other methods have been tried. One of these methods is continuous intraarticular analgesia (CIAA), which is a continuous (48 hours) intraarticular injection of ropivacaine by an elastomeric infusion pump set connected to an intraarticular catheter. Several other methods have been tried to reduce postoperative pain, such as femoral nerve block, single-shot injection LIA, patient-controlled analgesia, extraarticular LIA, and intracapsular LIA, but there is still no gold standard method to achieve this goal.

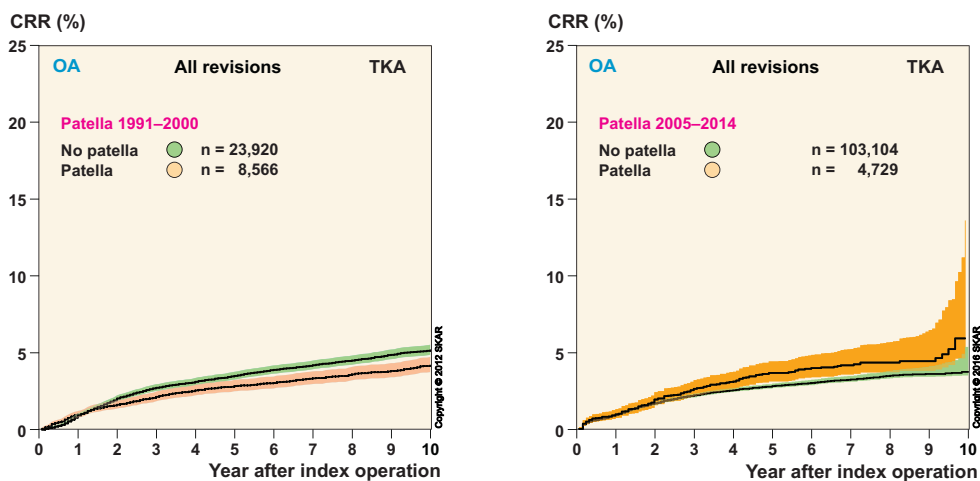


**Figure 2.** Distribution of TKAs with and without a patellar component in Sweden. From the SKAR Annual Report, 2016

## The patella in total knee arthroplasty

Patella-related problems are regarded as being one cause of knee pain after TKA, which might lead to revision. Patellar addition accounts for about 19% of all revisions between 2005–2014 in patients with a primary TKA for OA (SKAR 2016). Early models of TKA had a non-anatomical femoral component that more often led to patellar problems. Patellar resurfacing in primary TKA arthroplasty is still controversial. There are 3 possibilities regarding how to deal with the patella in TKA: routine resurfacing, never resurfacing, and selective resurfacing. Patellar resurfacing was popular in Sweden in the mid-1980s, when most patients underwent this procedure. However, the tradition of resurfacing has become less year by year since that time, and in 2015 only 2.5% of primary TKAs involved patellar resurfacing in Sweden (Figure 2). Internationally, patellar resurfacing in primary TKA ranges between 2% and 98% (AOANJRR 2015, DKR 2015, Paxton et al. 2011, Register N 2015, SKAR 2016).

The annual report of the SKAR in 2002 (for the period 1991–2000) showed that TKA with a patellar component had a significantly lower risk of revision than those without (RR = 1.3, CI: 1.1–1.4). Interestingly, the SKAR annual report in 2016 (for the period 2005–2014) stated that TKA with a patellar component is now associated with a significantly higher risk of revision than TKA without a patellar component (RR = 1.3, CI: 1.1–1.5) (Figure 3).



**Figure 3.** Cumulative revision rate of TKA with and without a patellar component. From the SKAR Annual Report, 2016.

## Patient-reported outcome measures

Traditionally, assessment of TKA outcome was done by orthopaedic surgeons based on the occurrence of postoperative surgical complications, on the number of reoperations, and on whether the patients could resume their usual activities. The doctor's opinion of the patient's information on outcome was to a certain degree subjective. During the last 3 decades, patient opinion has taken a wider place in the evaluation of surgical outcome. The definition of a successful operation may differ depending on whether the point of view is the doctor's or the patient's. Studies have shown that physician assessment and patient-reported outcomes differ (Gioe et al. 2009, Khanna et al. 2011, Lieberman et al. 1996). During the 1990s, the use of patient-relevant outcome measures—both generic and disease-specific—became more popular. This was an additional instrument to take account of patients' opinions. The 4 frequently used knee-specific PROMs are the Western Ontario and McMaster University osteoarthritis index (WOMAC), the Oxford Knee Score (OKS), the new Knee Society Score (KSS; 2011 version), and the Knee injury and Osteoarthritis Outcome Score (KOOS) (Ramkumar et al. 2015). WOMAC was the first patient-administered knee-specific instrument developed for OA. It has 3 subscales: pain (5 items), stiffness (2 items), and function (17 items). The subscales are calculated and reported

separately: pain (0–20), stiffness (0–8), and function (0–68) (Bellamy et al. 1988). The OKS is a 12-item patient-reported questionnaire for assessment of function and pain after total TKA. Total scoring is between 12 and 60, where 12 represents the least difficulties and 60 represents the most difficulties (Dawson et al. 1998). The new KSS has 4 subscales: (1) objective knee score (7 items; 100 points), (2) satisfaction score (5 items; 40 points), (3) expectation score (3 items; 15 points), and (4) functional activity score (19 items; 100 points) (Noble et al. 2012). The KOOS has 5 subscales with a total of 42 items: pain (9 items), other symptoms (7 items), function in daily living (ADL) (17 items), function in sport and recreation (Sport/Rec) (5 items), and knee-related quality of life (QOL) (4 items). Each question is assigned a score from 0 to 4. A normalized score (with 100 meaning no symptoms and 0 meaning extreme symptoms) is calculated for each subscale (Roos and Lohmander 2003, Roos et al. 1998).

KOOS is an extension of WOMAC. It is a responsive, validated, and reliable outcome measure instrument in TKA (Roos and Lohmander 2003, Roos and Toksvig-Larsen 2003). Nowadays, KOOS is used routinely in Skåne County as an outcome measure instrument for both primary TKA and revision TKA.

## The hospital anxiety and depression scale

There are different tools that can be used to evaluate the patient's psychological status. In 1983, Zigmond and Snaith introduced and developed the hospital anxiety and depression scale (HAD) (Zigmond and Snaith 1983). This method is reliable, validated, and easy to use (Axford et al. 2010, Bjelland et al. 2002). HAD has been used to identify patients with anxiety and/or depression, not only among psychiatric patients but even among patients with somatic dysfunction. About 17% of the Swedish general population has significant anxiety and/or depression, and of those almost 50% have comorbid disorders (Johansson et al. 2013). The HAD scale features 14 items with 0–4 points for each item. 7 of the items relate to anxiety and 7 to depression. The total score is categorized as normal (0–7), mild (8–10), moderate (11–14), or severe ( $\geq 15$ ) anxiety/depression (Zigmond and Snaith 1983). One benefit of HAD is identification of patients with anxiety/depression preoperatively. Together with the management of other risk factors—such as low physical activity, high BMI, smoking, and unrealistic patient expectations—and offering the patients a multimodal treatment of risk factors preoperatively, we might improve the surgical outcome.

## Radiography

Preoperative radiography is an essential tool for decision-making regarding TKA. The degree of pain and dysfunction is not always proportional to the severity of radiographic OA. A commonly used radiographic classification of OA severity is the Kellgren-Lawrence (K&L) classification from 1957, which has 5 degrees of OA (none = 0, doubtful = 1, minimal = 2, moderate = 3, and severe = 4) (Kellgren and Lawrence 1957). Another radiographic grading of OA severity is the Ahlbäck classification from 1968 (grades I–V, where grade I is joint space narrowing to less than 3 mm, grade II is joint space obliteration, grade III is minor bone attrition (0–5 mm), grade IV is moderate bone attrition (5–10 mm), and grade V is severe bone attrition (more than 10 mm)) (Ahlback 1968, Boegard et al. 1997). Preoperative radiography enables preparation and planning of surgery, such as the amount of bone cutting, prosthesis sizing, specially ordered prosthetic components, computer-assisted surgery in certain cases, and restoration of anatomical limb alignment by measurement of hip-knee-ankle angle and hip-knee-shaft angle. Postoperative radiography is a valuable objective outcome measure. Direct postoperative radiography gives information on component positioning, fracture, and overhang. Later radiographic control is important for evaluation of patella positioning, limb alignment, and signs of loosening. In some clinics, postoperative radiography is performed while the patient is still on the operating table, but it is usually carried out in the first postoperative days. Some surgeons, however, prefer not to have postoperative radiography at all, with some exceptions. In order to evaluate component rotation, computed tomography scan may be done (Berger et al. 1998). Other specialized investigations such as MRI and bone scan can be performed in certain situations.

# Purposes of this thesis

## General

To study the relationship between knee pain, physical function, radiography, anxiety/depression and dissatisfaction at early, mid-term and late follow-up in TKA.

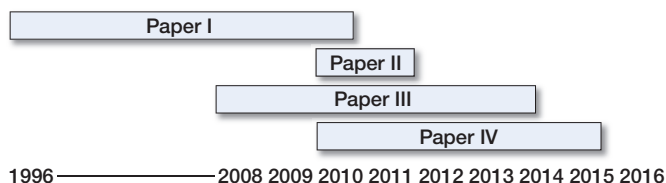
## Specific aims, papers I–IV

- I. To assess differences between dissatisfied patients and very satisfied patients after TKA.
- II. To determine whether CIAA has an effect on postoperative pain, knee function, LOS, consumption of analgesics, side effects of medicines, or complications.
- III. To evaluate the effect of patellar resurfacing in TKA using VAS pain, degree of patient satisfaction, KOOS, early performance-based tests, and reoperations as endpoints.
- IV. To find any correlations between preoperative anxiety/depression, VAS pain, comorbidities, degree of radiographic OA, KOOS, and dissatisfaction.

# Patients and methods

Altogether, 388 patients were studied from 2008 to 2015 in the different parts of this thesis (Figure 4).

Study I was a registry-based case-control study. Studies II and III were prospective, randomized double-blind studies. Study IV was a prospective, longitudinal cohort study. The patients and methods are described in each paper (see the original papers).

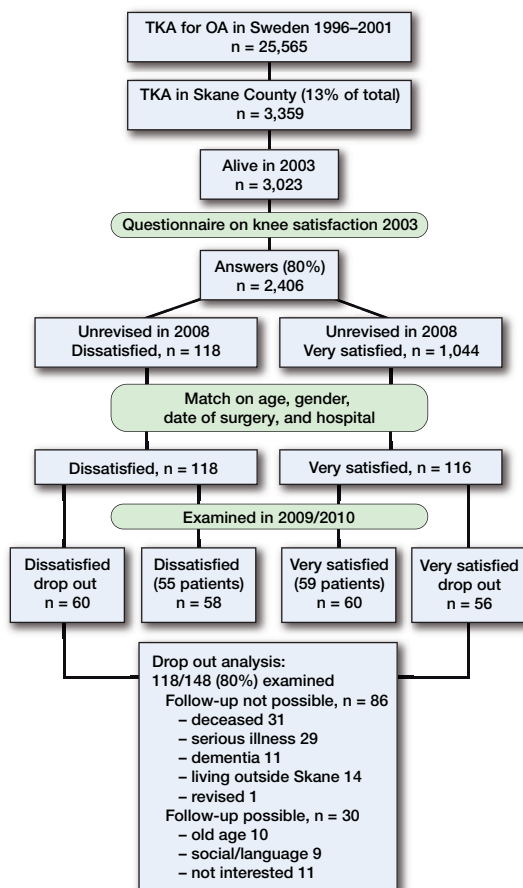


**Figure 4.**  
Study years, paper I–IV.

## Paper I

Between 1996 and 2001, 3,359 primary TKAs were performed for primary OA in the county of Skåne, which corresponds to 13% of the total number of TKAs performed in Sweden ( $n = 25,565$ ) during the same period. In 2003, a questionnaire was sent out by the SKAR to all living TKA patients in Sweden who had been operated on during these years. The patients were asked to grade their level of satisfaction regarding the operated knee as follows: 1, very satisfied; 2, satisfied; 3, uncertain; or 4, dissatisfied (Robertsson et al. 2000). In 2008, 114 patients (with 118 unrevised knees) were identified in the county of Skåne to be dissatisfied, and they formed one of our study groups. This group was compared to an age-, sex-, surgery date-, and hospital-matched group of 113 patients (with 116 unrevised knees) who were very satisfied with their knee. In 2008, 1 of the 234 knees had been revised. An invitation letter to attend a follow-up was sent to the remaining patients. 197 patients (with 202 TKAs; 101 TKAs from each group) replied, and were invited for a clini-



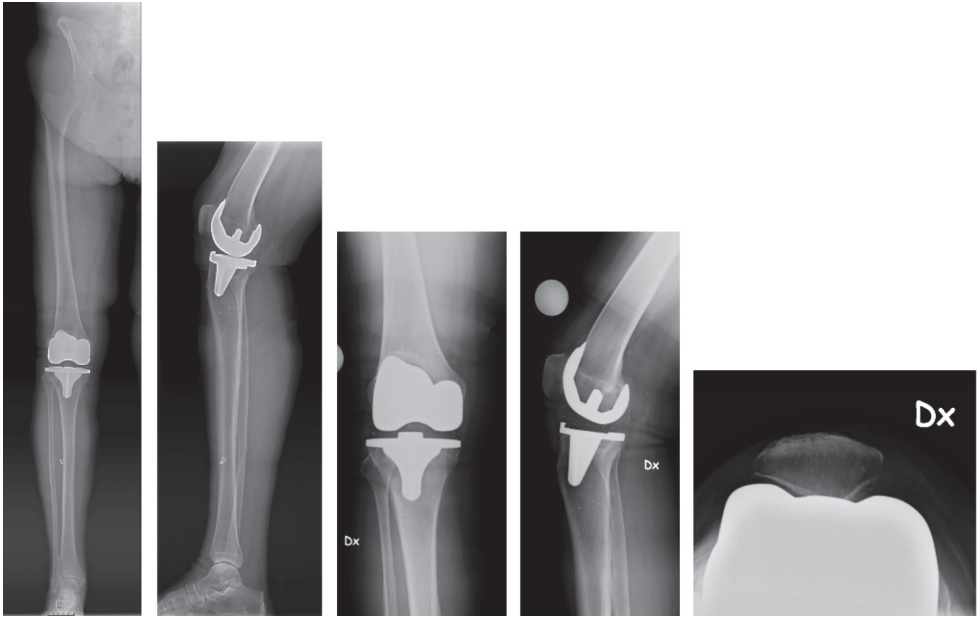


**Figure 5.**  
Flowchart in paper I.

cal and radiographic assessment. 114 patients (with 118 TKAs) were examined, 55 patients (58 TKAs) from the dissatisfied group and 59 patients (60 TKAs) from the very satisfied group (Figure 5).

The patients filled out the VAS pain (0–100 mm scale; 0 = no pain, 100 = severe pain), and the HAD. They were interviewed by Dr Anders Lindstrand and examined by Dr Abdulemir Ali. Examination concentrated on the patient’s knee, hip, spine, ROM of the knee, knee laxity, patella tenderness/subluxation, and 2 physical performance tests: the 6-minute walking test (6MW) (Steffen et al. 2002) and the chair-stand test (CS) (Guralnik et al. 1994). The examiner did not know which group the patients belonged to.

The patients underwent radiographic examinations (AP and lateral standing, patella view, and long-leg standing) (Figure 6). Two experienced skeletal radiolo-



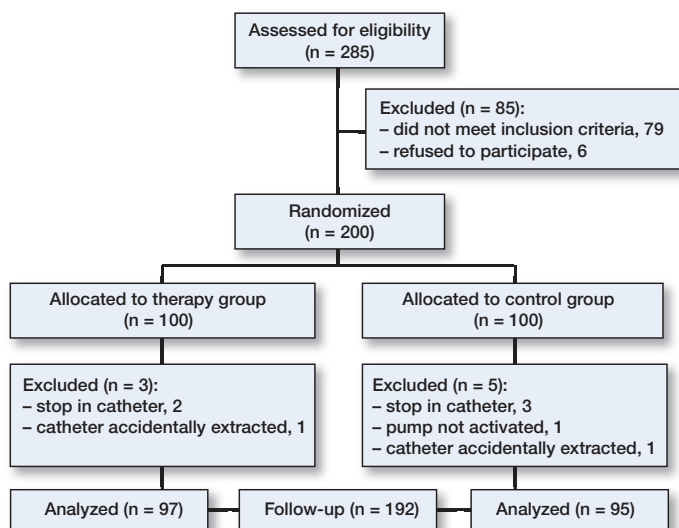
**Figure 6.**  
Radiography at last follow-up, 2010.

gists—who were unaware of what patient belonged to what group—interpreted the radiographs. Three options were used: normal, probably abnormal, and abnormal. The mechanical axis (HKA) was calculated from the long-leg standing radiographs.

## Paper II

Two hundred consecutive patients with OA, who fulfilled the inclusion criteria of having primary knee OA and who were planned for TKA (Figure 7), were included in this study. Exclusion criteria were bilateral TKA, taking warfarin, having contraindications for use of any of the study medications, dementia, or inability to speak Swedish. The patients were operated on between January, 2010 and April, 2011. They received either the Triathlon CR knee (Stryker, UK) (164 patients) or the PFC CR knee (DePuy, UK) (36 patients), depending on the surgeon's preference.

In total, all the patients received 156 ml of periarticular LIA containing a mixture of 100 ml ropivacaine (200 mg; 2 mg/ml), 1 ml ketorolac (30 mg; 30 mg/ml), and 5 ml epinephrine (0.5 mg; 0.1 mg/ml), 53 ml of which was injected in the posterior joint capsule and 53 ml around the fascia, the anterior capsule, and the lateral and medial collateral ligaments. A further 50 ml of ropivacaine (2 mg/ml) was injected



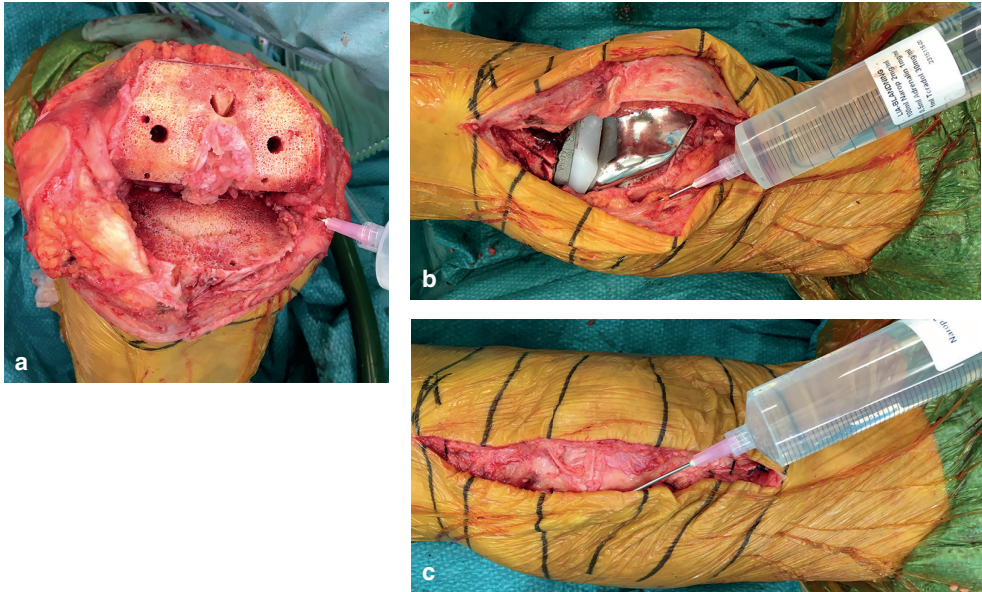
**Figure 7.**  
Flowchart in paper II.

subcutaneously (Figure 8). All patients got an epidural catheter placed in the knee joint. The catheter was connected through an epidural flat filter to a Homepump (I-Flow, Lake Forest, CA), which contained 100 ml of either ropivacaine (7.5 mg/ml) or NaCl (9 mg/ml), with an infusion rate of 2 ml/h for 48 hours (Figure 9). Randomization was done by a nurse using a computer-generated list. The nurse was not involved in the surgery.

To standardize the postoperative analgesia, all patients received the same kind of premedication and postoperative analgesia, consisting of paracetamol (500 mg, 2 × 4), diclofenac (25 mg, 1 × 3), and a patch with buprenorphine (10 µg/h), which was changed once a week for a total of 3 weeks. Additional oxycodone (5 mg) was administered as required. In addition to the postoperative analgesia, cold therapy (cryo/cuff) were used in all TKA patients.

VAS pain at rest was evaluated by the patient and recorded by a nurse at 12 a.m. and 8 p.m. for 3 days. Furthermore, registration was done regarding LOS, additional consumption of analgesics, occasions of nausea and/or vomiting, and number of changes of wound dressings during the hospital stay. Active ROM of the knee (by goniometry) and straight leg raising ability were measured and recorded by the physiotherapist both preoperatively and 3 days postoperatively.

Two weeks and 3 months postoperatively, VAS pain, analgesic consumption, and wound-healing complications were recorded again. At 3 months, ROM was also recorded.



**Figure 8.**  
LIA injections in the posterior joint capsule (a), the anterior subfascial tissue (b) and subcutaneously (c).



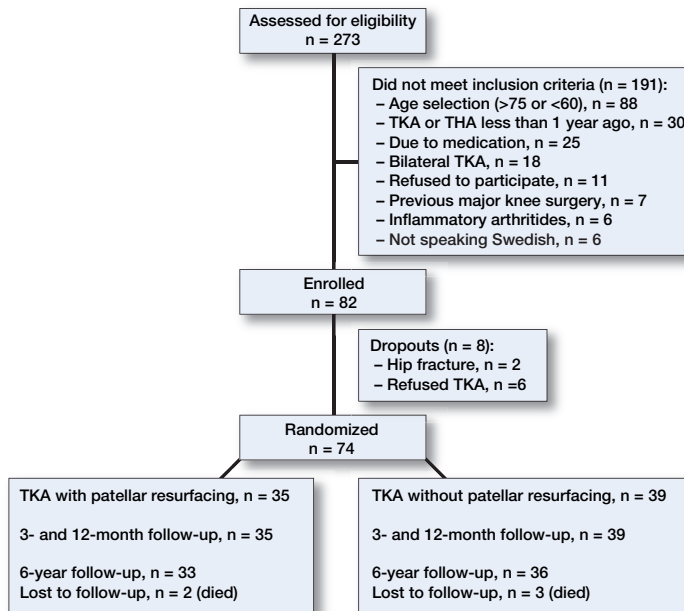
**Figure 9.**  
The pump used in paper II.

## Paper III

Paper III involved 74 patients aged between 60 to 75 years, with primary OA. Exclusion criteria were bilateral TKA, secondary OA, severe heart failure, neurological disease, diseases that influence physical function, having been operated with TKA or THA during the previous 12 months, patellar thickness less than 22 mm, dementia, or being unable to speak Swedish. Patients who used antidepressants, neuroleptics, anticonvulsive drugs, or steroids were also not included (Figure 10). The reason for the exclusion criteria was that the patients were also included in 2 other studies, the first regarding the effects of neuromuscular exercise and surgery on exercise-induced analgesia and pain sensitivity (Kosek et al. 2013), and the second regarding the effects of neuromuscular training on patient-reported outcomes and physical function (Ageberg et al. 2013).

Preoperatively, the patients filled out the KOOS questionnaire and VAS pain. A physiotherapist who was blind regarding the type of surgery administered the physical performance tests preoperatively and 3 months postoperatively: the 20-meter walking test (the time required for patients to walk 20 meters and the number of steps taken), the chair-stand test (the time required for 5 repetitions of rising from a chair and sitting down), the knee-bending test (the number of single-side knee bendings in 30 seconds), and knee extension strength (extension power in kg) (Andrews et al. 1996, Bremander et al. 2007, Martin et al. 2006, Villadsen et al. 2012). 3, 12, and 72 months postoperatively, the patients filled out the KOOS questionnaire, VAS pain, and degree of patient satisfaction. 72 months postoperatively, the patient files regarding complications and reoperations were checked in both our local complications register database and the SKAR.

The patients were operated on between February, 2008 and December, 2009. Spinal anesthesia was used as standard in 62 of 74 patients. All patients had a tourniquet, a standard straight central skin incision, medial parapatellar arthrotomy, patellar eversion, and preparation of the femur and tibia was done according to the instructions of the manufacturer. If the patellar thickness was less than 22 mm, the patient was excluded. Then a randomization envelope was opened to allocate the patient to a particular treatment. When the patient was randomized to patellar resurfacing, preparation of patella was done according to the Triathlon CR knee system. Tibial, femoral, and patellar components were cemented at the same time. The physiotherapists and patients were kept uninformed about the results of randomization.

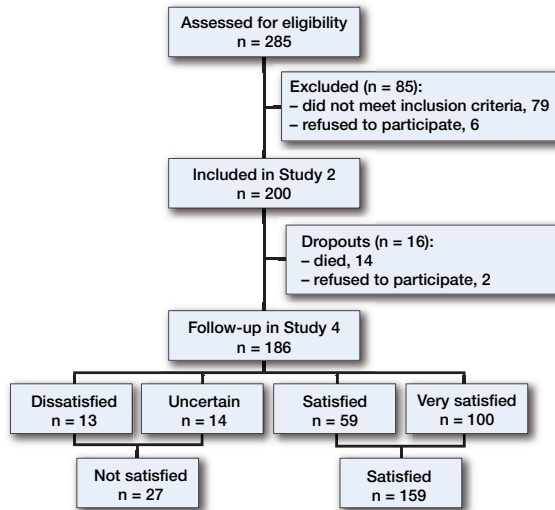


**Figure 10.**  
Flowchart in paper III.

## Paper IV

The patients in paper IV were the same patients as in paper II. After dropout of 14 patients over 4 years, 186 patients remained for analysis (Figure 11). We used preoperative and postoperative data regarding BMI, HAD scale, VAS pain, KOOS (Roos et al. 1998), ROM, degree of OA, comorbidities, CWP (Bergman et al. 2002), LOS, local surgical complications, and degree of patient satisfaction (very satisfied, satisfied, uncertain, dissatisfied) (Robertsson et al. 2000).

At 4 years postoperatively, the patients filled out the PROM questionnaires. Possible correlations between the following factors were analyzed: preoperative anxiety/depression, VAS pain, ROM, OA grade, postoperative LOS, local surgical complications and dissatisfaction.



**Figure 11.**  
Flowchart in paper IV.

## Statistics

Statistical analysis in papers I and IV was performed using STATA software version 12.0. (Stata Corp., College Station, TX) and in papers II and III, IBM SPSS Statistics version 21 was used (IBM Corp., Armonk, NY).

Cox multiple regression analysis with constant follow-up and robust variance estimation (Barros and Hirakata 2003) was used to study relative risks for categorical variables in dissatisfied groups. Continuous variables such as the mean difference between 2 groups was analyzed by ANCOVA. In papers I and IV, for both statistical methods we adjusted the model for patient gender, age, date of operation, hospital, and BMI.

In paper II and III, 2-sided Student's t-test was used for analysis of numerical variables and Fisher's exact test was used for binomial variable analysis.

Any p-value less than 0.05 was considered to be statistically significant. The statistical analysis was based on 1 knee per patient.

## Ethical considerations

Paper I was approved by the ethics committee of the Regional Council for Radiation Protection and Measurement in Lund and the ethics committee of the Faculty of Medicine, Lund University (entry nos. 2009/06 & 2009-04-29/NR:0909). All 9 hospitals involved and all patients had received written information about the study.

Papers II, III, and IV were performed in compliance with the Helsinki Declaration, and all the patients had given their informed written consent. The ethics committee of the Faculty of Medicine, Lund University, approved the studies (entry nos. 2009/368 and LU 812006).

Paper II was also registered at [ClinicalTrials.gov](https://clinicaltrials.gov) (identifier: NCT01726686).



# Results

## Paper I

The dissatisfied group had significantly higher mean VAS pain scores than the very satisfied group (52 mm and 22 mm, respectively;  $p < 0.001$ ). In the HAD scale, significantly more patients in the dissatisfied group had anxiety and/or depression (23/55) than in the very satisfied group (6/59) ( $p = 0.001$ ). The average active ROM was 97 degrees in the dissatisfied group and it was 108 degrees in the very satisfied group ( $p < 0.001$ ). The clinical examinations, performance-based tests, and the radiographic analyses showed no differences between the groups in any of the parameters studied (Tables 1 and 2).

**Table 1.**  
Patient characteristics in paper I

Variables	Dissatisfied n = 55	Very satisfied n = 59	RR <sup>a</sup>	Mean diff. <sup>b</sup>	p-value	95% CI
Mean age	78 (SD 8)	79 (SD 7)				
Gender (female)	39	43				
Mean follow-up, years	10.5 (SD 2.5)	10.5 (SD 2.5)				
Mean VAS score (0–100)	52	22		31	< 0.001	23 to 39
HAD <sup>c</sup> , no. patients	23	6	4.1		0.001	2 to 9
Mean ROM, degrees	97	108		-13	< 0.001	-18 to -7
Mean 6MW test result, m	295	318		-35	0.07	-74 to 3
Mean chair test result, s	19	17		2.7	0.1	-0.5 to 6
Mean BMI	32	30		1.4	0.2	-0.7 to 3
Smokers	2	4	0.8		0.3	0.6 to 1
Increased knee laxity	3	5	0.6		0.4	0.1 to 2
Patella tenderness	8	6	0.8		0.8	0.2 to 4

<sup>a</sup> RR: relative risk, dissatisfied vs. very satisfied.

<sup>b</sup> Mean difference, dissatisfied vs. very satisfied.

<sup>c</sup> Anxiety and/or depression according to the Hospital Anxiety and Depression scale

**Table 2.**  
Results of radiographic analysis

Variables <sup>a</sup>	Dissatisfied n = 55	Very satisfied n = 59	RR	p-value	95% CI
Suboptimal femoral component position	2	0	0.9	0.2	0.90–1.03
Suboptimal tibial component position	11	14	1.05	0.6	0.86–1.28
Patella subluxation	12	7	0.9	0.2	0.73–1.05
Zone	3	3	0.9	0.7	0.89–1.08
Polyethylene wear	2	3	0.8	0.8	0.17–4.03
Femoropatellar osteoarthritis	33	34	1.03	0.9	0.65–1.63
Mechanical axis 0° ± 4°	43	42	1.05	0.6	0.85–1.30

<sup>a</sup> Suboptimal outcome includes both possibly abnormal and abnormal findings.  
RR: relative risk, dissatisfied vs. very satisfied.

## Paper II

Eight patients were excluded, 3 in the therapy group and 5 in the control group (Figure 7). The remaining 192 patients were followed up for 3 months. The baseline data were similar between groups (Table 3). There was a statistically significant difference in VAS pain score between groups on postoperative day 1 only. Mean VAS at 12 noon in the therapy group was 33, and it was 40 in the control group ( $p = 0.02$ ); the corresponding values at 8 p.m. were 36 and 43 ( $p = 0.03$ ). We also found a significant difference between the groups regarding postoperative wound infection ( $p = 0.02$ ). All other recorded variables were similar between the groups (Table 4). Thirteen patients had a superficial or deep infection of the surgical site, which was verified by bacterial culture. Eleven of these patients were in the therapy

**Table 3.**  
Patient characteristics in paper II

	Therapy group (n = 100)	Control group (n = 100)
Age, years <sup>a</sup>	69 (9)	69 (8)
Sex (female/male)	65/35	62/38
BMI <sup>a</sup>	29 (5)	30 (5)
ASA classification		
ASA 1	21	22
ASA 2	69	66
ASA 3	10	12
Charnley classification		
A	35	30
B	23	32
C	42	38
Side TKA (right/left)	52/48	60/40
Anesthesia (spinal/general)	83/17	92/8

<sup>a</sup> Mean (SD)

**Table 4.**

Results from paper II. Data are mean (SD) or number of patients

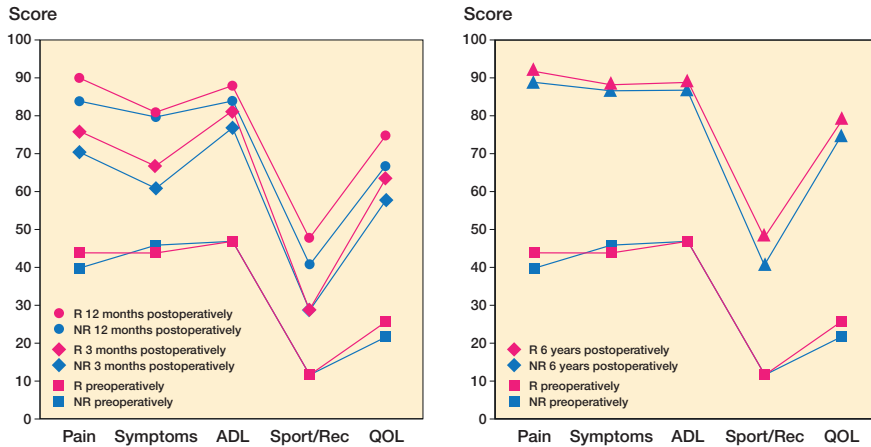
Variables	Therapy group (n = 97)	Control group (n = 95)	No. of missing observations		p-value	95% CI
			therapy group	control group		
VAS preop. (0–100)	60 (16)	61 (15)			0.9	–3.5 to 5.4
VAS on op. day, 8 p.m.	14 (20)	21 (25)	1		0.05	–0.3 to 13
VAS on day 1, 12 noon	33 (24)	40 (22)			0.02	1 to 14
VAS on day 1, 8 p.m.	36 (24)	43 (21)	1	4	0.03	0.8 to 14
VAS on day 2, 12 noon	34 (24)	33 (25)			0.8	–8.3 to 5.8
VAS on day 2, 8 p.m.	27 (20)	30 (22)	3	5	0.5	–3.8 to 8.5
VAS on day 3, 12 noon	26 (19)	23 (20)	11	10	0.3	–8.9 to 2.9
VAS 2 weeks postop.	34 (24)	29 (19)	3	1	0.8	–12 to 0.7
VAS 3 months postop.	19 (21)	17 (19)	6	5	0.4	–8.6 to 3.2
ROM preop., degrees	112 (16)	109 (23)			0.2	–8.2 to 3
ROM on day 3 postop.	82 (16)	84 (12)			0.6	–3.6 to 4
ROM 3 months postop.	113 (12)	110 (13)	2	3	0.1	–6.3 to 0.7
Dressing change	0.5 (0.9)	0.7 (1.1)			0.2	–0.5 to 0.1
Postop. stay, days	4.1 (0.9)	4.1 (1.0)			0.8	–0.2 to 0.3
Nausea/vomiting	0.8 (1.4)	1.1 (2.0)			0.2	–0.8 to 0.2
Leg-raising ability preop. <sup>a</sup>	96	93			0.6	
Leg-raising ability on day 3 <sup>a</sup>	93	92			1.0	
Wound infection <sup>a</sup>	11	2			0.02	
Total additional oxycodone, 5 mg	4 (5)	5 (6)			0.06	–0.1 to 3.2

<sup>a</sup>Number of patients

group (6 superficial infection and 5 deep infection). The 2 corresponding patients in the control group had 1 superficial infection and 1 deep infection. All 7 patients with superficial infection were treated successfully with antibiotics. 4 of the 6 patients with deep infection were revised successfully by debridement and change of insert, and 2 patients were reoperated successfully with 2-stage revision of the prosthesis.

## Paper III

We found a similar statistically significant improvement in VAS pain score and KOOS 5 subscale scores in both groups at 3, 12, and 72 months postoperatively (Figure 12). We found no statistically significant differences in patient satisfaction at 3, 12, or 72 months postoperatively between the patellar resurfacing and non-resurfacing groups (Table 5). We found no statistically significant differences in physical performance tests between the groups 3 months postoperatively. The mean chair-stand test result in seconds was 12 in both groups, the mean 20-meter walking test result in seconds was 17 in both groups and the mean number of steps was 30 as opposed to 32, the mean number of knee bendings in 30 seconds was 13 in both groups, and mean knee extension strength was 17 kg in both groups. None of the patients in either group was reoperated within 72 months.



**Figure 12.** KOOS subscales (with 0 meaning worst and 100 meaning best) preoperatively and 3 and 12 months postoperatively (left panel) and preoperatively and 6 years postoperatively (right panel). R: resurfacing; NR: no resurfacing.

**Table 5.** Results from paper III. Values are mean (SD) or number of patients

	R (n = 35)	NR (n = 39)	Missing observation		p-value	Difference (95% CI)
			R	NR		
VAS pain						
preoperatively	58 (17)	55 (17)	0	0	0.4	3 (-10 to 4.9)
3 months postoperatively	24 (17)	26 (19)	0	0	0.6	-2 (-9.8 to 4.8)
12 months postoperatively	15 (19)	14 (15)	2	3	0.6	1 (-9.1 to 6.4)
6 years postoperatively	11 (14)	10 (15)	2	3	0.7	1 (-6.1 to 8.4)
Chair stand test, s						
preoperatively	17 (6)	16 (7)	0	0	0.4	1 (-2.0 to 5.2)
3 months postoperatively	12 (3)	12 (3)	2	2	0.9	0 (-1.5 to 1.4)
20-m walk test						
preoperatively, time, s	21 (8)	20 (4)	0	0	0.4	1 (-1.5 to 3.9)
preoperatively, steps	34 (9)	33 (5)	0	0	0.8	1 (-2.9 to 5.5)
3 months postoperatively, time, s	17 (4)	17 (2)	3	1	0.5	0 (-1.0 to 1.9)
3 months postoperatively, steps	30 (4)	32 (3)	3	1	0.5	-2 (-1.9 to 1.2)
No. of knee bendings in 30 s						
preoperatively	13 (8)	14 (7)	4	5	0.5	-1 (-5.2 to 2.4)
3 months postoperatively	13 (7)	13 (8)	4	3	0.9	0 (-3.9 to 4.1)
Knee extension strength, kg						
preoperatively	18 (6)	19 (6)	2	1	0.5	-1 (-4.1 to 1.8)
3 months postoperatively	17 (5)	17 (6)	2	2	0.8	0 (-3.2 to 2.6)
Very satisfied or satisfied, n						
3 months postoperatively	33/35	38/39	0	0	0.6	
12 months postoperatively	34/35	37/38	0	1	0.7	
6 years postoperatively	31/33	34/36	2	3	0.5	

R: resurfacing; NR: no resurfacing.

## Paper IV

Patient characteristics and the overall results are given in Tables 6 and 7. Twenty-seven of the 186 patients (15%) reported that they were not satisfied with (dissatisfied with or uncertain about) the result of their TKA 4 years after surgery. Sixteen of those 27 patients (59%) reported having anxiety and/or depression according to the HAD score, as compared to 11 of 159 (7%) in the satisfied group (satisfied and very satisfied) at the 4-year follow-up. Preoperatively, the corresponding numbers were 14/27 and 12/159. As shown in Table 7, we found that the patients who had anxiety/depression preoperatively had more than a 6 times higher risk of being dissatisfied after TKA relative to those without any preoperative anxiety/depression. Mean LOS at the time of surgery for the group that was dissatisfied at 4-year follow-up was 1 day more than in the satisfied group. Patients who had a deep infection postoperatively had a 3 times higher risk of being dissatisfied 4 years after TKA, whereas superficial infection, stiffness, radiographically mild OA preoperatively, and CWP did not carry any higher risk of dissatisfaction 4 years postoperatively. All KOOS 5 subscale scores were significantly improved in both groups.

**Table 6.**  
Patient characteristic in paper IV

	Not satisfied (n=27)	Satisfied (n=159)
Age, years <sup>a</sup>	72 (8)	73 (10)
Sex, F/M	16/11	104/55
BMI <sup>a</sup>	30 (5)	30 (5)
ASA 1/2/3	7/17/3	34/108/17
Charnley A/B/C	7/5/15	49/48/62
Anesthesia: spinal/general	23 / 4	139 / 20
LOS <sup>a</sup> , days	5 (1)	4 (1)
ROM preoperatively <sup>a</sup>	109 (9)	113 (14)
K & L grade 1–2	9/27	37/159
Chronic widespread pain		
preoperatively	7/27	21/159
after 4 years	14/27	26/159
VAS pain <sup>a</sup>		
preoperatively	65 (12)	60 (16)
after 4 years	56 (18)	11 (10)
Anxiety/depression		
preoperatively	14/27	12/159
after 4 years	16/27	11/159
Deep infection	2/27	3/159
Superficial infection	2/27	4/159
Stiffness (flexion < 90°)	2/27	7/159

<sup>a</sup> Mean (SD)

**Table 7.**

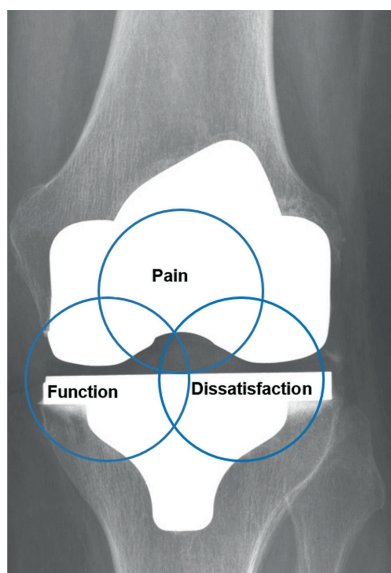
Relative risk (RR) for dissatisfaction, adjusted for differences in age, gender, and BMI

Factor	RR	95% CI	p-value
Deep infection	3.1	1.1–8.4	0.03
Superficial infection	2.3	0.78–6.6	0.1
Stiffness (flexion < 90°)	1.6	0.43–6.2	0.5
K & L grade 1–2	0.70	0.33–1.5	0.4
ASA class 1–2	0.85	0.42–1.7	0.6
LOS	1.6	1.3–2.0	< 0.001
Chronic widespread pain preop.	1.4	0.90–2.3	0.1
VAS pain preop.	1.02	1.00–1.05	0.1
ROM preop.	0.98	0.96–1.00	0.08
Anxiety/depression preop.	6.5	3.5–12	< 0.001
KOOS Pain preop.	1.00	0.98–1.02	0.8
KOOS Symptoms preop.	0.99	0.96–1.01	0.2
KOOS ADL preop.	0.99	0.97–1.01	0.3
KOOS Sport preop.	0.99	0.96–1.02	0.5
KOOS QOL preop.	1.00	0.97–1.02	0.8

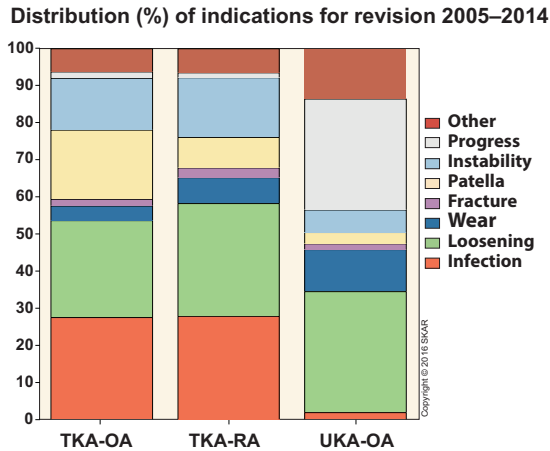
# Discussion

The incidence of TKA is increasing worldwide. The number of patients with high demands is also thought to be on the increase, as operations in the younger and middle-aged groups are being performed more often. To achieve the optimal outcome for different patient groups is challenging. The young active patient's wish is to get back to work and often to maintain an active lifestyle. This contrasts with the situation in elderly patients, who are often happy to return to a sedentary lifestyle.

The proportion of dissatisfied patients after TKA is remarkably high. This thesis concerns different aspects of TKA outcome regarding dissatisfaction in patients after the surgery—especially the association between pain, function, and psychological wellbeing, and any correlations with dissatisfaction (Figure 13). We identified a strong correlation between anxiety/depression and dissatisfaction (papers I and IV). To reduce the proportion of patients with early postoperative pain by more effective postoperative analgesia, CIAA was used in paper II. This trial, however, had no



**Figure 13.**  
Pain, function, and dissatisfaction after TKA.



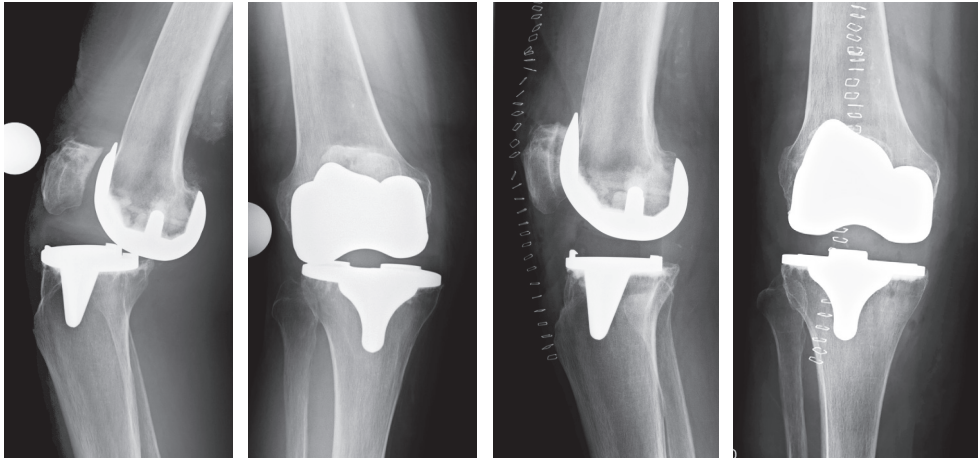
**Figure 14.** Causes of revision, 2005–2014. From the SKAR Annual Report, 2016.

effect on postoperative VAS pain score or on mobilization for discharge. Another reason for dissatisfaction postoperatively is pain due to patella-related problems. There is a large difference between surgeons and between countries regarding patellar resurfacing in TKA. In paper III, we could not find any advantage of patellar resurfacing regarding pain, physical performance, patient satisfaction, or PROMs in TKA compared to non-resurfacing.

The reasons for failure after TKA are multifactorial. TKA surgery has certain early and late local complications such as patella-related problems, infection, stiffness, loosening, instability, non-optimal component position, component failure, fracture, tendon rupture, and neurovascular injuries. The most common causes of primary TKA revision in Sweden in the period 2005–2014 were infection, loosening, patella-related problems, and instability (Figure 14) (SKAR 2016). However, painful TKA could have other extraarticular explanations such as hip diseases, spine disorders, neurovascular diseases, anxiety/depression, and complex regional pain (Djahani et al. 2013, Mandalia et al. 2008, Wylde et al. 2007). All of these reasons for failure can lead to dissatisfaction.

In paper I, we did not observe any TKA complications for which revision might have been indicated but not offered. Thus, we found no signs that the dissatisfied, unrevised TKA patients had neglected complications that would have indicated revision surgery, except in one patient with polyethylene wear, which caused dislocation of the joint. This patient belonged to the very satisfied group but became symptomatic after a fall one week before our follow-up. The patient was reoperated with an insert change only, and became very satisfied again (Figure 15). The failures in papers II and IV were 6 deep infections and 7 superficial infections, and all deep in-





**Figure 15.**  
Preoperative radiographs (left panels) and postoperative radiographs (right panels).

fections were revised. There were no more revisions or reoperations at the 4 years of follow-up. Finally, in paper III there were no revisions or reoperations after 6 years.

In summary, apart from the dislocated patient in paper I and the increased incidence of deep infections in the ropivacaine group in paper II, there were no known early or medium-term local failures and no more reoperations.

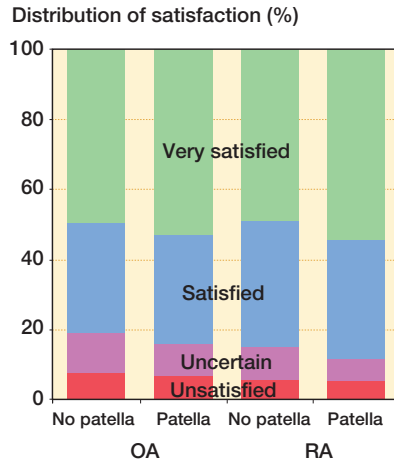
Unacceptable pain is the most important indication for operation with TKA for patients with OA of the knee. Cartilage damage, new bone formation, changes in subchondral bone, synovitis, and thickening of the joint capsule are characteristics of OA. Cartilage is not innervated; this is why it cannot directly generate pain, whereas surrounding tissues such as subchondral bone, periosteum, synovium, ligaments, and joint capsule are richly innervated and can be sources of pain (Kidd et al. 2004). Pain is a subjective feeling, with different degrees of severity and large variation between individuals regarding threshold levels at different times, which makes it difficult to measure pain objectively. One of the commonly used pain evaluation instruments is VAS pain, which has been used in all the papers in this thesis. The mean VAS pain score in the dissatisfied group in paper I was approximately the same as the VAS pain scores reported before revision of TKA (van Kempen et al. 2013). The mean VAS pain score in the very satisfied group in paper I was 22, corresponding to that reported from 1-year follow-up in the SKAR (2016). In papers II and III, there were no clinically relevant differences between the study groups regarding postoperative VAS pain at different time intervals. On the other hand, the dissatisfied patients in paper IV reported significantly higher VAS pain (approximately the same as the preoperative VAS pain score) than the satisfied group. In a systematic review of 11 cohort studies, Beswick et al. (2012) found moderate to severe long-term pain or no improvement in pain in 10–34% of patients after TKA.

**Table 8.**  
Proportion of dissatisfied patients in the literature

Author	Year of publication	TKA	Follow-up, years	Diagnosis	Dissatisfied (%)
Scott et al.	2010	1,217	1	Not presented	6
Fisher et al.	2007	1,024	1–6	OA, RA, other	7
Kim et al.	2009	438	1	OA	8
Robertsson et al.	2000	27,372	2–17	OA, RA, other	8
Heck et al.	1998	330	2	OA	9
Anderson et al.	1996	98	3	OA, RA	9
Hawker et al.	1998	1,193	2–7	OA	11
Bourne et al.	2010	1,703	1	OA, RA, other	12
Wylde et al.	2008	250	2	OA	12
Noble et al.	2006	253	1	OA, RA, other	14

Another essential aim of TKA is restoration of a favorable knee function, which can be achieved with a well-aligned stable knee, a good ROM, and reasonable muscle strength. These factors depend mainly on the preoperative planning, operating technique, and physiotherapy. Knee-related physical performance-based tests are objective instruments, which are of value for evaluation of the outcome of TKA. Several performance-based tests are recommended by OARSI (Dobson et al. 2013). Performance-based tests were used in papers I and III. The 6MW test even includes evaluation of the patient’s aerobic capacity. These tests include eccentric and concentric muscle contractions, and most of the patients are familiar with such kinds of exercise through physiotherapy management of OA. Dissatisfied patients in paper I had 6MW and chair-stand test results that were as good as those of the very satisfied group, despite having less ROM. In paper III performance-based tests at 3 months postoperatively were similar in the patellar resurfacing and non-resurfacing groups. However, it would have been an advantage if we had also had postoperative performance tests at 12 and 72 months. At the same time, VAS pain scores and KOOS subscale scores were similar between the groups, so the results of performance tests would probably also have been equal. In paper II, the degree of ROM and the straight leg raising test were used, but these 2 activities alone are not sufficient to evaluate physical function. However, the study was designed to evaluate the effect of CIAA on early postoperative pain and mobilization, and these 2 activities (ROM and straight leg raising) are an essential part of physical functioning and are performed in the first postoperative days. Objective evaluation of physical function with performance-based tests and subjective PROM data complement each other, which gives a better evaluation of outcome.

The proportion of dissatisfied patients after primary TKA, not counting revision, has been between 6% and 14% (Table 8). Historically, in Sweden the proportion of patients who are satisfied after TKA has been approximately 80% (Robertsson et al. 2000) (Figure 16). Patient satisfaction is an important outcome measure because it is well known that there is a disparity between patients’ and surgeons’ opinions of the



**Figure 16.**

Satisfaction in percentage in unrevised TKA patients (1981–1995). From *Acta Orthop Scand* 2000; 71 (3): 262-7.

postoperative result (Gioe et al. 2009, Khanna et al. 2011, Lieberman et al. 1996). One interesting finding in paper I was the high incidence of anxiety/depression in the dissatisfied group. The question is whether the dissatisfaction was the cause of the anxiety/depression or the result of it. This was difficult to answer because of the lack of preoperative data. The patients were dissatisfied despite the similarities in clinical examination, physical performance, and radiographic findings compared to the patients who were very satisfied. There was no indication for revision, except in one patient. In paper IV, there was a strong correlation between dissatisfaction and preoperative anxiety/depression. The risk increment was more than 6 fold, twice that of patients who had to undergo a revision operation because of deep infection. In paper III, patellar resurfacing had no effect on the proportion of satisfied patients—either at early or at late follow-up.

Several studies have shown correlations between preoperative psychological distress and surgical outcomes. There are some instruments available to evaluate psychological status. The HAD scale is an easy, reliable, and validated tool to identify patients with anxiety/depression (Axford et al. 2010, Bjelland et al. 2002). In a review of 10 studies, Bonnin et al. (2011) found that anxiety/depression, female gender, and age younger than 60 years were associated with painful TKA. In a review of 10 TKA cohort studies, Paulsen et al. (2011) identified 6 that had found a correlation between preoperative distress and functional outcome. Furthermore, Scott et al. (2010) found that depression and poor mental health had an influence on the degree of dissatisfaction in TKA-operated patients. Brander et al. (2007) also found that depression influenced outcome after TKA, and they postulated that

identifying and treating depression before surgery may be important in improving the result after TKA. Papers I and IV showed a strong correlation between dissatisfaction in patients and anxiety/depression. In papers II and III, anxiety/depression were not taken into account, as both studies were RCTs that supposedly included approximately similar proportions of patients with anxiety/depression. In addition, patients on antidepressants and neuroleptic drugs were excluded from paper III.

LIA is regarded as an effective and safe method of postoperative analgesia in TKA, and is used routinely nowadays in many clinics (Andersen et al. 2008, Busch et al. 2006, Essving et al. 2010, Kerr and Kohan 2008, SKAR 2016, Toftdahl et al. 2007, Vendittoli et al. 2006). Patients receiving LIA tend to experience more pain on the second postoperative day than on the first, because the effect of LIA disappears after 24 hours (Niemelainen et al. 2014). As the effect of LIA disappears so soon, attempts have been made to prolong the analgesic effect using continuous peripheral nerve blocks (Fischer et al. 2008) and CIAA (Zhang et al. 2011). There have, however, been controversies about the effect of CIAA after TKA. Some studies have found that it is an effective method (Rasmussen et al. 2004, Gomez- Cardero and Rodriguez-Merchan 2010, Zhang et al. 2011, Goyal et al. 2013), whereas others have not (Williams et al. 2013).

In paper II, patients in both groups received periarticular LIA during surgery. Postoperatively, the patients received either ropivacaine or placebo through a pump for 48 hours. There was no clinically relevant difference in VAS pain between the groups. There was no difference between the groups regarding analgesic consumption, medicine side effects, ROM, quadriceps function, or LOS. To our knowledge, there has been no other prospective randomized double-blind study similar to our study. We recorded VAS pain only at rest, to standardize the measurement as much as possible, and this was a limitation of the study. However, VAS pain is dependent on the type of patient activity, which is something that is difficult to control. At the same time, intensive postoperative pain at rest is not uncommon after TKA—in contrast to THA.

In a systematic review of 10 randomized studies, Sun et al. (2015) found that continuous LIA increases the risk of infection whereas other studies have shown that there is no increased risk of infection with intraarticular catheter placement for up to 72 hours (Bianconi et al. 2003, Rasmussen et al. 2004, Vendittoli et al. 2006). We found a higher rate of superficial and deep wound infection in the therapy group. This finding was remarkable, and difficult to explain. Both groups had the same type of pump, and only the content was different. It is unclear whether ropivacaine might cause tissue irritation when administered continuously over 48 hours. However, it has been shown that ropivacaine has an antiseptic effect (Batai et al. 2002, Kampe et al. 2003). The finding of more infections in the ropivacaine group is a serious complication, and further studies are needed to explain it.

The proportion of primary TKA patients with patellar resurfacing ranges between 2% and 98% (AOANJRR 2015, DKR 2015, Paxton et al. 2011, Register N

2015, SKAR 2016). In Sweden, patellar resurfacing in primary TKA has steadily decreased since the 1980s, from more than 70% down to 2.5% (SKAR 2016). However, after more than 4 decades there is still no consensus between different countries, and different surgeons argue about how to deal with the patella in TKA. In paper III, patellar resurfacing in TKA had no effect on postoperative VAS pain, patient satisfaction, or KOOS at 3, 12, and 72 months relative to patients with no resurfacing. The results of physical performance-based tests at 3 months postoperatively were similar in both groups. There was no reoperation during 72 months, either in the resurfacing group or in the non-resurfacing group. One strength of our randomized study III was that VAS pain, satisfaction, and KOOS are patient-reported instruments. Another strength was that a physiotherapist who was blind regarding the assignment of patients to groups conducted the performance-based tests. We included only patients with primary OA who were aged between 60 and 75 years, which is a common age for TKA in Sweden (SKAR 2016). It might have been an advantage to include all ages, and patients with other diagnoses. One limitation of our study may have been the low number of patients. Seventy-four patients may not be a sufficient number to show a small difference between the groups, as both resurfacing and no resurfacing are effective methods of reducing pain and improving knee function, with a high degree of satisfaction. At the same time, our power analysis indicated that 74 patients would be a sufficient number to show a statistically significant difference between the groups concerning pain, which is one of the most important outcomes in TKA. It would have been an advantage if we had had postoperative performance-based tests at 12 months. However, at that time VAS pain scores and KOOS subscale scores were similar between the groups, so the results of performance-based tests would probably also have been similar.

Several meta-analyses of RCT studies have not shown any statistically significant differences between resurfacing and non-resurfacing groups regarding anterior knee pain, knee function, and satisfaction, but they have found a higher incidence of reoperations in the non-resurfacing group (He et al. 2011, Li et al. 2011, Pavlou et al. 2011, Pilling et al. 2012). On the other hand, during the period 2005–2014 in Sweden, TKA with patellar resurfacing had a higher risk of revision than no resurfacing (Figure 3) (SKAR 2016). The reason for higher revision risk in the patellar resurfacing group might be because the patella is an additional component, thus increasing the possibility of infection, fracture, loosening, and wear.

There have also been several meta-analyses favoring patellar resurfacing in TKA (Forster 2004, Nizard et al. 2005, Pakos et al. 2005, Parvizi et al. 2005). However, these studies are older than 10 years and the prosthesis design that was used was not as modern as in recent years. One reason for more reoperations in non-resurfacing patients might be postoperative knee pain, which can be explained by patello-femoral dysfunction, and the surgeon has one more operation to offer that cannot be offered to the group that already has a resurfaced patella. However, there are many possible reasons for knee pain other than a non-resurfaced patella, such as scar dis-

comfort, numbness, neuromas, bursitis, tendinitis, patellar instability, patellar fracture, or muscle weakness.

In an observational Norwegian registry study, Lygre et al. (2010) found that resurfacing of the patella has no better effect on pain or knee function after TKA. On the other hand, in one of the largest RCT studies involving 514 patients, Waters and Bentley (2003) recommended patellar resurfacing in TKA because of less anterior knee pain. They found anterior knee pain in 25% of cases with no resurfacing, as compared to 5% in resurfacing group. In a recently published RCT study, Aunan et al. (2016) found that the mean subscores of the KOOS were in favor of patellar resurfacing whereas there were no significant differences in KSS, OKS, or patient satisfaction between the groups. Finally, Parvizi et al. (2012) found that secondary resurfacing was not always a rewarding procedure, as 8 of 39 patients who underwent secondary resurfacing failed because of remaining anterior knee pain. No patients in either group in our study III were reoperated within 6 years. The number of satisfied patients was very high in both groups. Many of the TKA designs in the referenced studies mentioned above are no longer in use, which makes comparison with the current prosthesis not fully relevant because of continuous improvement of the patello-femoral articulation since that time.

One strength of paper III was the use of KOOS at different periods of the follow-up. It is well known that there is a disparity between patients' and surgeons' opinions of the result postoperatively (Gioe et al. 2009, Khanna et al. 2011, Lieberman et al. 1996). In the majority of previous RCT studies, no PROMs such as KOOS were used, in contrast to our study.

One idea of paper III was a very early check of the 2 knee arthroplasty groups, where both PROMs and performance-based tests were used to help identify possible differences. Early (1-year) and medium-term (6-year) outcome were also assessed, to obtain a reasonably complete view of the time-related outcome. Compared to preoperative data, in both groups we found significantly lower VAS pain scores and improvements in all KOOS subscales, while performance-based test results were relatively similar to the preoperative values, which may have been due to the fact that 3 months is a short time to evaluate outcome after TKA (Nilsson et al. 2009). Both patient groups in paper III had high satisfaction rate, which was rather similar at 3, 12, and 72 months. VAS pain was becoming less with longer observation time. Patellar resurfacing is an additional trauma to the knee, but at 3 months postoperatively it did not cause poorer physical performance than no resurfacing. For example, values for knee extension strength and numbers of knee bendings in 30 seconds were roughly equal to the preoperative values.

# Conclusions

- Dissatisfied patients after TKA had significantly more anxiety/depression, significantly higher VAS pain scores, and significantly less ROM than those who were very satisfied.
- Patients who were dissatisfied after TKA had clinical findings, performance-based test results, and radiographic findings that were similar to those of very satisfied patients.
- Continuous intraarticular analgesia with ropivacaine in TKA had no clinically relevant effect on postoperative pain or mobilization.
- Continuous intraarticular analgesia with ropivacaine in TKA was associated with significantly more superficial and deep wound infections.
- Patellar resurfacing in primary TKA was of no advantage compared to non-resurfacing.
- Preoperative anxiety/depression was a strong indicator of postoperative dissatisfaction.
- The risk increment for postoperative dissatisfaction in patients with preoperative anxiety/depression was more than 6 fold—twice that for patients who had to undergo a revision operation because of deep infection.

# The future

- o Collect and handle psychometric PROM data before TKA.
- o Give proper information regarding the risk of inferior outcome in patients who are at high risk of being dissatisfied.
- o Consider psychological interventions in patients with anxiety/depression before TKA.
- o Identify patients with inferior PROM data one year after TKA and perform a thorough clinical and radiographic evaluation.



# Acknowledgments

It would not have been possible to write this thesis without the support of my family, friends, and colleagues. I wish to express my sincere gratitude, especially to:

**Martin Sundberg**, my supervisor and clinical mentor, for the endless support, encouragement, and patience during this time—as well as all the excellent help and advice.

**Anders Lindstrand**, my co-supervisor and mentor, for inviting me to the arthroplasty team, for all your expert support and guidance over the years, and all the invaluable advice in the clinical and academic fields.

**Gunnar Flivik**, my co-supervisor, for all the support, encouragement, constructive criticism, and rapid feedback to all my questions during this period.

**Anna Nilsson**, my co-supervisor, for cooperation, advice, and revision of manuscripts and thesis.

**All the other co-authors**, for their invaluable contributions to this work.

**Hans Wingstrand**, for introducing me to the Department of Orthopaedics in Lund and for teaching me to never give up.

**Lars Lidgren** and **Anders Rydholm**, for your unconditional and invaluable advice, support, and encouragement during this time.

**Leif Dahlberg**, for all your advice, guidance, and cooperation.

**Björn Person** and **Johan Nilsson**, for your trust and for allowing me to perform my first arthroplasty operation.

**Otto Robertsson**, for excellent help and support, and for extracting whatever I needed from the database.

**Kaj Knutson**, for all your advice and expert help with the layout of this thesis and for manuscript revision of paper II.

**Magnus Tägil**, for all advices and enjoyable discussions.

**Sören Toksvig-Larsen**, for all the encouragement and advice about doing clinical research.

**Current and previous heads of the department, Magnus Eneroth, Pelle Gustafsson, Peter Ljung, and Gunnar Häggglund**, for all your support and for the good times we have shared.

**Jonas Ranstam**, for guidance and advice on statistics.

**Björn Rosengren**, for support, technical help, and linguistic revision.

**Eric Dryver**, for revising my English.

**All my colleagues** at the orthopaedics department of Skåne University Hospital, for their inspiring discussions, support, and all kinds of advice.

**Annette W-Dahl**, for all advice, guidance, and interesting discussions.

**Ewa Persson, Åsa Björkqvist, and Gun-Britt Nyberg**, for all invaluable help with **data collection, cooperation, support, and guidance.**

**The staff of the orthopaedics departments** of Lund and Trelleborg Hospitals, for always being cooperative and encouraging.

**Yvonne Hultman Özek**, support and guidance with the EndNote and Portfolio programs.

**Saleem Sa'aed Qader**, my friend and brother for all your support and encouragement to start PhD work.

**My parents in law**, who have supported me in good and bad times.

**All my brothers and sisters** and their families, for supporting me and for always trusting me.

**Last but not least, my beloved family, Media, Lana, Sara, and Yusef**, for all their unconditional love, patience, and support.

This thesis work was supported by grants from the Faculty of Medicine, Lund University; Region Skåne; and the Erik and Angelica Sparre Foundation.

# References

- Ageberg E, Nilsson A, Kosek E, Roos E M. Effects of neuromuscular training (NEMEX-TJR) on patient-reported outcomes and physical function in severe primary hip or knee osteoarthritis: a controlled before-and-after study. *BMC Musculoskelet Disord* 2013; 14: 232.
- Ahlback S. Osteoarthrosis of the knee. A radiographic investigation. *Acta Radiol Diagn (Stockh)* 1968; Suppl 277:7-72.
- Aigner T, Stove J. Collagens--major component of the physiological cartilage matrix, major target of cartilage degeneration, major tool in cartilage repair. *Advanced drug delivery reviews* 2003; 55 (12): 1569-93.
- Andersen K V, Bak M, Christensen B V, Harazuk J, Pedersen N A, Soballe K. A randomized, controlled trial comparing local infiltration analgesia with epidural infusion for total knee arthroplasty. *Acta Orthop* 2010; 81 (5): 606-10.
- Andersen L O, Husted H, Otte K S, Kristensen B B, Kehlet H. High-volume infiltration analgesia in total knee arthroplasty: a randomized, double-blind, placebo-controlled trial. *Acta Anaesthesiol Scand* 2008; 52 (10): 1331-5.
- Anderson J G, Wixson R L, Tsai D, Stulberg S D, Chang R W. Functional outcome and patient satisfaction in total knee patients over the age of 75. *J Arthroplasty* 1996; 11 (7): 831-40.
- Andrews A W, Thomas M W, Bohannon R W. Normative values for isometric muscle force measurements obtained with hand-held dynamometers. *Phys Ther* 1996; 76 (3): 248-59.
- AOANJRR The Australian Orthopaedic Association National Joint Replacement Registry 2015.
- Aunan E, Naess G, Clarke-Jenssen J, Sandvik L, Kibsgard T J. Patellar resurfacing in total knee arthroplasty: functional outcome differs with different outcome scores. *Acta Orthop* 2016; 87 (2): 158-64.
- Axford J, Butt A, Heron C, Hammond J, Morgan J, Alavi A, et al. Prevalence of anxiety and depression in osteoarthritis: use of the Hospital Anxiety and Depression Scale as a screening tool. *Clin Rheumatol* 2010; 29 (11): 1277-83.
- Barros A J, Hirakata V N. Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. *BMC Med Res Methodol* 2003; 3: 21.
- Batai I, Kerenyi M, Falvai J, Szabo G. Bacterial growth in ropivacaine hydrochloride. *Anesth Analg* 2002; 94 (3): 729-31.
- Bellamy N, Buchanan W W, Goldsmith C H, Campbell J, Stitt L W. Validation study of

- WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. *J Rheumatol* 1988; 15 (12): 1833-40.
- Berger R A, Crossett L S, Jacobs J J, Rubash H E. Malrotation causing patellofemoral complications after total knee arthroplasty. *Clin Orthop Relat Res* 1998; (356): 144-53.
- Bergman S, Herrstrom P, Jacobsson L T, Petersson I F. Chronic widespread pain: a three year followup of pain distribution and risk factors. *J Rheumatol* 2002; 29 (4): 818-25.
- Beswick A D, Wylde V, Goberman-Hill R, Blom A, Dieppe P. What proportion of patients report long-term pain after total hip or knee replacement for osteoarthritis? A systematic review of prospective studies in unselected patients. *BMJ* 2012; 2 (1): e000435.
- Bianconi M, Ferraro L, Traina G C, Zanolli G, Antonelli T, Guberti A, et al. Pharmacokinetics and efficacy of ropivacaine continuous wound instillation after joint replacement surgery. *Br J Anaesth* 2003; 91 (6): 830-5.
- Bjelland I, Dahl A A, Haug T T, Neckelmann D. The validity of the Hospital Anxiety and Depression Scale. An updated literature review. *J Psychosomatic Res* 2002; 52 (2): 69-77.
- Blagojevic M, Jinks C, Jeffery A, Jordan K P. Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis. *Osteoarthritis Cartilage* 2010; 18 (1): 24-33.
- Boegard T, Rudling O, Petersson I F, Sanfridsson J, Saxne T, Svensson B, et al. Postero-anterior radiogram of the knee in weight-bearing and semiflexion. Comparison with MR imaging. *Acta Radiol* 1997; 38 (6): 1063-70.
- Bonnin M P, Basiglini L, Archbold H A. What are the factors of residual pain after uncomplicated TKA? *Knee Surg Sports Traumatol Arthrosc* 2011; 19 (9): 1411-7.
- Bourne R B, Chesworth B M, Davis A M, Mahomed N N, Charron K D. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? *Clin Orthop Relat Res* 2010; 468 (1): 57-63.
- Brand R A, Mont M A, Manring M M. Biographical sketch: Themistocles Gluck (1853-1942). *Clin Orthop Relat Res* 2011; 469 (6): 1525-7.
- Brander V, Gondek S, Martin E, Stulberg S D. Pain and depression influence outcome 5 years after knee replacement surgery. *Clin Orthop Relat Res* 2007; 464: 21-6.
- Brander V A, Stulberg S D, Adams A D, Harden R N, Bruehl S, Stanos S P, et al. Predicting total knee replacement pain: a prospective, observational study. *Clin Orthop Relat Res* 2003; (416): 27-36.
- Bremander A B, Dahl L L, Roos E M. Validity and reliability of functional performance tests in meniscectomized patients with or without knee osteoarthritis. *Scand J Med Sci Sports* 2007; 17 (2): 120-7.
- Busch C A, Shore B J, Bhandari R, Ganapathy S, MacDonald S J, Bourne R B, et al. Efficacy of periarticular multimodal drug injection in total knee arthroplasty. A randomized trial. *J Bone Joint Surg (Am)* 2006; 88 (5): 959-63.
- Dahlberg L, Billinghamurst R C, Manner P, Nelson F, Webb G, Ionescu M, et al. Selective enhancement of collagenase-mediated cleavage of resident type II collagen in cultured

- osteoarthritic cartilage and arrest with a synthetic inhibitor that spares collagenase 1 (matrix metalloproteinase 1). *Arthritis Rheum* 2000; 43 (3): 673-82.
- Dawson J, Fitzpatrick R, Murray D, Carr A. Questionnaire on the perceptions of patients about total knee replacement. *J Bone Joint Surg (Br)* 1998; 80 (1): 63-9.
- Djahani O, Rainer S, Pietsch M, Hofmann S. Systematic analysis of painful total knee prosthesis, a diagnostic algorithm. *Arch Bone Jt Surg* 2013; 1 (2): 48-52.
- DKR. Danish Knee Arthroplasty Register. 2015.
- Dobson F, Hinman R S, Roos E M, Abbott J H, Stratford P, Davis A M, et al. OARSI recommended performance-based tests to assess physical function in people diagnosed with hip or knee osteoarthritis. *Osteoarthritis Cartilage* 2013; 21 (8): 1042-52.
- Essving P, Axelsson K, Kjellberg J, Wallgren O, Gupta A, Lundin A. Reduced morphine consumption and pain intensity with local infiltration analgesia (LIA) following total knee arthroplasty. *Acta Orthop* 2010; 81 (3): 354-60.
- Fernandez-Moreno M, Rego I, Carreira-Garcia V, Blanco F J. Genetics in osteoarthritis. *Curr Genomics* 2008; 9 (8): 542-7.
- Fisher D A, Dierckman B, Watts M R, Davis K. Looks good but feels bad: factors that contribute to poor results after total knee arthroplasty. *J Arthroplasty* 2007; 22 (6 Suppl 2): 39-42.
- Forster M C. Patellar resurfacing in total knee arthroplasty for osteoarthritis: a systematic review. *Knee* 2004; 11 (6): 427-30.
- Gioe T J, Pomeroy D, Suthers K, Singh J A. Can patients help with long-term total knee arthroplasty surveillance? Comparison of the American Knee Society Score self-report and surgeon assessment. *Rheumatology* 2009; 48 (2): 160-4.
- Guralnik J M, Simonsick E M, Ferrucci L, Glynn R J, Berkman L F, Blazer D G, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol* 1994; 49 (2): M85-94.
- Hawker G, Wright J, Coyte P, Paul J, Dittus R, Croxford R, et al. Health-related quality of life after knee replacement. *J Bone Joint Surg (Am)* 1998; 80 (2): 163-73.
- He J Y, Jiang L S, Dai L Y. Is patellar resurfacing superior than nonresurfacing in total knee arthroplasty? A meta-analysis of randomized trials. *Knee* 2011; 18 (3): 137-44.
- Heck D A, Robinson R L, Partridge C M, Lubitz R M, Freund D A. Patient outcomes after knee replacement. *Clin Orthop Relat Res* 1998; (356): 93-110.
- Insall J, Ranawat C S, Scott W N, Walker P. Total condylar knee replacment: preliminary report. *Clin Orthop Relat Res* 1976; (120): 149-54.
- Johansson R, Carlbring P, Heedman A, Paxling B, Andersson G. Depression, anxiety and their comorbidity in the Swedish general population: point prevalence and the effect on health-related quality of life. *PeerJ* 2013; 1: e98.
- Kampe S, Poetter C, Buzello S, Wenchel H M, Paul M, Kiencke P, et al. Ropivacaine 0.1% with sufentanil 1 microg/mL inhibits in vitro growth of *Pseudomonas aeruginosa* and does not promote multiplication of *Staphylococcus aureus*. *Anesth Analg* 2003; 97 (2): 409-11

- Kellgren J H, Lawrence J S. Radiological assessment of osteo-arthrosis. *Ann Rheumatic Dis* 1957; 16 (4): 494-502.
- Kerr D R, Kohan L. Local infiltration analgesia: a technique for the control of acute postoperative pain following knee and hip surgery: a case study of 325 patients. *Acta Orthop* 2008; 79 (2): 174-83.
- Khan H I, Aitken D, Chou L, McBride A, Ding C, Blizzard L, et al. A family history of knee joint replacement increases the progression of knee radiographic osteoarthritis and medial tibial cartilage volume loss over 10 years. *Osteoarthritis Cartilage* 2015; 23 (2): 203-9.
- Khanna G, Singh J A, Pomeroy D L, Gioe T J. Comparison of patient-reported and clinician-assessed outcomes following total knee arthroplasty. *J Bone Joint Surg (Am)* 2011; 93 (20): e117(1)-(7).
- Khatib Y, Madan A, Naylor J M, Harris I A. Do psychological factors predict poor outcome in patients undergoing TKA? a systematic review. *Clin Orthop Relat Res* 2015; 473 (8): 2630-8.
- Kidd B L, Photiou A, Inglis J J. The role of inflammatory mediators on nociception and pain in arthritis. *Novartis Found Symp* 2004; 260: 122-33; discussion 33-8, 277-9.
- Kim T K, Chang C B, Kang Y G, Kim S J, Seong S C. Causes and predictors of patient's dissatisfaction after uncomplicated total knee arthroplasty. *J Arthroplasty* 2009; 24 (2): 263-71.
- Kosek E, Roos E M, Ageberg E, Nilsson A. Increased pain sensitivity but normal function of exercise induced analgesia in hip and knee osteoarthritis--treatment effects of neuromuscular exercise and total joint replacement. *Osteoarthritis Cartilage* 2013; 21 (9): 1299-307.
- Kurtz S M, Ong K L, Lau E, Widmer M, Maravic M, Gomez-Barrena E, et al. International survey of primary and revision total knee replacement. *Int Orthop* 2011; 35 (12): 1783-9.
- Kurtz S M, Ong K L, Schmier J, Mowat F, Saleh K, Dybvik E, et al. Future clinical and economic impact of revision total hip and knee arthroplasty. *J Bone Joint Surg (Am)* 2007; 89 Suppl 3: 144-51.
- Li S, Chen Y, Su W, Zhao J, He S, Luo X. Systematic review of patellar resurfacing in total knee arthroplasty. *Int Orthop* 2011; 35 (3): 305-16.
- Lidgren L. Looking back at the start of the Bone And Joint Decade what have we learnt? *Best Pract Res Clin Rheumatol* 2012; 26 (2): 169-71.
- Lieberman J R, Dorey F, Shekelle P, Schumacher L, Thomas B J, Kilgus D J, et al. Differences between patients' and physicians' evaluations of outcome after total hip arthroplasty. *J Bone Joint Surg (Am)* 1996; 78 (6): 835-8.
- Litwic A, Edwards M H, Dennison E M, Cooper C. Epidemiology and burden of osteoarthritis. *Br Med Bull* 2013; 105: 185-99.
- Losina E, Thornhill T S, Rome B N, Wright J, Katz J N. The dramatic increase in total knee replacement utilization rates in the United States cannot be fully explained by growth in population size and the obesity epidemic. *J Bone Joint Surg (Am)* 2012; 94 (3): 201-7.
- Lygre S H, Espehaug B, Havelin L I, Vollset S E, Furnes O. Does patella resurfacing really matter? Pain and function in 972 patients after primary total knee arthroplasty. *Acta Orthop* 2010; 81 (1): 99-107.

- Mandalia V, Eyres K, Schranz P, Toms A D. Evaluation of patients with a painful total knee replacement. *J Bone Joint Surg (Br)* 2008; 90 (3): 265-71.
- Martin H J, Yule V, Syddall H E, Dennison E M, Cooper C, Aihie Sayer A. Is hand-held dynamometry useful for the measurement of quadriceps strength in older people? A comparison with the gold standard Bodex dynamometry. *Gerontology* 2006; 52 (3): 154-9.
- Niemelainen M, Kalliovalkama J, Aho A J, Moilanen T, Eskelinen A. Single periarticular local infiltration analgesia reduces opiate consumption until 48 hours after total knee arthroplasty. A randomized placebo-controlled trial involving 56 patients. *Acta Orthop* 2014; 85 (6): 614-9.
- Nilsdotter A K, Toksvig-Larsen S, Roos E M. A 5 year prospective study of patient-relevant outcomes after total knee replacement. *Osteoarthritis Cartilage* 2009; 17 (5): 601-6.
- Nizard R S, Biau D, Porcher R, Ravaut P, Bizot P, Hannouche D, et al. A meta-analysis of patellar replacement in total knee arthroplasty. *Clin Orthop Relat Res* 2005; (432): 196-203.
- Noble P C, Conditt M A, Cook K F, Mathis K B. The John Insall Award: Patient expectations affect satisfaction with total knee arthroplasty. *Clin Orthop Relat Res* 2006; 452: 35-43.
- Noble P C, Scuderi G R, Brekke A C, Sikorskii A, Benjamin J B, Lonner J H, et al. Development of a new Knee Society scoring system. *Clin Orthop Relat Res* 2012; 470 (1): 20-32.
- Pakos E E, Ntzani E E, Trikalinos T A. Patellar resurfacing in total knee arthroplasty. A meta-analysis. *J Bone Joint Surg (Am)* 2005; 87 (7): 1438-45.
- Pan F, Ding C, Winzenberg T, Khan H, Martel-Pelletier J, Pelletier J P, et al. The offspring of people with a total knee replacement for severe primary knee osteoarthritis have a higher risk of worsening knee pain over 8 years. *Ann Rheumatic Dis* 2016; 75 (2): 368-73.
- Parvizi J, Rapuri V R, Saleh K J, Kuskowski M A, Sharkey P F, Mont M A. Failure to resurface the patella during total knee arthroplasty may result in more knee pain and secondary surgery. *Clin Orthop Relat Res* 2005; 438: 191-6.
- Paulsen M G, Dowsey M M, Castle D, Choong P F. Preoperative psychological distress and functional outcome after knee replacement. *ANZ J Surg* 2011; 81 (10): 681-7.
- Pavlou G, Meyer C, Leonidou A, As-Sultany M, West R, Tsiridis E. Patellar resurfacing in total knee arthroplasty: does design matter? A meta-analysis of 7075 cases. *J Bone Joint Surg (Am)* 2011; 93 (14): 1301-9.
- Paxton E W, Furnes O, Namba R S, Inacio M C, Fenstad A M, Havelin L I. Comparison of the Norwegian knee arthroplasty register and a United States arthroplasty registry. *J Bone Joint Surg (Am)* 2011; 93 Suppl 3: 20-30.
- Pilling R W, Moulder E, Allgar V, Messner J, Sun Z, Mohsen A. Patellar resurfacing in primary total knee replacement: a meta-analysis. *J Bone Joint Surg (Am)* 2012; 94 (24): 2270-8.
- Ramkumar P N, Harris J D, Noble P C. Patient-reported outcome measures after total knee arthroplasty: a systematic review. *Bone Joint Res* 2015; 4 (7): 120-7.
- Rasmussen S, Kramhoft M U, Sperling K P, Pedersen J H. Increased flexion and reduced hospital stay with continuous intraarticular morphine and ropivacaine after primary total knee replacement: open intervention study of efficacy and safety in 154 patients. *Acta Orthop* 2004; 75 (5): 606-9.



- Register N. The Norwegian Arthroplasty Register. <http://nrlweb.ihelse.net/eng/> 2015.
- Reilly K A, Beard D J, Barker K L, Dodd C A, Price A J, Murray D W. Efficacy of an accelerated recovery protocol for Oxford unicompartmental knee arthroplasty--a randomised controlled trial. *Knee* 2005; 12 (5): 351-7.
- Robertsson O, Dunbar M, Pehrsson T, Knutson K, Lidgren L. Patient satisfaction after knee arthroplasty: a report on 27,372 knees operated on between 1981 and 1995 in Sweden. *Acta Orthop* 2000; 71 (3): 262-7.
- Robertsson O, Dunbar M J. Patient satisfaction compared with general health and disease-specific questionnaires in knee arthroplasty patients. *J Arthroplasty* 2001; 16 (4): 476-82.
- Robertsson O, Ranstam J, Sundberg M, A W D, Lidgren L. The Swedish Knee Arthroplasty Register: a review. *Bone Joint Res* 2014; 3 (7): 217-22.
- Robinson R P. The early innovators of today's resurfacing condylar knees. *J Arthroplasty* 2005; 20 (1 Suppl 1): 2-26.
- Roos E M, Lohmander L S. The Knee injury and Osteoarthritis Outcome Score (KOOS): from joint injury to osteoarthritis. *Health Qual Life Outcomes* 2003; 1: 64.
- Roos E M, Roos H P, Ekdahl C, Lohmander L S. Knee injury and Osteoarthritis Outcome Score (KOOS)--validation of a Swedish version. *Scand J Med Sci Sports* 1998; 8 (6): 439-48.
- Roos E M, Toksvig-Larsen S. Knee injury and Osteoarthritis Outcome Score (KOOS) - validation and comparison to the WOMAC in total knee replacement. *Health Qual Life Outcomes* 2003; 1: 17.
- Scott C E, Howie C R, MacDonald D, Biant L C. Predicting dissatisfaction following total knee replacement: a prospective study of 1217 patients. *J Bone Joint Surg (Br)* 2010; 92 (9): 1253-8.
- SKAR. Swedish Knee Arthroplasty Register: Annual Report 2016. Available from <http://www.myknee.se/en/>
- Steffen T M, Hacker T A, Mollinger L. Age- and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and gait speeds. *Phys Ther* 2002; 82 (2): 128-37.
- Sun X L, Zhao Z H, Ma J X, Li F B, Li Y J, Meng X M, et al. Continuous local infiltration analgesia for pain control after total knee arthroplasty: a meta-analysis of randomized controlled trials. *Medicine (Baltimore)* 2015; 94 (45): e2005.
- Thorstensson C A, Garellick G, Rystedt H, Dahlberg L E. Better management of patients with osteoarthritis: development and nationwide implementation of an evidence-based supported osteoarthritis self-management programme. *Musculoskeletal Care* 2015; 13 (2): 67-75.
- Toftdahl K, Nikolajsen L, Haraldsted V, Madsen F, Tonnesen E K, Soballe K. Comparison of peri- and intraarticular analgesia with femoral nerve block after total knee arthroplasty: a randomized clinical trial. *Acta Orthop* 2007; 78 (2): 172-9.
- Turkiewicz A, Gerhardsson de Verdier M, Engstrom G, Nilsson P M, Mellstrom C, Lohmander L S, et al. Prevalence of knee pain and knee OA in southern Sweden and the proportion that seeks medical care. *Rheumatology* 2015; 54 (5): 827-35.



- Walldius B. Arthroplasty of the knee joint employing an acrylic prosthesis. *Acta Orthop Scand* 1953; 23 (2): 121-31.
- van Kempen R W, Schimmel J J, van Hellemond G G, Vandenneucker H, Wymenga A B. Reason for revision TKA predicts clinical outcome: prospective evaluation of 150 consecutive patients with 2-years followup. *Clin Orthop Rel Res* 2013; 471 (7): 2296-302.
- Wang H, Boctor B, Verner J. The effect of single-injection femoral nerve block on rehabilitation and length of hospital stay after total knee replacement. *Reg Anesth Pain Med* 2002; 27 (2): 139-44.
- Waters T S, Bentley G. Patellar resurfacing in total knee arthroplasty. A prospective, randomized study. *J Bone Joint Surg (Am)* 2003; 85-A (2): 212-7.
- Vendittoli P A, Makinen P, Drolet P, Lavigne M, Fallaha M, Guertin M C, et al. A multimodal analgesia protocol for total knee arthroplasty. A randomized, controlled study. *J Bone Joint Surg (Am)* 2006; 88 (2): 282-9.
- Villadsen A, Roos E M, Overgaard S, Holsgaard-Larsen A. Agreement and reliability of functional performance and muscle power in patients with advanced osteoarthritis of the hip or knee. *Am J Phys Med Rehabil* 2012; 91 (5): 401-10.
- Wylde V, Dieppe P, Hewlett S, Learmonth I D. Total knee replacement: is it really an effective procedure for all? *Knee* 2007; 14 (6): 417-23.
- Wylde V, Learmonth I, Potter A, Bettinson K, Lingard E. Patient-reported outcomes after fixed- versus mobile-bearing total knee replacement: a multi-centre randomised controlled trial using the Kinemax total knee replacement. *J Bone Joint Surg (Br)* 2008; 90 (9): 1172-9.
- Wylde V, Rooker J, Halliday L, Blom A. Acute postoperative pain at rest after hip and knee arthroplasty: severity, sensory qualities and impact on sleep. *Orthop Traumatol Surg Res* 2011; 97 (2): 139-44.
- Zhang W, Nuki G, Moskowitz R W, Abramson S, Altman R D, Arden N K, et al. OARSI recommendations for the management of hip and knee osteoarthritis: part III: Changes in evidence following systematic cumulative update of research published through January 2009. *Osteoarthritis Cartilage* 2010; 18 (4): 476-99.
- Zigmond A S, Snaith R P. The hospital anxiety and depression scale. *Acta Psychiatr Scand* 1983; 67 (6): 361-70.