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Reasons for and outcomes of performing secondary patella resurfacing after total knee arthroplasty

Degree Project in Medicine

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Abstract

This study aims to investigate reasons for and outcomes of performing Secondary Patella Resurfacing (SPR) after Total Knee Arthroplasty (TKA). Since there is no consensus regarding whether to perform primary patella resurfacing along with TKA or not[17] it is of interest to study the patients undergoing SPR in order to shed some light on the usefulness of this surgery.

Methods: This is a descriptive case-series study conducted at Lund University Hospital, including patients from all hospitals in region Skåne. Data has been extracted from a registry for orthopedic surgery, patient journals and from X-ray images. Logistic regression is used to compute odds ratios for risk of re-revision. Patient Reported Outcome Measures (PROM) have been used to investigate the impact of SPR on patients.

Results: The most common cause for SPR is found to be progression of femuropatellar osteoarthritis (66.7%). The risk of re-revision is high; 6.3%, 9.4% respective 12.1% at one year, five years respective ten years after SPR. Only a small proportion of all cases of TKA (1.05%) has had their patella resurfaced. The risk of re-revision is found to be greater for men than for women, odds ratios 9.6, 5.2 respective 6.1 at one year, five years respective ten years after SPR. Corresponding hazard ratios 8.9, 4.9 respective 5.5. Patients belonging to ASA class 3 are more likely to undergo re-revision than ASA 1 patients; odds ratios 10.7 respective 6.2 at one year respective five years after SPR. Corresponding hazard ratios being 9.3 respective 5.6. No such effect could be found at ten years after SPR. Surgical duration was found to significantly impact the risk of re-revision, but this result might have been affected by outliers. Comparison of Knee injury and Osteoarthritis Outcome scale (KOOS) and self-assessed pain according to Visual Analog Scale (VAS) before and one year after SPR indicates that, in general, patients undergoing SPR are benefited by the procedure. Self-assessed satisfaction (VAS) is in average 4.6.

Conclusion: Femuropatellar osteoarthritis is the main reason for performing SPR. The prosthesis survival of SPR is not great, patients having a high risk of re-revision.There are some possible predictors as to which SPR patients undergo re-revision; sex and ASA class. SPR seems to benefit the patients in general but the spread is large, making the outcome unpredictable. The patients are in general neither satisfied nor dissatisfied with the SPR. There seems to be merit to the policy of only performing primary patella resurfacing in special cases, although the high risk of complications for SPR indicates that it would be desirable to be able to predict which cases will undergo SPR so that patella resurfacing can be performed primarily in these cases.

Keywords: Secondary Patella Resurfacing · Reason for surgery · Re-revision · Prosthesis survival · KOOS · Pain · Osteoarthritis · Sex · Surgical duration · ASA class

Glossary

ADL Activities of Daily Living. 10, 19, 20

ASA American Society of Anesthesiologists. 1, 4, 11, 13, 21–26, 30, 33

BMI Body Mass Index. 4, 11, 13, 21, 22, 24, 26, 31

CI Confidence Interval. 12, 14, 15, 19, 21–31

CSV Comma-Separated Values. 10

CT Computer Tomography. 30, 33

EQ-5D A standardized instrument for measuring generic health status. 10

ICD International Classification of Diseases. 9, 10, 12

KOOS Knee injury and Osteoarthritis Outcome scale. 1, 3, 10, 18–21, 31, 33

NSAIDS Non-steroidal anti-inflammatory drugs. 6

PROM Patient Reported Outcome Measures. 1, 9–11, 18, 32

QOL Quality Of Life. 6, 10, 20

RA Rheumatoid Arthritis. 14

SD Standard Deviation. 13, 18, 20–24

SLE Systemic Lupus Erythematosus. 14

SPR Secondary Patella Resurfacing. 1, 3, 9–33

TKA Total Knee Arthroplasty. 1, 5, 8–12, 14, 15, 17, 18, 29, 30, 32, 33

VAS Visual Analog Scale. 1, 10, 18, 21–24, 31–33

Contents

1 Introduction

This introduction aims to provide a basis for understanding knee surgery and related treatment methods. Also, the goal is to explain why secondary patella resurfacing might be performed and what this means. As this thesis is focused on patella resurfacing second to Total Knee Arthroplasty (TKA), the topic of this surgical method will be given the most space.

There is a number of different symptoms related to a dysfunctional knee including pain, instability, constrained range of motion, locking and crepitations. A dysfunctional knee may be derived from a multitude of different underlying conditions but the main clinical indication for performing TKA is osteoarthritis[6] and thus it will be given a special focus in this introduction.

Treatment regimes for a dysfunctional knee include non-surgical treatment, joint sparing surgery and joint replacement surgery (of which TKA belongs).[14]

1.1 Osteoarthritis

Osteoarthritis is a complex disease which is not completely understood, but factors involved are density and morphology of the bone, derangement of the meniscus, sex and sex hormones, and trauma. The largest risk factors are, however, age and obesity.[6]

Even though it is generally accepted that changes in the subchondral bone, synovial membrane and articular cartilage are important factors, there is no real consensus on the pathogenesis of osteoarthritis. One view on this is that there is a failure of the cartilage due to an ageing process, a traumatic event or an originally defect extracellular matrix. A second view means that there is a net loss of matrix in the cartilage due to a dysfunctional balancing of synthesis and degradation in the chondrocytes. A third hypothesis means that there is a secondary cartilage damage due to external factors such as bone remodeling, vascular changes, microfractures and synovial changes.[14]

The diagnosis can be made clinically by evaluating the symptoms and can be confirmed by radioimaging. Symptoms of osteoarthritis are pain, decreased range of motion, stiffness, crepitations and swelling of the joint. The pain is typically dull and intermittent early in the disease; localised to one compartment, worsened by activity and eased by rest. Later in the progression the pain takes on a more diffuse and continuous character, can involve all compartments and remain during rest.[14]

1.2 Non-surgical treatment

Non-surgical treatments aim to relieve pain, delay the progression of the disease and to improve upon functioning.[14]

1.2.1 Life style changes

Certain life style changes have been shown to ease knee pain and reduce the risk of developing osteoarthritis. Among these are avoiding high-impact activities such as running, swiching to low-impact activities such as swimming, avoiding stair climbing and squatting and loosing weight in case of obesity.[14]

1.2.2 Physiotherapy

Muscle strengthening around the knee can help stabilising the joint and relieve symptoms. Stretching exercises may improve range of motion and prevent development of contractures.[14]

1.2.3 Pharmacotherapy

Non-steroidal anti-inflammatory drugs (NSAIDS) may relieve pain and dampen inflammation when a patient has exacerbated pain and a swollen knee.[14] When there is an exacerbation of symptoms despite ongoing treatment with NSAIDS intra-articular corticosteroids are efficient in reducing pain of osteoarthritis. The effect, however, lasts only approximately a week.[13] The use of hyaluronic acid can theoretically ease symptoms of osteoarthritis through lubrication, anti-inflammatory and chondroprotective effects.[4]

1.2.4 Orthoses

For patients with varus medial compartment osteoarthritis, unloader bracing can decrease the adduction movement of the knee and thereby relieve pain and stiffness while improving function and Quality Of Life (QOL). For other types of osteoarthritis, however, the proper use of orthoses is not yet determined.[26]

1.3 Joint sparing surgery

Before performing joint replacement surgery, the possibility of joint sparing surgical methods should first be considered.[6] These are artroscopy and osteotomy.[14]

1.3.1 Arthroscopy

Arthroscopy as a treatment for osteoarthritis is controversial and positive effects have been shown to be attributable to placebo.[16] Nevertheless, it can provide a beneficial effect in a younger patient group with symptoms such as locking, medial joint tenderness, mild to moderate eveidence of osteoarthritis on radiographic imaging and precense of degenerative tear of the meniscus.[14] Arthroscopy should, however, be avoided for patients of middle age or older with knee pain or where there are no signs of osteoarthritis.[32]

1.3.2 Osteotomy

The aim of osteotomy is to normalise the mechanical axis of a pathologic knee joint, offloading the degenerative side and thus removing or at least reducing symptoms. This can be done in a manner of different ways including opening wedge, closing wedge, oblique plane osteotomy and ball and socket osteotomy. Due to simpler technical procedure opening and closing wedge have been popularised. The patient should be younger than 60 years, have pain or disability due to an osteoarthritis that is limited to one compartment and have a preoperative range of flexion grater than 90 degrees. Osteotomy is contraindicated if the patient has an inflammatory arthritis, panarthrosis, severe restriction of movement in the joint or an instability of the ligament apparatus.[14]

1.4 Joint replacing surgery

End-stage arthritis and persistent severe pain are generally considered the main indications for performing knee replacement surgery. The diagnosis is determined with radiographic imaging along with clinical presentation of symptoms such as severe refractory knee pain, substantial disability and inadequate response to non-operative treatment methods. Moreover, indication for joint sparing surgical procedures should not be present, joint replacement must be technically possible and the patient must be medically fit for the procedure. A knee replacement surgery can be either total or partial; with surgery in either the lateral, the medial or the femuro-patellar compartment.[6]

1.4.1 Unicompartmental knee replacement

Unicompartmental knee replacement infer arthroplasty being performed in either the medial or lateral compartment of the knee, the arthroplasty being limited to the most affected parts.[6] The affected compartment is thus operated upon, replacing the femur condyle with a metal component and the associated part of the tibia with a plastic component.[3] Indications for partial knee replacement are unicompartmental osteoarthritis or osteonecrosis in either the medial or the lateral compartment, age over 60 years, low level of physical activity, a minimal pain at rest and a range of flexion over 90 degrees. Contraindications are inflammatory arthritis, age under 60 years, high level of physical activity, pain at rest, femuro-patellar pain or exposed bone in either the femuro-patellar or the opposite compartment.[3]

1.4.2 Femuro-patellar arthroplasty

Femuro-patellar arthroplasty aims to relieve symptoms related to the articulation of the patella in the femur trochlea such as anterior knee pain or crepitations. Options to treat this condition includes arthroplasty, with or without lateral release; osteotomy unloading the tibial tubercle; femuro-patellar arthroplasty with resurfacing of the patella; and TKA.[14] Resurfacing of the patella will be described in more detail below.

1.4.3 Total knee arthroplasty

Total Knee Arthroplasty (TKA) means replacing the distal femur with a metal component and the proximal tibia with a plastic component. Some countries include a patella resurfacing in the TKA while others do not. Indications for TKA include diagnosis of osteoarthritis or inflammatory arthritis, changes on X-ray imaging, severe refractory knee pain, substantial disability and inadequate response to non-surgical interventions. Joint sparing surgery must not be indicated and replacement surgery must be technically possible. The patient must also be medically fit to undergo the surgery.[6]

The main goals when performing a TKA are improving stability, function, range of motion and to relieve pain. Important factors in achieving these goals are proper implant alignment and soft-tissue balancing. The best method of how to optimise these factors is, however, controversial. Two different approaches are measured resection and gap balancing. Measured resection uses metal and plastic implants of the same thickness as the resected bone in order to restore the joint line position and set proper femural rotation in relation to anatomical landmarks. In gap balancing, on the other hand, the surgeon manipulates the tension in ligaments in order to reach equal and rectangular gaps i flexion respective extension. In many cases, a combination of the two methods is used in clinical practise.[29]

Proper alignment of the components is crucial in achieving good results. For example, the rotational alignment of the tibial component contributes, among other things, to a proper tracking of the patella. Internal rotation of this component leads to an external rotation of the tibial tubercle which will increase the Q-angle, i.e. the angle between the mechanical axis of the knee and the longitudinal axis of the femur, thus leading to a lateralisation of the patella, increasing mechanical tear.[20]

The result of performing TKA is usually good, but as many as 20% of the patients have remaining pain after the surgery.[6]

1.5 Patella resurfacing

As described above it is possible to perform a patella resurfacing along with a TKA. A patella resurfacing means that the visceral surface of the patella is replaced with a plastic component in order for the patella to articulate optimally against the trochlea of the femur component of the total knee prosthesis.[20]

The indication for resurfacing the patella is osteoarthritis in the femuro-patellar joint with significant pain and functional disability.[17][20][28] Contraindications include inflammatory arthritis, crystal arthropathy, severe maltracking of the patella, tibio-femural arthritis and a high level of physical activity.[14] A patella resurfacing can also be performed in a revision secondary to the primary TKA if the initial surgery has failed to attain satisfactory ease of symptoms or when new problems have emerged in a later stage.

Within the research field, and clinical practice, there are three different attitudes towards resurfacing the patella. One school chooses to routinely resurface the patella on all patients undergoing TKA, another school never chooses to resurface the patella on patients undergoing TKA while a third school chooses to selectively resurface the patella depending on the current status of the femuropatellar joint.[5] All of these three methods has scientific support[5] and there is presently no consensus within the field on which method should be chosen.[17] Moreover, there is research indicating that there is no statistically significant gain to resurface the patella along with the TKA compared to refraining.[17][19]

Because of the lack of consensus regarding this topic it would be interesting to more closely study the patients undergoing Secondary Patella Resurfacing (SPR) in order to see if there are any benefits to the procedure, why the patients undergo the surgery and what risks can be found related to SPR. It would be of great value if the patients undergoing SPR can be identified in an early stage so that patella resurfacing can be performed along with the TKA, avoiding the increased risks associated with revision surgery.

2 Aim

The aim of this study is to investigate reasons for and outcomes of performing Secondary Patella Resurfacing (SPR) after Total Knee Arthroplasty (TKA) has been conducted. In particular, focus is on the following research questions:

Q1: What are the main reasons for performing SPR?

Q2: How many of the SPR patients have later undergone re-revision and due to what reasons?

Q3: What factors influence risk of re-revision after SPR?

Q4: Is there any improvement in Patient Reported Outcome Measures (PROM) from before SPR to one year after?

3 Material and methods

This is a retrospective, descriptive case-series study examining the reasons for and outcomes of performing Secondary Patella Resurfacing (SPR) after Total Knee Arthroplasty (TKA) has been performed. It has been conducted at Lund University Hospital and includes patients from all hospitals in region Skåne.

The study includes cases of SPR according to ICD code NGC59 performed within the period from 1999 to 2019. This meaning surgery has been performed using

NGC59 as the first ICD code or where NGC59 has been performed solely in combination with change of plastic components of the total knee prosthesis. Cases where SPR were performed together with change of bone-anchored components have been excluded from this study.

All patients were required to have undergone surgery with TKA prior to SPR according to ICD codes NGB29 (uncemented), NGB39 (hybrid) or NGB49 (cemented). Cases where no such TKA was found prior to SPR have been excluded from this study. Accordingly, for the cases of SPR included in this study, TKA have been performed within the period from May 1999 to January 2019.

Data has primarily been extracted from Ortreg, a register for all orthopedic surgeries in region Skåne, and been saved in CSV format. Complementary data has been gathered from patient journals in Melior, the system for storing patient journals presently used in region Skåne, and from X-ray images in Sectra which is the system presently used for storing X-ray images in region Skåne. Extraction, handling and analysis of data has been performed primarily using the Python library Pandas and to some extent using Open Office.

Patient demographics for SPR patients are presented and reason for surgery has been analysed for the entirety of this population except for two cases where no clear reason could be found. For those patients who were undergoing re-revision posterior to SPR the reason for the re-revision surgery has been studied and Kaplan-Meier estimates computed for prosthesis survival. In addition to this the time between TKA and SPR has been studied as well as the time between SPR and first re-revision in those cases concerned.

The impact of SPR on Patient Reported Outcome Measures (PROM) is investigated by comparison between status before and one year after surgery regarding Charnley category, Knee injury and Osteoarthritis Outcome scale (KOOS), self-assessed pain according to Visual Analog Scale (VAS) and self-assessed pain (also according to VAS). Self-assessed satisfaction with surgery according to VAS is also analysed one year after SPR.

Visual Analog Scale (VAS) has been used for self-assessment of pain, state of health and satisfaction (all from the EQ-5D form). The patient points to a place on a 10 cm scale which is meant to represent their experience.[25] Regarding pain, a high number means a lot of pain while a high number regarding state o health means good health and a high value regarding satisfaction means a high satisfaction.

Knee injury and Osteoarthritis Outcome scale (KOOS) is a PROM with five subcategories; these being pain, Activities of Daily Living (ADL), sport and Quality Of Life (QOL). All of these measured on a scale from 0 to 100 where 0 is worst possible state and 100 best possible state. It is administered as a self-explanatory questionnaire.[11]

Charnley class is way to classify patients into different categories regarding comorbidity originally used to assess outcomes after hip arthroplasty but later modified to assess outcomes after knee arthroplasty.[10] Class A including those patients having trouble in one knee, class B1 including patients with TKA in one knee and symptoms in the other, class B2 including patients with bilateral TKA and class C including those patients having undergone TKA and having arthritis and/or other medical conditions affecting their ability to ambulate.[10]

When analysing PROM data there are considerable losses of data, limiting the analysis to the sub-population with available data. In those cases where statistically significant results have been found, demographics for the sub-population is presented and compared to the demographics of the entire population.

Factors influencing the risk of re-revision posterior to SPR have been analysed using simple logistic regression to compute odds ratios and Cox regression to compute hazard ratios, simultaneously checking for statistical significance. The independent variables used are age, ASA class, BMI, laterality, sex, surgical duration and wait for surgery. Simple logistic regression and Cox regression have been run three times for each independent variable with the dependent variable being “re-revision: yes or no” one year, five years respective ten years after SPR.

Statistical analysis has been performed using Python libraries Scipy, Numpy, Statsmodels and Lifelines. Confidence intervals for population proportions have been computed under the assumption of normally distributed data. When analysing differences in PROM data before and one year after SPR the wilcoxon test from Scipy's statistics module Stats has been used due to occurrence of statistically significant outliers. The library Lifelines was used to compute Kaplan-Meier estimates and Statsmodels was used to perform logistic regression. The python libraries Matplotlib and Seaborn have been used to visualize results of statistic analysis.

4 Ethics

This study has been conducted at the department of orthopaedics at Lund University Hospital and has the approval of the head of department. Since the work has consisted of data analysis, reading of patient journals and analysis of X-ray images there has been no need to apply for approval from an ethics committee.

5 Results

Among all the primary Total Knee Arthroplasty (TKA), performed from May 1999 to January 2019, 224 were revised with Secondary Patella Resurfacing (SPR).

As a comparison a total of 23664 cases of TKA were conducted during the same time period and only 224 of these, corresponding to 0.9% (95% CI: 0.8% - 1.0%), were accordingly later revised with SPR without change of bone-anchored components. In 25 of the remaining 23440 cases a primary patella resurfacing (ICD code NGB59) was conducted in the same seance as the TKA. Consequently, some form of patella resurfacing was conducted in only 249 cases out of 23664 corresponding to 1.05% (95% CI: 0.94% - 1.16%).

Figure 1 shows the revisions with SPR over the time period. The first years there is a loss of cases due to the exclusion of cases where TKA was conducted before the year 1999. Around 2004, this effect should start to become negligible as 75% of the SPR revisions were performed within 3.2 years after corresponding TKA(see table 7).

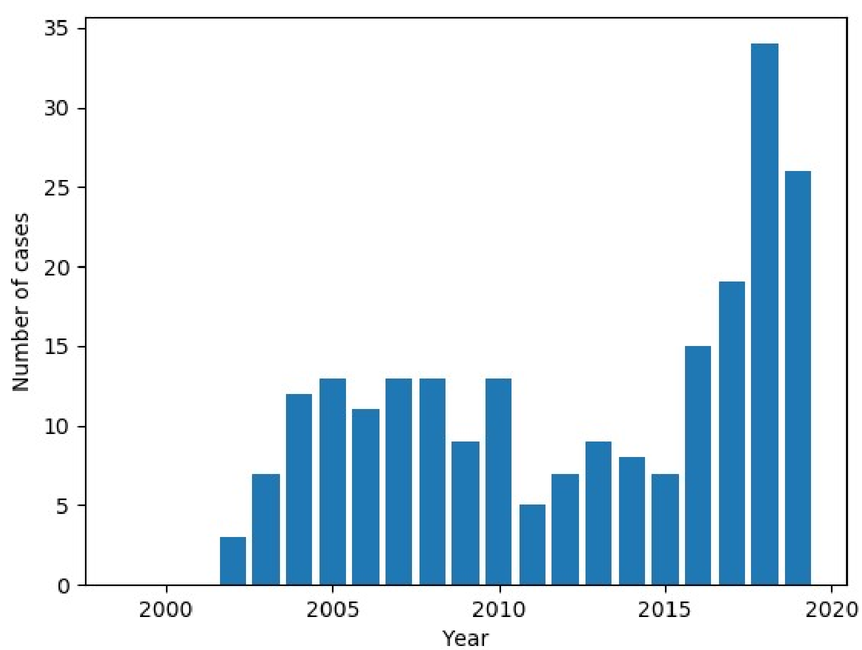


Figure 1: Number of SPR cases per year.

5.1 Demographics

Table 1 shows the demographics for the population undergoing SPR at the time of this surgery. Complete data regarding age, laterality and sex was found. Varying degrees of incomplete data were found regarding remaining variables; ASA class in 211 cases, BMI in 156 cases, surgical duration in 218 cases and wait for surgery in 220 cases. Consequently, the demographics in table 1 regarding these variables are estimates based on the available data.

Table 1: Demographics for patients undergoing SPR

(a) Categorical variables.

	Number	Prop. (%)	95% CI (%)
ASA class			
ASA 1	36	17.06	11.99 - 22.13
ASA 2	144	68.25	61.98 - 74.52
ASA 3	30	14.22	9.51 - 18.93
ASA 4	1	0.47	0.00 - 1.39
Laterality			
Left	122	54.46	47.95 - 60.97
Right	102	45.54	39.03 - 52.05
Sex			
Men	93	41.52	35.07 - 47.97
Women	131	58.48	52.03 - 64.93

(b) Continuous variables.

	Mean	Median	SD
Age (years)	67.2	68.0	9.0
BMI	29.0	28.5	4.2
Surgical duration (minutes)	58.1	52.0	26.7
Wait for surgery (days)	102.3	80.0	86.6

Observations to be made from table 1 are that there is a slight over-representation of women, the mean patient is overweight and at retirement age, the majority having mild systemic diseases (ASA 2) and that the mean wait for surgery is almost three and a half months. There is no significant difference in laterality and the mean surgical duration is almost an hour.

5.2 Reason for performing SPR

Out of the total of 224 cases of SPR the reason for surgery could be found in all but two cases. Thereby the reason for surgery can be studied in 222 cases. Each case is permitted to have only one reason. When more than one reason for surgery was present the reason for surgery was chosen accordingly: fracture was chosen over osteoarthritis; arthritis was chosen over osteoarthritis; instability was chosen over both arthritis and osteoarthritis; luxation/subluxation was chosen over both arthritis, instability and osteoarthritis; every other reason was chosen over pain.

Table 2: Reason for performing SPR (222 cases).

Cause	**Number**	**Prop. (%)**	**95% CI (%)**
Arthritis	6	2.70	0.57 - 4.83
Contracture	4	1.80	0.05 - 3.55
Fracture	1	0.45	0.00 - 1.33
Instability	7	3.15	0.85 - 5.45
Luxation/Subluxation	20	9.01	5.25 - 12.77
Osteoarthritis	148	66.67	60.48 - 72.86
Pain	36	16.22	11.38 - 21.06

Arthritis: Out of these six cases all patients were diagnosed with Rheumatoid Arthritis (RA) whereof one was also diagnosed with Bechterew's disease. Five of them had a femuropatellar osteoarthritis on X-ray.

Contracture: These four cases were all suffering from a restrained range of motion. In addition to the SPR two of these cases were revised with a partial synovectomy and the other two with an excision of fibrosis.

Fracture: In this case the X-ray showed a longitudinal fracture of the patella along with a femuropatellar osteoarthritis.

Instability: Out of these seven cases two had a femuropatellar osteoarthritis on X-ray whereof one patient was diagnosed with SLE. Three other patients were diagnosed with RA whereof one patient also had Sjögren syndrome.

In five of the cases a change to a higher plastic component in the femurotibial joint was performed in addition to the SPR.

Luxation/subluxation: Out of these 20 cases where the reason for surgery was either luxation or subluxation of the patella seven had a complete luxation while thirteen had a subluxation. One of the patients suffering from subluxation was diagnosed with RA and one patient had already been revised a multitude of times due to infection.

Osteoarthritis: Out of the 148 cases that were revised due to femuropatellar osteoarthritis X-ray images were found of the femuropatellar joint prior to corresponding surgery with TKA in 141 cases. In 52 of these 141 cases, corresponding to

36.9% (95% CI: 28.9 - 44.8), the patient already had a femuropatellar osteoarthritis on X-ray prior to their TKA.

Pain: Out of the 36 cases where the only reason for surgery was pain X-ray images were found prior to corresponding TKA in 29 cases. In five of these cases, corresponding to 17.2% (95% CI: 3.5% - 30.9%), the patients had a femuropatellar osteoarthritis on X-ray prior to their TKA.

5.3 Re-revisions

Out of the 224 SPR cases included in this study 27 patients required at least one re-revision. Table 3 shows the reason for performing re-revision where the dominating reason was infection.

Figure 2 shows the Kaplan-Meier estimator of time-to-re-revision for SPR patients and a steep drop can be observed within the first year where-after the curve flattens out a bit. Table 4 shows that an absolute majority of the re-revisions performed within one year of the SPR were performed due to infection.

Table 3: Reason for performing first re-revision after SPR (27 cases).

Cause	**Number**	**Prop. (%)**	**95% CI (%)**
Limited range of motion	1	3.70	0.00 - 10.82
Loosening of prosthesis	3	11.11	0.00 - 22.96
Infection	15	55.56	36.82 - 74.30
Instability	5	18.52	3.87 - 33.17
Pain	3	11.11	0.00 - 22.96

Table 4: Re-revision status one year, five years respective ten years after SPR.

(a) All re-revisions.

	1 year	**5 years**	**10 years**
Number	14	21	27
Prop. (%)	6.25	9.38	12.05
95% CI (%)	3.08 - 9.42	5.57 - 13.19	7.79 - 16.31

(b) Re-revisions due to infection.

	1 year	**5 years**	**10 years**
Number	12	15	15
Prop. (%)	5.36	6.70	6.70
95% CI (%)	2.41 - 8.31	3.43 - 9.97	3.43 - 9.97

In five out of the 27 cases that had undergone re-revision after SPR more than one re-revision was performed (table 5). Table 6 shows that in three of these cases

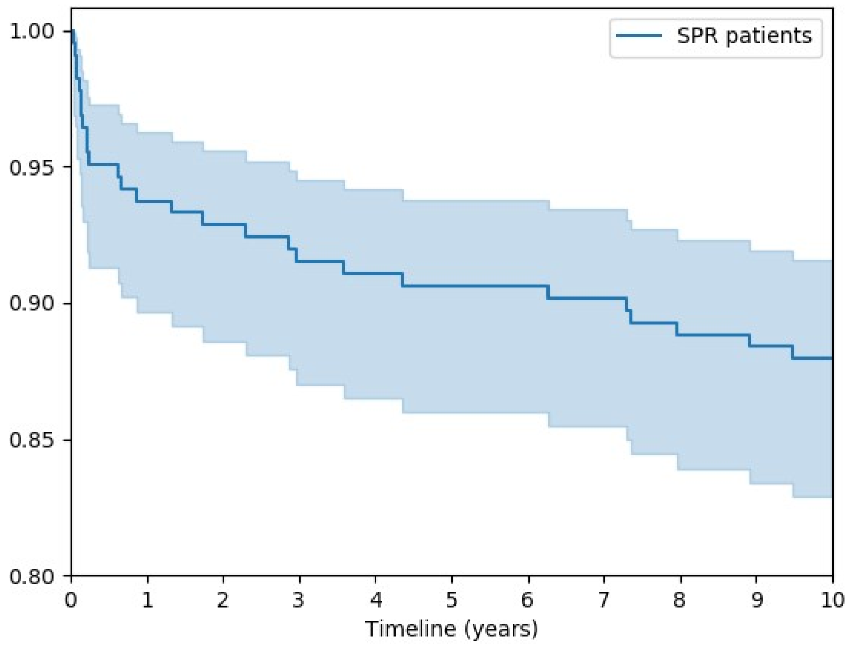


Figure 2: Kaplan-Meier estimator of time-to-re-revision for SPR patients.

two re-revisions were required (table 6c, 6d and 6e), in one case four re-revisions was performed (table 6b) and in another case six re-revisions was performed (table 6a). These cases show difficult postoperative courses that extends over at least a year and in some cases two or three years.

Table 5: Number of cases that has been re-revised a certain number of times after SPR (27 cases).

Number of re-revisions	Number of cases
1	22
2	3
4	1
6	1

Table 6: Individual study of courses after SPR for those cases requiring more than one re-revision.

(a) A case with six re-revisions.

Surgery	**Date**	**Cause**
TKA	2004-06-02	Osteonecrosis
SPR	2016-03-15	Osteoarthritis
1:st re-revision	2016-06-02	Instability
2:nd re-revision	2016-06-08	Infection
3:rd re-revision	2016-06-20	Infection
4:th re-revision	2017-11-30	Instability
5:th re-revision	2019-09-07	Infection
6:th re-revision	2019-09-25	Infection

(b) A case with four re-revisions.

Surgery	**Date**	**Cause**
TKA	2014-02-26	Osteoarthritis
SPR	2017-12-12	Osteoarthritis
1:st re-revision	2018-02-07	Infection
2:nd re-revision	2018-02-21	Infection
3:rd re-revision	2018-12-06	Infection
4:th re-revision	2019-09-04	Infection

(c) A case with two re-revisions.

Surgery	**Date**	**Cause**
TKA	2016-09-23	Osteoarthritis
SPR	2018-08-28	Osteoarthritis
1:st re-revision	2018-09-11	Infection
2:nd re-revision	2019-05-23	Infection

(d) A case with two re-revisions.

Surgery	**Date**	**Cause**
TKA	2016-01-18	Osteonecrosis
SPR	2018-09-19	Osteoarthritis
1:st re-revision	2019-05-20	Infection
2:nd re-revision	2019-09-17	Infection

(e) A case with two re-revisions.

Surgery	**Date**	**Cause**
TKA	2017-07-12	Osteoarthritis
SPR	2018-11-12	Osteoarthritis
1:st re-revision	2019-06-25	Infection
2:nd re-revision	2020-01-14	Infection

5.4 Time between surgeries

Table 7 shows that the mean time from TKA to SPR is 2.8 years and in median 1.9 years. Moreover, 75% out of these 224 cases was revised with SPR within 3.2 years after TKA was performed.

Regarding the time from revision with SPR to corresponding first re-revision the mean time is 2.6 years and in median 0.9 years. Moreover 75% of these 27 cases were re-revised within 3.2 years after their corresponding SPR.

Table 7: Time between surgeries.

	TKA to SPR (224 cases)		**SPR to first re-revision (27 cases)**	
	In days	**In years**	**In days**	**In years**
Mean	1008.8	2.8	947.8	2.6
SD	904.0	2.5	1130.6	3.1
Lowest value	141	0.4	14	0.0
1:st quartile	485.0	1.3	55.0	0.2
2:nd quartile	708.0	1.9	315.0	0.9
3:rd quartile	1159.0	3.2	1449.5	4.0
Highest value	5095	13.9	3464	9.5

5.5 Patient reported outcome measures

The impact of SPR on Patient Reported Outcome Measures (PROM) is investigated by comparing Charnley category, Knee injury and Osteoarthritis Outcome scale (KOOS), pain (VAS) and state of health (VAS) before and one year after SPR. Self-assessed satisfaction (VAS) one year after SPR is also presented.

5.5.1 Charnley category

Table 8 shows the Charnley categorizing for cases revised with SPR. Before surgery data was found in 54 cases (table 8a) and one year after surgery data was found in 88 cases (table 8b). Since the confidence intervals overlap between before surgery and one year after surgery for all Charnley categories no statistically significant difference can be seen after surgery compared to before surgery.

Table 8: Charnley category for cases revised with SPR.

(a) Before surgery (54 cases).

Charnley category	**Number**	**Prop. (%)**	**95% CI (%)**
A	12	22.2	11.1 - 33.3
B	3	5.6	0.0 - 11.7
B1	2	3.7	0.0 - 8.7
B2	6	11.1	2.7 - 19.5
C	31	57.4	44.2 - 70.6

(b) One year after surgery (88 cases).

Charnley category	**Number**	**Prop. (%)**	**95% CI (%)**
A	13	14.8	7.4 - 22.2
B	3	3.4	0.0 - 7.2
B1	3	3.4	0.0 - 7.2
B2	11	12.5	5.6 - 19.4
C	58	65.9	56.0 - 75.8

5.5.2 KOOS

Data regarding the KOOS has been found before and one year after SPR in 21 cases. The differences between before SPR and one year after are illustrated in table 9 and figure 3.

Pain: Here the mean score is 43.3 before surgery (table 9a) and 58.7 one year after surgery (table 9b). This is an improvement by 15.4 that is statistically significant ($P = 0.016$). For reference, the minimal detectable change for this variable on an individual level is considered to be 6-6.1.[8]

Symptoms: Here the mean score is 57.4 before surgery (table 9a) and 68.2 one year after surgery (table 9b). This is an improvement by 10.8 that is statistically significant ($P < 0.01$). For reference, the minimal detectable change for this variable on an individual level is considered to be 5-8.5.[8]

ADL: Here the mean score is 49.2 before surgery (table 9a) and 61.4 one year after surgery (table 9b). This is an improvement by 12.2 that is statistically significant ($P = 0.012$). For reference, the minimal detectable change for this variable is considered to be 7-8.[8]

Sport: Here the mean score is 5.2 before surgery (table 9a) and 19.3 one year after surgery (table 9b). This is an improvement by 14.1 that is statistically significant ($P < 0.01$). For reference, the minimal detectable change for this variable on an individual level is considered to be 5.8-12.[8]

QOL: Here the mean score is 20.4 before surgery (table 9a) and 47.5 one year after surgery (table 9b). This is an improvement by 27.1 that is statistically significant ($P < 0.01$). For reference, the minimal detectable change for this variable on an individual level is considered to be 7-7.2.[8]

Accordingly there is a detectable and statistically significant improvement regarding all variables in KOOS one year after surgery compared to before surgery.

Table 9: KOOS data related to SPR (21 cases).

(a) Before surgery.

	Pain	**Symptoms**	**ADL**	**Sport**	**QOL**
Mean	43.3	57.4	49.2	5.2	20.4
Median	44.0	57.0	49.0	5.0	25.0
SD	13.7	13.5	12.1	6.4	11.7

(b) One year after surgery.

	Pain	**Symptoms**	**ADL**	**Sport**	**QOL**
Mean	58.7	68.2	61.4	19.3	47.5
Median	55.0	68.0	59.0	10.0	44.0
SD	27.6	22.4	23.5	26.4	24.4

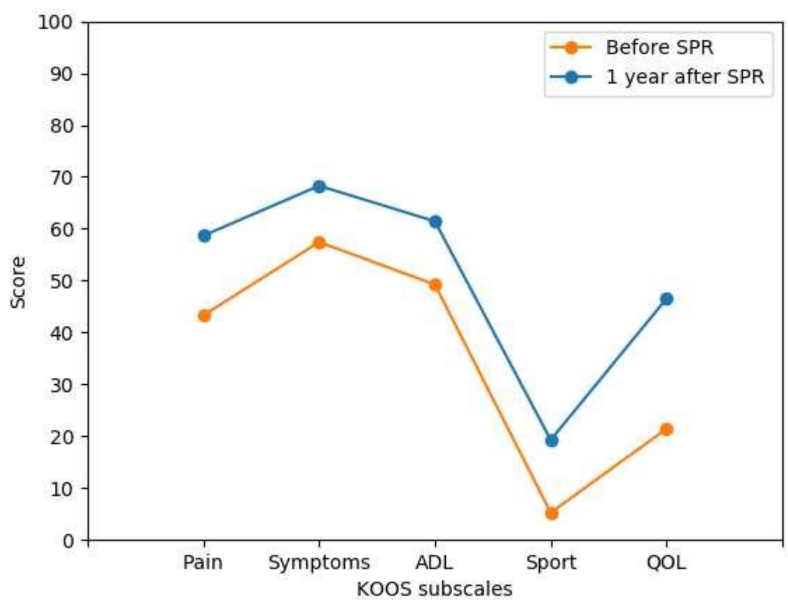


Figure 3: KOOS scores before respective one year after SPR.

Table 10 shows the demographics of the 21 patients with available KOOS data. The demographics data are complete except for one patient missing data for surgical duration and two patients missing data for BMI. There are no great differences compared to the demographics for the whole population (see table 1) except for a slightly longer surgical duration and a longer wait for surgery. The patients had their SPR between the years 2006 to 2018. None of them had undergone re-revision one year after SPR. One of these patients, 4.8% (95% CI: 0.0% - 13.9%), had undergone re-revision five years after SPR and two of them, 9.5% (95% CI: 0.0% - 22.1%), had been re-revised after ten years.

Table 10: Demographics for SPR patients with available KOOS data (21 cases).

(a) Categorical variables.

	Number	Prop. (%)	95% CI (%)
ASA class			
ASA 1	5	23.81	5.60 - 42.02
ASA 2	12	57.14	35.98 - 78.30
ASA 3	4	19.05	2.26 - 35.84
ASA 4	0	0	-
Laterality			
Left	10	47.62	26.26 - 68.98
Right	11	52.38	31.02 - 73.74
Sex			
Men	12	57.14	35.98 - 78.3
Women	9	42.86	21.70 - 64.02

(b) Continuous variables.

	Mean	Median	SD
Age (years)	65.3	66.0	10.4
BMI	31.9	32.4	4.2
Surgical duration (minutes)	65.7	54.5	28.4
Wait for surgery (days)	162.5	126.0	136.6

5.5.3 Pain

Data regarding self-assessed pain according to VAS has been found both before and one year after surgery in 28 cases of revision with SPR (table 11). Before surgery the mean is 6.2 (table 11a) and after surgery 4.2 (table 11b). This is a statistically significant improvement by 2.1 ($P < 0.01$). The minimal detectable change for measuring osteoarthritis-related pain is considered to be 0.08.[1]

Table 12 shows the demographics for these 28 patients, the data are complete except for one case missing surgical duration and for five cases missing BMI. There are no great differences compared to the demographics for the whole population (table 1) except for a slightly longer surgery duration and a longer wait for surgery. The patients had their SPR between the years 2006 to 2018. None of them had undergone re-revision one year after SPR. One of these patients, 3.57% (95% CI: 0.0% - 10.4%), had undergone re-revision five years after SPR and two of them, 7.1% (95% CI: 0.0% - 16.7%), had been re-revised after ten years.

Table 11: Self-assessed pain (VAS) related to SPR (28 cases).

(a) Before surgery.

	Pain (VAS)
Mean	6.24
Median	5.90
SD	1.48

(b) One year after surgery.

	Pain (VAS)
Mean	4.15
Median	4.00
SD	2.45

Table 12: Demographics for SPR patients with available pain (VAS) data (28 cases).

(a) Categorical variables.

	Number	Prop. (%)	95% CI (%)
ASA class			
ASA 1	5	17.86	3.68 - 32.04
ASA 2	18	64.29	46.54 - 82.04
ASA 3	5	17.86	3.68 - 32.04
ASA 4	0	0	-
Laterality			
Left	12	42.86	24.53 - 61.19
Right	16	57.14	38.81 - 75.47
Sex			
Men	13	46.43	27.96 - 64.90
Women	15	53.57	35.10 - 72.04

(b) Continuous variables.

	Mean	Median	SD
Age (years)	65.7	66.5	9.6
BMI	32.2	32.4	4.1
Surgical duration (minutes)	64.5	57.0	25.3
Wait for surgery (days)	146.7	119.0	127.9

5.5.4 State of health

Data regarding self-assessed state of health (VAS) has been found in 28 cases of revision with SPR (table 13). Before surgery the mean is 6.9 (table 13a) and one year after surgery 6.1 (table 13b). This difference is not statistically significant ($P = 0.77$).

Table 13: Self-assessed state of health (VAS) related to SPR (28 cases).

(a) Before surgery.

	State of health (VAS)
Mean	5.94
Median	6.15
SD	2.11

(b) One year after surgery.

	State of health (VAS)
Mean	6.13
Median	6.10
SD	2.61

5.5.5 Satisfaction

Data regarding self-assessed (VAS) satisfaction with surgery one year after revision with SPR has been found in 87 cases (table 14). The mean is 4.6 (95% CI: 3.9 - 5.3). The average patient is thus neither satisfied nor dissatisfied.

Table 14: Self-assessed satisfaction (VAS) with surgery one year after SPR (87 cases).

	Satisfaction (VAS)
Mean	4.56
Median	4.00
SD	3.33

Table 15 shows the demographics for these 87 patients. The demographics data are complete regarding age, laterality, sex and wait for surgery. Data are missing in one case regarding surgical duration, in two cases regarding ASA class and in 22 cases regarding BMI. No great difference can be seen compared to the demographics of the whole population (table 1) except for a slightly longer surgical duration and a longer wait for surgery. The patients had their SPR between the years 2004 to 2018. Four of them, corresponding to 4.6% (95% CI: 0.2% - 9.0%), had undergone re-revision one year after SPR; nine, corresponding to 10.3% (95% CI: 3.9% - 16.7%), had undergone re-revision five years after SPR and ten, corresponding to 11.5% (95% CI: 4.6% - 18.2%), had undergone re-revision ten years after SPR.

Table 15: Demographics for SPR patients with available satisfaction (VAS) data (87 cases).

(a) Categorical variables.

	Number	Prop. (%)	95% CI (%)
ASA class			
ASA 1	14	16.47	8.59 - 24.35
ASA 2	57	67.06	57.07 - 77.05
ASA 3	14	16.47	8.59 - 24.35
ASA 4	0	0	-
Laterality			
Left	47	54.02	43.55 - 64.49
Right	40	45.98	35.51 - 56.45
Sex			
Men	39	44.83	34.38 - 55.28
Women	48	55.17	44.72 - 65.62

(b) Continuous variables.

	Mean	Median	SD
Age (years)	66.3	61.0	9.0
BMI	29.3	29.1	4.3
Surgical duration (minutes)	65.6	58.5	24.6
Wait for surgery (days)	134.1	97.0	113.7

5.6 Factors influencing risk of re-revision

In order to identify possible factors influencing the risk of re-revision after SPR logistic regression has been performed to compute odds ratios and Cox regression has been performed to compute hazard ratios, simultaneously checking for statistical significance. The dependent variable being "re-revision: yes or no" evaluated after three different time spans; one year, five years respective ten years after SPR was performed. The independent variables analyzed are age, ASA class, BMI, laterality, sex, surgical duration and wait for surgery. All values of independent variables taken from the time of SPR.

An attempt was made to include "reason for SPR" as an independent variable in a simple logistic regression but it was excluded due to failure of convergence.

5.6.1 Age

No statistically significant impact of age on the risk of re-revision at any of the evaluation times has been found (table 16).

Table 16: Odds- and hazard ratios depending on age at time of SPR. Evaluating re-revision status at 1 year, 5 years respective 10 years after SPR.

	1 year after SPR	**5 years after SPR**	**10 years after SPR**
Odds ratio	0.98	0.99	0.98
95% CI	0.93 - 1.04	0.94 - 1.04	0.93 - 1.02
P-value	0.61	0.65	0.29
Hazard ratio	0.99	0.99	0.98
95% CI	0.93 - 1.04	0.94 - 1.04	0.94 - 1.02
P-value	0.62	0.65	0.30

5.6.2 ASA class

Table 17 shows the odds ratios and table 18 the hazard ratios evaluating the risk of re-revision when belonging to ASA 2 and ASA 3 compared to ASA 1. As the whole population only included one patient of ASA class 4, this ASA class has been excluded from the analysis.

Regarding ASA 2 no statistically significant difference can be seen compared to ASA 1 regarding either odds- or hazard ratios. ASA 3 patients, however, seems to be significantly more likely to undergo re-revision within one year compared to ASA 1 patients, odds ratio 10.7 (95% CI: 1.2 - 92.4) and hazard ratio 9.3 (95% CI: 1.2 - 75.9). This holds also within five years after SPR, odds ratio 6.2 (95% CI: 1.2 - 31.9) and hazard ratio 5.6 (95% CI: 1.2 - 26.3). When evaluating at ten years after SPR however, the statistical significance vanishes and the strong assumption of proportionality of the hazard ratio ceases to hold.

Table 17: Odds ratios depending on ASA class at time of SPR. Evaluating re-revision status at 1 year, 5 years respective 10 years after SPR.

	Odds ratio	**95% CI**	**P-value**
1 year after SPR			
ASA 2	1.52	0.18 - 13.05	0.70
ASA 3	10.65	1.23 - 92.40	0.03
5 years after SPR			
ASA 2	1.41	0.30 - 6.64	0.67
ASA 3	6.18	1.20 - 31.86	0.03
10 years after SPR			
ASA 2	0.50	0.17 - 1.41	0.19
ASA 3	1.82	0.55 - 5.99	0.33

Table 18: Hazard ratios depending on ASA class at time of SPR. Evaluating re-revision status at 1 year, 5 years respective 10 years after SPR.

	Hazard ratio	95% CI	P-value
1 year after SPR			
ASA 2	1.48	0.18 - 12.30	0.72
ASA 3	9.34	1.15 - 75.94	0.04
5 years after SPR			
ASA 2	1.37	0.30 - 6.17	0.68
ASA 3	5.61	1.19 - 26.31	0.03
10 years after SPR			
ASA 2	0.54	0.20 - 1.40	0.21
ASA 3	1.88	0.65 - 5.42	0.24

5.6.3 BMI

No statistically significant impact of BMI on the risk of re-revision at any of the evaluation times has been found (table 19).

Table 19: Odds- and hazard ratios depending on BMI at time of SPR. Evaluating re-revision status at 1 year, 5 years respective 10 years after SPR.

	1 year after SPR	5 years after SPR	10 years after SPR
Odds ratio	1.06	1.05	1.04
95% CI	0.93 - 1.22	0.92 - 1.19	0.93 - 1.17
P-value	0.38	0.47	0.52
Hazard ratio	1.06	1.05	1.04
95% CI	0.93 - 1.21	0.93 - 1.17	0.93 - 1.15
P-value	0.37	0.46	0.50

5.6.4 Sex

Table 20 shows a significant impact of sex on the risk of re-revision at all of the evaluation times. One year after SPR the odds ratio is 9.6 (95% CI: 2.1 - 40.0), meaning the odds are 9.6 times higher for men than for women to have undergone re-revision at this time. Similarly, the hazard ratio is 8.9 (95% CI: 2.0 - 40.0), meaning 8.9 times greater risk of undergoing re-revision. Five years after SPR the odds ratio is 5.2 (95% CI: 1.8 - 14.9) and hazard ratio 4.9 (95% CI: 1.8 - 13.3) and ten years after SPR the odds ratio is 6.1 (95% CI: 2.3 - 15.8) and hazard ratio 5.5 (95% CI: 2.2 - 13.6).

Table 20: Odds- and hazard ratios depending on sex (men compared to women). Evaluating re-revision status at 1 year, 5 years respective 10 years after SPR.

	1 year after SPR	**5 years after SPR**	**10 years after SPR**
Odds ratio	9.56	5.24	6.08
95% CI	2.08 - 43.80	1.84 - 14.87	2.34 - 15.75
P-value	< 0.005	< 0.005	< 0.001
Hazard ratio	8.93	4.89	5.47
95% CI	1.99 - 40.04	1.79 - 13.33	2.20 - 13.60
P-value	< 0.005	< 0.005	< 0.005

5.6.5 Laterality

No statistically significant impact of laterality on the risk of re-revision at any of the evaluation times has been found (table 21).

Table 21: Odds- and hazard ratios depending on laterality (left compared to right). Evaluating re-revision status at 1 year, 5 years respective 10 years after SPR.

	1 year after SPR	**5 years after SPR**	**10 years after SPR**
Odds ratio	2.19	1.76	1.49
95% CI	0.66 - 7.2	0.68 - 4.54	0.65 - 3.42
P-value	0.20	0.24	0.35
Hazard ratio	2.14	1.72	1.47
95% CI	0.67 - 6.82	0.70 - 4.26	0.67 - 3.22
P-value	0.20	0.24	0.33

5.6.6 Surgical duration

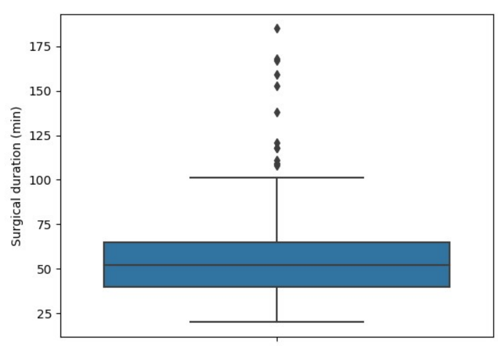
Table 22 shows a statistically significant impact of surgical duration on the risk of re-revision with both an odds ratio and a hazard ratio of 1.02 (95% CI: 1.01 - 1.03) both five and ten years after SPR. One year after SPR the odds ratio and hazard ratio both are 1.02 (95% CI: 1.00 - 1.03). Since the CI in this case includes 1.00 it is not possible to say with certainty that the surgical duration has any impact on the risk of re-revision one year after SPR.

An odds ratio of 1.02 would mean that each minute of prolonged surgical duration would increase the odds of re-revision by a factor of 1.02. For example, a ten minutes increase in surgical time would increase the odds of re-revision by a factor of 1.22. A hazard ratio of 1.02 would mean that a one minute of prolonged surgery increases the risk of re-revision by 1.02.

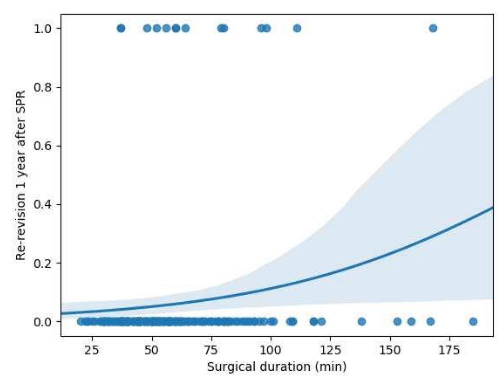
Figure 4 shows an analysis of the simple logistic regression model used to estimate the odds ratio of surgical duration. The box plot in figure 4a shows the occurrence of a multitude of statistically significant outliers, also to be seen in figure 4b, 4c and 4d. These figures also show that the surgical duration is linearly related to the log odds of the dependent variable in all three cases.

Table 22: Odds- and hazard ratios depending on surgical duration of SPR. Evaluating re-revision status at 1 year, 5 years respective 10 years after SPR.

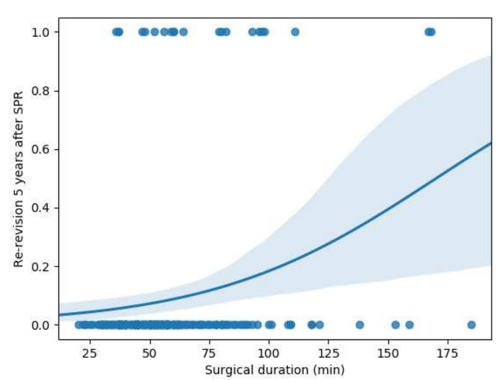
	1 year after SPR	**5 years after SPR**	**10 years after SPR**
Odds ratio	1.02	1.02	1.02
95% CI	1.00 - 1.03	1.01 - 1.03	1.01 - 1.03
P-value	0.02	< 0.005	< 0.005
Hazard ratio	1.02	1.02	1.02
95% CI	1.00 - 1.03	1.01 - 1.03	1.01 - 1.03
P-value	0.02	< 0.005	< 0.005



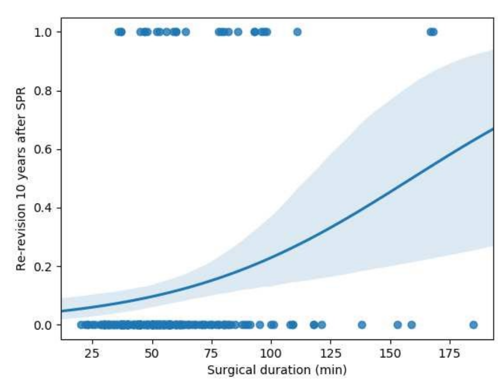
(a) Box plot of surgical duration for SPR.



(b) Log odds linear plot of surgical duration for SPR with re-revision status evaluated one year after SPR.



(c) Log odds linear plot of surgical duration for SPR with re-revision status evaluated five years after SPR.



(d) Log odds linear plot of surgical duration for SPR with re-revision status evaluated ten years after SPR.

Figure 4: Evaluation of logistic regression model for surgical duration of SPR.

5.6.7 Wait for surgery

No statistically significant impact of wait for surgery on the risk of re-revision at any of the evaluation times has been found (table 23).

Table 23: Odds- and hazard ratios depending on wait for SPR from the decision of surgery was taken. Evaluating re-revision status at 1 year, 5 years respective 10 years after SPR.

	1 year after SPR	**5 years after SPR**	**10 years after SPR**
Odds ratio	1.00	1.00	1.00
95% CI	0.99 - 1.01	0.99 - 1.00	1.00 - 1.00
P-value	0.82	0.86	0.89
Hazard ratio	1.00	1.00	1.00
95% CI	1.00 - 1.01	0.99 - 1.00	1.00 - 1.00
P-value	0.80	0.89	0.87

6 Discussion

This study shows that the dominating reason for performing Secondary Patella Resurfacing (SPR) is osteoarthritis in the femuropatellar joint (66.7%), followed by pain (16.2%) and luxation/subluxation (9.0%). More rare reasons being instability (3.2%), arthritis (2.7%), contracture (1.8%) and fracture (0.5%). Only 36.9% of the osteoarthritis cases and 17.2% of the pain cases showed a femuropatellar osteoarthritis on X-ray prior to their Total Knee Arthroplasty (TKA), indicating X-ray of the femuropatellar joint not being a useful tool to predict which of the patients who will later develop femuropatellar problems leading to SPR. The inability to predict which TKA patients will later require SPR would seem to indicate that the approach of routinely performing primary patella resurfacing along with TKA might be a sound approach. On the other hand, since only a small fraction (1.05%) of all TKA patients in region Skåne during the time period included in this study have ever undergone any form of patella resurfacing such a policy would lead to an overwhelming majority of TKA patients undergoing a patella resurfacing they would not benefit from. Especially since it has been shown that primary resurfacing of the patella provides no general benefits for patients undergoing TKA.[17][19] Thereby, the risks of performing primary patella resurfacing; chiefly the risk of patellar fracture, waste of medical resources and increased exposure time during surgery; has to be weighed against the high risk of re-revision for SPR patients. Weeks et al proposes that primary patella resurfacing along with TKA is cost effective if the revision rate with SPR is greater than 0.5%[33] which would indicate that such an approach might be cost effective considering the population of this study (revision rate of 0.9%). That calculation was, however, based on Canadian healthcare costs[33] and the applicability on Swedish healthcare is therefore not clear.

Table 4 and figure 2 shows that prosthesis survival for SPR is not great; 6.3%, 9.4% respective 12.1% having undergone re-revision within one year, five years respective ten years after SPR. The dominating reason for re-revision are found to be prosthesis infection (55.6%), the majority of these happening within one year after SPR. Other reasons for re-revision are instability (18.5%), pain (11.1%), loosening of prosthesis (11.1%) and limited range of motion (3.7%). A non-negligible proportion of the re-revision-patients (18.5%) have undergone more than one re-revision leading to difficult post-operative courses extending, some times, over years. Thus, SPR can be concluded to be a risky procedure. Due to this study being limited to a finite time period it is reasonable to assume that the long time complications leading to re-revision are somewhat underestimated. The short term complications, however, would be accurately captured.

Table 7 shows that the time between TKA and SPR is relatively short, being 2.8 years in average and 1.9 years i median. This indicates that the problem leading to SPR can be derived from the TKA itself. What this problem might be can not be discerned by this study, the only finding regarding this is that there is a high rate of progression of femuropatellar osteoarthritis from the time of TKA to the SPR. A possible problem might be valgus malalignment in the knee joint displacing the patella laterally and possibly causing increased wear and/or instability in the femuropatellar joint. Other problems might originate in an erroneous positioning of the femur- or tibial component of the total knee prosthesis. For example, Bhattee et al proposes that a malrotation of the femur component in the total knee prosthesis might affect patient satisfaction with SPR.[2]

It would be interesting to investigate connections between discrepancies in the total knee prosthesis and occurrence of SPR but in order to examine this one would need to perform a CT to measure, for example, the Q angle after TKA has been performed which is outside the scope of this study. Some attempts have been made to analyze what factors can possibly predict which TKA patients will later undergo SPR. For example, Roessler et al propose that patella tilt, patella height, patella thickness and the delta angle might be possible such predictors.[27]

This study finds that patients belonging to ASA 3 are more likely to be re-revised than ASA 1 patients, the odds ratios being 10.65 (95% CI: 1.2 - 92.4) respective 6.18 (95% CI: 1.2 - 31.9) and hazard ratios being 9.3 (95% CI: 1.2 - 75.9) and 5.6 (95% CI: 1.2 - 26.3) at one year respective five years after SPR. This effect could not be found at ten years after SPR. Other research have found ASA class to have a strong, independent associations with post-operative medical complications and mortality across procedures.[12] This is not the same, however, as claiming ASA class having impact on the revision rate for surgical procedures. Phan et al have found that a higher ASA class was shown to increase the risk of 30-day readmissions for patients undergoing anterior cervical discectomy and fusion.[24] The comparability of Phan et al to this study can be put in question as spine surgery and knee arthroplasty are two different surgical procedures. Especially since Donegan et al have found ASA class to be related to perioperative problems in hip fracture surgery but could find no infuence of ASA class on postoperative complications.[9]

The odds of undergoing re-revision have been found to be significantly greater for men compared to women, the odds ratios being 9.6 (95% CI: 2.1 - 43.8), 5.2 (95% CI: 1.8 - 14.9) respective 6.1 (95% CI: 2.3 - 15.8) at one year, five years respective ten years after SPR. The hazard ratios were found to be 8.9 (95% CI: 2.0 - 40.0), 4.9 (95% CI: 1.8 - 13.3) respective 5.5 (95% CI: 2.2 - 13.6) at one year, five years respective ten years after SPR. The reason for this difference between sexes can not be discerned in this study. A possible reason could be differences in compliance regarding postoperative physiotherapy, but Sluijs et al could find no such difference in their study.[30] Although Katz et al found a difference in improvement for orthopedic surgery, where women improved more than men, they could not find any difference regarding postoperative complications.[15] Morris et al found that men are more likely to suffer from postoperative complications than women after undergoing colorectal surgery.[22] This is, however, a very different procedure compared to SPR.

Surgical duration for SPR has also been found to significantly increase the risk of re-revision within five and ten years after SPR, the odds ratios and hazard ratios both being 1.02 (95% CI: 1.01 - 1.03) at both times. There is possibly an impact also at one year after SPR, odds ratio and hazard ratio both being 1.02 (95% CI: 1.00 - 1.03), but since the CI includes 1.00 it can not be said with certainty. The finding in itself is not surprising since prolonged exposure time during surgery has been found to increase the risk of infection.[7] However, the validity of the finding should be questioned since figure 4 shows the occurrence of a multitude of outliers. The impact of these outliers on the logistic regression are unclear. It is reasonable to believe that since there are relatively few patients who have been re-revised, one outlier would be able to disturb the logistic regression. In order to say something with certainty one would need to analyze a larger population.

No significant impact on the risk of re-revision has been found for any of the independent variables age, BMI, laterality or wait for surgery.

This study finds a statistically significant improvement regarding all variables in Knee injury and Osteoarthritis Outcome scale (KOOS) between before SPR and one year after (table 9 and figure 3). The validity of this result should, however, be questioned due to the occurrence of available data in only 21 cases. Although this sub-population captures the demographics of the whole population reasonably well, none of these patients have been re-revised within one year after their SPR, which is the time of KOOS evaluation. Thus it is reasonable to believe that the improvement regarding KOOS scores are somewhat overestimated.

There is also a statistically significant improvement regarding self-assessed pain (VAS) between before SPR until one year after SPR (table 11). This result should, however, also be questioned as this analysis too suffers from loss of data (only 28 cases). The demographics of this sub-population captures the demographics of the whole population reasonably well but also in this case none of the patients had re-revision within one year after SPR. Thus, this is probably also an overestimation of the effect of performing SPR. It has been found though, that SPR significantly improves anterior knee pain, rendering this finding not unreasonable.[23] On the other hand, however, Mockford et al found that the success rate was poor for easing anterior knee pain in SPR patients.[21]

The average self-assessed satisfaction (VAS) of SPR patients was found to be 4.6, which is to say that in general they were neither satisfied nor dissatisfied with the procedure. There is also a large spread which would indicate that the procedure was successful in some cases and unsuccessful in other cases, making this a surgical procedure with unpredictable outcome. This is in line with other reasearh.[18][23][31] Although there was a considerable loss of data also in this case (87 cases available), the demographics for this sub-population captures the demographics of the whole population relatively well and the rate of re-revisions one year after SPR was 4.6% compared to 6.3% for the entire population. Thus it is reasonable to believe this result to be somewhat accurate.

This study was unable to find any significant difference in Charnley category or self-assessed state of health one year after compared to before SPR.

The main strength of this study lies in the level of detail provided regarding cause of surgery for SPR cases and description of re-revised cases. Also, a relatively large amount of cases was included in the study providing a sound basis for studying a relatively uncommon surgery. This study's main weakness is the lack of complete data regarding several of the demographic variables used in the logistic regression and regarding all of the PROMs used to analyze subjective improvement from before to one year after SPR. The design of this study is also a weakness in itself, descriptive case-series considered the weakest study design.

7 Conclusions and implications

The progression of femuropatellar osteoarthritis is the dominating reason (66.7%) for performing SPR. This progression is found hard to predict from X-ray images prior to TKA which makes it difficult to indicate which patients would benefit from undergoing a primary patella resurfacing along with the TKA.

This study finds that the prosthesis survival of SPR is not great, with a high risk of re-revision; 6.3%, 9.4% respective 12.1% at one year, five years respective ten years after SPR. Thus SPR can be concluded to be a risky procedure.

Since most patients undergoing TKA in region Skåne during the time period included in this study never undergo patella resurfacing of any kind, the policy of performing primary patella resurfacing along with TKA in all cases would mean exposing 98.95% of the TKA patients to prolonged exposure time during surgery and an increased risk of patellar fracture as well as wasting healthcare resources. Thus, the policy used in region Skåne, performing primary patella resurfacing only in special cases, seems to be the right course. However, since there is a high risk of complications when performing SPR, it would be preferable if it was possible to discern which of the TKA patients that will later undergo SPR and resurface the patella primarily in these cases.

This study is, however, not designed to be able to fully predict which of the TKA patients who will later undergo revision with SPR. Such a study could possibly be performed using the available patient data from region Skåne but would preferably have the study design of a case-control-study, include a greater number of patients in total and is outside the scope of this study.

The risk of undergoing re-revision after SPR have been found to be significantly impacted by sex, showing an increased risk for men compared to women, thus raising the question if this surgery is really appropriate for men.

Prolonged surgical duration during SPR has been found to possibly increase the risk of re-revision. Although statistically significant and supported by other research[7] this result must be questioned due to outliers possibly impacting the statistical analysis.

Patients belonging to ASA class 3 seem to be more likely to undergo re-revision within five years after SPR compared to ASA 1 patients.

This study shows a significant improvement regarding all variables in KOOS and a significant easement of self-assessed pain (VAS) one year after SPR compared to before the surgery. Although these findings probably overestimate the improvements by SPR it indicates that, at least for some patients, SPR is beneficial. Patients must, however, be chosen with care as the risks associated with undergoing SPR have been found in this study to be substantial.

An interesting direction for future research might be to perform CT on SPR patients in order to analyse whether these patients have a valgus malalignment in the knee or there is a sub-optimal rotation of either the femur- or the tibial component of the total knee prosthesis that can possibly explain why they undergo SPR.

8 Populärvetenskaplig sammanfattning

Anledningar till- och utfall av att utföra knäskålsoperation sekundärt till helprotes i knä

När man opererar ett knä med protesdelar på både lårbenssidan och underbenssidan, en s.k. helprotes, är det möjligt att även montera på en plastkomponent på insidan av knäskålen. Anledningen till att göra detta är exempelvis en minskad broskmängd (artros) i knäskålens led eller för att få knäskålen att leda bättre mot den underliggande lårbensytan.[17][20][28]

Då man ser att vissa patienter kommer att opereras för sin knäskål i ett senare skede så frågar man sig inom forskningsfältet om man bör operera knäskålen på alla patienter som får knäprotes eller inte. Detta har länge varit en pågående diskussion inom forskningsfältet och det finns idag ingen forskning som säger om det är rätt eller fel att göra detta.[17] På grund av detta inriktar sig denna studie på att studera de patienter som har opererats för sin knäskål i efterhand för att undersöka varför de blev opererade, om de blev bättre efter sin operation och vilka komplikationer som uppstått.

Denna studie visar att en absolut majoritet har genomgått operationen på grund av artros i leden mellan knäskålen och lårbenet. En relativt stor andel av patienterna har drabbats av komplikationer som lett till ytterligare operationer; 6,3%, 9.4% respektive 12,1% har genomgått omoperation ett år, fem år respektive tio år efter knäskålsoperationen. Risken att omopereras verkar vara större för män än för kvinnor, den verkar öka för längre knäskålsoperationer den är större för patienter med allvarliga sjukdomar. Patienterna uppvisar generellt en viss förbättring efter knäskålsoperation, men spridningen på individuell nivå är stor och patienterna förefaller i genomsnitt vara varken nöjda eller missnöjda med operationen.

Att rutinmässigt operera knäskålen på alla patienter som genomgår operation med helprotes i knä kan möjligen vara motiverat p.g.a. den stora komplikationsrisken om man opererar knäskålen i ett senare skede. Emellertid opereras 98.95% av all patienter som genomgår helprotes i knä aldrig någon knäskålsoperation och man skulle i så fall utsätta en absolut majoritet av patienterna för en operation som de inte har någon nytta av och de risker som detta medför, framförallt frakturer i knäskålen och infektioner. Därmed förefaller det rimligt att bara operera knäskålen primärt i vissa utvalda fall. Det skulle dock vara fördelaktigt att kunna förutse vilka patienter som senare kommer att opereras för knäskålen för att kunna operera dessa patienter primärt. Något sätt att förutse detta på har emellertid inte kunnat hittas i denna studie, men vore en intressant inriktning för framtida forskning.

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