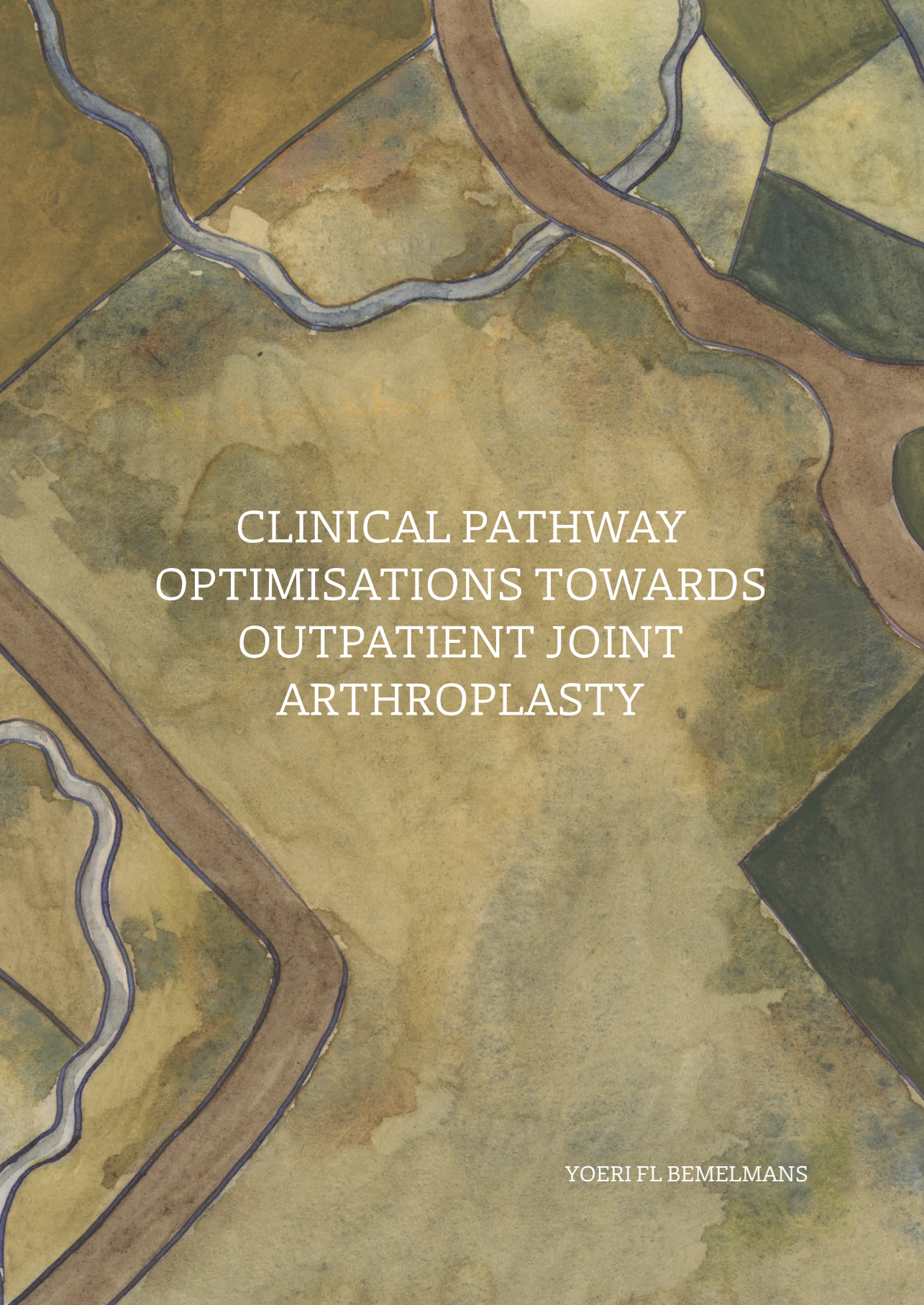

CLINICAL PATHWAY OPTIMISATIONS TOWARDS OUTPATIENT JOINT ARTHROPLASTY

YOERI FL BEMELMANS

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CLINICAL PATHWAY OPTIMISATIONS TOWARDS OUTPATIENT JOINT ARTHROPLASTY

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Table of contents

CHAPTER 1

GENERAL INTRODUCTION

General introduction

Osteoarthritis (OA) is one of the most common forms of arthritis and chronic disease of the hip and knee joints [1]. It is affecting millions of people worldwide and is projected to increase even more due to ageing of the global population. When conservative treatment fails, end-stage OA of the hip and knee joint is commonly treated with arthroplasty surgery. These surgeries have proven to achieve long-lasting improvement of disability and pain symptoms with restoring patients' quality of life [2]. Over the past decades, these arthroplasty procedures are increasingly performed and are expected to increase even more in the upcoming years. Estimations in the United States projected a raise of primary hip arthroplasty up to 174%, and a growth of primary knee arthroplasty with 673% by 2030 [3]. Making these operations one of the most performed and successful surgeries worldwide within orthopaedic care.

Clinical pathways

Over the past decade, hip and knee arthroplasty surgeries evolved rapidly. Minimal invasive techniques were developed, for example patient-specific instruments were introduced, and thereby outcomes after surgery improved [4]. Besides these technical solutions, the optimisation of the 'patient journey' towards this result is becoming more important. Traditionally, patients undergoing hip and/or knee arthroplasty are treated in so-called joint arthroplasty pathways. These pathways are defined as a combination of evidence-based clinical features included in the pre-, peri-, and postoperative protocols, with its aim to streamline the arthroplasty procedure from admission to discharge. The main goals are to reduce mortality, morbidity and to improve (medical and functional) outcome during and after surgery. Ideally, the usage of these pathways results in a decreased length of hospital stay (LOS) and improved patient satisfaction regarding the complete surgical process [5].

From a historical point of view, patients were in the hospital for several weeks after arthroplasty surgery with obligated bed rest for the first days up to several weeks. Patients were then mobilised with restricted weight-bearing during their hospital stay. This resulted in a high level of comorbidities and (serious) adverse events ((S)AEs) regarding arthroplasty surgery (e.g. risk of thrombosis, high percentage of perioperative blood transfusions and extensive use of (opioid) pain medication resulting in postoperative nausea and vomiting (PONV)).

In the late 90's, arthroplasty pathways were optimised. Several introductions were made to prevent for blood transfusions (e.g. autologous transfusion of drain content, preoperative erythropoietin usage), reduce pain experience (e.g. patient controlled

analgesia (PCA)), shorten LOS (e.g. introduction of discharge criteria) and improved patient satisfaction (e.g. involvement of a coach, patient centred care) [6,7]. A less stringent postoperative policy was then introduced, making it able for patients to be mobilised the first day after surgery. These optimisations tremendously changed the in-hospital treatment of arthroplasty patients in terms of postoperative outcomes (e.g. reduction of transfusion rate and thrombo-embolic events, and improvement of pain scores and patient reported outcomes measures (PROMs)) and reduced LOS [8]. The introduction of evidence-based pathways was thereby established as an indispensable factor in the treatment of hip and knee arthroplasty patients.

Fast-track surgery and surgical stress response

As a further development of the previously described pathways, fast-track surgery pathways were introduced in the 21st century [9]. The fast-track philosophy is based on the reduction of the surgical stress response [10]. This response is characterized by activation and changes of several systems. After surgical tissue injury, the nervous system activates the stress response leading to an endocrine response, as well as induction of changes in the immunological and haematological systems with a systemic inflammatory response [11].

To manage and even reduce this response, optimised perioperative protocols are needed to guide the patient through the operative process with minimized effects of surgical stress.

The surgical stress tops within the first days after surgery. Therefore, the first days (even first hours) after surgery are of crucial importance to prevent for (S)AEs. Several crucial optimisations are the basis of an optimised pathway and the reduction of surgical stress, starting preoperatively until the end of the rehabilitation. For example, with the introduction of a multimodal pain protocol, which included a time-based schedule of several non-opioid medications, the consumption and need for opioid medication could be significantly reduced [12]. One of these factors is the usage of local infiltration analgesia (LIA) in knee arthroplasty [13]. Furthermore, systemic glucocorticoids were introduced to prevent for PONV [14]. With a positive side effect on pain reduction, systemic glucocorticoid holds an important role in early discharge. Low-dose spinal anaesthesia or low dose opioid general anaesthesia provided the basics for patients to be mobilised early during the direct postoperative phase. Combined with LIA, patients are able to mobilise safe within several hours after surgery. Which allows to rapidly achieve discharge criteria (e.g. safe mobilisation, walking stairs with crutches if necessary, adequate aids at home) and decreases (S)AEs (e.g. thrombo-embolic events, joint stiffness).

Traditions were thereby ceased; patients were no longer obligated to be in hospital for more than 2 days, based on their medical conditions. To facilitate early mobilisation (and thereby early achievement of these discharge criteria), urinary catheters and closed-suction drainage were no more used on a regular basis but only in case of an adverse course or in patients with pre-existing comorbidities. One of the most remarkable optimisations can be seen in the usage of tranexamic acid (TXA) perioperatively [15,16]. It reduced allogenic blood transfusion dramatically and ruled out the arguments to use autologous blood (re)transfusion via closed-suction drains.

Fast-track surgery pathways are characterised by the multidisciplinary approach to patient care with use of evidence-based protocols [5]. The multidisciplinary team consist of surgeons, anaesthesiologists, hospital pharmacist, nursing staff and physiotherapists on the medical basis, coordinated by a professional project leader and person of contact, such as a physician assistant. Other specialities are involved as well on the more practical side of the process (e.g. managers, planners, secretaries, communication office). Success depends on the collaboration of these different entities as a total process.

Outpatient joint arthroplasty

With the ongoing improvement of the perioperative process and the further reduction in LOS of fast-track surgery programs, outpatient joint arthroplasty (OJA) becomes feasible. Substantiated with an increasing amount of evidence, these OJA pathways are extended to daily practice [17,18,19,20,21]. The introduction of OJA pathways was done on the basics of two major principles. Firstly, due to the growing trends in amounts of arthroplasties performed globally. As the global population ages, demand for hip and knee arthroplasty will rise. To cope with this demand, hospitals need to be equipped to treat high volumes of patients in the upcoming years. By reducing the LOS, the volume of arthroplasty procedures can be increased, substantiated with an optimisation of the complete arthroplasty process in the hospital (e.g. operation-room planning, improvement of surgery duration). Secondly, patient's preferences should be taken into account. Although no precise evidence is available, it is assumed that patients prefer to recover in their own environment. OJA pathways encounter these preferences. Despite the growing trend and evidence of OJA, these pathways are at the beginning of their development [22]. Evidence-based guidelines on the selection of 'appropriate' patients should be investigated further [17,23]. With an aim to first improve the arthroplasty pathway, a safe and efficient reduction of LOS towards OJA can be made without compromising the postoperative outcomes in terms of (S)AEs and readmissions.

AIM of this thesis

The studies of the present thesis were performed to analyse several aspects of the implementation of clinical pathway features, to improve outcome after hip and knee arthroplasty (part 1). Additional aims for this thesis were to examine the safety and efficacy of the implementation of outpatient joint arthroplasty pathways into daily practice in a teaching hospital (part 2). Resulting in the following research questions:

Part 1: Clinical pathway optimisation

1. Preoperative patient education: Are patients satisfied with the offered preoperative information?
2. Blood management: Does tranexamic acid reduce, in a safe manner, perioperative allogenic blood transfusions?
3. Pain management: Is local infiltration analgesia with ropivacaine alone at least equal effective compared to ropivacaine with adrenaline in the mixture?
4. Urinary management: Can we omit standard usage of urinary catheters in primary hip and knee arthroplasty without causing increased postoperative urinary retention?

Part 2: Outpatient joint arthroplasty

5. Outpatient unicompartimental knee arthroplasty: Is outpatient joint arthroplasty feasible for unicompartmental knee arthroplasty in a selected group of patients?
6. Evidence based practice and the literature: Are outpatient joint arthroplasty pathways safe and effective?
7. Patient selection: Which patients are eligible for outpatient joint arthroplasty?
8. Physical activity: How physically active are patients after outpatient surgery in their own environment compared to inpatient knee arthroplasty?
9. Quality of life: Does outpatient joint arthroplasty, compared to the standard inpatient joint arthroplasty, effect the improvement of patient reported quality of life after surgery?

Outline of the thesis

The presented studies in this thesis are divided into two parts; firstly the pre- and perioperative clinical optimisations and secondly the implementation of outpatient joint arthroplasty.

Part one starts with a qualitative study regarding patients experiences on preoperative patient information and thus patients' expectations. Management of these expectations after surgery directly influence postoperative outcomes and is therefore of major importance. Chapter 2 outlines the patients' experiences on the usage of an information brochure handed out to knee arthroplasty patients.

The following chapters focusses on three major issues in primary hip and knee arthroplasty; firstly, the introduction of TXA (chapter 3), to reduce blood loss and prevent for allogenic blood transfusions after hip and knee surgery, was examined. Secondly, LIA in total knee arthroplasty (TKA), administered via an intra-operative single shot analgesic mixture with or without adrenaline was studied (chapter 4). And finally, examination of a management protocol for prevention of urinary retention after hip and knee arthroplasty was performed (chapter 5).

Part two continues the journey on implementing an OJA pathway. Chapter 6 presents the first results of a selective group of patients undergoing unicompartmental knee arthroplasty (UKA) in an outpatient setting. These patients were compared to a match cohort of patients receiving the standard of care (inpatient).

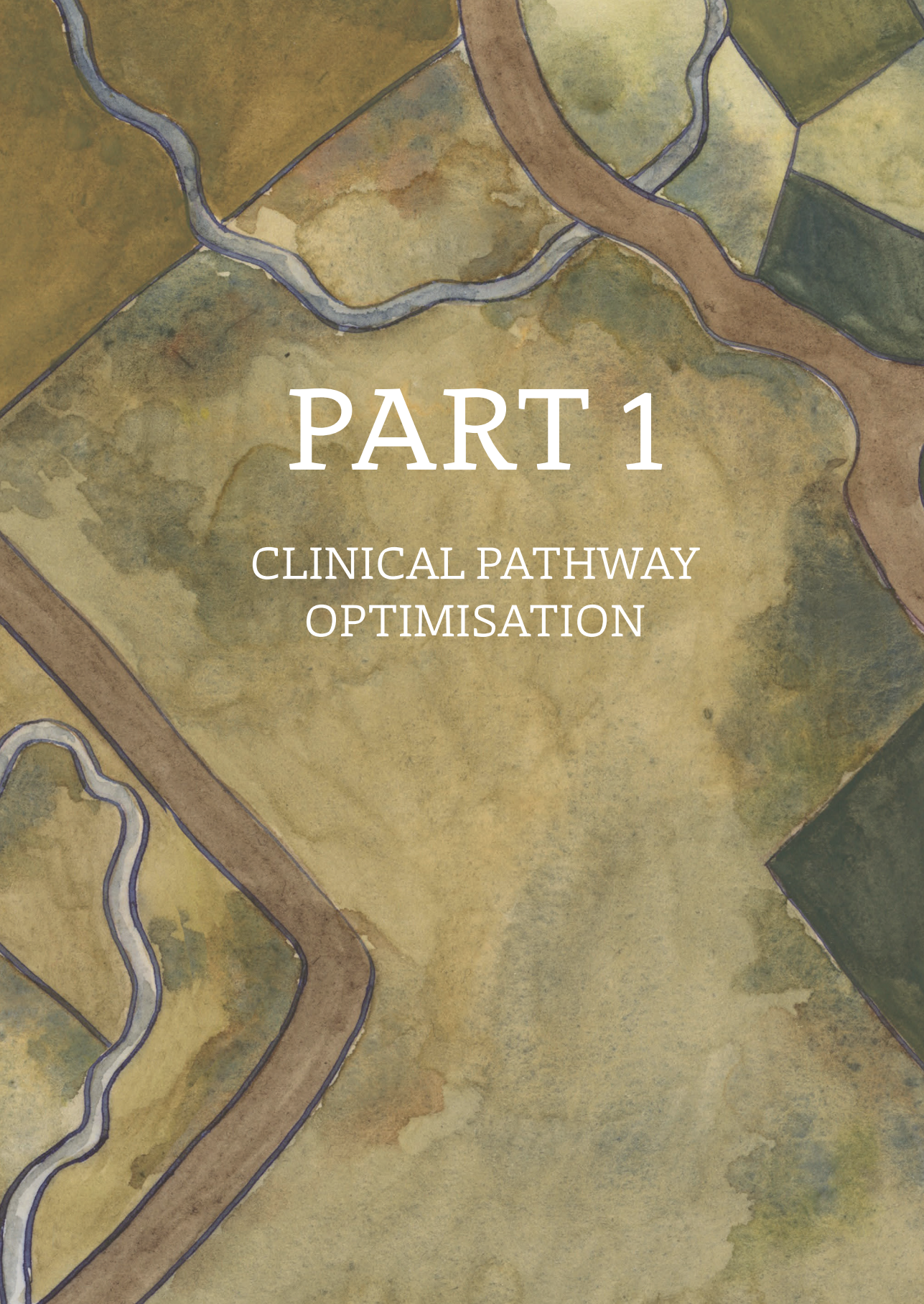
A systematic review with meta-analysis was performed to review the current literature regarding OJA pathways compared to the standard of care (chapter 7). Chapter 8 shows an evidence based statement regarding patient selection criteria for OJA pathways. To prevent for (S)AEs in the (early) postoperative phase and to successfully discharge patients on the day of surgery, adequate patient selection is paramount. In chapter 9 patients' physical activity after TKA was assessed in the patients' home-environment. Patients' activity level undergoing TKA on an outpatient base were compared to patients undergoing surgery in an inpatient (fast-track) pathway.

Finally, a comparison between outpatient and inpatient arthroplasty patients in the improvement of quality of life after surgery is outlined in chapter 10.

References

1. O'Neill TW, McCabe PS, McBeth J (2018) Update on the epidemiology, risk factors and disease outcomes of osteoarthritis. Best Pract Res Clin Rheumatol. 32(2):312-326.
2. Ethgen O, Bruyère O, Richy F, Dardennes C, Reginster JY (2004) Health-related quality of life in total hip and total knee arthroplasty. A qualitative and systematic review of the literature. J Bone Joint Surg Am. 86(5):963-74.
3. Kurtz S, Ong K, Lau E, Mowat F, Halpern M (2007) Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am. 89(4):780-5.
4. Schotanus MGM, Boonen B, van der Weegen W, Hoekstra H, van Drumpt R, Borghans R, Vos R, van Rhijn L, Kort NP (2019) No difference in mid-term survival and clinical outcome between patient-specific and conventional instrumented total knee arthroplasty: a randomized controlled trial. Knee Surg Sports Traumatol Arthrosc. 27(5):1463-1468.
5. Husted H (2012) Fast-track hip and knee arthroplasty: clinical and organizational aspects. Acta Orthop Suppl. 83(346):1-39.
6. Moonen AF, Knoors NT, van Os JJ, Verburg AD, Pilot P (2007) Retransfusion of filtered shed blood in primary total hip and knee arthroplasty: a prospective randomized clinical trial. Transfusion. 47(3):379-84.
7. Moonen AF, Thomassen BJ, Knoors NT, van Os JJ, Verburg AD, Pilot P (2008) Pre-operative injections of epoetin-alpha versus post-operative retransfusion of autologous shed blood in total hip and knee replacement: a prospective randomised clinical trial. J Bone Joint Surg Br. 90(8):1079-83.
8. Pilot P, Bogie R, Draijer WF, Verburg AD, van Os JJ, Kuipers H (2007) Experience in the first four years of rapid recovery; is it safe? Injury. 37 Suppl 5:S37-40.
9. Kehlet H, Wilmore DW (2008) Evidence-based surgical care and the evolution of fast-track surgery. Ann Surg. 248(2):189-98.
10. Kehlet H (1991) The surgical stress response: should it be prevented? Can J Surg. 34(6):565-7.
11. Kehlet H (1989) The stress response to surgery: release mechanisms and the modifying effect of pain relief. Acta Chir Scand Suppl. 550:22-8.
12. Andersen LØ, Gaarn-Larsen L, Kristensen BB, Husted H, Otte KS, Kehlet H (2009) Subacute pain and function after fast-track hip and knee arthroplasty. Anaesthesia. 64(5):508-13.
13. Kehlet H, Andersen LØ (2011) Local infiltration analgesia in joint replacement: the evidence and recommendations for clini-cal practice. Acta Anaesthesiol Scand 55:778–784
14. Backes JR, Bentley JC, Politi JR, et al. (2013) Dexamethasone reduces length of hospitalization and improves postoperative pain and nausea after total joint arthroplasty: a prospective, randomized controlled trial. J Arthroplasty. 28(8 Suppl):11-7.
15. Fillingham YA, Ramkumar DB, Jevsevar DS, et al. The Efficacy of Tranexamic Acid in Total Knee Arthroplasty: A Network Meta-Analysis. J Arthroplasty 2018;33(10):3090–3098.e1.
16. Fillingham YA, Ramkumar DB, Jevsevar DS, Yates AJ, Shores P, Mullen K, Bini SA, Clarke HD, Schemitsch E, Johnson RL, Memtsoudis SG, Sayeed SA, Sah AP, Della Valle CJ (2018) The Efficacy of Tranexamic Acid in Total Hip Arthroplasty: A Network Meta-analysis. J Arthroplasty. 33(10):3083-3089.e4.
17. Mariorenzi M, Levins J, Marcaccio S, Orfanos A, Cohen E (2020) Outpatient Total Joint Arthroplasty: A Review of the Current Stance and Future Direction. R I Med J. 103(3):63-67.

18. Pollock M, Somerville L, Firth A, Lanting B (2016) Outpatient Total Hip Arthroplasty, Total Knee Arthroplasty, and Unicompartmental Knee Arthroplasty: A Systematic Review of the Literature. JBJS Rev. 4(12):01874474-201612000-00004.
19. Hoffmann JD, Kusnezov NA, Dunn JC, Zarkadis NJ, et al. (2018) The Shift to Same-Day Outpatient Joint Arthroplasty: A Systematic Review. J Arthroplasty 33(4):1265-1274.
20. Jaibaji M, Volpin A, Haddad FS, Konan S (2020) Is Outpatient Arthroplasty Safe? A Systematic Review. J Arthroplasty http://doi:10.1016/j.arth.2020.02.022.
21. Xu J, Cao JY, Chaggar GS, Negus JJ (2019) Comparison of outpatient versus inpatient total hip and knee arthroplasty: A systematic review and meta-analysis of complications. J Orthop 17:38-43.
22. Hamilton WG (2019) Protocol Development for Outpatient Total Joint Arthroplasty. J Arthroplasty. 34(7S):S46-S47.
23. Meneghini RM, Ziemba-Davis M, Ishmael MK, Kuzma AL, Caccavallo P (2017) Safe Selection of Outpatient Joint Arthroplasty Patients With Medical Risk Stratification: the "Outpatient Arthroplasty Risk Assessment Score". J Arthroplasty. 32(8):2325-2331.



PART 1

CLINICAL PATHWAY OPTIMISATION

CHAPTER 2

PATIENTS' EXPERIENCES OF AN INFORMATION BROCHURE IN KNEE ARTHROPLASTY. A BRIEF QUALITATIVE STUDY.

Yoeri FL Bemelmans, Bob Heijkens, Emil H van Haaren, Melanie Kleynen, Martijn GM Schotanus.

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Abstract

Introduction Patient information holds an important role in knee arthroplasty surgery regarding patients' expectations and therefore outcome after surgery. The purpose of the present study was to explore the experiences and opinions of patients undergoing knee arthroplasty (KA) surgery on a preoperatively provided information brochure.

Methods A qualitative case study in 8 patients, with use of individual semi-structured interviews, was conducted to evaluate patients' opinion on an information brochure in KA surgery.

Results Patients rated the brochure as good and recommended its use. Unsatisfying information regarding wound healing, pain expectations, postoperative exercises and usage of walking aids was reported. Patients stated that the table of content was insufficient and the size of the brochure (A4-format) too large. Patients reported to have no need for additional digital sources (e.g. applications, websites).

Conclusion These opinions support the use of an information brochure and improved the content and formal requirements. The reported opinions were used to improve the brochure. Future research should focus on the improvement of information sources by involving patients (and other users) in de development process, in which the information is tailored towards the patient demands.

Keywords Knee Arthroplasty; Patient Information; Preoperative Education

Introduction

Patient information holds an important role in knee arthroplasty (KA) surgery. Traditionally, patients receive verbal and written information by the surgeon on the preoperative preparations, hospital admission, surgical procedure, postoperative care and expectations after surgery. Walker [21] reviewed the literature on the effects of information on general patient satisfaction. Despite the fact that this study concluded that there is contradicting evidence, good-quality preoperative information seems to facilitate patients to get actively involved in their care. In the information process, patient expectation management holds an indispensable role and good preoperative information can prevent unfulfilled expectations [18]. Patient information is ideally provided as written content, since the retention of verbal information by patients is low [8,13]. To increase reproducibility, patient information should be repeatedly available for patients.

The purpose of the present study was to explore the experiences and opinions of patients undergoing KA surgery on a preoperatively provided information brochure.

Methods

This study included patients undergoing primary elective unicompartmental or total KA. A qualitative and exploratory case study, with use of individual semi-structured face-to-face interviews, was conducted.

Preoperative patient information
After consultation of the orthopaedic surgeon, patients undergoing KA surgery received a brochure on the day that the patient was added to the waiting list. The orthopaedic operation room (OR) planner handed out the brochure and explained its use. On average, patients received the brochure 6-8 weeks prior to surgery. The brochure (A4 format) contains information on the patient pathway, divided in several sections (table 1). It was developed in collaboration with all stakeholders forming the multidisciplinary team (consisting of nurses, physiotherapists, physician assistants, anaesthesiologists, hospital pharmacist orthopaedic surgeons, managers, planners and communications department). Content of the brochure was based on the information supplied by the Dutch Orthopaedic Society [15] and adjusted to incorporate in our clinical pathway. Continues improvements were made after several patients gave solicited and unsolicited advice on the content of the brochure.

Furthermore, patients underwent a physical education session by the hospital physiotherapists and were trained to walk with crutches and climbing stairs. A preoperative consultation by the anaesthesiologist was performed to prepare and discuss type anaesthesia during surgery, and consultation by a nurse to help patients preparing their environment prior to surgery.

Table 1. Content of the brochure.

Topic	Subtopic
Preoperative information and preparation	• Information on the illness and arthroplasty procedure • Expectations after surgery regarding functional improvements and possible adverse events • Home preparations • Relative or coach selection for postoperative aiding • Screening by anaesthesiologist and nurse • Physical physiotherapy education class
Hospital admission	• Timetable of admission • Procedures and transfers within the hospital • Preoperative medication protocol • General preparations for surgery
Postoperative treatment	• Expectations after surgery regarding anaesthesia, pain and length of hospital stay • Exercise instructions and physiotherapy sessions • Self-administration of thrombosis prophylaxis • Postoperative medication protocol • Wound care • Discharge criteria
Follow-up after surgery	• Information in case of any adverse events or questions after discharge • Postoperative outpatient visits

Procedure

Patients were invited to participate on their six weeks postoperative visit. It was assumed that within this timeframe, patients would still remember their experiences after surgery, and they had enough opportunities to actually apply the information of the brochure. Participants who received primary elective KA surgery and who are able to read and understand the Dutch language were eligible candidates. Patients who were not able to read the brochure (e.g. because of cognitive disorders) and/or experienced severe complications (e.g. requiring re-admission or re-operation) after surgery, were excluded. Eligible participants received an information letter and gave written informed consent. The interview took place at the patient's home.

Interviews

Semi-structured interviews were conducted by two researchers, one functioning as conversation partner and the other as subscribe. The interviews were audio recorded. A semi-structured topic list was used (table 2). Patients had the opportunity to give and explain their opinion on each topic. Summarization was used during the interviews to determine accuracy and correctly interpreted data. Subsequently, idea's on and need for other information sources were evaluated.

Table 2. Semi-structured interview topic list.

Topic	Subtopic	
Explanation of the interview	•	Purpose of the interview
	•	Practical considerations
Design of brochure	•	First impression
	•	Size
	•	Formal requirements (font size, style)
	•	Titles
	•	Colour
	•	Figures / pictures / tables
Structure of the brochure	•	Table of contents
	•	Chapter structure
	•	Order of subjects
	•	Clarity
Content of the brochure	•	Importance of information
	•	Description of the content
	•	Completeness of the information
	•	Depth of the topics
	•	Adequacy
Usage of the brochure	•	Frequency
	•	Other users
Need for usage of other information sources	•	Video material
	•	Website
	•	Applications
	•	Additional figures / pictures
Other	•	Patients' input
	•	Questions

Data-analysis

Demographic data of the participants were collected. All interviews were transcribed verbatim. Data analysis was performed with use of inductive content analysis. The answers were collected and coded according to the topics. To state the codes, the most extensive interviews were coded first. If no new information emerges during the

interviews, code saturation was expected to be reached. Investigator triangulation was achieved by interviewing the patients and analysing the data with two researchers separately. Any discrepancies between researcher's interpretations were discussed until agreement was reached

Ethics

This study was performed in compliance with the Helsinki Declaration of 1975, as revised in 2013 and was studied and approved by the IRB and conducted in accordance with the guidelines for Good Clinical Practice.

Results

A total of 8 participants were included. The demographic data of the participants are presented in table 3. Patients' experiences and opinions are outlined according to the topic list (table 2).

Table 3. Patient characteristics and demographics.

ID	Gender	Age (years)	Education level	Profession	Type of arthroplasty
1	Male	72	Bachelor's degree	Commercial manager	UKA
2	Male	53	Associate degree	Grocer	UKA
3	Female	58	Associate degree	Cabdriver	UKA
4	Male	71	Bachelor's degree	Architect	UKA
5	Male	60	Associate degree	Assembly operator	UKA
6	Female	64	Associate degree	Fitness instructor	TKA
7	Male	76	Associate degree	Justice	TKA
8	Female	71	High school	Saleswoman	TKA

UKA, unicompartmental knee arthroplasty; TKA, total knee arthroplasty

Design of the brochure

Patients reported that the brochure is written with a clear letter size, letter type, line spacing and sizing of the paragraphs. The current size of the brochure is too large and had a deterrent effect on the participants and they prefer a smaller size (A5 instead of A4 format).

P1: "I actually thought it was a big brochure. I thought, hey, what am I getting here?"

Structure of the brochure

Patients reported that the table of content was not clear enough, which made it hard for them to find certain information on specific subjects.

P2: "[…] and then you just have to browse […] the index is not really clear."

Not all pictures regarding exercises clarified the plain text enough and could be presented in a higher resolution.

Content of the brochure
The content was overall clear and written in an understandable language. Patients stated that the information as reliable. Several adjustments were proposed, such as description on other walking aids, besides canes/crutches, is missing.

P7: "Well I found out; it just tells you about crutches. That you have to bring them in advance, but I have found that it is much easier to walk with a walker instead."

There should be more information on self-exercising and intensity build-up of exercises during rehabilitation. One patient stated to describe more accurate expectations on pain experiences.

P1: "[…] there, you highlight what you are not allowed to do. But maybe the process of what you feel after the surgery, where you say the first step is wound pain […] so that you are at least reassured."

Patients advised to describe more accurate information on spinal anaesthesia and in particular how long the anaesthetic would last. Furthermore, patients were interested in information about the surgeons (e.g. background information, specialties). It was advised by several patients to delete the 3-month outpatient visit, since this was omitted from the follow-up after surgery.

Usage of the brochure
All patients stated that they used the brochure and recommend its use. Patients indicated that the brochure was necessary to provide all the information regarding their KA surgery. Caregivers also used the brochure.

P3: "Yes, my daughter and son used it very extensive. They liked it."

Need for usage of other information sources
Patients stated that medical care apps were not an option for them, although they could imagine the usage of it by next generations.

P1: "Of course, you could have a video, or you could download a mobile app. But maybe that's for a few years later. Because now I saw almost all older people who, like me, don't really like apps. You wouldn't fulfill their needs, I guess."

Discussion

The most important finding of this study is that the overall experiences on the provided patient information were positive. Patients were satisfied with the given information regarding their KA surgery.

Patient expectation management holds an important role in KA surgery, unmet expectations after surgery can result in dissatisfaction [5,10,14]. To prepare patients before surgery, information regarding the procedure and expectations after surgery can be done by providing oral and written content, with a possible addition of face-to-face contacts (e.g. physical therapy sessions, preoperative information classes, so-called 'joint-schools'). Besides providing written content, patients had several face-to-face contacts in the current study; the orthopaedic surgeon provided oral information, patients received information from the OR planner regarding practical considerations (e.g. date of surgery), had a preoperative consultation by the anaesthesiologist/nurse and underwent a physical education session by the physiotherapist. The combination of preoperative educational programs with written information has been examined before [11,16,2]. These papers concluded that this strategy did not (positively) affect postoperative outcomes in terms of safety (e.g. complication rates, length of hospital stay). When analysing other outcomes, a multimodal educational approach (verbal and written information) on opioid consumption and pain resulted in reduced usage of opioids after surgery [16]. The authors stated further that information solely on patients' expectations after surgery did not reduce pain scores, indicating that a multimodal educational approach is desirable. This is in line with another study reporting no effect of preoperative education alone on postoperative pain scores [3].

Another proposed advantage of patient education is reduced preoperative anxiety. As anxiety is strongly related to poorer postoperative outcomes (in terms of patients satisfaction after KA), it is of major importance to address this anxiety prior to surgery [1]. Aydin et al. [2] reported a reduction of preoperative anxiety after implementation of preoperative patient education. In addition, Tong et al. [19] reported psychological interventions prior to surgery to be beneficial in the reduction of anxiety and mental components of quality of life on the long term. This addresses the need for patient specific and targeted preoperative patient information.

Several studies [12,17] examined the patients' needs regarding perioperative information. They concluded that patients need information on the healthcare specialists, postoperative care, recovery and medication. Especially information on medication (e.g. expected levels of pain, medication use, side-effects) was found to be of major importance, which is in line with the presented opinions and recommendations by the patients in the current study.

The points for improvement to increase readability (e.g. table of content, figure/image resolution), are also in line with other studies. As stated by other authors, these aspects regarding design are of major importance (e.g. letter type, letter size, paragraph usage) [6,7,9,20].

With the introduction of applications and websites, the availability of information increased. Despite great advantages of this freely available information, concerns regarding the reliability and variability are present [4]. Although patients reported less need for additional applications or websites, patients reported the size of the brochure as a limitation, in which an application could be more tailored towards the patient's wishes regarding size. Another major advantage would be the ease to change and manage information. For example, patients reported that the given information was outdated on the postoperative visits in the hospital.

This study has several limitations. The sample might be biased because all participants stated that they were satisfied with their overall treatment process. To extract more insight in adverse experiences, the cohort should ideally include dissatisfied patients as well. Furthermore, it is to be expected to gain more data saturation in a larger cohort of patients.

The next step should be to improve information brochures (or other material) by involving the patients (and other users) in the development process (co-creation).

Conclusion

In conclusion, patients rated the information brochure on KA surgery as good and recommended its use. The reported opinions on content (e.g. wound healing, pain experiences, exercise intensity build-up, usage of walking aids) and formal requirement (e.g. table of content, size) were used to improve the brochure.

Ethical approval statement

This study was performed in compliance with the Helsinki Declaration of 1975, as revised in 2013 and was studied and approved by the IRB and conducted in accordance with the guidelines for Good Clinical Practice. IRB-approval was obtained from the Regional Ethics Committee of Heerlen (METC Z, Heerlen, the Netherlands, IRB Nr. METCZ 17-N-53). All patients who participated in the study gave their written informed consent.

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Declaration of competing interest

All authors declare that they have no conflict of interest to report.

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References

1. Alattas SA, Smith T, Bhatti M, Wilson-Nunn D, Donell S (2017) Greater pre-operative anxiety, pain and poorer function predict a worse outcome of a total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 25(11):3403-3410
2. Aydin D, Klit J, Jacobsen S, Troelsen A, Husted H (2015) No major effects of preoperative education in patients undergoing hip or knee replacement - a systematic review. Dan Med J 62(7):A5106
3. Barry MA (2017) The effect of preoperative education on postoperative pain after joint surgery: an integrative literature review. Creat Nurs 1;23(1):42-46
4. Brunnekreef JJ, Schreurs BW (2011) Total hip arthroplasty: what information do we offer patients on websites of hospitals? BMC Health Serv Res 11:83
5. Choi YJ, Ra HJ (2016) Patient satisfaction after total knee arthroplasty. Knee Surg Relat Res 28(1):1-15
6. Clark NB (2016) Patient education materials. Florida. College of Medicine. 1-18
7. Dzulkifli MA, Mustafar MF (2013) The influence of colour on memory performance: a review. Malays J Med Sci 20(2): 3-9
8. Feiner DE, Rayan GM (2016) Preoperative surgical discussion and information retention by patients. J Hand Surg Asian Pac Vol 21(3): 326-332
9. Frost MH, Thompson R, Thiemann KB (1999). Importance of format and design in print patient information. Cancer pract 7(1): 22-27
10. Gunaratne R, Pratt DN, Banda J, Fick DP, Khan RJK, Robertson BW (2017) Patient dissatisfaction following total knee arthroplasty: a systematic review of the literature. J Arthroplasty 32(12):3854-3860
11. Jordan RW, Smith NA, Chahal GS, Casson C, Reed MR, Sprowson AP (2014) Enhanced education and physiotherapy before knee replacement; is it worth it? A systematic review. Physiotherapy 100(4):305-12
12. Kennedy D, Wainwright A, Pereira L, et al. (2017) A qualitative study of patient education needs for hip and knee replacement. BMC Musculoskelet Disord 18(1): 413
13. Kessels RPC (2003) Patients' memory for medical information. J R Soc Med 96(5): 219-222
14. Mahdi A, Svantesson M, Wretenberg P, Hälleberg-Nyman M (2020) Patients' experiences of discontentment one year after total knee arthroplasty - a qualitative study. BMC Musculoskelet Disord 14;21(1):29
15. Nederlandse Orthopaedische Vereniging (NOV) – patientenvoorlichting https://www.orthopeden.org/kwaliteit/patientenvoorlichting
16. Rucinski K, Cook JL (2020) Effects of preoperative opioid education on postoperative opioid use and pain management in orthopaedics: A systematic review. J Orthop 21;20:154-159
17. Soever LJ, MacKay C, Saryeddinne T, et al. (2010) Educational needs of patients undergoing total joint arthroplasty. Physiother Can 62(3): 206-214
18. Tilbury C, Haanstra TM, Leichtenberg CS, et al. (2016) Unfulfilled expectations after total hip and knee arthroplasty surgery: there is a need for better preoperative patient information and education. J Arthroplasty 31(10): 2139-2145
19. Tong F, Dannaway J, Enke O, Eslick G (2020) Effect of preoperative psychological interventions on elective orthopaedic surgery outcomes: a systematic review and meta-analysis. ANZ J Surg 90(3):230-236
20. Weiss BD (2007) Health literacy and patient safety: Help patients understand. Manual for Clinicians AMA Foundation 2:1-62
21. Walker JA (2007) What is the effect of preoperative information on patient satisfaction? Br J Nurs 16(1): 27-32

CHAPTER 3

LOW BLOOD TRANSFUSION RATE AFTER IMPLEMENTATION OF TRANEXAMIC ACID FOR FAST-TRACK HIP AND KNEE ARTHROPLASTY.

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Abstract

Purpose The purpose of this study was to retrospectively evaluate the efficacy of a tranexamic acid (TXA) perioperative protocol for primary hip- and knee arthroplasty, in terms of allogenic blood transfusion rates.

Methods A retrospective cohort study was conducted and included all primary hip and knee arthroplasty procedures in the period of 2014-2019. Patients who underwent surgery due to trauma or revision were excluded. A total amount of 5205 patients were eligible for inclusion. Two equal and weight depending doses of TXA were given, preoperative as an oral dose and intravenously at wound closure. The primary outcome was blood transfusion rate. Further analysis on patient characteristics (e.g. age, gender), blood loss, perioperative haemoglobin (Hb) levels and complication/readmission rate was performed.

Results A total of 49 (0.9%) patients received perioperative allogenic blood transfusions. Mean age, distribution of gender, body-mass index, American Society of Anaesthesiologists score, duration of surgery, type of arthroplasty, estimated blood loss, perioperative Hb levels and length of stay were statistically significant different between transfused and not-transfused patients. The incidence of thromboembolic adverse events (e.g. deep vein thrombosis/lung embolism) was 0.5%.

Conclusion Low blood transfusion rate was found after implementation of a standardized perioperative TXA protocol for primary hip and knee arthroplasty.

Keywords Tranexamic Acid, Fast-Track Surgery, Knee Arthroplasty, Hip Arthroplasty, Unicompartmental Knee Arthroplasty

Introduction

Since the introduction of tranexamic acid (TXA) usage in primary hip- and knee arthroplasty procedures, perioperative blood loss is reduced with a decreased incidence of allogenic blood transfusions [1,7,15,27,30]. TXA is a synthetic analogue of the amino acid lysine that reduces blood loss by inhibiting the degradation of fibrin and disintegration of blood clots. Perioperative allogenic blood transfusions are strongly related to increased risk of surgical site infection and deep venous thrombosis [14,17]. Therefore, it is of paramount importance to prevent blood transfusions. Standardized perioperative protocols are used without an increased risk of perioperative thrombo-embolic events (e.g. deep venous thrombosis/pulmonary embolism) [8,9,10,19]. Given these benefits, a perioperative TXA protocol is increasingly implemented and used in primary hip and knee arthroplasty. Different perioperative protocols exist on type of administration, frequency of administration, dosage and timing of administration. TXA can be administered orally, intravenously or topical, with equal safety and efficacy in terms of postoperative blood transfusions and (low) adverse events (AE) rates [2,3,8,10,11,19,21,28,29]. To maximise the effect of TXA and minimise AE rates, perioperative protocols are needed with substantial clinical evidence. The aim of this study was to evaluate the incidence of perioperative allogenic blood transfusions after the implementation of a combined low-dose oral and intravenous TXA protocol for elective hip and knee arthroplasty.

Patients and methods

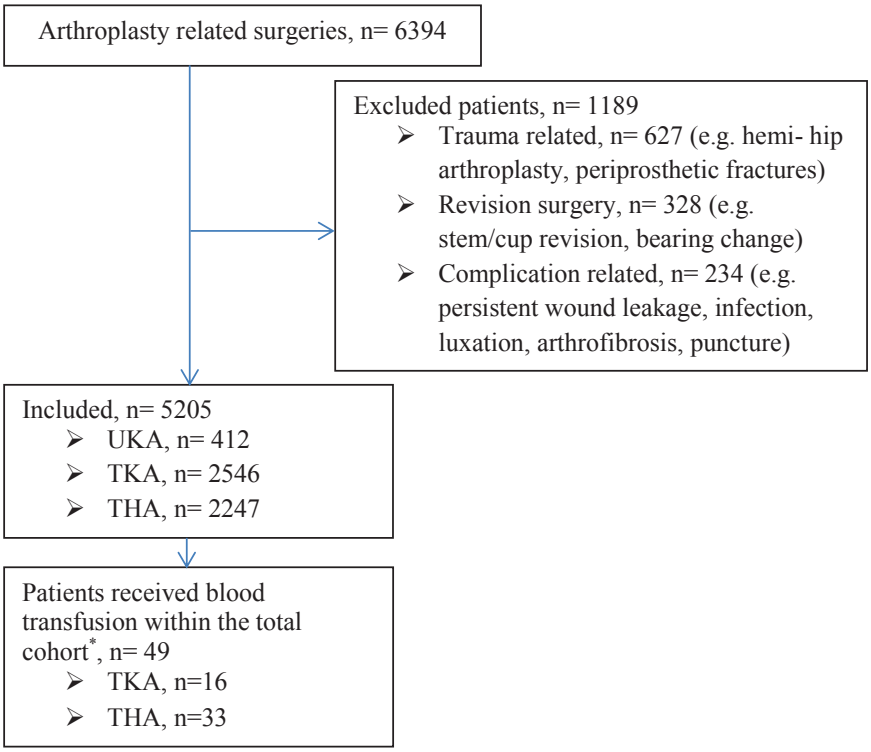
This retrospective cohort study evaluates the incidence of allogenic blood transfusions in patients who have been operated on primary total hip (THA), unicompartimental (UKA) - and total knee arthroplasty (TKA). All data was obtained from the hospital transfusion and surgery registration. To evaluate possible inclusion in this study, the complete database of surgeries performed between June 2014 and June 2019 were screened. All primary unilateral THA, UKA and TKA patients were included. Arthroplasty surgeries related to complications, revision or trauma were excluded from analysis. Selection of patients is presented in figure 1.

Pre-, peri, and postoperative protocols

All patients were operated with the use of standardized perioperative protocols regarding fast-track or outpatient surgery (e.g. multimodal pain management, mobilisation <24hrs after surgery, no drain/urinary catheter) [22]. In UKA procedures, tourniquet was used. Only in knee arthroplasty patients, local infiltration analgesia was used. Patients were

either operated in the inpatient pathway, with an average length of hospital stay of 2 days, or as an outpatient with discharge from the hospital on the day of surgery [18]. Blood typing and cross matching was performed preoperatively in all patients. Patients were screened for preoperative anaemia and if deemed necessary, further analysed preoperatively in our hospital. Operations were performed under general or spinal anesthesia (with or without sedation). All patients received antibiotic prophylaxis (intravenous (IV) administration of 2000mg (<100 kg); 3000mg (>100 kg) Cefazolin) in three doses; 15-60min before incision, 8 and 24hrs postoperative. In case of a known allergy for Cefazolin, Vancomycin (IV administration of 1000mg (<100 kg); 1500mg (>100 kg), preoperative dose and 12hrs postoperative second dose) was given. For patients following the outpatient pathway, the last dose was not given due to practical consideration.

Figure 1. Patient selection process.



TXA was given in two doses. First dose was given orally (Cyclokapron®, Mylan, Hatfield, United Kingdom) 2hrs before incision by the nurse on the orthopaedic ward. Second dose was given IV (Cyclokapron®, Pfizer, New York City, United States) at the end of the surgery when the wound was closed, administered by the anaesthesiology assistant.

The dosage, orally and intravenously, depended on the weight of the patient; <100kg: 1000mg, >100kg: 1500mg. In case of a known hypersensitivity for TXA, severe renal function disorders (<50 mL/min creatinine clearance or dialysis depending) or recent history (<6 months) of a vascular event (e.g. cerebrovascular/myocardial infarction or deep venous thrombosis/pulmonary embolism), TXA was not given. Postoperatively, all patients received thrombosis prophylaxis with the use of low molecular weight heparin (LMWH), except for patients who were on vitamin K antagonists (VKA) or non-VKA oral anticoagulants (NOAC) prior to surgery. LMWH thrombosis prophylaxis (subcutaneous injection of 5000IE (Dalteparin®, Pfizer, New York City, United States) once daily started on the day of surgery and was continued up to six weeks after the arthroplasty. After surgery patients were monitored at the Post Anaesthesia Cure Unit (PACU) for several hours, before being transferred to the orthopaedic ward. Postoperatively, haemoglobin (Hb) levels were determined the first postoperative day. Except for patients undergoing UKA surgery via the outpatient pathway, Hb levels were not routinely measured. In case of general unwell-being, Hb levels were determined. Depending on Hb levels and clinical evaluation of the patient by the orthopaedic ward physician, allogenic blood transfusion was considered according to the recent national guidelines [20].

Data collection

Data collection was performed via the in-hospital registration system of blood transfusions and the patient's digital medical records.

Outcome measures

The primary endpoint of this study was the incidence of blood transfusions in elective hip- and knee arthroplasty. As secondary outcomes, patients in the transfusion group were compared to patient in the non-transfusion group on the following variables: gender, side of surgery, age, body-mass index (BMI), American Society of Anaesthesiologists (ASA) classification, type of anaesthesia (spinal or general), duration of surgery (minutes), type of arthroplasty (THA, UKA or TKA), patient specific instruments (PSI) usage in TKA, cementation in THA, estimated blood loss, pre- and postoperative Hb levels and length of hospital stay (LoS). In addition, the incidence of postoperative thrombo-embolic events (e.g. deep venous thrombosis/pulmonary embolism, cerebrovascular, myocardial) up to 3 months postoperatively was assessed in both groups.

Ethics

This study was performed in compliance with the Helsinki Declaration of 1975, as revised in 2013 and was studied and approved by the IRB (METC Z, Heerlen, the Netherlands, IRB Nr. METCZ20190123) and conducted in accordance with the guidelines for Good Clinical Practice (GCP).

Statistics
All statistical analyses were performed with the use of Statistical Package for the Social Sciences version 26.0 for windows (SPSS., Inc., Chicago, IL). Descriptive statistics are used to summarize data. Student's t-tests were performed on significant interactions between both groups. Chi-square test was used for categorical variables. A threshold for all statistical comparisons of p-value ≤ 0.05 was considered to be statistically significant. Data are presented as means with standard deviations, 95% confidence level (CI), frequencies (%) or medians with ranges.

Results

A total group of 5205 patients were analysed. The incidence of perioperative blood transfusion was 0.94% (n=49). One patient (TKA) received blood transfusion during the operation, as the other patients received blood transfusion after surgery on the clinical ward. Study patients were divided into two groups, transfused- (BT) and non-transfused (non-BT) patients. Differences for patient demographics and perioperative outcome measures between BT and non-BT patients are presented in table 1.

Patients in the BT group had significant (P ≤ 0.05) higher ASA score (≥ III), age, prolonged LoS, and lower BMI scores. No significant differences were found for type of anesthesia and side of surgery. Only in THA patients, the BT group had a longer duration of surgery, higher estimated blood loss and consisted of significantly more uncemented arthroplasties.

Pre- and postoperative Hb levels in THA and TKA patients were statistically significant different between BT and non-BT patients. Since there were no transfusions in the UKA group; estimated blood loss, duration of surgery and perioperative Hb levels could not be sub-analysed. AE's and readmission rates are presented in table 2 for both groups with an incidence of 0.46% for thromboembolic AE's (e.g. deep vein thrombosis/lung embolism/cerebrovascular- or myocardial event).

Table 1. Demographic data for non-transfused and transfused patients are presented as mean (SD) with 95% confidence interval [CI] or frequencies (%). A p-value of ≤ 0.05 was considered to be statistically significant different.

	Non-transfused (n=5.156)	Transfused (n=49)	p-value
Patient demographics			
Gender, female	3140 (60.9)	39 (79.6)	**0.008**
Side of surgery, right	2779 (53.9)	24 (49.0)	0.492
Age[a]	69.0 (9.3) [68.8-69.3]	76.3 (10.2) [73.4-79.2]	**0.000**
BMI[b]	28.9 (5.0) [28.7-29.0]	26.1 (4.8) [24.7-27.5]	**0.000**
ASA classification, I/II/III/IV	788/3918/444/6	0/38/10/1	**0.000**
Anesthesia, spinal/general	3743/1413	36/13	0.891
THA/TKA/UKA	2206/2523/412	33/16/0	**0.001**
Duration of surgery[c], THA	0:59 (0:16) [0:58-0:59]	1:02 (0:19) [0:56-1:09]	**0.028**
Duration of surgery[c], TKA	1:04 (0:16) [1:03-1:05]	1:10 (0:25) [0:56-1:24]	0.133
PSI usage in knee arthroplasty	1481 (58.7)	7 (43.8)	0.221
THA uncemented/cemented/ hybrid/reversed hybrid	1860/154/143/38	19/11/2/1	**0.000**
Blood loss[d], THA	362.3 (171.7) [354.4-370.2]	421.7 (263.2) [307.9-535.6]	**0.024**
Blood loss[d], TKA	261.5 (119.1) [256.1-266.8]	323.1 (123.5) [248.4-397.7]	0.262
Pre-OR Hb level[e], THA	8.7 (0.8) [8.6-8.7]	7.2 (1.1) [6.8-7.6]	**0.000**
Post-OR Hb level[e], THA	7.3 (0.9) [7.2-7.3]	5.7 (0.7) [5.4-6.0]	**0.000**
Pre-OR Hb level[e], TKA	8.7 (0.8) [8.7-8.8]	7.3 (1.2) [6.6-7.9]	**0.000**
Post-OR Hb level[e], TKA	7.4 (0.8) [7.4-7.5]	5.5 (0.7) [5.1-5.8]	**0.000**
Delta Hb level[e], THA	1.4 (0.6) [1.3-1.4]	1.5 (0.8) [1.3-1.8]	0.873
Delta Hb level[e], TKA	1.3 (0.6) [1.2-1.3]	1.8 (1.2) [1.2-2.4]	**0.000**
Length of stay[f]	2.5 (2.0) [2.5-2.6]	5.4 (4.1) [4.3-6.6]	**0.000**

THA, total hip arthroplasty; TKA, total knee arthroplasty; UKA, unicompartimental knee arthroplasty; ASA, American Society of Anaesthesiologists; PSI, Patient Specific Instruments; [a] presented in years; [b] BMI: body-mass index is presented in kg/m^2; [c] presented in minutes; [d] presented in mL; [e] Hb, hemoglobin levels were presented in mmol/L; [f] presented in days

Table 2. Adverse event and readmission rates for the total cohort presented as frequencies (%).

	Total
Embolism (VTE/LE)	15 (0.29)
Neurologic (e.g. CVA, TIA)	7 (0.13)
Infection (e.g. surgical site infection)	23 (0.44)
Wound related (e.g. persistent drainage, dehiscence, haematoma)	79 (1.5)
Prosthesis related (e.g. dislocation, periprosthetic fracture)	74 (1.4)
Cardiac (e.g. acute myocardial infarction, acute heart failure, rhythm disorder)	16 (0.3)
Urologic (e.g. postoperative urinary tract infection, urinary retention)	191 (3.6)
Other (e.g. organ infection/dysfunction, nerve lesion)	77 (1.5)
Readmissions <3mnd post OR	262 (5.0)

VTE, venous thrombo embolism; LE, lung embolism; CVA, cerebrovascular accident; TIA, transient ischemic attack

Discussion

The most important finding of the present study is that the use of TXA in primary hip- and knee arthroplasty results in low allogenic blood transfusion rates. Before implementation of TXA in hip- and knee arthroplasty, allogenic blood transfusion rates rose to more than half of the patients [9]. These transfusion rates decreased significantly by implementing a perioperative TXA protocol without increasing perioperative complications (e.g. thromboembolic, cardiovascular events) [10,19,11]. Different protocols are examined and proven to be effective and safe [3,8,10,11,19,21,29]. Nevertheless, none of these regimens regarding type of administration (e.g. topical, IV and oral), dosage and timing is superior [10]. In previous high-quality studies (e.g. meta-analysis) different types of administration resulted in similar decreased transfusion risks for TKA and THA patients [11,27,30]. Only in TKA patients, slight superiority is found for pre-incisional administration of IV TXA [11]. In terms of safety, multiple doses induce a prothrombotic state but do not provoke thrombosis in TKA and THA patients and would therefore be safe to use [28]. But, as known from the recent literature, a second or extended dose seems not to be more effective than single dosage in knee or hip arthroplasty [11]. No differences were found between low (<20mg/kg) and high (>20mg/kg) dose intravenous TXA in hip and knee arthroplasty [11]. As well as for timing of administration, no regimen is superior [2,11].

The protocol in this study was set-up to be firstly evidence based, but secondly manageable without any nuisance for the patient. Due to the current fast-track protocols, which include 2hrs preoperative oral administration of pain medication, the implementation of preoperative oral TXA was done at that same administration time.

When looking closely to the pharmacokinetics and pharmacodynamics of TXA, oral uptake is rapid, which makes oral TXA eligible. Bioavailability of TXA is approximately 45% in a healthy population, therefore a preoperative high dose of oral TXA can be considered to maximise the intraoperative blood sparing effect. T-max of TXA was estimated to be around 3 hours, in which the oral dose would almost be maximum at time of incision. Equal timeframe is stated for the elimination half-life of TXA. Therefore, the IV administration at the end of the surgery provides coverage for the first postoperative hours. These first 4 hours postoperative were stated by Jung et al. [16] to be most crucial in postoperative blood loss after knee arthroplasty.

A topical dose was not considered due to the use of local infiltration analgesia in TKA patients. Thereby, an addition of TXA would result in a high fluid volume which would be infiltrated in the surrounding knee tissue.

Various IV doses are used, with similar blood transfusion results [21,27,29,30]. Doses above 20mg/kg are considered to be a 'high dose'. Thus, in the presented study, a low dose oral and IV TXA was used which led to low blood transfusion rates. These results are in line with previous studies and would support a low dose TXA usage to prevent for drug side effects [11].

The BT group consisted of significant more females. Other studies report female gender to be a risk factor for perioperative blood transfusion [12,25]. The exact mechanism remains unclear, but several hypotheses (e.g. lower preoperative haematocrit level and smaller body habitus) exists [23]. BT patients were significantly older and had a higher ASA classification, in line with previous findings [12,23]. This could be explained by the fact that in this group, blood transfusion was considered more often due to comorbidity status. On the other hand, the decision for blood transfusion was not only based on ASA classification, but also strongly dependent on postoperative Hb levels and the clinical well-being of the patient. Since different thresholds for Hb levels were used, the transfusion rate could be biased. Nevertheless, BT patients had significant lower Hb levels preoperatively which can be seen as a risk factor for transfusion. Basora et al.[4] reported similar results regarding preoperative Hb level (7.7 mmol/L) and ASA classification (III-IV) in transfused TKA patients. A cut-off value for preoperative optimisation was not given, but based on these and our results, preoperative Hb level seems to play a role in postoperative blood transfusion and should therefore be monitored preoperatively which was also found by other studies [4,25]. Unsurprisingly the BT group consisted of more THA patients, since blood loss in THA is higher and therefore significant higher risk for blood transfusion [23,24].

In uncemented procedures more blood transfusions were given. In contrast to our results, Trice et al. [26] found no differences between a small cohort of uncemented and cemented/hybrid THA patients. Possible explanation for our results could be the opening of the intra-medullar canal, which is directly covered after cementation of the prosthesis in cemented THA. In the current cohort, uncemented THA was the preferred operation technique, even for patients with a higher age and thus relatively higher comorbidity status, which could have biased the results. To our knowledge, no clear evidence exists on the underlying mechanism.

No difference in anaesthesia method was found between BT and non-BT patients. In contrast to previous results, which have shown that spinal anaesthesia protects against allogenic blood transfusions [13,23]. Spinal anaesthesia decreases blood loss based on a reduction in sympathetic tone and blood flow to the operative extremity [23]. But these results were found in studies before implementation of TXA which makes it less comparable to the presented study. In most of the high-quality TXA studies, no data is provided.

There is of course a relation between duration of surgery and amount of blood loss with a self-evident increased transfusion risk [12]. Duration of surgery was previously described by Song et al. [25] as an independent risk factor for blood transfusion in THA patients. These results were obtained from arthroplasty surgeries with duration longer than 2 hours and only in THA patients [25]. For TKA patients, no significant difference was found. This is in line with our results. Although we found a significant longer duration of surgery in blood transfused THA patients, mean time between both groups was merely three minutes. The clinical relevance of three minutes is doubtful in our opinion.

Carling et al. [6] found low BMI to be associated with an increased risk of excessive blood loss and thereby increased risk for blood transfusion. In line with these results, our study found that BMI was significant lower in the BT group. Contrarily, other studies reported no difference or even significant more blood loss in obese patients [5]. The current evidence is divided on the role of BMI in blood transfusion risk after arthroplasty surgery. In this study we can't give more clarification on this topic and further studies are thus needed.

There are some potential limitations. Due to the retrospective nature of the study, presented perioperative complications (in particular vascular/hematologic) could possibly be underestimated. Data in this study depends on the registration of complications in our hospital system. On the other hand, similar (low) rates of thrombo-

embolic events were found after the implementation of high-dose TXA in other studies [8,9,19,28]. In advantage of these results, the current protocol consists of a low-dose TXA protocol and should therefore be safe to implement in daily practice. Another possible limitation of the study is the lack of correction for anti-coagulant usage. This could potentially bias the blood transfusion rates due to the negative influence on perioperative blood loss.

Conclusions

Substantiated among with high-quality trials, TXA use in primary hip and knee arthroplasty holds an indispensable role in the perioperative process. As presented in this retrospective cohort study, an oral and IV administration protocol of TXA was found to be effective and safe for primary hip and knee arthroplasty procedures.

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References

1. Abdel MP, Chalmers BP, Taunton MJ, et al. (2018) Intravenous Versus Topical Tranexamic Acid in Total Knee Arthroplasty: Both Effective in a Randomized Clinical Trial of 640 Patients. J Bone Joint Surg Am. 100(12):1023-1029
2. Balachandar G, Abuzakuk T (2019) Is there an optimal timing of administration of single-dose intravenous tranexamic acid in bilateral total knee arthroplasty? A comparison between preoperative and intraoperative dose. J Orthop Surg 2019. 27(3):2309499019880915
3. Barrachina B, Lopez-Picado A, Remon M, et al. (2016) Tranexamic Acid Compared with Placebo for Reducing Total Blood Loss in Hip Replacement Surgery: A Randomized Clinical Trial. Anesth Analg. 122(4):986–995
4. Basora M, Tió M, Martin N, et al. (2014) Should all patients be optimized to the same preoperative hemoglobin level to avoid transfusion in primary knee arthroplasty? Vox Sang. 107(2):148–152
5. Bowditch MG, Villar RN (1999) Do obese patients bleed more? A prospective study of blood loss at total hip replacement. Ann R Coll Surg Engl. 81:198–200
6. Carling MS, Jeppsson A, Eriksson BI, Brisby H (2015) Transfusions and blood loss in total hip and knee arthroplasty: a prospective observational study. J Orthop Surg Res. 10:48
7. Clavé A, Gérard R, Lacroix J, et al. (2019) A randomized, double-blind, placebo-controlled trial on the efficacy of tranexamic acid combined with rivaroxaban thromboprophylaxis in reducing blood loss after primary cementless total hip arthroplasty. Bone Joint J. 101–B(2):207–212
8. Dastrup A, Pottegård A, Hallas J, Overgaard S (2018) Perioperative Tranexamic Acid Treatment and Risk of Cardiovascular Events or Death After Total Hip Arthroplasty: A Population-Based Cohort Study from National Danish Databases. J Bone Joint Surg Am. 100(20):1742–1749
9. Duncan CM, Gillette BP, Jacob AK, et al. (2015) Venous thromboembolism and mortality associated with tranexamic acid use during total hip and knee arthroplasty. J Arthroplasty. 30(2):272–276
10. Fillingham YA, Ramkumar DB, Jevsevar DS, et al. (2018) The Safety of Tranexamic Acid in Total Joint Arthroplasty: A Direct Meta-Analysis. J Arthroplasty. 33(10):3070–3082.e1
11. Fillingham YA, Ramkumar DB, Jevsevar DS, et al. (2018) The Efficacy of Tranexamic Acid in Total Knee Arthroplasty: A Network Meta-Analysis. J Arthroplasty. 33(10):3090–3098.e1
12. Frisch NB, Wessell NM, Charters MA, et al. (2014) Predictors and complications of blood transfusion in total hip and knee arthroplasty. J Arthroplasty. 29(9 Suppl):189–192
13. Guay J (2016) The effect of neuraxial blocks on surgical blood loss and blood transfusion requirements: a meta-analysis. J Clin Anesth.18(2):124-8
14. Jiang T, Song K, Yao Y, Pan P, Jiang Q (2019) Perioperative allogenic blood transfusion increases the incidence of postoperative deep vein thrombosis in total knee and hip arthroplasty. J Orthop Surg Res. 14(1):235
15. Johansson T, Pettersson LG, Lisander B (2005) Tranexamic acid in total hip arthroplasty saves blood and money: a randomized, double-blind study in 100 patients. Acta Orthop. 76(3):314–319
16. Jung WH, Chun CW, Lee JH, et al. (2013) No difference in total blood loss, haemoglobin and haematocrit between continues and intermittent wound drainage after total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 21(12):2831-6
17. Kim JL, Park JH, Han SB, Cho IY, Jang KM (2017) Allogeneic Blood Transfusion Is a Significant Risk Factor for Surgical-Site Infection Following Total Hip and Knee Arthroplasty: A Meta-Analysis. J Arthroplasty. 32(1):320–325

18. Kort NP, Bemelmans YFL, Schotanus MGM (2017) Outpatient surgery for unicompartmental knee arthroplasty is effective and safe. Knee Surg Sports Traumatol Arthrosc. 25(9):2659–2667
19. Madsen RV, Nielsen CS, Kallemose T, Husted H, Troelsen A (2017) Low Risk of Thromboembolic Events After Routine Administration of Tranexamic Acid in Hip and Knee Arthroplasty. J Arthroplasty. 32(4):1298–1303
20. No authors stated. Federatie Medisch Specialisten – guideline (2019) 'bloedtransfusiebeleid' URL: https://richtlijnendatabase.nl/richtlijn/bloedtransfusiebeleid/startpagina_-_bloedtransfusiebeleid.html
21. Sandri A, Mimor BF, Ditta A, et al. (2019) Perioperative intravenous tranexamic acid reduces blood transfusion in primary cementless total hip arthroplasty. Acta Biomed. 90(1-S): 81–86
22. Schotanus MGM, Bemelmans YFL, Grimm B, Heyligers IC, Kort NP (2017) Physical activity after outpatient surgery and enhanced recovery for total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 25(11):3366–3371
23. Sizer SC, Cherian JJ, Elmallah RD, et al. (2015) Predicting Blood Loss in Total Knee and Hip Arthroplasty. Orthop Clin North Am. 46(4):445–459
24. Slover J, Lavery JA, Schwarzkopf R, et al. Incidence and Risk Factors for Blood Transfusion in Total Joint Arthroplasty: Analysis of a Statewide Database. J Arthroplasty. 32(9):2684–2687.e1
25. Song K, Pan P, Yao Y, Jiang T, Jiang Q (2019) The incidence and risk factors for allogenic blood transfusion in total knee and hip arthroplasty. J Orthop Surg Res. 14(1):273
26. Trice ME, Walker RH, D'Lima DD, Morris BA, Colwell CW Jr (1999) Blood loss and transfusion rate in noncemented and cemented/hybrid total hip arthroplasty. Is there a difference? A comparison of 25 matched pairs. Orthopedics. 22(1 Suppl):s141-4
27. Wang N, Xiong X, Xu L, et al. (2019) Transfusions and cost-benefit of oral versus intravenous tranexamic acid in primary total hip arthroplasty: A meta-analysis of randomized controlled trials. Medicine. 98(17):e15279
28. Wu XD, Chen Y, Tian M, et al. (2019) Application of thrombelastography (TEG) for safety evaluation of tranexamic acid in primary total joint arthroplasty. J Orthop Surg Res. 14(1):214
29. Xie J, Zhang S, Chen G, et al. (2019) Optimal route for administering tranexamic acid in primary unilateral total hip arthroplasty: Results from a multicenter cohort study. Br J Clin Pharmacol. 85(9):2089–2097
30. Xiong H, Liu Y, Zeng Y, Wu Y, Shen B (2018) The efficacy and safety of combined administration of intravenous and topical tranexamic acid in primary total knee arthroplasty: a meta-analysis of randomized controlled trials. BMC Musculoskelet Disord. 19(1):321

CHAPTER 4

NO ADVANTAGE OF ADRENALINE IN THE LOCAL INFILTRATION ANALGESIA MIXTURE DURING TOTAL KNEE ARTHROPLASTY. RANDOMIZED CONTROLLED TRIAL.

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Abstract

Purpose Local infiltration analgesia (LIA) is widely applied in patients undergoing total knee arthroplasty (TKA). In daily practice, adrenaline is added to the LIA mixture to achieve vasoconstriction. However, adrenaline has some possible negative side effects (e.g. tissue necro-sis). This trial investigated whether ropivacaine alone is at least as effective for postoperative pain relief after LIA.

Methods Fifty patients scheduled for primary TKA were included in this prospective randomized, double-blind, controlled pilot study receiving high-volume (150 mL) single-shot intra-capsular LIA with ropivacaine (2 %) with (Ropi+) or without (Ropi−) adrenaline (0.01 %). All patients received the same pre-, peri- and postoperative care with multimodal oral pain protocol. Postoperative pain was assessed before and after the first mobilization and during the first 48 h postoperative using the visual analogue scale (VAS). Secondary outcomes were rescue medication use, early mobilization, length of hospital stay, adverse events (AE's) and readmission rates. Patient reported outcomes measures (PROMS); Oxford Knee Score and WOMAC, were obtained preoperative and 3 months postoperative.

Results VAS scores were not significantly different before (n.s.) and after the first mobilization (n.s.), neither over the first 48 h postoperative (n.s.). Patients who needed rescue medication (n.s.), who mobilized < 6 h postoperative (n.s.), who were discharged before postoperative day 3 (n.s.), AE's and readmission rate (n.s.) were comparable between both groups. At 3-month follow-up, PROMS significantly improved within both groups.

Conclusion To prevent possible negative side effects (e.g. tissue necrosis), adrenaline should be omitted from the LIA mixture. Single-shot LIA with ropivacaine alone results in clinical acceptable adequate pain control and can be used in daily TKA practice.

Keywords Adrenaline; Epinephrine; Local infiltration analgesia; Pain management; Total knee arthroplasty; Early mobilization; Early discharge; Fast track

Introduction

Early mobilization after TKA can be delayed due to severe high intense pain 3 to 6 h postoperative [6, 11]. Recent literature supports the use of LIA to challenge with direct postoperative pain after TKA [17]. LIA with ropivacaine in joint replacement surgery was first described in 2003 after which the technique was further developed [4, 19, 31]. The literature shows progressive results in terms of pain control, early mobilization and discharge from hospital and reduced opiate use [1, 3, 11, 30, 31]. Several results are attributable to different analgesic infusion techniques after TKA, all with positive and negative side effects [11, 30]. This technique involves intra-operative infiltration of an analge-sic mixture. The combination of ropivacaine with adrena-line is most common used and described in the literature to deal with postoperative pain [17]. During surgery, the use of locally administered adrenaline reduces potentially toxic blood concentrations of ropivacaine [4, 6, 17, 22, 24], decreases the clearance and distribution processes into the blood flow [29], and it may also reduce the risk of bleeding into the knee [7]. However, there are also some potential local and systemic adverse effects such as tissue necrosis and increased risk of infections [12, 21, 22, 29, 30]. The data are limited to support the role of adrenaline during intra-operative single-shot LIA in combination with ropiv-acaine in patients undergoing TKA [17, 18, 23, 27, 28, 30, 34]. The theoretical advantage of adrenaline is the vaso-constrictive effect. On the other hand, ropivacaine itself is a long-acting analgesic with vasoconstrictive properties to reduce local absorption [4, 5, 22, 24]. There are no data to support the effect of ropivacaine alone for single-shot LIA on postoperative pain relief after TKA compared with LIA, consisting a ropivacaine and adrenaline mixture.

This study hypothesized that LIA with only ropivacaine is at least as effective in short terms as the widely used current method, LIA procedure with mixture of ropivacaine and adrenaline. This prospective, randomized, double-blind controlled trial examines the effect of adrenaline in the LIA mixture in patients undergoing TKA.

Materials and methods

Fifty patients with a painful and disabled knee joint result-ing from osteoarthritis, a high need to obtain pain relief and improve function, able and willing to follow instructions were included after informed consent. Patients with a general or an active knee infection, failure of previous joint replacement of the knee to be operated on, pregnancy, con-traindication for ropivacaine and/or adrenaline, and patients who were not able to understand and complete the proce-dure due to cognitive dysfunction or language barrier were not included in this pilot study.

Multidisciplinary enhanced clinical pathway

The following pathway applies to both groups. A personal coach was involved as much as possible to inspire, correct and support the patient while in hospital and directly after discharge. In addition, the coach also indirectly reduces the workload on the nursery in terms of helping with all-day activities. All patients received preoperative education and exercise training, to become familiar with walking (stairs) with crutches and transfers from bed to a chair and vice versa, information about the in- and outpatient pro-cess and home-based rehabilitation. The first mobilization was attempted < 6 h postoperative including transfer from a bed to a chair and vice versa following walking with a walker if possible under supervision of a physiotherapist and nurse. All patients were familiar with the overall dis-charge criteria: mobilize and transfer into and out of bed individual and safe, able to get into and up from a chair, walk independently with crutches and if necessary walk-ing stairs with crutches. After discharge, physiotherapy in their home environment was started 14 days postoperative. All patients were seen at the outpatient clinic at 2, 6 and 12 weeks postoperative.

Table 1. Multimodal opioid sparing pain protocol was provided.

	Preoperative	**Postoperative**			
	2h	**4h**	**8h**	**First day**	**Day 2-14**
Arcoxia (mg)	90			90	90
Paracetamol (g)	1	1	1	1*	1*
Gabapentin (mg)	600		300	300	
Omeprazol (mg)	40			40	40

*Paracetamol (1g) was given four times daily on fixed intervals throughout the day.

Randomization and blinding

To make sure LIA medication was blinded to the patients, orthopaedic surgeon, investigator and other persons direct and indirect involved in the study, randomization and prep-aration of the syringes for both ropivacaine with (Ropi+) and without adrenaline (Ropi−), were performed by the hospital pharmacist (HK). Randomization was performed using computer, web-based generated randomized num-bers (www.random.org). Three syringes (50 ml each) were numbered from one to three, whereas syringe one and two contained ropivacaine (2 %) with or without adrenaline (0.01 %) and the third syringe was always without adrena-line. Randomization was unblinded after study completion or in case of a suspected unexpected serious adverse reac-tion (SUSAR).

Operative and analgesia treatment

According to a standardized pain protocol (Table 1), patients received premedication 2 h before operation. Patients were operated under spinal or general anaes-thetic treatment by a single experienced knee arthroplasty surgeon (NK) with the use of patient-specific positioning instruments (Signature™, Biomet, Warsaw IN) for TKA. All patients received a cemented Vanguard™ Complete Knee System. (Biomet, Inc, Warsaw, IN) A pneumatic tourniquet was positioned on the thigh before surgery and inflated to 350 mmHg during cementing. Single-shot LIA was injected by the orthopaedic surgeon (NK), intra-oper-atively according to Kerr and Kohan [19]. Mean operation time (incision to closure in minutes) and mean blood loss (total volume of blood in the suction device prior to rins-ing the knee with pulse lavage system in millilitres) were recorded in the patients' operative records. Patients did not receive an intra-articular catheter, nor postoperative injec-tions with analgesia nor a drain or urinary catheter. Urinary retention was tested with the use of a bladder scan (Vera-thon®, BVI 9400). Pre- and postoperative patients received a multimodal opioid sparing pain protocol (Table 1). Daily thromboprophylaxis (Fondaparinux) was administered sub-cutaneously once each evening for 35 days, starting on the day of surgery. Compression bandage was removed < 24 h. On day one postoperative patients received analgesics in the morning (Table 1) and daily four times paracetamol (1 g). If analgesics were ineffective on the day of surgery or the first or second day postoperative, rescue analgesia (Tramadol, 100 mg) once daily was provided on demand. From day two till day 14 postoperative, patients received analgesics according to a multimodal opioid sparing pain protocol (Table 1).

Study endpoints

Experienced pain was measured with a visual analogue scale (VAS; 0 to 100, 100 being 'worst pain'). Pain was measured before and after the first mobilization and dur-ing the first 48 h postoperative on fixed time points (direct postoperative, and daily 8:00, 16:00 and on 22:00 h). Res-cue medication use was evaluated, the amount of patients who used postoperative Tramadol were registered. Early mobilization (minutes) was recorded as time between the start of anaesthesia until the first mobilization. Length of hospital stay (days) was evaluated as time between hospi-tal admission and discharge. Adverse events (AE's) were classified as patient related [e.g. postoperative nausea and vomiting (PONV)], thromboembolic events and wound dis-orders (e.g. persistent wound leakage), surgical related (e.g. infection) and/or prosthesis related (e.g. loosening). Pain, PONV and discharge criteria were evaluated daily on fixed time points (8:00, 16:00 and on 22:00 h). Besides the dif-ference of the LIA mixture, pre-, peri- and postoperative procedures and pain protocol were identical in both groups as well as the completed operative and clinical case report

forms. PROMS were obtained preoperative and 3 months postoperative including the Oxford Knee Score (OKS; 12 to 60, 12 being the best outcome) [13] and Western Ontario and McMaster Universities Arthritis Index (WOMAC; 0 to 100, 100 being the best outcome) [25].

This prospective, randomized, double-blind pilot study was performed in compliance with the Helsinki Dec-laration of 1975, as revised in 2000 and was studied and approved by the IRB (METC Atrium-Orbis Zuyd, Heerlen, the Netherlands, IRB Nr. 13T112) and registered online at the European Clinical Trials Database (EudraCT, Nr. NL 20140403), the Dutch Trial Register (www.trialregister. nl, Nr. NTR4769) and conducted in accordance with the guidelines for Good Clinical Practice (GCP).

Statistical analysis
Sample size and power calculations were made based on our expectations. We assumed that both LIA with (Ropi+) or without (Ropi−) adrenaline significantly improves the mean VAS pain score by 20 mm postoperative with a stand-ard deviation of 15 mm on a VAS pain score of 100 mm. With an alpha of 0.05 and 1-beta error of 0.8, we needed 21 patients: 25 taking into account 10 % lost of follow-up. This study included 50 consecutive patients, 25 in each arm. The Shapiro–Wilk test showed that the data were not normal distributed. Statistically significant differences between both groups were analysed with nonparametric Mann–Whitney U test (e.g. VAS pain score, early mobili-zation, early discharge and PROMS), and Chi-square tests were used for categorical variables (e.g. rescue medication use and AE's). P value was considered to be statistically significant at $P \leq 0.05$ for all analysis. All statistical analyses were performed with use of SPSS version 17.0 for win-dows (Inc., Chicago, IL). Results are presented as either with frequencies (%), mean (SD), or median (range).

Results

Fifty randomized patients completed this study. None of the patients were lost to follow-up. Randomization was unblinded after study completion no SUSAR's occurred. Baseline demographics and OR data were not significant different (Table 2).

One patient in both groups used rescue medication on day two. Early mobilization was comparable between both groups (n.s.). Twenty-two patients (88 %) in the Ropi+ group could mobilize within a mean of 336 min (76.0) compared to 21 patients (84 %) who mobilized within a mean of 350 min (68.0) after anaesthesia in the Ropi− group. Length of hospital stay was comparable between both groups (n.s.). Twenty patients

(80 %) in the Ropi+ group compared to 15 patients (60 %) in the Ropi− group were discharged before postoperative day 3 (n.s.). AE's are summarized in Table 3. There were no thromboembolic or prosthesis related AE's although one patient in the Ropi+ group underwent electric cardioversion due to atrial fibrillation and was discharged on postoperative day 3. At 3-month follow-up, the mean WOMAC and OKS significantly ($P < 0.00$) improved within each group with a mean of 30.7 (22.6) and 15.5 (10.9) in the Ropi+ group and 23.5 (25.3) and 12.5 (10.8) in the Ropi− group. There were no significant differences between both groups for both PROMS.

Table 2. Baseline demographics and OR data presented as mean (SD) or absolute number between the groups.

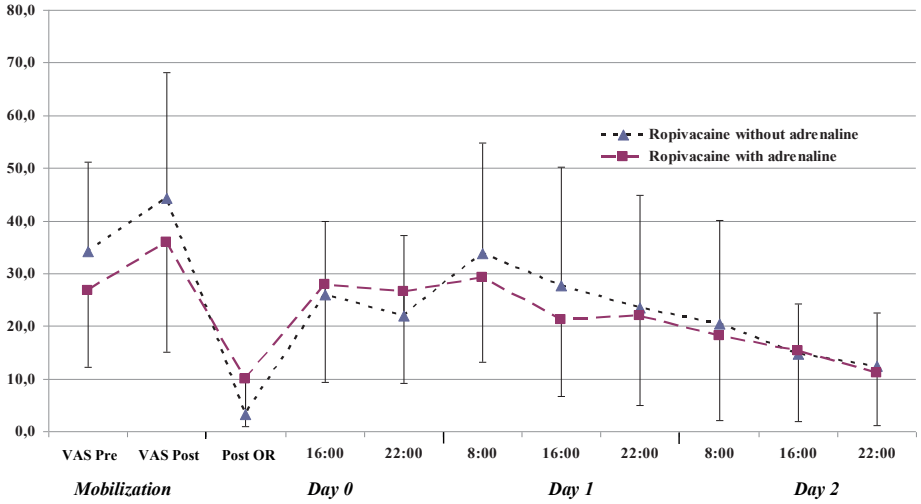
Variables	**Ropi +**	**Ropi-**
Age (years) at index surgery	62.8 (6.1)	66.3 (9.8)
Gender M/F	14/11	10/15
BMI kg/m²	27.6 (5.7)	29.6 (3.8)
ASA classification I/II/III	7/17/1	6/19/0
Operative data		
General/ Spinal	2/23	6/19
Blood loss ml	251.1 (97.7)	235.4 (96.1)
OR time min	62.4 (12.1)	63.0 (15.1)

VAS pain scores were not significantly different (Fig. 1). Thirteen patients (52 %) in the Ropi− group used rescue medication on postoperative day one compared to 7 patients (28 %) in the Ropi+ group (n.s.).

Table 3. The amount of AE's between both groups were not significant different. All adverse events occurred during initial admission except for the readmissions (*)

AE's	**Ropi +**	**Ropi-**	**Remarks**
Patient related	10	6	PONV, vasovagal syncope, electric cardioversion, delirium
Wound disorders	3	0	Major wound leakage
Surgical related	3	1	Loss of sensibility due to delayed recovery from anesthesia, limited knee flexion*, superficial wound infection*

Figure 1. Mean experienced pain (vertical axis) before and after the first mobilization, during the first 48h, measured direct postoperative (post OR), and daily 8:00, 16:00 and on 22:00 h (horizontal axis) with use of a VAS pain score. Standard deviations (SD) are displayed with whiskers.



Discussion

The most important findings of the present study was that the ropivacaine and adrenaline LIA mixture was not clearly superior to LIA consisting only ropivacaine with respect to experienced pain before and after the first mobilization and during the first 48 h postoperative. In this study, both groups gave improved and comparable pain relief after TKA.

These comparable results on pain relief could be explained by the fact that ropivacaine itself is a long-acting analgesic with vasoconstrictive properties to reduce local absorption [4, 5, 22, 24]. Poorly managed postoperative pain after TKA negatively influences early postoperative recovery [14] and discharge [8, 16, 17]. In this trial none of the patients had a delayed mobilization due to high pain intensity. Most of the delayed mobilization occurred in patients infiltrated with adrenaline including vasovagal syn-copes, major wound leakages and one patient did not had any sensibility in both legs due to delayed recovery from spinal anaesthesia. These patients had a delayed discharge, which was in line with the results of Husted et al. [15, 16] who found a relation between length of hospital stay and early mobilization. In this trial serious side effects were observed in both groups, which resulted in prolonged hos-pital stay and hospital readmissions.

Many studies have shown the effects of postoperative LIA [3, 8, 34]. Most of these studies focus on analgesic consumption, early mobilization, pain relief and early dis-charge from hospital [17]. The postoperative pain relief presented in this trial may be comparable to the results from other studies [4, 8, 9, 14]. However, not all results are based on single-shot injections [4]. Many techniques are described in literature, but there is no gold standard in the treatment of pain control after TKA. Most of the studies included single-, continuous [32, 34], intra- or extra-artic-ular infiltrations [3, 7, 26, 30] and with frequent postop-erative injections through an intra- [19, 20] or extra-artic-ular catheter [10] Recent published series consist positive results on the LIA technique with ropivacaine and adrena-line infiltrated intra-operatively with single-shot injections [8, 33]. This trial found comparable results in the literature if it becomes to pain, PONV, early mobilization and dis-charge after single-shot injections of ropivacaine with or without adrenaline. However, also high postoperative pain scores were seen after single-shot injection LIA [34].

One of the limitations in this study, circulating blood levels of ropivacaine were not measured to check for pos-sible considerable chondrotoxicity. Adrenaline reduces potentially toxic blood concentrations of ropivacaine and can extend the effects of the local anaesthetics by keep-ing it localized to the area of injection, but with possible side effects such as tissue necrosis and increased risk of infections, which was found in one patient per group in our series [12, 21, 22, 29, 30]. Both patients were success-fully treated with antibiotics. Other than Andersen et al. [2] reported, a possible risk of considerable chondrotoxic-ity is clinical relevant in case of performing a TKA without resurfacing the patella.

Secondly, it can be argued that the absent effect of adren-aline may be explained by a continuous effect of the used optimised pain protocol although both groups received the same pre- peri- and postoperative treatment including the same opioid sparing multimodal oral pain protocol. In contrast to other published trials, ketorolac was not added to the LIA mixture. Etoricoxib was part of the multimodal oral pain protocol, administered 2 h pre- and daily up to postoperative day 14.

Thirdly, a comparison with a placebo-controlled group that received LIA with only saline was not made. Given the fact that single-shot LIA is an added value after TKA to cope with postoperative pain relief, LIA should belong to the daily practice during TKA [33]. However, it is unclear which LIA mixture has the most favourable outcome with minimal side effects. Recently, Xu et al. [33] published their meta-analysis of RCT's on single-shot LIA in TKA patients. They concluded that single-shot LIA is effective for postoperative pain management in TKA patients with satisfactory short-term safety without any

consensus on the widespread used analgesia. This study found limited evi-dence to support the role of adrenaline during intra-oper-ative single-shot LIA in combination with ropivacaine in patients undergoing TKA. Further larger RCT's exploring the effect of adrenaline are of interest [10, 17, 27, 28, 30, 33].

Finally, we recommend that LIA with only ropivacaine should be part of daily practice in TKA including a well-established multimodal pain protocol to cope with postop-erative pain, without the possible negative side effects of adrenaline.

Conclusion

This randomized, double-blind, prospective clinical trial could not confirm the added value of adrenaline into the ropivacaine solution for LIA, since both groups showed comparable experienced pain during the first 48 h postoperative.

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Authors' contribution
MS, HK, JJ and NK designed the study. HK did the randomization. MS collected the data. MS and YB analysed and interpreted the data. MS and YB wrote the manuscript, HK, JJ and NK revised it.

References

1. Affas F, Nygårds EB, Stiller CO, Wretenberg P, Olofsson C (2011) Pain control after total knee arthroplasty: a randomized trial comparing local infiltration anesthesia and continuous fem-oral block. Acta Orthop 82:441–447
2. Andersen LØ, Husted H, Kristensen BB, Otte KS, Gaarn-Larsen L, Kehlet H (2010) Analgesic efficacy of intracapsular and intra-articular local anaesthesia for knee arthroplasty. Anaesthesia 65:904–912
3. Andersen LØ, Husted H, Otte KS, Kristensen BB, Kehlet H (2008) High-volume infiltration analgesia in total knee arthro-plasty: a randomized, double-blind, placebo-controlled trial. Acta Anaesthesiol Scand 52:1331–1335
4. Bianconi M, Ferraro L, Traina GC, Zanoli G, Antonelli T, Guberti A, Ricci R, Massari L (2003) Pharmacokinetics and efficacy of ropivacaine continuous wound instillation after joint replacement surgery. Br J Anaesth 91:830–835
5. Bouaziz H, Iohom G, Estèbe JP, Campana WM, Myers RR (2005) Effects of levobupivacaine and ropivacaine on rat sciatic nerve blood flow. Br J Anaesth 95:696–700
6. Busch CA, Shore BJ, Bhandari R, Ganapathy S, MacDonald SJ, Bourne RB, Rorabeck CH, McCalden RW (2006) Efficacy of periarticular multimodal drug injection in total knee arthroplasty: a randomized trial. J Bone Joint Surg Am 88:959–963
7. Dobrydnjov I, Anderberg C, Olsson C, Shapurova O, Angel K, Bergman S (2011) Intra-articular vs. extraarticular ropivacaine infusion following high-dose local infiltration analgesia after total knee arthroplasty: a randomized double-blind study. Acta Orthop 82:692–698
8. Essving P, Axelsson K, Åberg E, Spännar H, Gupta A, Lundin A (2011) Local infiltration analgesia versus intrathecal morphine for postoperative pain management after total knee arthroplasty: a randomized controlled trial. Anesth Analg 113:926–933
9. Essving P, Axelsson K, Kjellberg J, Wallgren O, Gupta A, Lun-din A (2010) Reduced morphine consumption and pain inten-sity with local infiltration analgesia (LIA) following total knee arthroplasty. Acta Orthop. 81:354–360
10. Essving P, Axelsson K, Kjellberg J, Wallgren O, Gupta A, Lun-din A (2009) Reduced hospital stay, morphine consumption, and pain intensity with local infiltration analgesia after unicompart-mental knee arthroplasty. Acta Orthop. 80:213–219
11. Gómez-Cardero P, Rodríguez-Merchán EC (2010) Postoperative analgesia in TKA: ropivacaine continuous intra-articular infu-sion. Clin Orthop Relat Res 468:1242–1247
12. Hartzell TL, Sangji NF, Hertl MC (2010) Ischemia of postmas-tectomy skin after infiltration of local anesthetic with adrenaline: a case report and review of the literature. Aesthetic Plast Surg 34:782–784
13. Haverkamp D, Breugem SJM, Sierevelt IN, Blankevoort L, van Dijk CN (2005) Translation and validation of the Dutch version of the Oxford 12-item knee questionnaire for knee arthroplasty. Acta Orthop 76:347–352
14. Holm B, Kristensen MT, Myhrmann L, Husted H, Andersen LØ, Kristensen B, Kehlet H (2010) The role of pain for early reha-bilitation in fast track total knee arthroplasty. Disabil Rehabil 32:300–306
15. Husted H, Holm G, Jacobsen S (2008) Predictors of length of stay and patient satisfaction after hip and knee replacement surgery: fast-track experience in 712 patients. Acta Orthop 79:168–173
16. Husted H, Lunn TH, Troelsen A, Gaarn-Larsen L, Kristensen BB, Kehlet H (2011) Why still in hospital after fast-track hip and knee arthroplasty? Acta Orthop 82:679–684

17. Kehlet H, Andersen LØ (2011) Local infiltration analgesia in joint replacement: the evidence and recommendations for clini-cal practice. Acta Anaesthesiol Scand 55:778–784
18. Kehlet H, Wilmore DW (2008) Evidence-based surgical care and the evolution of fast-track surgery. Ann Surg 248:189–198
19. Kerr DR, Kohan L (2008) Local infiltration analgesia: a tech-nique for the control of acute postoperative pain following knee and hip surgery a case study of 325 patients. Acta Orthopaedica 79:174–183
20. Lunn TH, Husted H, Solgaard S, Kristensen BB, Otte KS, Kjersgaard AG, Gaarn-Larsen L, Kehlet H (2011) intra-operative local infiltration analgesia for early analgesia after total hip arthroplasty: a randomized, double-blind, placebo-controlled trial. Reg Anesth Pain Med 36:424–429
21. Ong JC, Chin PL, Fook-Chong SM, Tang A, Yang KY, Tay BK (2010) Continuous infiltration of local anaesthetic following total knee arthroplasty. J Orthop Surg (Hong Kong) 18:203–207
22. Piper SL, Kramer JD, Kim HT, Feeley BT (2011) Effects of local anesthetics on articular cartilage. Am J Sports Med 39:2245–2253
23. Raeder JC (2011) Local infiltration analgesia for pain after total knee replacement surgery: a winner or just a strong runner-up? Anesth Analg 113:684–686
24. Ratajczak-Enselme M, Estebe JP, Rose FX, Wodey E, Malinovsky JM, Chevanne F, Dollo G, Ecoffey C, Le Corre P (2007) Effect of epinephrine on epidural, intrathecal, and plasma pharmacokinetics of ropivacaine and bupivacaine in sheep. Br J Anaesth 99:881–890
25. Roorda LD, Jones CA, Waltz M, Lankhorst GJ, Bouter LM, van der Eijken JW, Willems WJ, Heyligers IC, Voaklander DC, Kelly KD, Suarez-Almazor ME (2004) Satisfactory cross cultural equivalence of the Dutch WOMAC in patients with hip osteoar-thritis waiting for arthroplasty. Ann Rheum Dis 63:36–42
26. Rosen AS, Colwell CW Jr, Pulido PA, Chaffee TL, Copp SN (2010) A randomized controlled trial of intra-articular ropiv-acaine for pain management immediately following total knee arthroplasty. HSS J 6:155–159
27. Rosenberg PH, Veering BT, Urmey WF (2004) Maximum rec-ommended doses of local anesthetics: a multifactorial concept. Reg Anesth Pain Med 29:564–575
28. Röstlund T, Kehlet H (2007) High-dose local infiltration anal-gesia after hip and knee replacement—what is it, why does it work, and what are the future challenges? Acta Orthopaedica 78:159–161
29. Solanki DR, Enneking FK, Ivey FM, Scarborough M, Johnston RV (1992) Serum bupivacaine concentrations after intra-articu-lar injection for pain relief after knee arthroscopy. Arthroscopy 8:44–47
30. Toftdahl K, Nikolajsen L, Haraldsted V, Madsen F, Tønnesen EK, Søballe K (2007) Comparison of peri- and intra-articular analgesia with femoral nerve block after total knee arthroplasty: a randomized clinical trial. Acta Orthop 78:172–179
31. Vendittoli PA, Makinen P, Drolet P, Lavigne M, Fallaha M, Guertin MC, Varin F (2006) A multimodal analgesia protocol for total knee arthroplasty. A randomized, controlled study. J Bone Joint Surg Am 88:282–289
32. Williams D, Petruccelli D, Paul J, Piccirillo L, Winemaker M, de Beer J (2013) Continuous infusion of bupivacaine following total knee arthroplasty: a randomized control trial pilot study. J Arthroplasty 28:479–484
33. Xu CP, Li X, Wang ZZ, Song JQ, Yu B (2014) Efficacy and safety of single-dose local infiltration of analgesia in total knee arthroplasty: a meta-analysis of randomized controlled trials. Knee. 21:636–646
34. Zhang S, Wang F, Lu ZD, Li YP, Zhang L, Jin QHJ (2011) Effect of single-injection versus continuous local infiltration analgesia after total knee arthroplasty: a randomized, double-blind, placebo-controlled study. Int Med Res 39:1369–1380

CHAPTER 5

LOW INCIDENCE OF POSTOPERATIVE URINARY RETENTION WITH THE USE OF A NURSE-LED BLADDER SCAN PROTOCOL AFTER HIP AND KNEE ARTHROPLASTY: A RETROSPECTIVE COHORT STUDY.

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Abstract

Purpose Postoperative urinary retention (POUR), defined as the inability to empty the bladder voluntary after surgery, is a commonly reported complication. This study reports the incidence and possible risk factors for POUR after elective fast-track hip or knee arthroplasty when using a nurse-led bladder scan protocol.

Methods This retrospective cohort study included data from 803 patients who underwent unilateral hip or knee arthroplasty. Patients' digital clinical records were reviewed for eligibility. Patients with incomplete data registration, preoperative bladder volume >250 ml, preexisting bladder catheterization, and/or patients following the outpatient pathway were excluded. Bladder volumes were assessed at different moments pre- and postoperatively. The outcome was the incidence of POUR, defined as the inability to void spontaneously with a bladder volume >600 ml, treated with indwelling catheterization. Further analysis between POUR and non-POUR patients was performed to detect possible risk factors for POUR.

Results Six hundred and thirty-eight patients operated on primary unilateral hip or knee arthroplasty were analyzed. The incidence of POUR was 12.9% (n = 82, 95% CI 9.4–15.5). Gender, age, BMI, ASA classification, preoperative bladder volume, type of anesthesia, type of arthroplasty, and perioperative fluid administration were not significant different between POUR and non-POUR patients. Patients with a bladder volume of >200 ml at the recovery room were at higher risk (OR 5.049, 95% CI 2.815–9.054) for POUR.

Conclusions When using a nurse-led bladder scan protocol in fast-track hip and knee arthroplasty, the incidence of POUR was 12.9%, with a bladder volume of >200 ml at the recovery room as a risk factor for POUR.

Keywords Postoperative urinary retention; POUR; Bladder scan; Hip arthroplasty; Knee arthroplasty

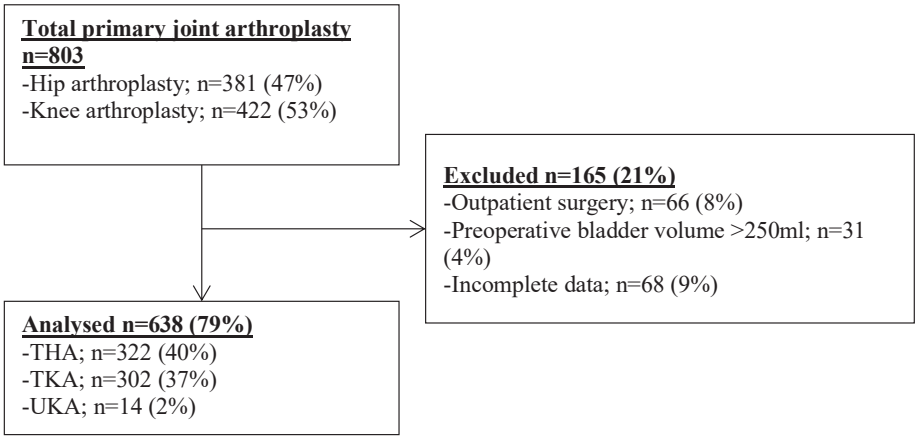
Introduction

Since the introduction of fast-track surgery pathways in orthopedic departments, peri- and postoperative indwelling bladder catheterization is no longer routinely performed [19,22,27]. Postoperative urinary retention (POUR), defined as the inability to empty the bladder voluntary after anesthesia and surgery, is a commonly reported adverse event after elective total hip- (THA) and knee arthroplasty (TKA) [1,2,4,5]. The reported incidence of POUR after TKA and THA following a fast-track or conventional pathway ranges widely between 0-75% [1,4-6,16,17,27]. Many factors contribute to the risk of POUR, such as type of anesthesia, male gender, comorbidities and perioperative fluid management [2,3,4-6,13,21]. An ultrasound bladder scan is introduced as a diagnostic tool to monitor bladder volume in the prevention of POUR [8,9,18]. General consensus on definition of POUR, cut-off values, time of measurement with a bladder scan and treatment strategies (intermittent vs. indwelling catheterization) is lacking [4,14,29]. Most studies reported POUR as the inability to void spontaneously after surgery with a high bladder volume, ranging between 400-800ml [2,5,6]. As other studies defined POUR as the need for postoperative urologic consultation [26] or the postoperative inability to void spontaneously without monitoring bladder volume [21,27]. Based on physiological knowledge, exceeding 600ml of bladder volume is considered to be pathophysiological [29]. The potential risk of POUR is overdistension of the bladder, which can cause urologic adverse events [3]. Indications for postoperative catheterization after THA and TKA in fast-track surgery are based on the bladder volume and is widely diverse in literature [1-3,5,6] ranging from 400-800ml. Early detection and treatment of POUR is paramount in prevention of bladder overdistension and thereby urologic adverse events [23]. Treatment of POUR consists of intermittent or indwelling catheterization, which both is often associated with an increased risk of urinary tract infection, morbidity and prolonged hospital stay [7,25,29]. With the use of an ultrasound-guided bladder scan protocol, elective bladder catheterization is unnecessary in patients undergoing THA and TKA [2]. However, there is limited evidence regarding a standardized pre-, peri- and postoperative bladder scan protocol with general applicable cut-off values and strategies regarding the treatment of high bladder volumes to prevent for POUR [2,5,14,18]. This study reports the incidence and the potential risk factors for POUR, after elective fast-track hip- and knee arthroplasty, when using a nurse-led bladder scan protocol.

Materials and methods

This retrospective analysis included all patients who underwent elective unilateral primary total hip (THA), total knee (TKA), or unicompartmental knee (UKA) arthroplasty in a fast-track pathway between June 2014 and May 2015 in the Zuyderland Medical Center (Sittard-Geleen, the Netherlands). Patients were excluded from analysis in case of incomplete data registration, preoperative bladder volume >250 ml, and therefore placement of an indwelling catheter prior to surgery, preexisting usage of bladder catheterization, and/or patients who underwent arthroplasty surgery in an outpatient pathway. A total of 638 patients were analysed after application of the exclusion criteria (Fig. 1). A urinary bladder management protocol was used for the prevention of POUR by using an ultrasound bladder scanner (BladderScan® BVI 9400; Verathon Medical Europe BV, the Netherlands), based on the available literature [2, 3, 14, 18, 28] and the expert opinion of the hospital urologists (Fig. 2).

Figure 1. Selection of patients.



Pre-, peri-, and postoperative treatment

Bladder volumes were monitored preoperatively after voiding to detect a possible urinary retention >250 ml, which has been found as a risk factor for POUR [3]. In case of >250 ml of urinary retention preoperative after spontaneous voiding, indwelling catheter was placed prior to surgery [27]. When indwelling catheter was used, it was removed the next day.

All nurses were trained in using the bladder scanner and were familiar with the online available bladder scan protocol (Fig. 2). All surgeries were performed by seven experienced arthroplasty surgeons. Patients were operated under spinal or

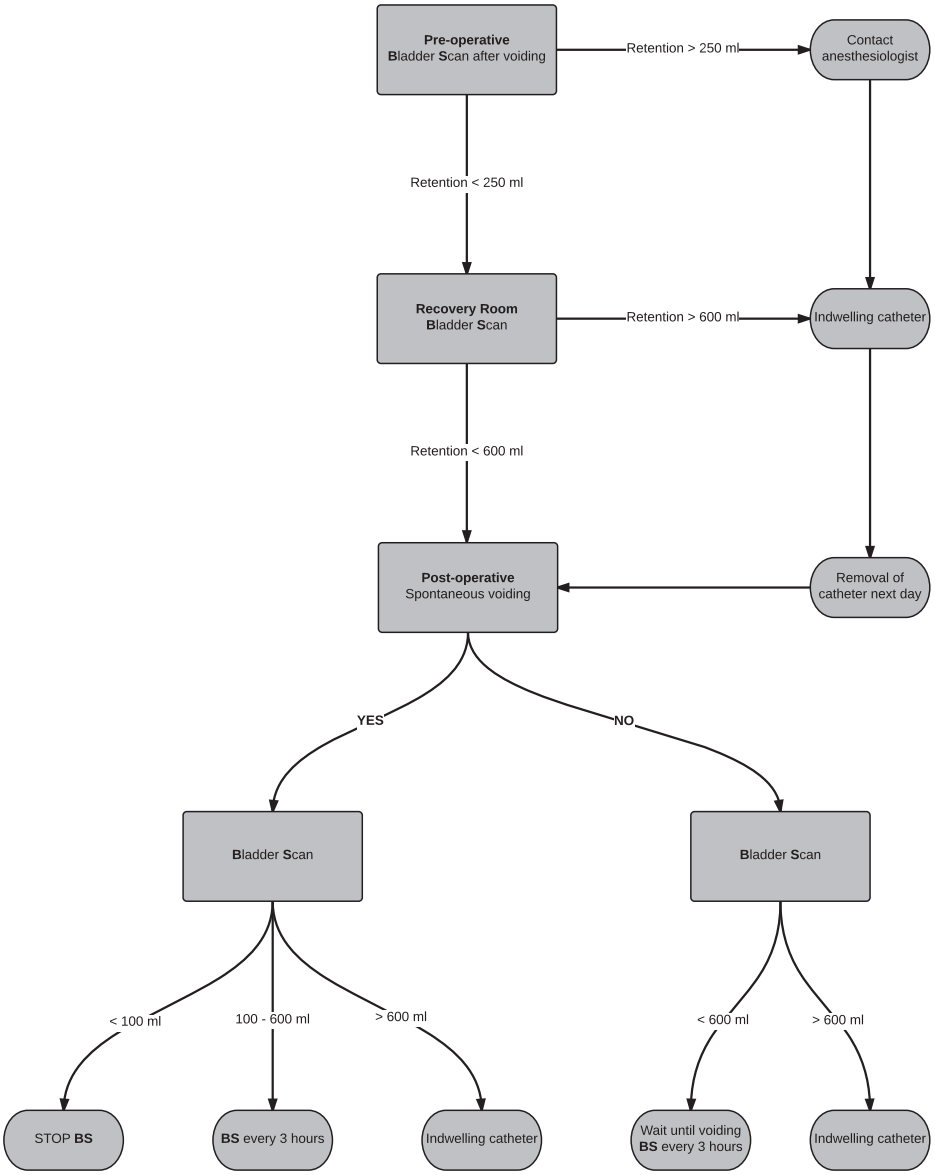
general anesthesia with intravenous fluid restriction (max. 1000 ml). Local infiltration analgesia (LIA) was used intraoperative in knee arthroplasty [24]. In order to prevent PONV, intravenous dexamethasone (single shot, 8 mg) was administrated during the surgery. Oral tranexamic acid (1 g if weight <100 kg, 1.5 g if weight >100 kg) was provided preoperatively. At wound closure, the same doses were given intravenous for prevention of blood loss. No wound drains were used. An opioid-sparing pain protocol was provided (Table 1). In case of inadequate pain control, tramadol was used with a maximum of two times 50 mg per day, and occasional oxycodone was used when the patient experienced side effects from tramadol. After surgery, patients were observed in the recovery room until their cardiorespiratory status was stable and pain control was adequate before transferring them to the orthopedic ward.

Directly postoperative at the recovery room and every 3 h at the orthopedic ward, bladder volume was monitored until spontaneous voiding (Fig. 2). If the bladder volume exceeded more than 600 ml, with the inability to void spontaneously, catheterization was performed with an indwelling catheter to cope with a possible overdistension of the bladder [23]. In case of catheterization, the catheter was removed the next day. If the patient was able to void spontaneously, with a bladder volume <100 ml, monitoring was discontinued. Within 6 h postoperative, the patient was mobilized under supervision of a physiotherapist after recovery from anesthesia. After the first mobilization, patients were transferred to the restroom under guidance of a nurse in case of urge to void. Patients were discharged from the hospital if they met the discharge criteria: overall general well-being, spontaneous voiding with bladder volume <100 ml, a dry wound, adequate pain control, individual and safe mobilization with transfer into and out of bed and chair, walk independently with a walking aid, and if necessary walking stairs with crutches.

Outcome

The primary outcome of this study was the incidence of POUR defined as the inability to void spontaneously with a bladder volume >600 ml, detected with a bladder scan, requiring indwelling catheterization. Secondary, to detect potential risk factors: gender, age, body mass index (BMI), ASA classification, preoperative bladder volume, type of anesthesia, type of arthroplasty, perioperative fluid administration, and bladder volume at the recovery room were analysed between POUR and non-POUR patients. All outcomes were recorded in the patients' digital clinical record. This study was performed in compliance with the Declaration of Helsinki 1975, as revised in 2000, and the study was approved by the IRB (METC Zuyderland, Heerlen, the Netherlands, IRB Nr. 15-N-136) and conducted in accordance with the guidelines for Good Clinical Practice (GCP).

Figure 2. Pre- and postoperative bladder scan (BS) protocol for the prevention of POUR used by the nursing staff.



Statistics

All data collected for this study was entered into an Excel database (Microsoft Office 2003) and analyzed using the SPSS 17.0 (SPSS Inc. Chicago, IL) statistical program. A descriptive analysis of the sample was done using rates for categorical variables and the mean (SD) for continuous variables. The collected data were tested for normality with use of the Shapiro–Wilk test. Since data were not normally distributed, differences between the POUR and non- POUR group were tested with the use of Mann–Whitney *U* test. A p value ≤ 0.05 was considered to be statistically significant. If there was a significant difference for one of the secondary outcomes measures, the odds ratio (OR) with 95% confidence interval (CI) was calculated to determine possible risk factors for POUR. To create a cutoff point, median values of the total group were used. Results are presented as either frequencies (%) or mean (SD).

Table 1. Pain protocol.

	Preoperative	**Postoperative**			
	2hrs	4hrs	8hrs	First day	Day 2-14
Meloxicam (mg)	15			15	15
Paracetamol (g)	1	1	1	1	1
Gabapentine (mg)	600	300		300	
Pantoprazol (mg)	40			40	40

Results

The incidence of POUR was 12.9% (n = 82; 95% CI 9.4–15.5%). There were no significant differences for patient demographics and pre- and perioperative outcome measures between POUR and non-POUR patients (Table 2).

Table 2. Baseline demographics are presented as frequencies (%) or mean (SD) with p-value.

	Pour (n=82)	Non-Pour (n=556)	p-value
Patient demographics			
Male/female, (%)	29/53 (35/65)	200/365 (36/64)	0.915
Age in years, (SD)	68.64 (11.04)	69.42 (8.72)	0.827
BMI in kg/m^2, (SD)	28.63 (4.39)	28.94 (5.97)	0.742
ASA classification, I/II/III	7/43/5	35/332/20	0.312
Spinal/general anesthesia, (%)	59/23 (72/28)	398/158 (72/28)	1.000
THA/TKA, (%)	51/31 (62/38)	272/284 (49/51)	0.059
Fluid administration in ml, mean (SD)	941.89 (367.80)	881.49 (343.33)	0.231

None of the patients underwent re-catheterization after treatment of POUR. Median bladder volume at the recovery room for the total group was 200 ml. When using this as a cutoff value, bladder volume of >200 ml at the recovery room was a risk factor for POUR (OR 5.049, 95% CI 2.815–9.054) (Table 3).

Table 3. Pre- and postoperative bladder volume outcomes are presented as mean (SD) with p-value.

	Pour (n=82)	Non-Pour (n=556)	P-value
Preoperative			
Preoperative bladder volume in ml, (SD)	47.78 (61.69)	37.99 (53.68)	0.131
Postoperative			
Bladder volume at recovery room in ml, mean (SD)	468.21 (257.67)	215.47 (139.59)	**0.000**

Discussion

The most important finding of the present study was that with the use of a nurse-led bladder scan protocol combined with pre-, peri-, and postoperative optimisations (e.g., fluid restriction, opioid-sparing pain protocol), the incidence of POUR after arthroplasty patients following a fast-track pathway was 12.9%, with >200 ml of bladder volume at the recovery room as a risk factor for POUR. The first large-scale and multicenter prospective study on POUR after arthroplasty showed an incidence of approximately 40% [5]. Later series found an incidence of 13–32% depending on the used cutoff value for bladder volume, respectively, 800 and 500 ml [6]. Balderi et al. [2] reported an incidence of 25% in arthroplasty patients and concluded that the use of a bladder scan algorithm can reduce the incidence of POUR. An even lower incidence of POUR after hip and knee arthroplasty was found by Tischler et al. [27]. They performed only bladder scans on patients with symptomatic bladder distention and could therefore underrate the incidence of POUR. Compared to these studies, the presented incidence of POUR in this study was low. A possible explanation for the low incidence of POUR could be the selection prior to surgery. Since it is known that a preoperative bladder volume of >270 ml is a risk factor for POUR [3], the present study created a safe cutoff value for preoperative urinary retention (>250 ml) and excluded these patients from analysis. In case of preoperative urinary retention, patients were treated with indwelling catheterization prior to surgery [29]. Another explanation could be the wide range of bladder volume as cutoff values (400–800 ml) in the literature [2, 5, 6, 29]. These cutoff values can affect a valid comparison between the study results. Frequent monitoring with the use of a bladder scan decreases the incidence of POUR [8, 9, 18] and should be performed 6–8 h after the start of anesthesia [15]. In the current study, monitoring continued directly postoperative at the recovery room and was repeated every 3 h at

the orthopaedic ward until spontaneous voiding. As far as we know, this is the first study showing that >200 ml of bladder volume on the recovery room is a risk factor (OR 5.049) for POUR after hip or knee arthroplasty. Previously, Keita et al. [20] found >270 ml at the post anesthesia care unit as a predictive factor for POUR (OR 4.8), but these results were found after surgeries of different specialties (e.g., orthopedic, abdominal, urologic). Bladder volume monitoring should be performed directly postoperative to detect an early development of POUR [14]. For patients who exceed >200 ml of bladder volume at the recovery room, a more stringent follow-up, in terms of frequent bladder scan monitoring at the orthopaedic ward, should be considered. Treatment strategies in case of POUR (intermittent vs. indwelling catheterization) and duration of catheterization remain controversial [3]. Zhang et al. [29] found that indwelling catheterization was superior to intermittent catheterization in the prevention of POUR after the routine use of indwelling catheterization for all patients undergoing THA or TKA. They found comparable risk of urinary tract infection. The superior treatment of POUR, without the routine use of preoperative indwelling catheterization, remains questionable. In case of POUR and treatment with indwelling catheterization in the postoperative phase, the present study found no recurrent POUR as seen after intermittent catheterization [5, 6, 12]. Literature on anesthesia technique as a risk factor for POUR is divided. Several studies found that the use of spinal anesthesia increased the risk of POUR [5, 6, 15, 22], as other studies concluded that type of anesthesia did not influence the incidence of POUR [1, 21, 26]. Based on the negative influence on detrusor activity, which can lead to a subsequent atonic bladder, postoperative epidural anesthetics can increase POUR [2, 21]. Patient-controlled analgesia [15] and intrathecal morphine use [10, 11, 27, 28] were also found to be risk factors and should be avoided in the pain management to prevent for POUR. Higher amounts of perioperative fluid administration are related to increased risk of POUR [3, 13]. Unfortunately, a precise cutoff value is unknown. When using a restrictive protocol (max. 1000 ml), perioperative fluid administration did not increase the risk of POUR in the present study. Several studies reported male gender as a risk factor for POUR [1–3, 11, 13, 15, 21, 26]. Bjerregaard et al. [5] did not find gender to be a risk factor, but an increased International Prostate Symptom Score (IPSS) was related to POUR. In a retrospective analysis on 376 male THA patients, Hollman et al. [15] could not confirm these results since they found no relation between POUR and prostate pathology. Nevertheless, a high incidence (39.9%) of POUR after THA in men was reported [15]. This study has several limitations. Firstly, the presented study examined a general applicable protocol for hip and knee arthroplasty patients following a fast-track pathway, without consideration of the patients' specific comorbidity (e.g., IPSS, urologic or renal comorbidities), which could have led to confounding results. Secondly, there is no consensus on cutoff value's for bladder volume. Therefore, the presented incidence of POUR, when using a cutoff value of more than 600 ml, could be

underrated. Randomized controlled trials on the bladder scan protocol are needed to confirm the presented results and should focus on cutoff value's at different steps in the bladder scan protocol. Furthermore, selection criteria are needed to detect high-risk patients. To ensure patient's safety, these patients should be treated with indwelling catheterization prior to surgery. When using a nurse-led bladder scan protocol, this study showed a low incidence of POUR after fast-track hip and knee arthroplasty in comparison with recent literature.

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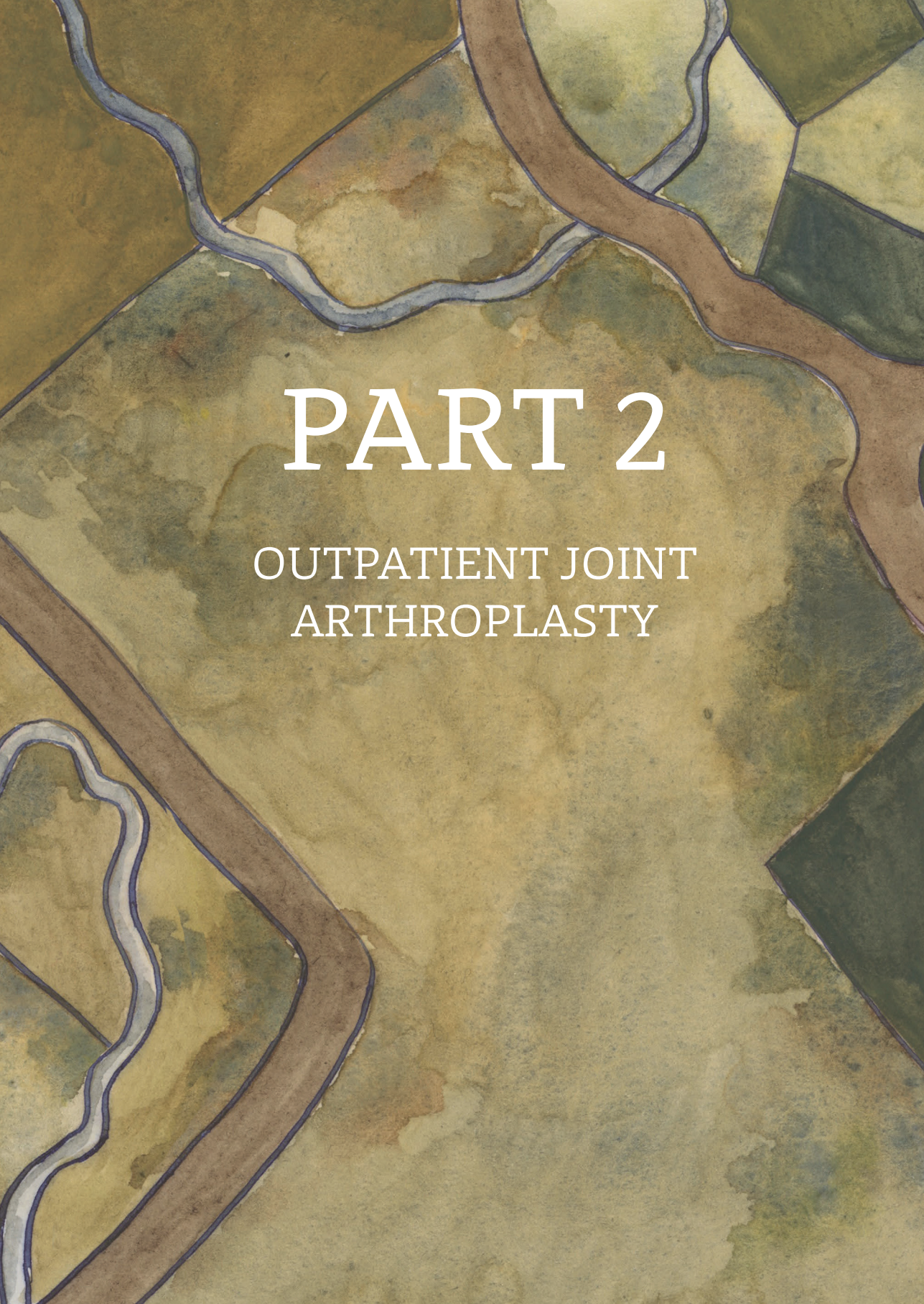
Compliance with ethical standards

Conflict of interest
One author (NK) is a paid consultant for Zimmer Biomet, Europe. This was not the case when the study was set up. The other authors certify that they have no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements) that might pose a conflict of interest in connection with the submitted manuscript. The other authors declare that they have no conflict of interest. No financial support was received for this study.

References

1. Balderi T, Carli F (2010) Urinary retention after total hip and knee arthroplasty. Minerva Anestesiol 76(2):120–130
2. Balderi T, Mistraletti G, D'Angelo E, Carli F (2011) Incidence of postoperative urinary retention (POUR) after joint arthroplasty and management using ultrasound-guided bladder catheterization. Minerva Anestesiol 77:1050–1057
3. Baldini G, Bagry H, Aprikian A, Carli F (2009) Postoperative urinary retention: anesthetic and perioperative considerations. Anesthesiology 110(5):1139–1157
4. Bjerregaard LS, Bagi P, Kehlet H (2014) Postoperative urinary retention (POUR) in fast-track total hip and knee arthroplasty. Acta Orthop 85(1):8–10
5. Bjerregaard LS, Bogo S, Raaschou S, Troldborg C, Hornum U, Poulsen AM, Bagi P, Kehlet H (2015) Incidence of and risk factors for postoperative urinary retention in fast-track hip and knee arthroplasty. Acta Orthop 86(2):183–188
6. Bjerregaard LS, Hornum U, Troldborg C, Bogoe S, Bagi P, Kehlet H (2016) Postoperative urinary catheterization thresholds of 500 versus 800 ml after Fast-track total hip and knee arthroplasty: a randomized, open-label, controlled trial. Anesthesiology 124(6):1256–1264
7. Choi S, Awad I (2013) Maintaining micturition in the perioperative period: strategies to avoid urinary retention. Curr Opin Anaestesiol 26(3):361–367
8. Collard V, Mistraletti G, Taqi A, Asenjo JF, Feldman LS, Fried GM, Carli F (2007) Intraoperative esmolol infusion in the absence of opioids spares postoperative fentanyl in patients undergoing ambulatory laparoscopic cholecystectomy. Anesth Analg 105:1255–1262
9. Daurat A, Choquet O, Bringuier S, Charbit J, Egan M, Capdevila X (2015) Diagnosis of postoperative urinary retention using a simplified ultrasound bladder measurement. Anesth Analg 120(5):1033–1038
10. Fernandez MA, Karthikeyan S, Wyse M, Foguet P (2014) The incidence of postoperative urinary retention in patients undergoing elective hip and knee arthroplasty. Ann R Coll Surg Engl 96(6):462–465
11. Griesdale DE, Neufeld J, Dhillon D, Joo J, Sandhu S, Swinton F, Choi PT (2011) Risk factors for urinary retention after hip or knee replacement: a cohort study. Can J Anaesth 58(12):1097–1104
12. Hälleberg-Nyman M, Gustafsson M, Langius-Eklöf A, Johansson JE, Norlin R, Hagberg L (2013) Intermittent versus indwelling urinary catheterisation in hip surgery patients: a randomised controlled trial with cost-effectiveness analysis. Int J Nurs Stud 50(12):1589–1598
13. Huang Z, Ma J, Shen B, Pei F (2015) General anesthesia: to catheterize or not? A prospective randomized controlled study of patients undergoing total knee arthroplasty. J Arthroplasty 30(3):502–506
14. Hansen BS, Søreide E, Warland AM, Nilsen OB (2011) Risk factors of post-operative urinary retention in hospitalised patients. Acta Anaesthesiol Scand 55(5):545–548
15. Hollman F, Wolterbeek N, Veen R (2015) Risk factors for postoperative urinary retention in men undergoing total hip arthroplasty. Orthopedics 38(6):507–511
16. Iorio R, Healy WL, Patch DA, Appleby D (2000) The role of bladder catheterization in total knee arthroplasty. Clin Orthop Relat Res 380:80–84
17. Iorio R, Whang W, Healy WL, Patch DA, Najibi S, Appleby D (2005) The utility of bladder catheterization in total hip arthroplasty. Clin Orthop Relat Res 432:148–152

18. Joelsson-Alm E, Ulfvarson J, Nyman CR, Divander MB, Svensén C (2012) Preoperative ultrasound monitoring can reduce postoperative bladder distension: a randomized study. Scand J Urol Nephrol 46(2):84–90
19. Kehlet H (2013) Fast-track hip and knee arthroplasty. Lancet 381(9878):1600–1602
20. Keita H, Diouf E, Tubach F, Brouwer T, Dahmani S, Mantz J, Desmonts JM (2005) Predictive factors of early postoperative urinary retention in the postanesthesia care unit. Anesth Analg 101(2):592–596
21. Lingaraj K, Ruben M, Chan YH, Das SD (2007) Identification of risk factors for urinary retention following total knee arthroplasty: a Singapore hospital experience. Singapore Med J 48(3):213–216
22. Miller AG, McKenzie J, Greenky M, Shaw E, Gandhi K, Hozack WJ, Parvizi J (2013) Spinal anesthesia: should everyone receive a urinary catheter? A randomized, prospective study of patients undergoing total hip arthroplasty. J Bone Joint Surg (Am) 95(16):1498–1503
23. Pavlin DJ, Pavlin EG, Gunn HC, Taraday JK, Koerschgen ME (1999) Voiding in patients managed with or without ultrasound monitoring of bladder volume after outpatient surgery. Anesth Analg 89(1):90–97
24. Schotanus MG, Bemelmans YF, van der Kuy PH, Jansen J, Kort NP (2015) No advantage of adrenaline in the local infiltration analgesia mixture during total knee arthroplasty. Knee
Surg Sports Traumatol Arthrosc 25(9):2778–2783. doi:10.1007/ s00167-015-3723-4
25. Stamm WE (1991) Catheter-associated urinary tract infections: epidemiology, pathogenesis, and prevention. Am J Med 91:65–71
26. Sung KH, Lee KM, Chung CY, Kwon SS, Lee SY, Ban YS, Park MS (2015) What are the risk factors associated with urinary retention after orthopaedic surgery? Biomed Res Int 2015:613216
27. Tischler EH, Restrepo C, Oh J, Matthews CN, Chen AF, Parvizi J (2016) Urinary retention is rare after total joint arthroplasty when using opioid-free regional anesthesia. J Arthroplasty 31(2):480–483
28. Tomaszewski D, Bałkota M, Truszczyński A, Machowicz A (2014) Intrathecal morphine increases the incidence of urinary retention in orthopaedic patients under spinal anaesthesia. Anaesthesiol Intensive Ther 46(1):29–33
29. Zhang W, Liu A, Hu D, Xue D, Li C, Zhang K, Ma H, Yan S, Pan Z (2015) Indwelling versus intermittent urinary catheterization following total joint arthroplasty: a systematic review and metaanalysis. PLoS ONE 10(7):0130636



PART 2

OUTPATIENT JOINT ARTHROPLASTY

CHAPTER 6

OUTPATIENT SURGERY FOR UNICOMPARTIMENTAL KNEE ARTHROPLASTY IS EFFECTIVE AND SAFE. PROSPECTIVE CASE-CONTROLLED STUDY.

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Knee Surgery and Sports Traumatology Arthroscopy. 25(9):2659-2667.
2017

Abstract

Purpose There has been increasing interest in accelerated programs for knee arthroplasty. We examined the efficacy and safety of an outpatient surgery (OS) pathway in patients undergoing unicompartmental knee arthroplasty (UKA).

Methods This case-controlled study evaluates patients operated for UKA in an OS pathway (n=20) compared to Rapid Recovery (RR), the current standard (n=20). We investigated whether patients could be discharged on the day of surgery, resulting in comparable or better outcome by means of adverse events (AE's) in terms of pain (Numerical Rating Scale, NRS), incidences of postoperative nausea and vomiting (PONV) and opiate use (<48hrs postoperative), complication and readmission rates (<3mth postoperative). Patient reported outcomes measures (PROMS) were obtained pre- and 3mth postoperative.

Results Postoperative pain (NRS >5) was the most common reason for prolonged hospital stay in the OS pathway. Eighty-five percent of the patients were discharged on the day of surgery, whereas 95% of the patients were discharged on postoperative day 3 in the RR pathway. Overall, median pain scores in both pathways did not exceed a NRS score of 5, without significant differences (RR vs. OS) in the number of patients with PONV (4 vs. 2) and opiate use (11 vs. 9) <48hrs postoperative. At 3mth postoperative, no significant differences were found for AE's and PROMS between both pathways.

Conclusions The results of this study illustrates that an OS pathway for UKA is effective and safe with acceptable clinical outcome. Well-established and adequate standardized protocols, in- and exclusion criteria and a change in mindset for both the patient and the multidisciplinary team are the key factors for the implementation of an OS pathway.

Keywords Outpatient surgery; Short-stay; Unicompartmental knee arthroplasty; Partial knee arthroplasty; Pain management

Introduction

Care pathways in orthopedic surgery are designed to prepare and optimise patients before, during, and after surgery. These pathways improve the quality of the patient's care ensuring reduction of surgical stress, PONV and pain, [16-19, 21] with increased patient satisfaction whilst reducing the length of stay [17]. Slowly but surely, orthopedic surgeons are convinced of revolutionary changes on evidence-based interventions within the elective knee arthroplasty [16-19, 21]. Success requires the implementation of a clear pathway applying a selected number of scientifically supported procedures, used together and implemented in a multimodal care pathway [15, 19, 20, 33]. Outpatient surgery (OS) pathways are designed for patients initiated for elective surgery on the day of admission into the hospital with a planned discharge, without an overnight stay in a hospital bed [32]. OS is commonly used for small elective surgical procedures, but may be used for more complex and challenging cases. For example, knee arthroplasty, which is more common in the United States of America (USA) than in Europe [31].

Due to the ageing of the population and the implantation of prosthesis in younger patients, the number of knee joint replacement surgeries in Western countries are increasing strongly [26]. The number of joint arthroplasties in the USA in 2006 was estimated at 600.000 operations [9]. This number of operations will even increase with 134% in 9 years [23]. Due to the advancement of multidisciplinary pathways, outpatient UKA is allowing more surgical procedures to be performed; a cost reduction should be possible [3, 30].On the other hand, health care organizations create strategies to decline the use of resources, with the preservation of the quality of care [27].

In 2011 optimisation of the conventional pathway [28] resulted into an enhanced recovery pathway for knee arthroplasty. After years of experience, this optimisation resulted in an OS pathway for UKA. OS is accomplished by a patient specific approach, an optimised process in which the individual proactive patient is essential. Recent literature supports early discharge on the day of operation [4,8,10,13,22]. Published results on outpatient knee arthroplasty are rare and only consist papers from the USA. Europe is more conservative to change care pathways and/or healthcare systems. At the moment optimised enhanced recovery programs still needs to be implemented in most of the orthopedic departments around Europe, since the literature on enhanced recovery for knee arthroplasty mostly included literature from the scandinavian countries.

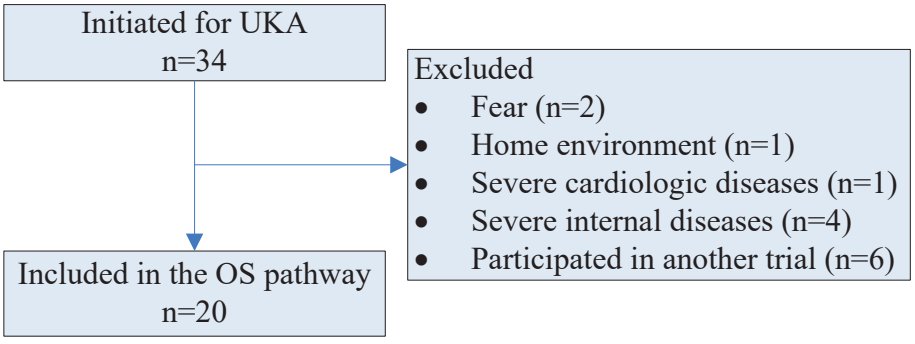
Further research needs to be done to emphasize the effectiveness and safety of outpatient pathways in patients undergoing UKA with the use of generally applicable protocols.

A case-controlled pilot study was performed over the first 20 consecutive cases operated in an OS pathway, these results were compared with a control group operated in a convential enhanced recovery pathway (RR). We investigated whether patients could be discharged on the day of surgery as scheduled, resulting in comparable or better outcome by means of adverse events (AE's) and patient reported outcome measurements (PROMS).

Materials and Methods

All patients were informed and consented to providing data for anonymous use. Between December 2013 and June 2014, 34 patients with indication for primary UKA [29] were potential candidates to participate in the OS pathway. Patients with severe cardiologic, pulmonary and/or internal diseases were excluded. These patients required an overnight stay for additional treatment pre-, peri- and postoperative for adjustment of medication (e.g. diabetes mellitus (DM), bridging anticoagulation). Patients who were not able to understand and complete the procedure due to cognitive dysfunction, fear to follow the outpatient procedure, or those who could not be discharged to their home environment were also excluded (Figure 1). Twenty patients were eligible candidates to participate in the OS pathway. If patients were excluded from the OS pathway, they were treated in the RR pathway as the standard pathway in our department for hip- and knee arthroplasty.

Figure 1. Flowchart of potential and included patients for the OS pathway.



Pathways

Within OS, a personal coach (a relative) indirectly reduces the workload on the ward, by involvement as much as possible, to inspire, correct, and support the patient during inpatient and outpatient for the first 48 hours (hrs) postoperative.

Patients received preoperative education and exercise training, to become familiar with walking (stairs) with crutches and transfers from bed to a chair and vice versa, information about the in- and outpatient process and home-based rehabilitation.

All surgeries were performed with the use of patients specific pin guides (Signature, Biomet, Warsaw INC) and tourniquets by a single experienced knee arthroplasty surgeon (NK). Patients received the (un-) cemented Oxford phase III UKA (Biomet, Bridgend, UK). Prophylactic antibiotics (2g Cefazoline) were administered 30 minutes (min) before incision. A second dose (1g Cefazoline) was administered before discharge. The third dose (300mg Cedax) was taken orally the first postoperative morning at home. Patients were operated under general or spinal anesthesia. Local infiltration analgesia (LIA) was used intraoperative according to Kerr and Kohan [21]. In order to prevent PONV, dexamethasone was used intraoperative (8mg i.v.). Tranexamic acid (dose: 1g if weight <100kg, 1,5g if weight >100kg) was provided intravenously at wound closure. No drains or urinary catheters were used. Urinary retention was tested with the use of a bladder scan (Verathon®, BVI 9400). A compression bandage was used to reduce knee swelling [7] and to increase the effect of the LIA [1] during the first 8hrs postoperative and was removed before discharge. Cooling by ice packs, to cope with knee swelling, was advised within the first 24hrs postoperative. An optimised and opioid sparing-pain protocol was provided (Table 1). As rescue pain medication, Tramadol 50mg was administered (max. 2 times daily). If the patient still suffered from high pain intensity while still in hospital after Tramadol, 15mg of dipidolor was injected intramuscular (max. 6 times daily).

Table 1. Optimised pain protocol.

	Preoperative	**Postoperative**			
	2hrs	**4hrs**	**8hrs**	**First day**	**Day 2-14**
Arcoxia (mg)	90			90	90
Paracetamol (g)	1	1	1	1*	1*
Gabapentine (mg)	600	300		300	
Omeprazol (mg)	40			40	40

*One Paracetamol (1g) was given four times daily on fixed intervals throughout the day.

The first mobilization was attempted within 4-6hrs postoperative, including transfer from the bed to a chair, standing and walking with a walker if possible. If necessary in their home-environment, walking stairs with crutches was practiced before discharge. Patients received instructions for self-administering subcutaneous syringes for thrombosis prophylaxis (Fondaprinux 2.5 mg, Arixtra®, GlaxoSmithKline) administered once each evening for 35 days, starting at 22:00pm directly postoperative. After

discharge, physiotherapy in their home environment was started 14 days postoperative. All patients were seen at the outpatient clinic on day 4 and 14, and at the 6 weeks (wks) and 3 months (mth) postoperative.

Patients were briefed on the overall discharge criteria (dry wound, general well-being, independent mobilization with crutches and if necessary walking stairs with crutches). The ward physician examined the discharge criteria. If there was any deterioration or a lack of progress in the function, the operating surgeon was consulted. All patients were contacted by telephone the first day after discharge by the ward physician.

Twenty patients without severe cardiologic, pulmonary, internal diseases, and/or cognitive dysfunction, who had been operated on by the same surgeon between December 2011 and November 2012 for UKA following the RR pathway, were randomly selected from this cohort (n=79). Beside the differences between both pathways as summarized in Table 2, pre-, peri- and postoperative procedures and pain protocol were identical in both groups as well as the completed operative and clinical reports.

Table 2. Differences between both pathways extracted for pre-, peri- and postoperative care and discharge criteria.

	RR pathway	**OS pathway**
Preoperative		
Admission	Night before/day of operation	Day of operation
Planned discharge	<3 days postoperative	Day of admission
Perioperative		
Dexamethason	No	Yes, perioperative
Tranexamic acid	No	Yes, perioperative
Antibiotics prophylactic	I.v.	I.v. and oral
Postoperative		
First mobilization	<6hrs	<4hrs
Compression bandages	24hrs postoperative	8hrs postoperative, first 4 days postoperative elastic bandage
Discharge criteria		
Knee flexion of	70 degrees	Not assisted as discharge criteria

Outcome

AE's were classified as patient related (e.g. pain, PONV), thrombo-embolic events (e.g. deep venous thrombosis; DVT) and wound disorders, surgical related (e.g. infection) and/or prosthesis related (e.g. loosening). Experienced pain, measured by a Numerical Rating Scale (NRS, 0 to 10, 10 being 'worst pain'), and incidences of PONV were evaluated

during the first 48hrs postoperative. If pain or PONV was reason for delayed first mobilization and/or prolonged hospital stay, it was recorded in the patient's clinical report. All patients filled in a diary on if they were affected with (extreme) pain and/or PONV. All AE's and re-admissions to the hospital were recorded throughout the entire study period of 3mth postoperative. Length of hospital stay was evaluated as time between hospital admission and discharge in days. Early mobilization (hrs) was recorded as time between the start of anesthesia until the first mobilization. PROMS were obtained pre- and 3mth postoperative including the Dutch validated Oxford knee score (OKS; 12 to 60, 12 being the best outcome) [14] and EuroQol-5D (EQ-5D; 0 to 1, 1 indicates the best health state) [6].

This case-controlled study was performed in compliance with the Helsinki Declaration of 1975, as revised in 2000, and was studied and approved by the local Institutional Review Board (IRB: Atrium-Orbis Zuyd, Heerlen, The Netherlands, IRB Nr. 14-N-52) and registered online at the Dutch Trial Register (www.trialregister.nl, Nr. NTR4579).

Statistical analysis

The primary outcome of this case-control pilot study was to investigate whether UKA patients can go home as scheduled on the day of surgery. Sample size calculations were performed based on the results with two different pathways we used before implementation of the OS pathway; Joint Care [28] and RR (see materials and methods). Ten random selected patients (Joint Care) undergoing elective UKA had a mean (SD) hospitalization of 3.7 (1.17) days. The mean (SD) hospitalization of 10 other random selected patients, who followed the RR pathway, was 2.6 (0.97) days. With an alpha of 0.05 and 1- beta error of 0.8, an expected reduction of 1.6 days in the OS group, we would need 18 patients; 20 taking into account if assumed that both groups have the largest SD (1.17). This study included 40 patients, 20 in each arm. Statistically significant differences between both groups were analyzed with non-parametric Mann-Whitney-U test, since data were not normally distributed as tested with the Shapiro-Wilk test. Chi-square tests was used for categorical variables. P-values were considered to be statistically significant at $P \leq 0.05$ for all analysis. All statistical analysis were done with use of SPSS version 17.0 for windows (Inc., Chicago, IL). Results are presented as either with frequencies (%), mean (SD), or median (range).

Results

Forty patients were recruited for this study, 20 patients in each group. No patients were lost to follow-up. Baseline demographics and operative data are summarized in Table 3.

Table 3. Baseline demographics were not significant different between the groups.

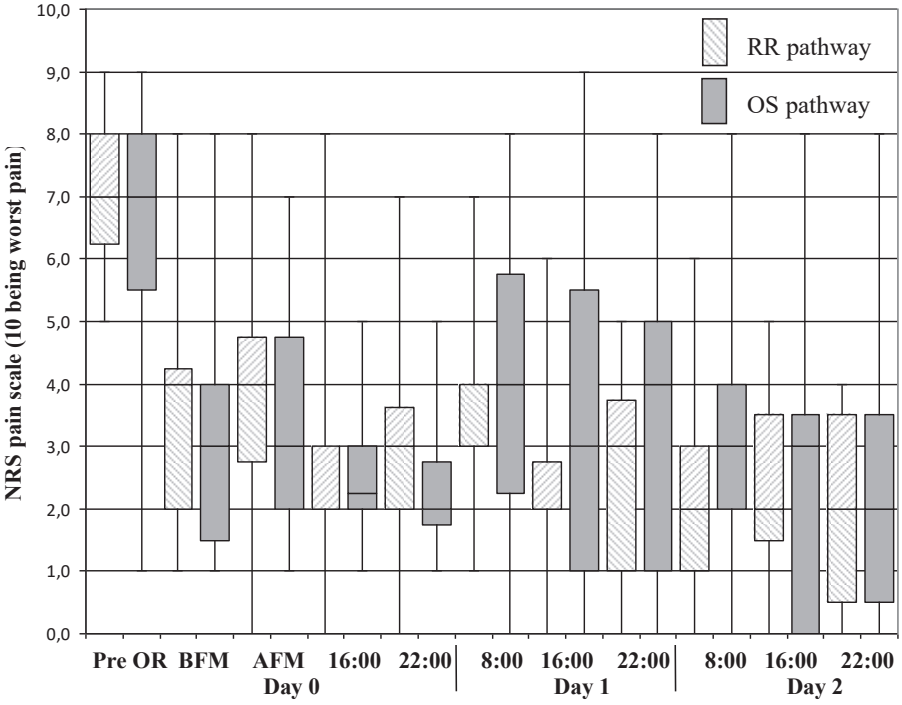
Baseline	***RR pathway***	***OS pathway***	***p-value***
Age, years, at index surgery	61.2 (5.15)	60.5 (5.65)	n.s.
BMI, kg/m^2	27.7 (3.27)	29.1 (3.85)	n.s.
Gender, male	11 (55)	13 (65)	n.s.
ASA classification I/II/III	6/13 /1	10 /10/0	n.s.
Operative data			
General/ Spinal/ Spinal +Sedation	4/12/4	1/19/0	n.s.
OR time, min	48.0 (8.5)	57 (15.3)	n.s.
Secondary disorders and concomitant diseases			
Cardial (heart failure, hypertension)	1	3	n.s.
Pulmonal (bronchitis, COPD)	2	3	n.s.
Other*	6	3	n.s.

*Autoimmune diseases, renal function disorders, diabetes mellitus type 2, sleep apnea.

All patients were discharged to their home environment, accompanied by a personal coach or relative. Seventeen patients (85%) in the OS pathway were discharged on the day of surgery as scheduled whereas in the RR pathway 95% of the patients were discharged <3 days postoperative. Prolonged hospital stay was not significantly different. Three patients in the OS pathway had a prolonged hospital stay; 2 patients suffered from high pain intensity (NRS >5) and both were discharged on postoperative day 2, as 1 other patient had a fear to go home and was discharged on postoperative day 1. In the RR pathway, 1 patient was suspicious for a DVT and therefore discharge was delayed (discharged on postoperative day 3). However, DVT was not diagnosed with echo duplex.

Early mobilization was comparable between the RR and OS pathway (n.s.). In both pathways, 1 patient was not able to mobilize due to high pain intensity <6hrs and <4hrs respectively. Delayed first mobilization occurred in 1 patient (RR) because of PONV, as another patient in the RR pathway had to cope with vasovagal syncope. Time between hospital admission and discharge was significantly different ($p < 0.00$) between both pathways: 2.6 days (1.2 – 4.1) in the RR pathway compared to 0.5 day (0.4 – 2.2) in the OS pathway. NRS pain scores were not significantly different preoperatively and <48hrs postoperative, measured on fixed time points throughout the day. Overall, median postoperative pain scores did not exceed a NRS score of 5 during the first 48hrs (Figure 2).

Figure 2. Distribution of median, 1st and 3rd percentile and range for NRS pain scores (Y-axis) for both pathways (RR: Rapid Recovery, OS: Outpatient Surgery) measured preoperative (Pre OR), before- (BFM) and after (AFM) the first mobilization, at 16:00hrs and 22:00hrs and on day 1 and 2 at 8:00hrs, 16:00hrs and 22:00hrs (X-axis). Minimum and maximum are displayed with the whiskers.



There were no significant differences (RR vs. OS) in the number of patients with PONV (4 vs. 2) and opiate use (11 vs. 9) < 48hrs postoperative. AE's occurred only in one patient in the OS pathway. This patient was readmitted < 3mth postoperative. The patient did not follow instructions for home based physiotherapy during the first 6 weeks postoperative and suffered from knee stiffness resulting in a limited knee flexion of 30 degrees. This required manipulation under anesthesia after which the patient recovered completely. At 3mth follow up, the mean (SD) OKS and EQ-5D significantly ($p < 0.05$) improved within each pathway, from 35.2 (8.1) to 22.7 (6.5) and 0.77 (0.1) to 0.85 (0.1) for the RR pathway and 32.0 (7.5) to 24.4 (7.6) and 0.75 (0.1) to 0.85 (0.1) in the OS pathway. There were no significant differences between both pathways.

Discussion

The most important findings of the present study was that outpatient unicompartimental knee arthroplasty is effective and safe with good short term clinical results in selected patients, with comparable outcomes as patients operated in a conventional pathway.

Only six papers studied the feasibility of an outpatient pathway for knee arthroplasty of which the methodological evidence was poor (Table 4). These papers have considerable limitations including poorly presented details of their cohorts [4,13,10,22]. For example, only four studies provided data on in- and exclusion criteria and only the study of Kolisek et al. [22] included a control group. However, they all reported comparable outcome without significant worsened results, in terms of AE's, readmission rates and prolonged hospital stay. This paper presents the preliminary results on elective UKA in an OS setting in The Netherlands.

There are some contradictions about the definition of OS. Kolisek et al. [22] aimed to discharge patients <23hrs after surgery. As presented by the WHO [32], OS is defined as admission and discharge on the day of surgery, without an overnight stay in the hospital. Berger et al. [4, 5] operated patients in an outpatient pathway as the first surgeries of the day [5] or before noon [4]. Their pain protocol allows sufficient time for postoperative pain control. Therefore, these organisational aspects should be taken into account in order to prevent a prolonged hospital stay.

Our results show that it is effective and safe to operate selected patients in an outpatient UKA pathway, as 85% of all the UKA patients were discharged on the day of surgery as scheduled, without increased AE's and readmission rate as compared to our conventional pathway. This was in line with our expectations and with previously published results by others, who also studied the feasibility and safety of outpatient knee arthroplasty (Table. 4). Cross et al. [8] reported that 100% of the patients operated for UKA (n=105) were directly discharged home on the day of surgery. Slightly less (93%) were discharged on the day of surgery with total knee arthroplasty (TKA) compared to 96% of the patients operated for UKA [4]. Recently, Gondusky et al. [13] published their prospective study comparing UKA patients in a pathway with a planned overnight stay (n=47) and one with a planned discharge on the day of surgery (n=160). They found that 100% of the patients were able to return home the evening of the day of surgery.

In our series, high pain intensity was the main factor for an overnight stay in our hospital. Berger et al. [4] found that 3.6% of the TKA patients could not be discharged on the day of surgery due to inadequate pain control. Pain management is one of the key factors for acceptable outcomes of multidisciplinary outpatient pathways [4]. This includes a well-established multimodal protocol, consisting peri-operative LIA [3,12] and an optimised pain protocol for pre-, peri- and postoperative analgesia.

The optimised pain protocol also intended to prevent side effects of medication, which enables patients to mobilize <4hrs postoperative. Only one patient (RR) could not mobilize due to PONV. As we know, these preventions are crucial for early mobilization [11] and length of hospital stay [25]. Our discharge results could be influenced by the use of tranexamic acid and dexamethasone in the OS pathway, since there is extensive literature on the advantages of using these medications during arthroplasty procedures in the prevention of blood loss [34] and PONV [2]. This could be seen as a confounder in our series, although none of the patients in the OS and RR pathway needed blood transfusion or had a prolonged hospital stay due to wound leakage. Even though the amount of patients with PONV was lower in the OS pathway without a significant difference. Another possible reason for prolonged hospital stay is fear to go home, as found by Berger et al. [4]. Therefore, fear to go home must be included as exclusion criteria for the OS pathway, which was seen in one patient in the OS pathway, resulting in prolonged hospital stay with discharge the first day postoperative. Other causes that can delay discharge are administrative failures [3, 30] but were not seen in our series.

AE's and readmission rates were not significantly different between both groups. This was in line with the results published by others (Table. 4). More complications <1 week postoperative were seen after TKA rather than UKA during the outpatient procedure [4]. Previous series published by Berger et al. [5], showed fewer complications for outpatient TKA, in which they used more stringent inclusion criteria. Recently, Lovald et al. [24] concluded that pre-existing co morbidities and particularly heart failure are major risk factors for AE's after outpatient and short stay TKA. Furthermore, evidence to in- or exclude patients in an outpatient setting is limited. Beside the pre-selected patients in our series, based on general criteria, we suggest that there is a need for proper in- and exclusion criteria for outpatient knee arthroplasty.

Table 4. Literature overview on outpatient knee arthroplasty pathways.

Author(s)	N	Arthroplasty	Study design	In-/exclusion criteria
Berger et al. 2005 [5]	50	TKA	Case series	Primary TKA without history of prior open knee surgery, between 50-80 years of age / history <1year of myocardial infarction, pulmonary embolism or anticoagulation therapy
Berger et al. 2009 [4]	111	UKA and TKA	Case series	None
Cross and Berger 2014 [8]	105	UKA	Case series	None
Dervin et al. 2012 [10]	24	UKA	Case series	ASA I&II, caregiver the first 3-4 days, understanding post operative analgesia regimen / major systemic illness, ASA>II, chronic pain or opioid consumption, contraindications to FNB and residence outside the catchments area of homecare services.
Gondusky et al. 2014 [13]	160	UKA	Case series	Cardiac clearance, ASA I-III, social situation and home environment needed to be deemed safe with adequate aid of a caregiver available / cognitive issues and not capable of complying with the peri-operative protocol

	Discharge	Prolonged hospital stay	Complications/readmission
	96%, day of surgery	N=1, not willing to go home N=1, PONV and orthostatic hypotension	N=1, GI bleeding 8 days postoperative N=1, delayed wound healing necessitating superficial irrigation and debridement N=1, manipulation under anaesthesia 9weeks postoperative
	94%, day of surgery	N=4 difficulty with pain control N=1 chest pain, workup for myocardial infarction, which was negative N=1 fear to go home N=1 PONV	*<1week* N=2, symptomatic anaemia requiring blood transfusion N=1, GI bleeding N=1, DVT *>1week and <3 mth* N=2, wound complications necessitating superficial irrigation and debridement N=1, manupilation under anesthesia N=1, GI bleeding
	100%, day of surgery	None	N=1, infection/>1 week and <12 weeks
	NA, same-day of surgery	NA	N=1 patient had prolonged wound drainage that required daily dressing changes and, ultimately, repeat arthrotomy for definitive wound closure. N=1 had a dislocation of a lateral mobile-bearing insert at 9 mth, which was successfully revised to a fixed bearing.
	100%, day of surgery	None	N=2 reoperation (dislocation mobile bearing and revision to TKA due to progression of lateral sided arthritis). N=1 haematoma day 6 post operative, / N=1 wound healing disorders<24hrs, n=1 internal multifactorial etiology at day 9 post operative

Table 4. Continued.

Author(s)	N	Arthroplasty	Study design	In-/exclusion criteria
Kolisek et al. 2009 [22]	64	TKA	Case controlled	lived <1hrs from the office, who had an adult to help them at home / any history of diabetes, myocardial infarction, stroke, congestive heart failure, venous thrombo-embolism, cardiac arrhythmia, respiratory failure, or chronic pain requiring regulair opioid medications.
Current study	40	UKA	Case controlled	severe cardiologic, pulmonary and/or internal diseases, not able to understand and complete the procedure due to cognitive dysfunction, fear to follow the outpatient procedure, not be discharged to their home environment.

This single surgeon, case-controlled pilot study, with a limited number of patients, could raise questions about the general applicability. We agree with Berger et al. [4], based on the experience with the use of clinical pathways, a stepwise implementation of an enhanced pathway, with the aim to discharge patients on the day of surgery, will be more effective and safe. Once these changes have been put in place, it will often be necessary to re-evaluate the new structures, to explore and extend the roles of the multidisciplinary team, to ensure optimal pre-, peri- and postoperative care. On the other hand, expansion of a day care surgery pathway involves an extensive change in mindset, both for patients and dedicated multidisciplinary team. Health care organizations and hospital management needs to be convinced of the possibilities of optimised clinical pathways. With the use of simplified protocols and standards, wich are applicable in every hospital, each hospital is able to reduce waiting periods and length of hospital stay [28]. This could result in lower costs, with comparable or improved patient satisfaction.

Obviously, there are some methodological limitations in order to say something about the AE's beceause of the small number of patients included in this study. These results might be inappropriate to use to conclude that the amount of AE's are comparable between both pathways. Further studies on AE's as an outcome with sufficient power and sample size are needed to assess whether these outcome measures differs between both pathways.

Discharge	Prolonged hospital stay	Complications/readmission
100%, <23hrs	None	N=1, developed a foot drop and a heel ulcer secondary to peroneal nerve dysfunction. N=1, revisions for a genu recurvatum deformity <10 N=1, tibial plateau fracture >1 YPO N=2, manipulation under anaesthesia to treat knee stiffness >3 and>6 MPO
85%, <11hrs	N=2, high pain intensity N=1, fear to go home	N=1, manipulation under anaesthesia to treat knee stiffness >6 WPO

Finally, we recommend that further well designed randomized controlled trials with larger patient series will be needed to confirm our preliminary results. After this, health care organizations and hospital management will probally be convinced of the need of optimised clinical pathways.

Conclusion

Well-established and adequate protocols, standardized general applicable in- and exclusion criteria and a change in mindset for both the patient and the multidisciplinary team are the key factors for the successful implementation of an outpatient surgical pathway for unicompartimental knee arthroplasty.

Conflict of interest
One author (NK) is a payed consultant for Biomet on the Signature surgical procedure. The other authors declare that they have no conflict of interest. No financial support was received for this study.

References

1. Andersen LØ, Husted H, Otte KS, et al.(2008) A compression bandage improves local infiltration analgesia in total knee arthroplasty. Acta Orthop. 79(6):806-11
2. Backes JR, Bentley JC, Politi JR, et al. (2013) Dexamethasone reduces length of hospitalization and improves postoperative pain and nausea after total joint arthroplasty: a prospective, randomized controlled trial. J Arthroplasty. 28(8 Suppl):11-7
3. Beard DJ, Murray DW, Rees JL, et al. (2002) Accelerated recovery for unicompartmental knee replacement--a feasibility study. Knee 9(3):221-4.
4. Berger RA, Kusuma SK, Sanders SA, et al. (2009) The feasibility and perioperative complications of outpatient knee arthroplasty. Clin Orthop Relat Res 467(6):1443-9
5. Berger RA, Sanders S, Gerlinger T, et al. (2005) Outpatient total knee arthroplasty with a minimally invasive technique. J Arthroplasty 20:33–38
6. Brooks R (1996) EuroQol: the current state of play.Health Policy. 37(1):53-72
7. Cheung A, Lykostratis H, Holloway I (2014) Compression bandaging improves mobility following total knee replacement in an enhanced recovery setting. J Perioper Pract. 24(4):84-6
8. Cross MB, Berger R (2014) Feasibility and safety of performing outpatient unicompartmental knee arthroplasty. Int Orthop 38(2):443-7
9. Del Pozo JL, Patel R (2009) Clinical Practice. Infection Associated with Prosthetic Joints. New Engl J Med 361:787-94
10. Dervin F, Madden SM, Crawford-Newton BA, et al. (2012) Outpatient unicompartment knee arthroplasty with indwelling femoral nerve catheter. J Arthroplasty 27(6):1159-65
11. Essving P, Axelsson K, Åberg E, et al. (2011) Local infiltration analgesia versus intrathecal morphine for postoperative pain management after total knee arthroplasty: a randomized controlled trial. Anesth Analg 113(4):926-33
12. Essving P, Axelsson K, Kjellberg J, et al. (2009) Reduced hospital stay, morphine consumption, and pain intensity with local infiltration analgesia after unicompartmental knee arthroplasty. Acta Orthopaedica 80(2):213-9
13. Gondusky JS, Choi L, Khalaf N, et al. (2014) Day of Surgery Discharge after Unicompartmental Knee Arthroplasty: An Effective Perioperative Pathway. J Arthroplasty 29(3):516-9
14. Haverkamp D, Breugem SJ, Sierevelt IN, et al. (2005) Translation and validation of the Dutch version of the Oxford 12-item knee questionnaire for knee arthroplasty. Acta Orthop. 76(3):347-52
15. Husted H, Holm G (2006) Fast-track in total hip and knee arthroplasty--experiences from Hvidovre University Hospital, Denmark. Injury 37(5):31-5
16. Husted H, Lunn H T, Troelsen A, et al. (2011) Why still in hospital after fast-track hip and knee arthroplasty? Acta Orthopaedica 82:679–684
17. Kehlet H, Andersen LØ (2011) Local infiltration analgesia in joint replacement: the evidence and recommendations for clinical practice. Acta Anaesthesiol Scand 55:778-84
18. Kehlet H, Dahl JB (2003) Anaesthesia, surgery, and challenges in postoperative recovery. Lancet 362: 1921-8
19. Kehlet H, Wilmore DW (2002) Multimodal strategies to improve surgical outcome. Am J Surg 183:630-41
20. Kehlet H, Wilmore DW (2008) Evidence-based surgical care and the evolution of fast-track surgery. Ann Surg 248:189-98

21. Kerr DR, Kohan L (2008) Local infiltration analgesia: a technique for the control of acute postoperative pain following knee and hip surgery. A case study of 325 patients. Acta Orthopaedica 79:174–183
22. Kolisek FR, McGrath MS, Jessup NM, et al. (2009) Comparison of outpatient versus inpatient total knee arthroplasty. Clin Orthop Relat Res 467(6):1438-42
23. Losina E, Thornhill TS, Rome BN, et al. (2012) 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 94(3):201-7
24. Lovald S, Ong K, Lau E, et al. (2014) Patient selection in outpatient and short-stay total knee arthroplasty. J Surg Orthop Adv 23(1):2-8
25. Munk S, Dalsgaard J, Bjerggaard K, et al. (2012) Early recovery after fast-track Oxford unicompartmental knee arthroplasty. 35 patients with minimal invasive surgery. Acta Orthopaedica 83(1):41-5
26. Ostendorf M, Johnell O, Malchau H, et al. (2002) The epidemiology of total hip replacement in The Netherlands and Sweden: present status and future needs. Acta Orthopaedica 73(3):282-6
27. Pearson SD, Goulart-Fisher D, Lee TH (1995) Critical pathways as a strategy for improving care: problems and potential. Ann Intern Med 123(12):941-8
28. Pilot P, Bogie R, Draijer WF, et al. (2006) Experience in the first four years of rapid recovery; is it safe? Injury 37 (5): 37-40
29. Price AJ, Webb J, Topf H, et al. (2001) Oxford Hip and Knee Group. Rapid recovery after oxford unicompartmental arthroplasty through a short incision. J Arthroplasty 16(8):970-6
30. Reilly KA, Beard DJ, Barker KL, et al. (2005) Efficacy of an accelerated recovery protocol for Oxford unicompartmental knee arthroplasty - a randomised controlled trial. Knee 12(5):351-7
31. Verma R, Alladi R, Jackson I, et al. (2011) Day case and short stay surgery: 2. Anesthesia 66:417-434
32. World Health Organization (2007) European Obeservatory on Health Systems and Policies; Day Surgery: Make it happen
33. Wilmore DW, Kehlet H (2001) Management of patients in Fast-track surgery. BMJ 24;322:473-6
34. Zhang H, Chen J, Chen F, et al. (2012) The effect of tranexamic acid on blood loss and use of blood products in total knee arthroplasty: a meta-analysis. Knee Surg Sports Traumatol Arthrosc. 20(9):1742-52

CHAPTER 7

SAFETY AND EFFICACY OF OUTPATIENT HIP AND KNEE ARTHROPLASTY. SYSTEMATIC REVIEW WITH META-ANALYSIS.

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Abstract

Introduction This systematic review aimed to assess the safety and efficacy of outpatient joint arthroplasty (OJA) pathways compared to inpatient pathways.

Materials and methods An electronic literature search was conducted to identify eligible studies. Studies comparing OJA with inpatient pathways—following hip and/or (partial) knee arthroplasty—were included. Included studies were assigned—based on OJA definition—to one of the following two groups: (1) outpatient surgery (OS); outpatient defined as discharge on the same day as surgery; and (2) semi-outpatient surgery (SOS); outpatient defined as discharge within 24 h after surgery with or without an overnight stay. Methodological quality was assessed. Outcomes included (serious) adverse events ((S)AEs), readmissions, successful same-day discharge rates, patient-reported outcome measures (PROMs) and costs. Meta-analyses and subgroup analyses by type of arthroplasty were performed when deemed appropriate.

Results A total of 41 studies (OS = 26, SOS = 15) met the inclusion criteria. One RCT and 40 observational studies were included, with an overall risk-of-bias of moderate to high. Forty studies were included in the meta-analysis. Outpatients (both OS and SOS) were younger and had a lower BMI and ASA class compared to inpatients. Overall, no significant differences between outpatients and inpatients were found for overall complications and readmission rates, and improvement in PROMs. By type of arthroplasty, only THAs in OS pathways were associated with fewer AEs [OR = 0.55 (0.41–0.74)] compared to inpatient pathways. 92% of OS patients were discharged on the day of surgery. OJA resulted in an average cost reduction of $6.797,02.

Conclusion OJA pathways are as safe and effective as inpatient pathways in selected populations, with a potential reduction of costs. Considerable risk of bias in the majority of studies emphasizes the need for further research.

Keywords Outpatient joint arthroplasty; Knee arthroplasty; Hip arthroplasty; Clinical pathway

Introduction

As a result of successful fast-track surgery pathways and its continuous optimisation, hip and knee arthroplasty are increasingly performed on an outpatient basis. These day-care surgery pathways are being designed to discharge patients home without an overnight stay in the hospital [1]. This might benefit patients in terms of possible reduced risk for hospital-acquired infections, starting early rehabilitation in their own home environment, and the possibility of enhanced patient participation and improved satisfaction. Besides, there is potential to reduce the economic burden on the healthcare systems, as the demand for hip and knee arthroplasties is increasing internationally [2,3,4,5,6]. When implementing a new treatment (e.g. an outpatient joint arthroplasty (OJA) pathway following hip and knee arthroplasty), it is paramount to ensure the quality of the provided care and safety of patients. Acceptable clinical outcomes, in terms of complications and readmission rates, were found for both hip and (partial) knee arthroplasty in previous systematic reviews [7,8,9,10]. These systematic reviews mainly consisted of observational case series, which included a selected group of patients. Patients selected for OJA are generally expected to be healthier compared with the average population undergoing hip or knee arthroplasty. However, even in an unselected group of patients, similar results were found [11, 12].

When comparing outcomes on OJA, variation in used definitions in the literature has to be accounted for. Some authors defined outpatient as a length of stay (LOS) less than 24 h, whereas others defined outpatient as hospital discharge on the day of surgery. Also large national registry databases (e.g. the NSQIP) which are frequently used in OJA research, use a controversial outpatient definition. A study by Bovonratwet et al. reported that only 11–12% of patients who were registered as outpatients were actually discharged on the day of surgery, because regulations in the USA allow these patients to stay more than 1 night in hospital under observation status. Off all studies reporting on the NSQIP data, different variables are used to indicatie OJA: (1) the "outpatient status variable"; and (2) the "LOS (= 0) variable" (which appears to be more accurate). To ensure clarity and uniformity, we agree with Vehmeyer et al. [13] to reserve the term "outpatient joint arthroplasty" solely for patients who are discharged to their own home on the day of surgery and who do not have an overnight stay at either the hospital or another non-home facility.

The purpose of this systematic review was to study the safety and efficacy of outpatient pathways compared with standard inpatient recovery pathways following hip and (partial) knee arthroplasty, accounting for the abovementioned definitional differences

in OJA. We primarily aimed to assess whether there were significant differences in (1) the number of (serious) adverse events ((S)AEs) and readmission rates; (2) postoperative improvement in patient-reported outcome measures (PROMs) and (3) total hospital costs.

Materials and methods

A review protocol was developed according to the Preferred Items for Reporting Systematic Reviews and Meta-Analysis (PRISMA-P) statement [14] and registered in PROSPERO (under review: no 161688), the International Prospective Register of Systematic Reviews.

Search strategy

A comprehensive electronic literature search was conducted to identify eligible studies on outpatient pathways following primary hip and (partial) knee arthroplasty. Five databases (Embase, PubMed, Wiley/Cochrane Library, Clarivate Analytics/Web of Science and EBSCO/CINAHL) and three trial registers (World Health Organization portal, ClinicalTrials.gov, and PROSPERO) were searched in December 2019 for published and ongoing trials. Reference lists of included studies were also searched by two independent reviewers to identify eligible studies that were missed by the search. The full search strategies are presented in the supplementary data.

Eligibility of studies

Both randomized controlled trials (RCTs) and (prospective or retrospective) observational studies were included in this systematic review. Only studies that compared safety and/or efficacy outcomes (e.g. (S)AEs, readmission rates, PROMs, costs) between OJA pathways and standard inpatient pathways—following hip and/or (partial) knee arthroplasty—were included. Results needed to be published as a full report and there were no restrictions on the date of study publication. Only studies published in English were selected. Studies were excluded if they reported on patients undergoing revision surgery, bilateral arthroplasty or arthroplasty due to traumatic conditions. Strictly descriptive studies (e.g. historical and/or editorial studies) were also excluded.

Selection and data collection process

Two reviewers independently extracted the search results of the different databases with the RefWorks tool (ProQuest LLC ©, 2020). The aforementioned two reviewers independently screened titles and abstracts of all studies retrieved by the literature

search. Then the full texts of all potentially eligible studies were retrieved and independently reviewed. The decision regarding study selection was based on the inclusion criteria. Discrepancies between reviewers were discussed and, if necessary, an agreement was reached by the adjudication of a third reviewer.

Data extraction and outcomes

Two reviewers independently extracted the data for each included study using a predefined standardized data extraction form. The data extraction form contained information on study characteristics (e.g. author, year, country, setting, study design, type of arthroplasty and number of selected patients), patient demographics (e.g. age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) classification and type of anesthesia) and outcomes (e.g. complication rates, readmission rates, success rates of same-day discharge (SDD), PROMs and/or costs).

To account for differences in "outpatient" definitions, studies were assigned to one of the following two categories: (1) outpatient surgery (OS); outpatient defined as discharge to their own home on the day of surgery; and (2) semi-outpatient surgery (SOS); outpatient defined as discharge within 24 h after surgery with or without an overnight stay. Studies that did not specifiy the "outpatient" definition were also included in the SOS group.

Complications were defined as adverse events (AEs), including wound dehiscence, wound leakage, urinary retention/infection, pneumonia, renal disorder, and blood transfusion; or serious adverse events (SAEs), including death, sepsis, coma, (prolonged) intubation, stroke, thromboembolic event (deep vein thrombosis/pulmonary embolism), infection of the prosthesis, myocardial infarction, cardiac arrest, arrhythmia, acute renal failure, perioperative fracture, failure of prothesis, hip dislocation and/or peripheral nerve injury, and return to the operating room (all re-operations). A minimal follow-up period of 30 days was required.

Patient demographics were described as means with standard deviations (SD) for continuous variables (age and BMI) and frequencies with percentages for categorical variables (gender, ASA score > II, and type of anesthesia). (S)AEs, readmission rates, and successful SDD rates were described as frequencies with percentages. PROMs and costs were reported descriptively. The two reviewers had to reach a consensus on data extraction. Any discrepancies between reviewers were discussed and, if necessary, an agreement was reached by the adjudication of a third author.

Risk of bias in individual studies

Two reviewers independently assessed the risk of bias of each of the included studies. The Cochrane Risk of Bias tool [15] (version 2 of the Cochrane risk-of-bias tool for randomized trials) was used to assess the risk of bias in randomized trials. The risk of bias for non-randomized studies was assessed with use of the ROBINS-I tool [16]. Any discrepancies between reviewers were discussed and, if necessary, an agreement was reached by the adjudication of a third author.

Data synthesis

All outcome measures were analysed using RevMan 5 [17]. Continuous data were described as mean differences with 95% confidence intervals (CI) or standardized mean differences. Dichotomous data were described as odds ratios (OR). Where possible, the data were pooled in a meta-analysis. To quantify statistical heterogeneity, the Cochran's Q test and I2 statistic (the proportion of the total variance explained by heterogeneity) were conducted. I2 values of > 75% were interpreted as high heterogeneity [18]. Subanalyses were performed for the two defined outpatient groups (experimental): (1) OS versus (2) SOS, compared with inpatient pathways (control) to account for differences in "outpatient" definitions as described above. Subanalyses were also performed for THA, TKA and UKA to account for fundamental differences between the three types of arthroplasty. In case meta-analysis was eligible, forest and funnel plots were presented.

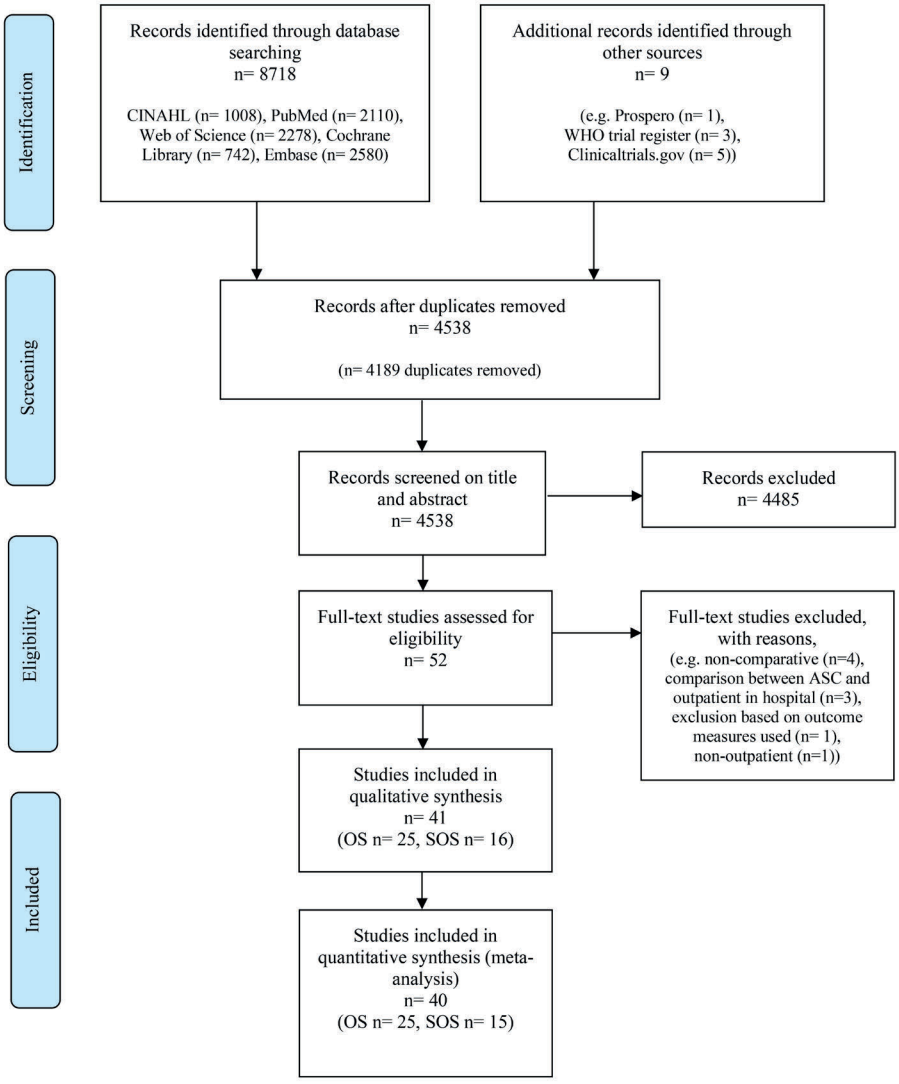
Ethical considerations

This review is a non-Medical Research Involving Human Subjects Act study.

Results

This systematic electronic search identified 8.718 references. No additional records were identified by cross-checking reference lists. The search and selection process are shown in the PRISMA flow diagram (Fig. 1). After removal of duplicates, 4.538 references remained for screening on title and abstract. In total, 52 full texts were assessed for eligibility. After review, 41 studies met the inclusion criteria and were included in the systematic review. Twenty-six studies were allocated to the OS group [2,3,4,5,6, 12, 19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38] and 15 to the SOS group [39,40,41,42,43,44,45,46,47,48,49,50,51,52,53] for subanalyses.

Figure 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram of the literature search.



CINAHL, Cumulative Index to Nursing and Allied Health Literature database; WHO, World Health Organization; OS, outpatient surgery; SOS, semi outpatient surgery.

Thirty-one studies were conducted in the United States [2,3,4,5, 19, 21,22,23,24, 26,27,28, 30, 31, 33, 35, 38,39,40,41,42,43, 45,46,47,48,49,50,51,52,53], four in the Netherlands [25, 29, 36, 38], three in Canada [6, 32, 34], two in France [20, 44] and one in Denmark [12] (Fig. 1). All studies were published between 2005 and 2019. Of the included studies, there was 1 RCT [24], 5 prospective observational studies [5, 6, 28, 36, 51], 1 prospective observational study with a matched inpatient cohort [43], 16 retrospective observational studies [5, 6, 29, 37, 52], 1 prospective observational study with a matched inpatient cohort [44], 16 retrospective observational studies [20, 21, 27, 30, 35, 36, 38,39,40,41, 43, 44, 47, 49, 51, 53], 16 retrospective observational studies with a matched inpatient cohort [2,3,4, 12, 19, 22, 23, 28, 31,32,33,34, 42, 45, 46, 50], and 2 qualitative studies [25, 26]. Of the included studies, 18 used large national databases (e.g. national private insurance databases or national registry databases) [2,3,4, 19, 21, 28, 31,32,33, 39, 40, 42, 43, 46, 48,49,50,51]. The setting of the outpatient pathways varied from ambulatory surgical centers [22, 26, 41, 45] or hip/knee centers [5, 38], secondary and tertiary care hospitals [6, 12, 20, 23,24,25, 27, 29, 30, 34, 36, 37, 44, 48, 52, 53], or a combination of settings [35]. Ten studies described OJA following total hip arthroplasty (THA) [5, 24, 27, 31, 34, 40, 41, 44, 51, 53], 13 following total knee arthroplasty (TKA) [3, 6, 20, 21, 28, 30, 32, 37, 39, 47,48,49, 52], 6 following unicompartmental knee arthroplasty (UKA) [2, 22, 25, 29, 35, 46] and 11 studies presented results on both hip and (partial) knee arthroplasty [4, 12, 19, 23, 26, 33, 36, 38, 42, 43, 45, 50]. In total, the complete sample of studied patients consisted of 40.758 outpatients (OS = 8.358; SOS = 32.400) and 1.212.370 inpatients. A summary of the study characteristics and patient demographics is presented in Table 1.

Risk of bias

For all observational studies, more than 75% of the studies had a moderate or high risk of bias (Fig. 2). The included RCT was of high-quality regarding the low risk-of-bias judgment (Fig. 3). Blinding of participants, to prevent performance bias, was not possible because of the nature of the studied objective.

Figure 2. Overall risk of bias for non-randomized trials, with use of the ROBINS-I tool.

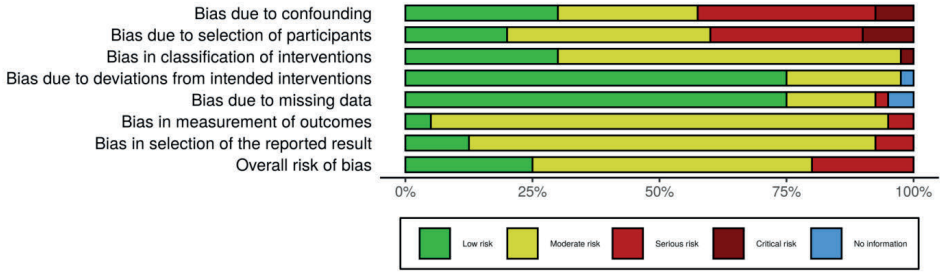
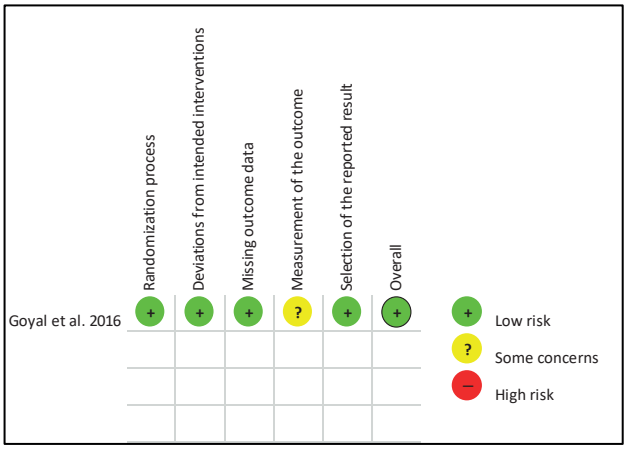


Figure 3. Risk-of-bias assessment for randomized studies, with use of the Cochrane risk-of-bias tool.



Heterogeneity

The methodological structure, measured outcomes, and description of data types varied between studies. Only studies that used comparable outcomes with a similar description of data were included in a meta-analysis. Data were pooled for total complication rates, SAEs, AEs, and readmissions.

In OS studies, demographics on the distribution of gender, BMI, and type of anesthesia were homogeneous, whereas data on age and ASA class were highly heterogeneous. All data on primary outcomes (e.g. total complication rate, (S)AEs and readmission rates) were homogeneous. In SOS studies, all data on total complication rate, SAEs, readmission rates and demographics (age, gender, BMI, ASA, and type of anesthesia) showed heterogeneity. Subanalysis on AEs for THA, showed homogeneity. Data on PROMs and costs were analysed in a qualitative method.

Demographic data

Demographics were pooled and presented in the supplementary data. Within the OS studies, patients were significantly younger ($P = 0.009$), had a lower BMI ($P < 0.001$), and had a lower ASA class ($P = 0.002$) compared to patients in the inpatient pathways.

Patients in the SOS studies were significantly younger ($P = 0.002$) and were significantly more likely to be female ($P = 0.03$) compared to patients in the inpatient pathways. The amount of ASA score > II patients, between the SOS pathways and inpatient pathways was not statistically significant different ($P = 0.13$).

Table 1. Summary of included study characteristics and demographics.

Author	Year	Type of arthroplasty	Country	Setting	Design of study
Arshi et al.[39]	2017	TKA	USA	HS-PDPR database (2007-2015)	Retrospective observational study
Arshi et al.[40]	2019	THA	USA	HS-PDPR database (2007-2016)	Retrospective observational study
Aynardi et al.[41]	2014	THA	USA	ASC allied to tertiary care hospital	Retrospective observational study
Basques et al.[19]	2014	THA, TKA and UKA	USA	ACS-NSQIP database (2005-2014)	Retrospective observational study (matched cohorts)
Bertin[5]	2005	THA	USA	Hip and knee center	Prospective observational study
Bovonratwet et al.[2]	2017	UKA	USA	ACS-NSQIP database (2005-2015)	Retrospective observational study (matched cohorts)
Bovonratwet et al.[3]	2017	TKA	USA	ACS-NSQIP database (2005-2014)	Retrospective observational study (matched cohorts)
Bovonratwet et al.[4]	2017	THA and TKA	USA	ACS-NSQIP database (2005-2014)	Retrospective observational study (matched cohorts)
Carey et al.[42]	2019	THA and TKA	USA	THAMCR database	Retrospective observational study (matched cohorts)
Cassard et al.[20]	2018	TKA	FR	Secondary care hospital	Retrospective observational study
Courtney et al.[43]	2017	THA and TKA	USA	ACS-NSQIP database (2011-2014)	Retrospective observational study

	Definition of outpatient	Allocation based on definition	In-patient (n)	Out-patient (n)	Baseline characteristics presented	Outcomes used for review
	Discharge from hospital or ASC without inpatient hospital admission and absolute LOS of < 24hrs	SOS	128,951	4,391	Age, gender	(S)AE's
	Discharge from hospital or ASC without inpatient hospital admission and absolute LOS of < 24hrs	SOS	73,596	2,184	Age, gender	(S)AE's
	Discharged home or transferred from the hospital at 23h postoperatively	SOS	78	119	Age, gender, BMI	SDD success rate, (S)AE's, readmissions, costs
	Discharge the day of the surgical procedure	OS	1,236	1,236	Age, gender, BMI, ASA, type of anaesthesia	(S)AE's
	Surgery and discharge < 12hrs	OS	10	10	Age, gender, BMI	SDD success rate, (S)AE's, costs
	Patients with a LOS of 0 days and discharged on the same day of surgery	OS	1,704	568	Age, gender, BMI, ASA	(S)AE's, readmissions
	Patients with a LOS of 0 days and discharged on the same day of surgery	OS	112,280	642	Age, gender, BMI, ASA	(S)AE's, readmissions
	Patients with a LOS of 0 days and discharged home on the same day of surgery without overnight stay in the hospital	OS	189,006	1,099	Age, gender, BMI	(S)AE's
	Not specified in methods and materials	SOS	4,443	1,481	NA	(S)AE's, readmissions, costs
	SDD (excluded patients who were alone at home on the evening of the procedure)	OS	513	61	Age, gender, ASA	SDD success rate, (S)AE's, readmissions
	Hospital definition of outpatient and inpatient, according to database	SOS	168,186	1,220	Age, gender, BMI, ASA	(S)AE's, readmissions

Table 1. Continued.

Author	Year	Type of arthroplasty	Country	Setting	Design of study
Courtney et al.[21]	2018	TKA	USA	ACS-NSQIP database (2014-2015)	Retrospective observational study
Crampet et al.[44]	2019	THA	FR	Tertiary care hospital	Retrospective observational study
Darrith et al.[45]	2019	THA, RHA, TKA and UKA	USA	ASC allied to university hospital	Retrospective observational study (matched cohorts)
Ford et al.[22]	2019	UKA	USA	ASC allied to university hospital	Retrospective observational study (matched cohorts)
Gogineni et al.[23]	2019	THA and TKA	USA	Tertiary care hospital	Retrospective observational study (matched cohorts)
Gromov et al.[12]	2019	THA and TKA	DK	Tertiary care hospital	Retrospective observational study (matched cohorts)
Goyal et al.[24]	2016	THA	USA	Tertiary care hospital	Randomized controlled trial
Gruskay et al.[46]	2019	UKA	USA	National private insurance database	Retrospective observational study (matched cohorts)
Hoorntje et al.[25]	2017	UKA	NL	Secondary care hospital	Qualitative study
Huang et al.[6]	2017	TKA	CA	Tertiary care hospital	Prospective observational study
Johnson et al.[47]	2019	TKA	USA	ACS-NSQIP database (2011-2016)	Retrospective cohort study
Kelly et al.[26]	2018	THA, RHA, TKA and UKA	USA	ASC allied to university hospital	Qualitative study

Definition of outpatient	Allocation based on definition	In-patient (n)	Out-patient (n)	Baseline characteristics presented	Outcomes used for review
LOS of 0 days (same day discharge)	OS	48,771	365	Age, gender, BMI, ASA, type of anaesthesia	(S)AE's, readmissions
Discharge on the day of surgery with admission the night before surgery	SOS	77	50	Age, gender, BMI, ASA	SDD success rate, (S)AE's, readmissions
Discharged home <23hrs without overnight stay	SOS	243	243	Age, gender, BMI, ASA	SDD success rate, (S)AE's, readmissions
Discharge on the day of surgery	OS	48	48	Age, gender, BMI, ASA	SDD success rate, (S)AE's, readmissions
SDD	OS	105	136	Age, gender, BMI, ASA, type of anaesthesia	SDD success rate, (S)AE's, readmissions
SDD	OS	116	339	Age, gender, BMI, type of anaesthesia	Readmissions
Less than 12hrs of hospital stay	OS	108	112	Age, gender, BMI, type of anaesthesia	SDD success rate, (S)AE's, readmissions
Based on service location codes (outpatient hospital or ASC) according to database	SOS	5,084	2,600	Age, gender	(S)AE's, readmissions
SDD	OS	18	18	Age, gender, BMI, ASA, type of anaesthesia	SDD success rate, (S)AE's, readmissions, PROMs
SDD	OS	20	20	Age, gender, BMI	SDD success rate, (S)AE's, readmissions, costs
Less than 24hrs of hospital stay after surgery	SOS	191,941	18,134	Age, gender, BMI, ASA, type of anaesthesia	(S)AE's
SDD	OS	102	64	Age, gender, BMI, type of anaesthesia	PROMs

Table 1. Continued.

Author	Year	Type of arthroplasty	Country	Setting	Design of study
Kim et al.[27]	2018	THA	USA	Tertiary care hospital	Retrospective cohort study
Kimball et al.[28]	2019	TKA	USA	THAMCR database	Retrospective observational study (matched cohorts)
Kolisek et al.[48]	2009	TKA	USA	Secondary care hospital	Prospective observational study (matched cohorts)
Kort et al.[29]	2017	UKA	NL	Secondary care hospital	Prospective observational study
Lovald et al.[49]	2014	TKA	USA	Medicare database (1997-2009)	Retrospective observational study
Lovecchio et al.[50]	2016	THA and TKA	USA	ACS-NSQIP database (2011-2013)	Retrospective observational study (matched cohorts)
Malahias et al.[51]	2019	THA	USA	HS-PDPR database (2007-2017)	Retrospective cohort study
Moore et al.[30]	2019	TKA	USA	Secondary and tertiary care hospitals	Retrospective observational study
Nelson et al.[31]	2017	THA	USA	ACS-NSQIP database (2005-2014)	Retrospective observational study (matched cohorts)
Nowak et al.[32]	2019	TKA	CA	ACS-NSQIP database (2005-2016)	Retrospective observational study (matched cohorts)
Otero et al.[33]	2016	THA, TKA and UKA	USA	ACS-NSQIP database (2011-2013)	Retrospective observational study (matched cohorts)
Richards et al.[34]	2018	THA	CA	Secondary and tertiary care hospital	Retrospective observational study (matched cohorts)

Definition of outpatient	Allocation based on definition	In-patient (n)	Out-patient (n)	Baseline characteristics presented	Outcomes used for review
SDD	OS	164	168	Age, gender, BMI, ASA, type of anaesthesia	SDD success rate, readmissions
SDD	OS	863	863	Age, gender	(S)AE's, readmissions, costs
<23hrs discharge after surgery	SOS	64	64	Age, gender, BMI	SDD success rate, (S)AE's, PROMs
SDD	OS	20	20	Age, gender, BMI, ASA, type of anaesthesia	SDD success rate, (S)AE's, readmissions, PROMs
Outpatient coded as location of service and discharged to home	SOS	102,230	454	Age	(S)AE's, readmissions
LOS <1 day	SOS	1,476	492	Age, gender, BMI, ASA, type of anaesthesia	(S)AE's, readmissions
Discharged within a day; LOS <24hrs	SOS	39,284	754	Age, gender	(S)AE's, readmissions
SDD	OS	293	32	Age, gender, BMI, ASA	NA
LOS=0 days, discharge before spending a night in the hospital	OS	63,424	420	Age, gender, BMI, ASA	(S)AE's
SDD, LOS=0 days	OS	75,260	986	Age, gender, BMI, ASA, type of anaesthesia	(S)AE's
SDD, LOS=0 days	OS	762	762	Age, gender, BMI, ASA	(S)AE's, readmissions
SDD (to home)	OS	136	136	Age, gender, BMI, ASA	SDD success rate, (S)AE's, readmissions

Table 1. Continued.

Author	Year	Type of arthroplasty	Country	Setting	Design of study
Richter et al.[35]	2017	UKA	USA	Tertiary care hospital and ASC	Retrospective observational study
Schoifet et al.[52]	2011	TKA	USA	Secondary care hospital	Quasi experimental design (prospective treatment arm and retrospective control arm)
Schotanus et al.[36]	2017	TKA and UKA	NL	Secondary care hospital	Retrospective observational study
Schotanus et al.[37]	2017	TKA	NL	Secondary care hospital	Prospective observational study
Springer et al.[38]	2017	THA and TKA	USA	Hip and knee center	Retrospective observational study
Weiser et al.[53]	2018	THA	USA	Tertiary care hospital	Retrospective observational study

THA, total hip arthroplasty; RHA, resurfacing hip arthroplasty; TKA, total knee arthroplasty; UKA, unicompartmental knee arthroplasty; USA, United States of America; FR, France; DK, Denmark; NL, Netherlands; CA, Canada; HS-PDPR, Humana subset PearlDiver Patient Record; ASC, ambulatory surgical center; ACS-NSQIP, Amercian College of Surgeons National Surgical Quality Improvement

Complications ((S)AEs)

Overall complication rates were described in 33 studies (OS = 19; SOS = 14) [2,3,4,5,6, 19,20,21,22,23,24,25, 28, 29, 31, 32, 34, 35, 38,39,40,41,42,43,44,45,46,47,48,49,50,51,52] . No significant differences were found for overall complication rates in OJA pathways (OS, P = 0.24; SOS, P = 0.71) compared to inpatient pathways (Fig. 4).

Adverse events (AEs) were described in 27 studies (OS = 17, SOS = 10) [2,3,4,5,6, 19, 21, 22, 24, 25, 28, 29, 31, 32, 34, 35, 38,39,40,41, 44,45,46,47,48,49, 52]. For OS studies, only THAs showed statistically significant fewer AEs in outpatient pathways [OR = 0.55 (0.41–0.74); I2 = 0%] compared to inpatient pathways (Fig. 5). For SOS studies, no statistically significant differences (by types of arthroplasty) were found for AEs between the two pathways.

Definition of outpatient	Allocation based on definition	In-patient (n)	Out-patient (n)	Baseline characteristics presented	Outcomes used for review
SDD (to home)	OS	10	12	Age, gender, BMI, ASA	SDD success rate, (S)AE's, readmissions, costs
Not specified in methods and materials	SOS	50	50	Type of anaesthesia	SDD success rate, (S)AE's, readmissions, costs
SDD (to home)	OS	267	94	Age, gender, BMI, ASA	SDD success rate, PROMs
SDD (to home)	OS	10	10	Age, gender, BMI, ASA	SDD success rate, PROMs
SDD (to home)	OS	106	137	Age, gender, BMI	SDD success rate, (S)AE's, readmissions, PROMs
SDD	SOS	1,315	164	Age, gender, BMI	SDD success rate, readmissions

Program; THAMCR, Truven Health Analytics Marketscan Commercial Research; LOS, length of stay; hr(s), hours; SOS, semi outpatient surgery; OS, outpatient surgery; BMI, body-mass index; ASA, american society of anesthesiologists score; NA, not applicable; (s)AE's, (serious) adverse events; SDD, same day discharge.

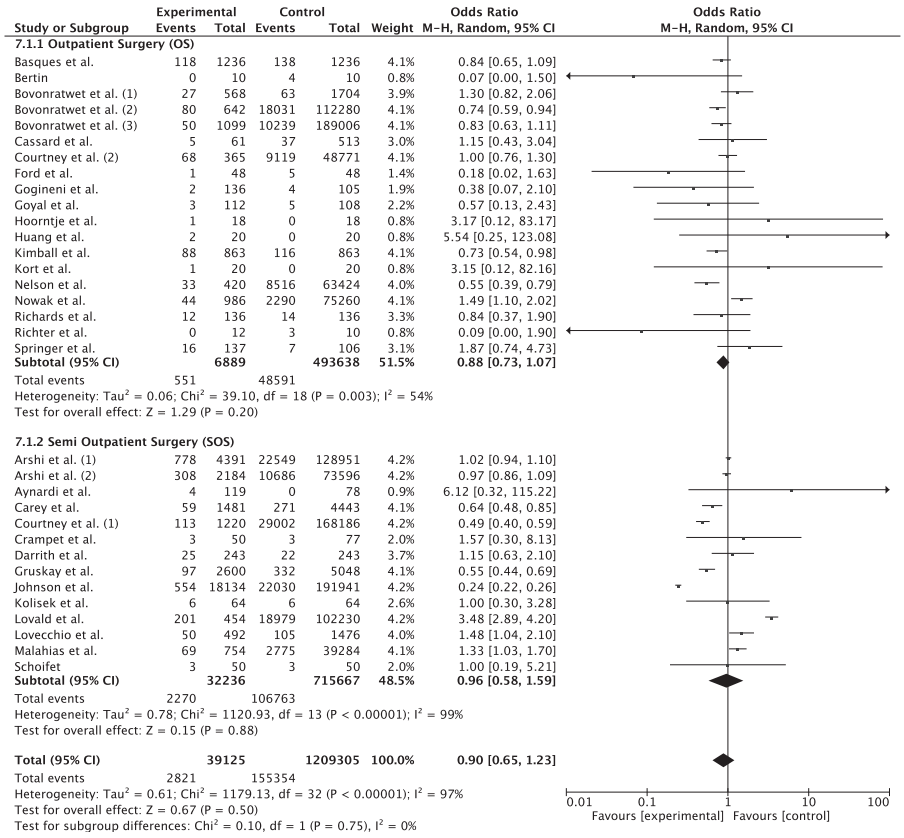
Readmission rates

No statistically significant differences (by types of arthroplasty) were found for readmission rates in both outpatient pathways (OS and SOS) compared to inpatient pathways (Fig. 7). The follow-up period ranged from 4 weeks to 1 year.

SDD success rate

Success rates of SDD following an OJA pathway was presented in 14 studies [5, 6, 20, 22,23,24,25, 27, 29, 34,35,36,37,38]. Overall, we found that 941 of 1.077 outpatients of the OS studies (average success rate of 92%, ranging from 61 to 100%) were successfully discharged on the day of surgery. TKAs and UKAs had an average SDD success rate of 95%, whereas 86% of THAs were successfully discharged on the day of surgery.

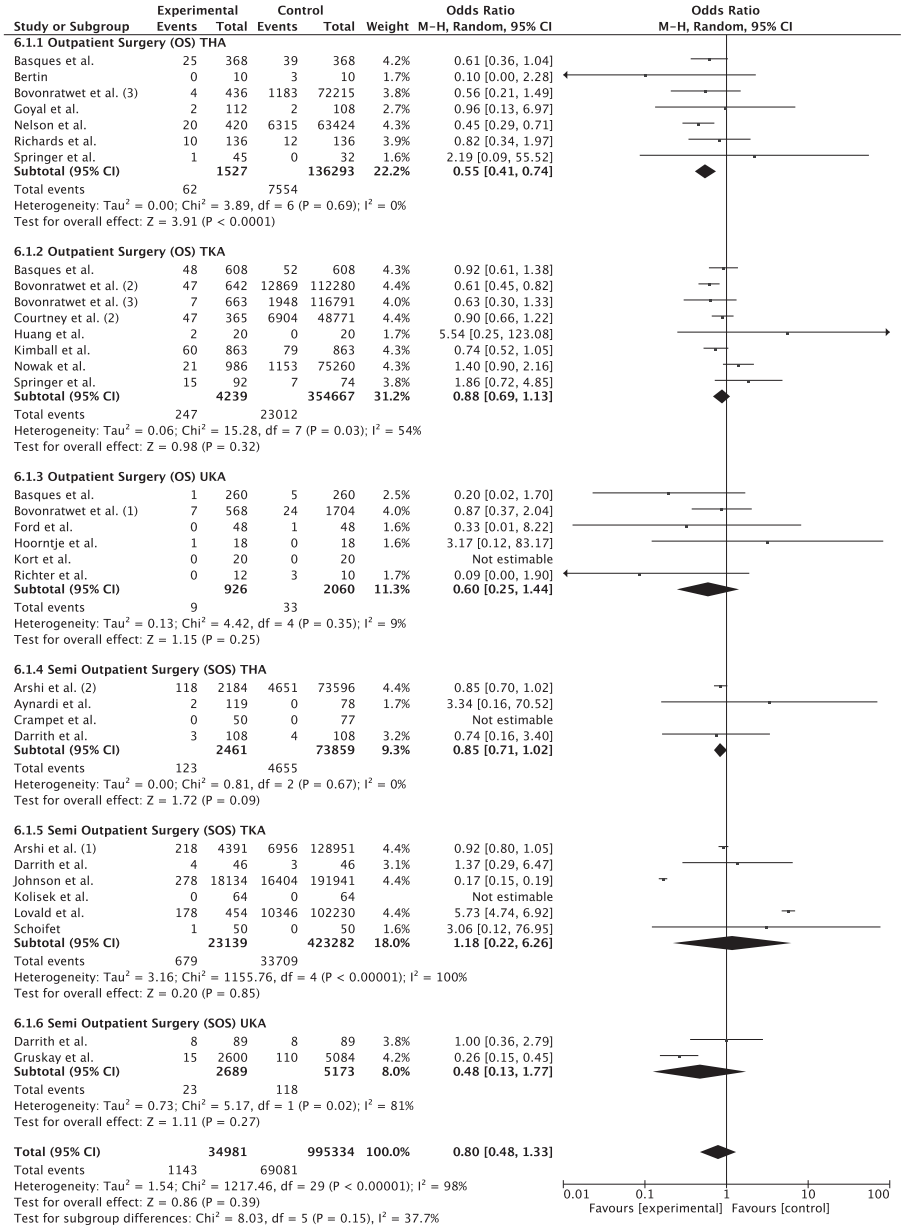
Figure 4. Forest plot for overall complication rate, presented as numbers (n).



Experimental, outpatient joint arthroplasty pathway; control, inpatient pathway.

Serious adverse events (SAEs) were described in 29 studies (OS = 17, SOS = 12) [2,3,4,5,6, 19, 21, 22, 24, 25, 28, 29, 38,39,40,41,42, 44,45,46,47,48,49, 51, 52]. For both OS and SOS studies, no statistically significant differences (by types of arthroplasty) were found for SAEs compared to inpatients (Fig. 6).

Figure 5. Forest plot for adverse events with subgroup analysis for total hip arthroplasty (THA), total knee arthroplasty (TKA) and unicompartmental knee arthroplasty (UKA), presented as numbers (n).



Experimental, outpatient joint arthroplasty pathway; control, inpatient pathway.

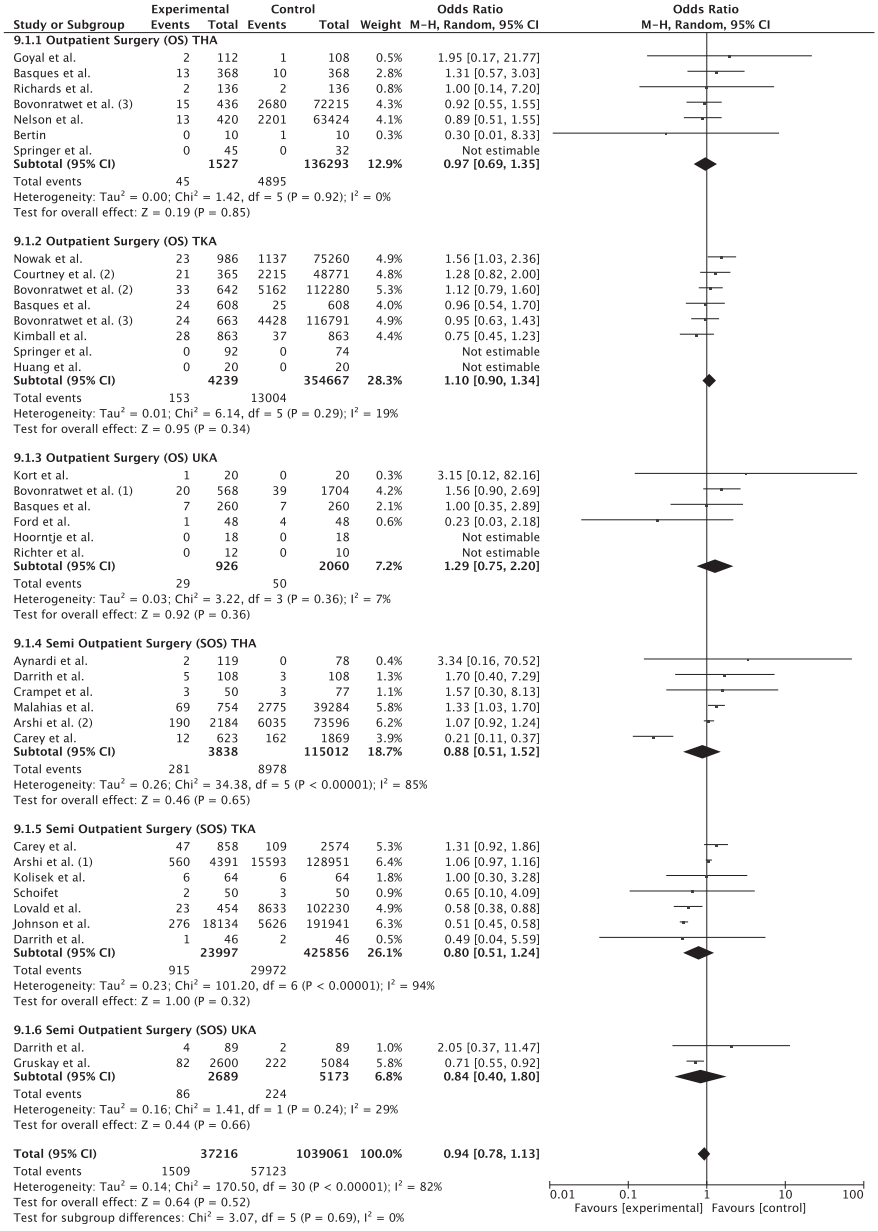
PROMs

Seven studies reported a comparison of postoperative improvements in PROMs between outpatient and inpatient pathways [25, 26, 29, 36,37,38, 48]. Used PROMs varied and included the Knee Injury and Osteoarthritis Outcome Score (KOOS), Oxford Knee Score (OKS), Knee Society Score (KSS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), EuroQol-5D (EQ-5D), Visual Analogue Scale (VAS) for pain, and patient satisfaction questionnaires. The postoperative improvement was similar between outpatient pathways and inpatient pathways for all PROMs. The follow-up period ranged from 30 days to 1 year. High patient satisfaction was reported in three studies for OJA and inpatient pathways [26, 38, 48]. Two studies (one in an ambulatory surgical center and one in a hip/knee center) [26, 38] reported favorable outcomes on patient satisfaction. Patient satisfaction was either measured with a numerical scale [48] or with the use of a survey by telephone [26, 38].

Costs

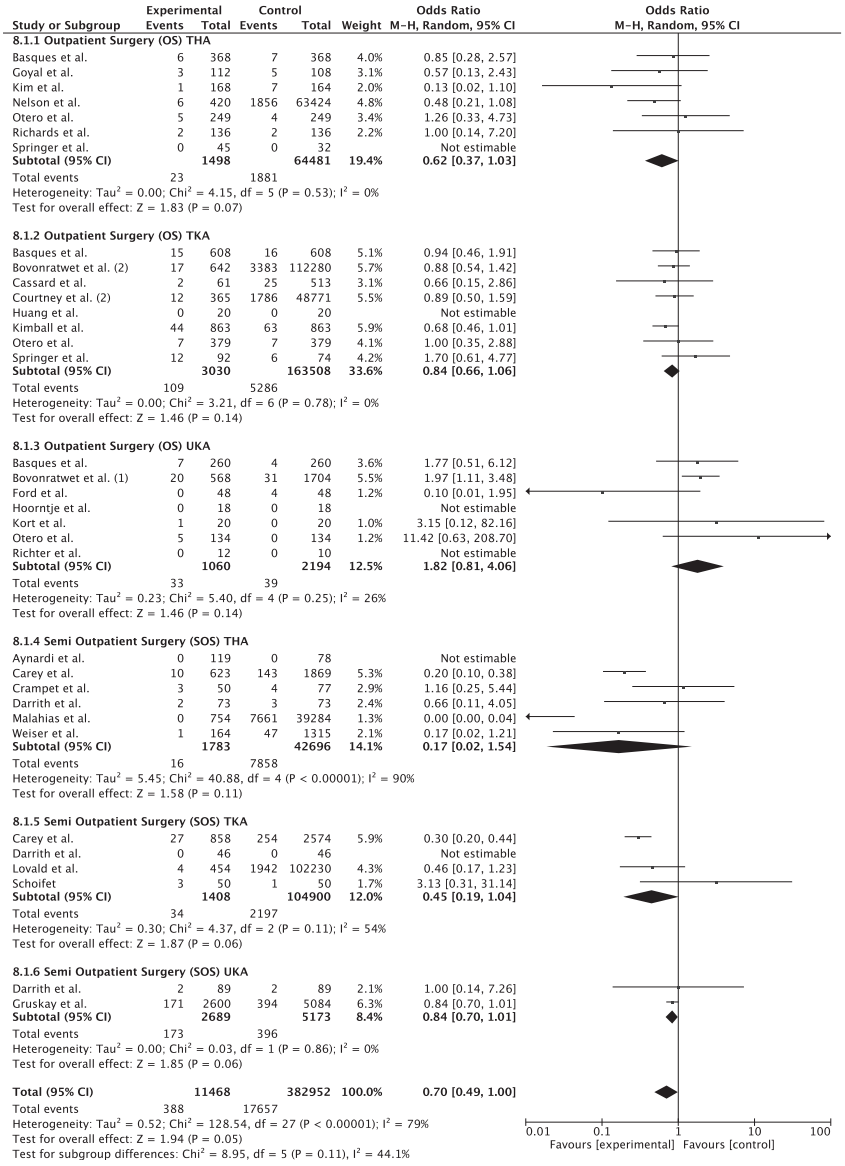
Seven observational studies reported on costs [5, 6, 28, 35, 41, 42, 52]. Evaluation and description of costs varied highly across studies. Six of seven studies (86%) reporting on costs were conducted in the United States. Only total costs were compared between outpatient and inpatient pathways. A mean (SD) cost reduction of $6.797,02 ($5.394,81) was found in favor of outpatient pathways, but with a large range ($2.468,62-$20.573,00). Overall, usage of surgery (e.g. surgery facility fee, operation room supplies) and hospital facility (e.g. nursing, room charges, laboratory tests, medication, perioperative physiotherapy) contributed the most in the cost reduction.

Figure 6. Forest plot for serious adverse events with subgroup analysis for total hip arthroplasty (THA), total knee arthroplasty (TKA) and unicompartmental knee arthroplasty (UKA), presented as numbers (n).



Experimental, outpatient joint arthroplasty pathway; control, inpatient pathway.

Figure 7. Forest plot for readmissions with subgroup analysis for total hip arthroplasty (THA), total knee arthroplasty (TKA) and unicompartmental knee arthroplasty (UKA), presented as numbers (n).



Experimental, outpatient joint arthroplasty pathway; control, inpatient pathway.

Discussion

Current literature is divided on the safety (in terms of complications and readmissions) of OJA pathways. Several studies reported an increased risk for (S)AEs if patients were discharged on the same day of surgery [32, 39, 50], while others stated that there were no safety issues [9, 24, 29, 34, 53]. The most important finding of this study was that the implementation of OJA pathways in a selective group of patients resulted in acceptable clinical outcomes regarding complications and readmission rates while reducing costs and preserving the patient-reported outcome compared to standard inpatient pathways. Subanalyses by type of arthroplasty (e.g. THA, TKA, UKA) found that THAs in OS pathways were associated with fewer AEs compared to inpatient pathways. For SAEs and readmissions, subanalyses found no significant differences between outpatient and inpatient pathways, suggesting that OJA following hip or knee arthroplasty is most likely safe in a selected patient population.

The current literature on OJA, however, consists of low to moderate quality with moderate to high risk of selection bias. Only one RCT was included in the present systematic review. Most included studies, however, had a retrospective and observational design, with high risk of selection bias [5, 6, 20, 21, 25,26,27, 29, 30, 35,36,37,38,39,40,41, 43, 44, 47, 51,52,53].

Many studies on outpatient joint arthroplasty used large (national claims and administrative) databases [2,3,4, 19, 21, 28, 31,32,33, 39, 40, 42, 43, 46, 47, 49,50,51]. These databases provide high power to outcome measures and although results can provide a raw estimate of certain relationships, heterogeneity in the sample (as variations in practice patterns are not accounted for can lead to potential recording bias and/or confounding) may worsen the accuracy that comes with interpreting the results. Bonvonratwet et al. [4] also found that definitional differences in "outpatient" status were present in the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP®) – a national (USA) database which is used in many studies on OJA [4]. The same study also described the possible influence of definitional differences on outcomes. An explanation for this could be a more stringent patient selection for patients discharged on the day of surgery compared to patients discharged within 24 h (i.e. the first postoperative day). Besides, there is substantial potential of confounding by selection bias in these database and observational studies, as OJA is often reserved for the more "active" and "healthy" patients. As expected, we found that patients included in the OJA pathways were overall younger and less infirm (in terms of ASA class), and had a lower BMI compared to patients in the inpatient pathways [20, 24, 28, 34, 43, 45, 48]. This should

be taken into account while interpreting the current results and emphasizes the need for large randomized controlled clinical trials comparing outpatient with inpatients pathways following hip and knee arthroplasty.

Another factor that might impede the interpretation of the results is a lack of consistent use of the same definitions for complications/adverse events [54]. Some studies described (S)AEs in terms of surgical versus medical complications [50], whereas others described minor versus major complications [32]. Scoring of complications was based on the authors' interpretation or the availability of data in databases. Furthermore, the majority of (S)AEs occur within 4 days postoperatively [54]. Most inpatient pathways (consisting of fast-track recovery pathways) discharge patients within 2–3 days after surgery. This might explain why the current meta-analysis did not find differences in terms of overall complications and readmission rates, since both outpatients and inpatients are discharged within this time-frame. Another potential limitation could be the fact that the follow-up period for reporting complications and readmission rates varied between studies.

Patients in the outpatient pathways improved equally postoperatively in terms of PROMs compared to patients in the inpatient pathways. Previous research did not find differences in the long-term (1 year) outcomes between these pathways [36]. PROMs are used to transform qualitative symptoms and limitations into quantitative data that can be compared over time, across patients, and benchmarked against different populations [55]. In the literature, the utilization of PROM tools varies strongly in and between measured domains following hip and knee arthroplasty, making it difficult to compare and interpret outcomes. The possible implementation of Patient-Reported Outcomes Measurement Information System (PROMIS®)—a systematic measurement system applying a standardized metric that is based on the normative data of the general population—is increasingly being researched in the orthopedic [55, 56] and might allow for a better comparison of PROMs (also between different domains and populations) if adopted internationally in research.

All studies on costs (and made a comparison between outpatient and inpatient pathways) included in this systematic review showed a total cost reduction in favor of outpatient pathways. All of these studies, however, treated costs differently which led to a wide range of outcome and made comparison difficult. One study assessed total charges to a patient's insurance carrier (including surgical facility fees, OR supplies, hospital room facility, et cetera) and negotiated reimbursement [35]. Another study assessed total hospital charges because they found it impossible to assign actual costs to items such as nursing or therapist care and used fixed facility costs [5]. Two studies assessed direct costs (charges to the

patient including costs for medical supplies, implants, nursing and medication et cetera), indirect costs (overhead expenses that were not directly related to patient care including administration, housekeeping et cetera), and total costs [6, 52]. Two studies assessed payment for the index hospitalization or index outpatient encounter, with a correction of payments for all post-acute care to 90-day follow-up [28, 42]. Almost all studies reporting on costs were conducted in the United States. Since healthcare systems and reimbursement models differ between countries, these results lack external validity. This implicates that there is a need for cost-efficiency analysis in different settings to assess the potential benefits of outpatient joint arthroplasty internationally [5, 6, 28, 35, 41, 42, 52].

Conclusions

The present systematic review and meta-analysis suggests that OJA pathways are as safe and effective as inpatient pathways following hip and knee arthroplasty in selected populations, with a potential reduction of costs. Considerable risk of bias in the majority of studies, however, emphasizes the need for large randomized controlled clinical trials comparing outpatient with inpatients pathways.

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Conflict of interest
Author Bert Boonen is unpaid consultant for Materialise NV. The other authors declare that they have no conflict of interest.

Compliance with ethical standards

Authors' contributions
Yoeri Bemelmans: Conceptualization, Methodology, Writing – Original draft, Supervision Mark Keulen: Conceptualization, Methodology, Writing – Original draft, Supervision Marion Heymans: Methodology, Resource utilization, Writing – Original draft Emil van Haaren: Conceptualization, Methodology, Writing – Review & Editing Bert Boonen: Writing – Review & Editing Martijn Schotanus: Conceptualization, Methodology, Resources, Writing – Original draft, Supervision.

Supplementary information

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References

1. Bailey CR, Ahuja M, Bartholomew K, et al. (2019) Guidelines for day-case surgery 2019: Guidelines from the Association of Anaesthetists and the British Association of Day Surgery. Anaesthesia. 74(6):778-792
2. Bovonratwet P, Ondeck NT, Tyagi V, et al. (2017) Outpatient and Inpatient Unicompartmental Knee Arthroplasty Procedures Have Similar Short-Term Complication Profiles. J Arthroplasty 2017;32(10):2935-2940
3. Bovonratwet P, Ondeck NT, Nelson SJ, et al. (2017) Comparison of Outpatient vs Inpatient Total Knee Arthroplasty: An ACS-NSQIP Analysis. J Arthroplasty 32(6):1773-1778
4. Bovonratwet P, Webb ML, Ondeck NT, et al. (2017) Definitional Differences of 'Outpatient' Versus 'Inpatient' THA and TKA Can Affect Study Outcomes. Clin Orthop Relat Res 475(12):2917-2925
5. Bertin KC (2005) Minimally invasive outpatient total hip arthroplasty: a financial analysis. Clin Orthop Relat Res (435):154-63
6. Huang A, Ryu JJ, Dervin G (2017) Cost savings of outpatient versus standard inpatient total knee arthroplasty. Can J Surg 60(1):57-62
7. Pollock M, Somerville L, Firth A, Lanting B (2016) Outpatient Total Hip Arthroplasty, Total Knee Arthroplasty, and Unicompartmental Knee Arthroplasty: A Systematic Review of the Literature. JBJS Rev 4(12) :01874474-201612000-00004
8. Hoffmann JD, Kusnezov NA, Dunn JC, Zarkadis NJ, et al. (2018) The Shift to Same-Day Outpatient Joint Arthroplasty: A Systematic Review. J Arthroplasty 33(4):1265-1274
9. Jaibaji M, Volpin A, Haddad FS, Konan S (2020) Is Outpatient Arthroplasty Safe? A Systematic Review. J Arthroplasty http://doi:10.1016/j.arth.2020.02.022
10. Xu J, Cao JY, Chaggar GS, Negus JJ (2019) Comparison of outpatient versus inpatient total hip and knee arthroplasty: A systematic review and meta-analysis of complications. J Orthop 17:38-43
11. Berger RA, Kusuma SK, Sanders SA, et al. (2009) The feasibility and perioperative complications of outpatient knee arthroplasty. Clin Orthop Relat Res 467:1443–1449
12. Gromov K, Jorgensen CC, Petersen PB, et al. (2019) Complications and readmissions following outpatient total hip and knee arthroplasty: a prospective 2-center study with matched controls. Acta Orthop 90(3):281-285
13. Vehmeijer SBW, Husted H, Kehlet H (2018) Outpatient total hip and knee arthroplasty. Acta Orthop 89(2):141-144
14. Moher D, Liberati A, Tetzlaff J, Altman DG (2009) The PRISMA Group, Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7):e1000097
15. Higgins JP, Green S. Cochrane handbook for systematic reviews of interventions. Wiley online library. Accessed December 2019
16. Sterne JAC, Hernán MA, Reeves BC, et al. (2016) ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions BMJ 355:i4919
17. No authors listed. Review Manager (RevMan) 5.3. URL: https://training.cochrane.org/Accessed January 2020
18. Higgins JP, Thompson SG, Deeks JJ, Altman DG (2003) Measuring inconsistency in meta-analyses. BMJ 327(7414):557-60
19. Basques BA, Tetreault MW, Della Valle CJ (2017) Same-Day Discharge Compared with Inpatient Hospitalization Following Hip and Knee Arthroplasty. J Bone Joint Surg Am 6;99(23):1969-1977

20. Cassard X, Garnault V, Corin B, et al. (2018) Outpatient total knee arthroplasty: Readmission and complication rates on day 30 in 61 patients. Orthop Traumatol Surg Res 104(7):967-970
21. Courtney PM, Froimson MI, Meneghini RM, et al. (2018) Can Total Knee Arthroplasty Be Performed Safely as an Outpatient in the Medicare Population? J Arthroplasty 33(7S):S28-S31
22. Ford MC, Walters JD, Mulligan RP, et al. (2020) Safety and Cost-Effectiveness of Outpatient Unicompartmental Knee Arthroplasty in the Ambulatory Surgery Center: A Matched Cohort Study. Orthop Clin North Am 51(1):1-5
23. Gogineni HC, Gray CF, Prieto HA, et al. (2019) Transition to outpatient total hip and knee arthroplasty: experience at an academic tertiary care center. Arthroplast Today 5(1):100-105
24. Goyal N, Chen AF, Padgett SE, et al. (2017) Otto Aufranc Award: A Multicenter, Randomized Study of Outpatient versus Inpatient Total Hip Arthroplasty. Clin Orthop Relat Res 475(2):364-372
25. Hoorntje A, Koenraadt KLM, Boeve MG, van Geenen RCI (2017) Outpatient unicompartmental knee arthroplasty: who is afraid of outpatient surgery? Knee Surg Sports Traumatol Arthrosc 25(3):759-766
26. Kelly MP, Calkins TE, Culvern C, et al. (2018) Inpatient Versus Outpatient Hip and Knee Arthroplasty: Which Has Higher Patient Satisfaction? J Arthroplasty 33(11):3402-3406
27. Kim KY, Feng JE, Anoushiravani AA, et al. (2018) Rapid Discharge in Total Hip Arthroplasty: Utility of the Outpatient Arthroplasty Risk Assessment Tool in Predicting Same-Day and Next-Day Discharge. J Arthroplasty 33(8):2412-2416
28. Kimball CC, Nichols CI, Vose JG (2019) Outpatient Versus Rapid Recovery Inpatient Knee Arthroplasty: Comparison of Matched Cohorts. Orthopedics 43(1):36-41
29. Kort NP, Bemelmans YFL, Schotanus MGM (2017) Outpatient surgery for unicompartmental knee arthroplasty is effective and safe. Knee Surg Sports Traumatol Arthrosc 25(9):2659-2667
30. Moore MG, Brigati DP, Crijns TJ, et al. (2019) Enhanced Selection of Candidates for Same-Day and Outpatient Total Knee Arthroplasty. J Arthroplasty 35(3):628-632
31. Nelson SJ, Webb ML, Lukasiewicz AM, et al. (2017) Is Outpatient Total Hip Arthroplasty Safe? J Arthroplasty 32(5):1439-1442
32. Nowak LL, Schemitsch EH (2019) Same-day and delayed hospital discharge are associated with worse outcomes following total knee arthroplasty. Bone Joint J 101-B(7_Supple_C):70-76
33. Otero JE, Gholson JJ, Pugely AJ, et al. (2016) Length of Hospitalization After Joint Arthroplasty: Does Early Discharge Affect Complications and Readmission Rates? J Arthroplasty 31(12):2714-2725
34. Richards M, Alyousif H, Kim JK, et al. (2018) An Evaluation of the Safety and Effectiveness of Total Hip Arthroplasty as an Outpatient Procedure: A Matched-Cohort Analysis. J Arthroplasty 33(10):3206-3210
35. Richter DL, Diduch DR (2017) Cost Comparison of Outpatient Versus Inpatient Unicompartmental Knee Arthroplasty. Orthop J Sports Med 14;5(3):2325967117694352
36. Schotanus M, Bemelmans Y, Kort N (2017) Improved Health-Related Quality of Life after Knee Arthroplasty Following an Outpatient Surgery Pathway: an Observational Comparative Case Study. J Clin Trials 7(5):1-4
37. Schotanus MGM, Bemelmans YFL, Grimm B, et al. (2017) Physical activity after outpatient surgery and enhanced recovery for total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 25(11):3366-3371
38. Springer BD, Odum SM, Vegari DN, et al. (2017) Impact of Inpatient Versus Outpatient Total Joint Arthroplasty on 30-Day Hospital Readmission Rates and Unplanned Episodes of Care. Orthop Clin North Am 48(1):15-23

39. Arshi A, Leong NL, D'Oro A, et al. (2017) Outpatient Total Knee Arthroplasty Is Associated with Higher Risk of Perioperative Complications. J Bone Joint Surg Am 6;99(23):1978-1986
40. Arshi A, Leong NL, Wang C, et al. (2019) Outpatient Total Hip Arthroplasty in the United States: A Population-based Comparative Analysis of Complication Rates. J Am Acad Orthop Surg 15;27(2):61-67
41. Aynardi M, Post Z, Ong A, et al. (2014) Outpatient surgery as a means of cost reduction in total hip arthroplasty: a case-control study. HSS J 10(3):252-255
42. Carey K, Morgan JR, Lin MY, et al. (2019) Patient Outcomes Following Total Joint Replacement Surgery: A Comparison of Hospitals and Ambulatory Surgery Centers. J Arthroplasty 35(1):7-11
43. Courtney PM, Boniello AJ, Berger RA (2017) Complications Following Outpatient Total Joint Arthroplasty: An Analysis of a National Database. J Arthroplasty 32(5):1426-1430
44. Crampet C, Common H, Bajeux E, et al. (2019) Does performing outpatient total hip arthroplasty contribute to early complications and readmissions? Retrospective case-control study of 50 patients. Orthop Traumatol Surg Res 105(7):1245-1249
45. Darrith B, Frisch NB, Tetreault MW, et al. (2019) Inpatient Versus Outpatient Arthroplasty: A Single-Surgeon, Matched Cohort Analysis of 90-Day Complications. J Arthroplasty 34(2):221-227
46. Gruskay J, Richardson S, Schairer W, et al. (2019) Incidence and safety profile of outpatient unicompartmental knee arthroplasty. Knee 26(3):708-713
47. Johnson DJ, Castle JP, Harwell MJ, et al. (2019) Risk Factors for Greater Than 24-Hour Length of Stay After Primary Total Knee Arthroplasty. J Arthroplasty 35(3):633-637
48. Kolisek FR, McGrath MS, Jessup NM, et al. (2009) Comparison of outpatient versus inpatient total knee arthroplasty. Clin Orthop Relat Res 467(6):1438-1442
49. Lovald ST, Ong KL, Malkani AL, et al. (2014) Complications, mortality, and costs for outpatient and short-stay total knee arthroplasty patients in comparison to standard-stay patients. J Arthroplasty 29(3):510-515
50. Lovecchio F, Alvi H, Sahota S, et al. (2016) Is Outpatient Arthroplasty as Safe as Fast-Track Inpatient Arthroplasty? A Propensity Score Matched Analysis. J Arthroplasty 31(9 Suppl):197-201
51. Malahias MA, Gu A, Richardson SS, et al. (2019) Hospital Discharge Within a Day After Total Hip Arthroplasty Does Not Compromise 1-Year Outcomes Compared With Rapid Discharge: An Analysis of an Insurance Claims Database. J Arthroplasty 2019; https://doi: 10.1016/j.arth.2019.10.059
52. Schoifet SD (2011) Comparative Safety and Resource Utilization of Total Knee Arthroplasty in Inpatient and Outpatient Settings. J Manage Care Med 09;14(3):27-32
53. Weiser MC, Kim KY, Anoushiravani AA, et al. (2018) Outpatient Total Hip Arthroplasty Has Minimal Short-Term Complications with the Use of Institutional Protocols. J Arthroplasty 33(11):3502-3507
54. Sokol DK, Wilson J (2008) What is a surgical complication? World J Surg 32(6):942-944
55. Kortlever JTP, Leyton-Mange A, Keulen MHF, Liu TC et al. (2019) PROMIS Physical Function Correlates with KOOS, JR in Patients with Knee Pain. PROMIS Physical Function Correlates with KOOS, JR in Patients with Knee Pain. J Knee Surg https://doi: 10.1055/s-0039-1688780
56. Moore MLG, Kortlever JTP, Keulen MHF, Brigati DP, et al. (2020) PROMIS PF correlates with HOOS, JR in patients with hip pain. J Orthop 7;21:58-61

CHAPTER 8

PATIENT SELECTION CRITERIA FOR OUTPATIENT JOINT ARTHROPLASTY. CLINICAL REVIEW.

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Knee Surgery and Sports Traumatology Arthroscopy. 25(9):2668-2675. 2017

Abstract

Purpose General consensus of patient selection criteria for outpatient joint arthroplasty is lacking, which is paramount to prevent prolonged hospital stay, adverse events and/or readmissions. This review highlights patient selection criteria for OJA based on the current literature and expert opinion.

Methods A search of the English and International electronic healthcare databases including MEDLINE/PubMed, EMBASE, AMED and the Cochrane library was performed in November 2015 to include studies published during the last 10 years. Furthermore, a survey of physicians from different specialties was performed.

Results Fourteen studies described results regarding outpatient joint arthroplasty. Studies on outpatient hip and/or knee arthroplasty resulted in similar outcome in preselected patients. Patients who are able and willing to participate, with a low ASA classification (<III), undergoing primary arthroplasty, age <75 and with support at home during the first postoperative days are eligible candidates for outpatient joint arthroplasty. Patients with a high ASA classification (>II), bleeding disorders, poorly controlled and/or severe cardiac (e.g. heart failure, arrhythmia) or pulmonary (e.g. embolism, respiratory failure) comorbidities, uncontrolled DM (type I or II), a high BMI (>30 m2/kg), chronic opioid consumption, functional neurological impairments, dependent functional status, chronic/endstage renal disease and/or reduced preoperative cognitive capacity should be excluded from outpatient joint arthroplasty. The expert opinion-based selection criteria were comparable to literature with a further extension of exclusion for patients with practical issue's, urologic medical history and/or severe mobility disorders.

Conclusion Based on the current literature, the presented patient selection criteria provide a basis for outpatient joint arthroplasty and can be useful when selecting patients. Together with a change in mindset, a multidisciplinary approach and literature-based protocols, outpatient joint arthroplasty can be applied in daily orthopaedic practice while ensuring patients' safety.

Keywords Outpatient surgery; Hip arthroplasty; Knee arthroplasty; Patient selection criteria

Introduction

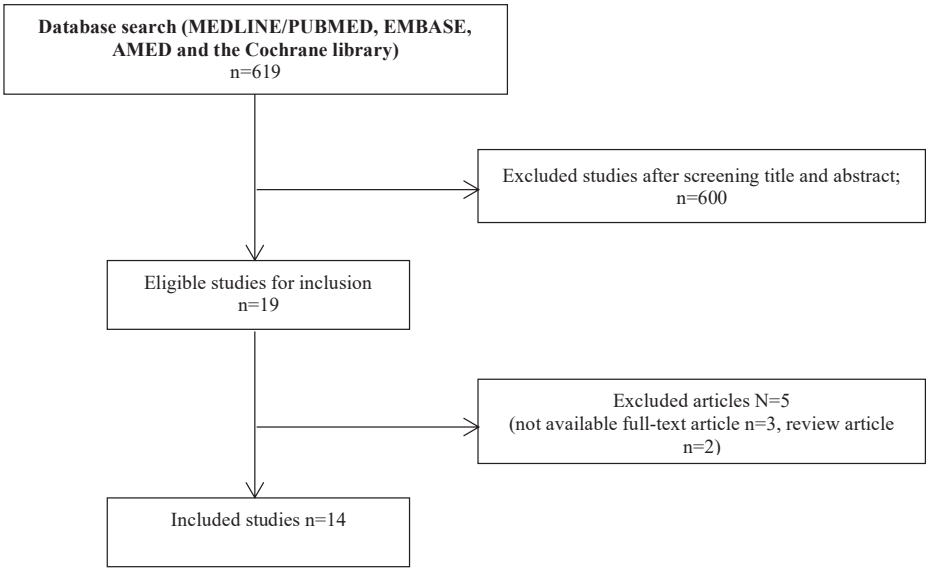
In recent years, care pathways in orthopaedic surgery have improved, resulting in high quality of patient care with increased patient satisfaction [19, 23]. Outpatient surgical pathways are designed for elective surgery patients, as these patients are admitted and discharged on the same day without an overnight stay in a hospital bed [9]. These pathways were first used for less complex surgeries, and there have been an increasing number of more complex surgeries performed on an outpatient basis. Due to the advancement of these multidisciplinary pathways, outpatient joint arthroplasty (OJA) is increasingly performed in the general practice of orthopaedic departments, which allows more arthroplasty procedures to be performed and may be cost effective while preserving the quality of care [17]. Previous studies have found that OJA is a safe and effective procedure without increased incidence of peri- and post-operative complications [2, 4–6, 10–13, 15, 16, 26, 27, 30]. These studies included preselected patients, whereas patients with severe comorbidities were excluded. Recently, Lovald et al. [28] concluded that pre-existing comorbidities and particularly heart failure are major risk factors for adverse events (AEs) after outpatient and short-stay total knee arthroplasty (TKA). The evidence for patient selection criteria for OJA is limited, and no generally applicable criteria exist to safely operate OJA patients. Nevertheless, it is paramount to develop these criteria, as they affect clinical outcomes and the incidence of postoperative complications [4]. This review highlights patient selection criteria for OJA based on current literature and expert opinion.

Materials and methods

A search of the English and International electronic healthcare databases including MEDLINE/PubMed, EMBASE, AMED and the Cochrane library was performed in November 2015 to include studies published during the last 10 years (2005–2015). The following keywords were used: 'outpatient', 'day care surgery', 'hip arthroplasty' and 'knee arthroplasty' which were combined with AND/OR as follows: (outpatient surgery OR day care surgery) AND (hip arthroplasty OR knee arthroplasty). The lead author performed the search and the results were agreed on by a consensus of two other authors (YB, MS), who independently reviewed the list of titles and all studies concerning outpatient surgery and arthroplasty and, if available, the abstracts to determine their potential usefulness. All studies on outpatient knee and/or hip arthroplasty were eligible for inclusion, with exclusion of review articles. Only full-text published articles were used. A consensus method was used to resolve disagreements, and the third or fourth author (JJ, HK) was consulted. Prior to formulating general conclusions, final

consensus on the included studies concerning patient selection criteria for OJA was achieved between the authors. Quality assessment was performed on the included studies using the Critical Appraisal Skills Programme (CASP) tools [8]. The study flow chart is demonstrated in Fig. 1. Besides this extended literature search, a survey of seven physicians from different specialties in the hospital (cardiology, pulmonology, internal medicine, geriatric medicine, urology, neurology and psychiatry) was performed. All the experts were familiar with the OJA pathway. In daily practice, in cases of pre-existing comorbidities, patients were screened and treated by these experts. They were asked to give their expert opinion on possible inclusion and exclusion criteria, based on general comorbidities and comorbidities which were related to their disciplines.

Figure 1. Flow chart of database search with excluded and included studies for final analysis.



Outpatient joint arthroplasty (OJA) pathway at the Zuyderland Medical Center

Indications for hip and knee arthroplasty were osteoarthritis, pain and loss of function as generally accepted [32, 33, 35]. Patients could be included in the OJA pathway if they satisfied three criteria; (1) able and willing to participate in the OJA pathway, (2) able to understand the procedures and (3) a personal coach (partner or relative) needs to be involved as much as possible, to inspire, correct, and support the patient during the first 48 h postoperatively. Patients with severe cardiologic, pulmonary and/or internal diseases (e.g. diabetes mellitus (DM), renal function disorders) that required additional pre-, peri- and postoperative treatment were excluded. Patients who were not able to understand

and complete the procedure due to cognitive dysfunction (based on medical history), fear of following the outpatient procedure, or those who could not be discharged to their home environment were also excluded. Pre-, peri- and post-operative protocols (e.g. type of anaesthesia, multi-modal pain protocol) were described by Kort et al. [27], which included patients for unicompartmental knee arthroplasty (UKA). These protocols are the same protocols used for total hip arthroplasty (THA) and TKA. Local infiltration analgesia was only used perioperative for TKA according to Kerr and Kohan [25] without adrenaline [36].

Results

The search revealed 14 clinical studies describing the results of outpatient surgery in 109.233 arthroplasty patients, including 10 case series and 4 case–control studies. These studies on OJA consisted of 9 knee and 5 hip arthroplasty papers (Table 1). There were no prospective randomized controlled trials. The results from these studies mostly consisted papers from the USA [20, 25]. The first studies on outpatient knee arthroplasty [4, 5, 1, 12, 15, 26–28, 30] concluded that the pathway was safe and effective. Low complication and readmission rates (0.7–8 %) were found, including a high percentage of discharge on the day of surgery (73.7–98.9 %) and cost reduction [30]. Studies on outpatient hip arthroplasty [2, 6, 10, 13, 16] resulted in similar outcome in pre-selected patients.

Inclusion criteria

In all of these studies, an extensive diversity of inclusion criteria were used. Most of the inclusion criteria used were the understanding, ability and willingness to participate in the outpatient procedure [2, 12, 16, 27]. Only primary arthroplasty patients were included in all these studies; additionally, Berger et al. [5, 6] included patients without a history of previous hip or knee surgery. Classification of patients according to the ASA was used as inclusion to select patients varying from ASA I–III [12, 15, 16]. Poorer health status (ASA > II) and bleeding disorder was associated with higher readmission rates and AEs (revision, infection, mortality, deep vein thrombosis (DVT) and wound complications) after both hip and knee arthroplasty [7, 28]. Patients were operated if they were younger than 65 years of age [13] or ranging from 45 to 80 years [5, 6]. As previously found [27], a high age (>75 years) was a risk factor for postoperative falls, knee stiffness, pain and urinary retention with an increased readmission risk at 1 year postoperative. In particular, patients >80 years of age were at even at higher risk for falls [hazard ratio (HR) 2.06] and readmissions (HR 1.27), which can increase AEs [28]. Therefore, health status and age should be considered when selecting patients for OJA. Preoperative cardiac examination was performed if patients had a history of a cardiovascular disease [15]. Besides transient postoperative hypotension [13], which led to delayed discharge, no cardiovascular-related

AEs or readmissions were reported in these series without preoperative cardiac clearance. Nevertheless, patients with a history of heart failure were at higher risk for readmission [28]. On the other hand, patients with severe cardiologic comorbidities (ASA > II) were not included for OJA [2, 5, 6, 10, 12, 16, 26, 27].

Logistic factors such as surgery completed by noon [4] or living <1 h from the hospital [26] were used as inclusion criteria. In these studies, neither prolonged hospital stay nor readmissions were documented based on these logistic factors. Support at home (partner or relative) during the first days after surgery and an adopted home environment was frequently performed [12, 15, 16, 26, 27]. Dorr et al. [13]. reported 'home problem' as a reason for delayed discharge. However, exact insight information on these 'home problems' were not described. One of the reasons for fear of early discharge is the postoperative dependence on someone else [5]; this fear can cause delayed discharge [27]. Nevertheless, a change in the mindset of the patient, in terms of an early discharge, is a key factor for prevention of prolonged hospital stay [27]. Therefore, preoperative screening and preparation of the home environment is crucial for preventing a prolonged hospital stay and should be considered as an inclusion criteria for OJA.

Exclusion criteria

As for the inclusion criteria, a wide range of criteria were reported in OJA studies. Two studies [4, 11] examined the feasibility of an outpatient knee arthroplasty pathway in an unselected group. Berger et al. [4] found higher readmission rates within the first week (3.6 %) compared to preselected patients (0.0 %) in their previous series [5] during the same postoperative period. It was concluded that a more stringent screening process could prevent complications and subsequent readmissions [4]. This preoperative screening process has been studied before, in outpatient and short-stay TKA [28, 30]. Patients with poorer health status, older patients, inpatients, patients not receiving a femoral nerve block (FNB) and those with a history of heart failure were at higher risk for readmission. When reviewing the exclusion criteria in the OJA studies, only two AEs related to the cardiovascular and/or pulmonary system were reported. Overall, patients with cardiac (e.g. heart failure, history of myocardial infarction, arrhythmia) [5, 6, 10, 16, 26, 27], pulmonary (e.g. embolism, respiratory failure) [5, 6, 10, 26, 27] and poorly controlled comorbidities [2, 6] were excluded. This might be the reason for the low incidence of AEs and readmissions. On the other hand, outpatient or short-stay TKA patients with a history of ischaemic heart disease were not at higher risk for postoperative AEs [28]. Nevertheless, postoperative myocardial ischaemia can prolong hospital stay [3, 21]. Kallio et al. [21] suggested that preoperative anaesthesia evaluation and treatment may improve postoperative outcome in diabetic patients. Pain, dizziness, general weakness and postoperative nausea and vomiting (PONV) were seen as clinical reasons for prolonged hospital stay when patients

were operated in an enhanced recovery pathway for joint arthroplasty [18]. Most reported reasons for prolonged hospital stay in outpatient literature also consisted of pain and PONV [4, 5, 13, 16, 27]. When using peripheral nerve blocks, no prolonged hospital stay or readmission due to uncontrolled pain was found after OJA [12]. Readmission rate was lower in patients receiving a FNB. However, the risk of pain after 1 year postoperative was significantly higher [28]. Protocols for OJA should focus on adequate analgesia and prevention for PONV [5,10, 11, 15, 27, 30]. Some papers excluded patients with DM (type I and II) [16, 26]. Diabetic patients were at higher risk for AEs after joint arthroplasty [21, 28, 29, 38]. Patients with a high body mass index—BMI (>40 m2/kg) were excluded [6]. Although there was no correlation between prolonged hospital stay and BMI in THA [18] or TKA [4] patients, Ibrahim et al. [20] concluded that a high BMI (>40 m2/kg) increases operative time and intraoperative blood loss in THA due to technical difficulties in obese patients. After TKA, obese patients (≥30 m2/kg) are at higher risk for deep infection and revision surgery [24]. Therefore, a high BMI of >30 m2/kg should be considered as a general exclusion criteria for arthroplasty and not specifically for OJA.

Chronic opioid consumption prior to THA resulted in worse clinical outcome, opioid-induced hyperalgesia and prolonged hospital stay [34]. Since these patients need a more stringent analgesia treatment, it seems justified to exclude these patients from OJA for postoperative pain control [12, 26]. Evidence on arthroplasty after stroke is rare, and functional impairments due to neurologic deficits (e.g. Parkinson's disease) are preferably treated in an enhanced recovery pathway [37]. Nevertheless, history of a stroke was reported as exclusion criterion [26]. In case of unavailability for homecare service [12] or discharge other than home environment [27], which were also applied as exclusion criteria, one needs to consider whether OJA is possible. On the other hand, dependent functional status (partial or total independency) was found to be a risk factor for increased readmissions after THA [7]. Patients with difficulties with self-care tasks should be excluded from OJA [38]. The incidence of chronic renal disease is high (26–27 %) in patients undergoing joint arthroplasty [39]. A significantly higher risk for postoperative AEs was found in patients with moderate to severe chronic renal disease. In particular, there is a twofold higher risk of mortality. Preoperative screening for renal function should be performed and risks for complications in patients with moderate to severe chronic renal disease should be discussed when performing elective joint arthroplasty, since these comorbidities (renal impairment and major systemic illness) were reported as exclusion criteria [12, 27, 30]. Postoperative cognitive dysfunction is frequently (20–40 %) reported after joint arthroplasty [1]. Enhanced recovery programs may decrease the risk of this cognitive dysfunction [38]. One of the most important determinants for development of cognitive dysfunction is reduced preoperative cognitive capacity [31], which is used as exclusion criterion [15, 27].

Table 1. Literature overview on patient selection criteria in OJA pathways. *Only described post-clinical outcome. **AEs and readmission rate were not specified for outpatient TKA.

Author(s)	N	Arthroplasty	Study design	AEs
Aynardi et al.[2]	197	THA	Case controlled	4 patients (3.4%) intraoperative fracture, atelectasis, monitoring after ECG changes
Berger et al.[5]	50	TKA	Case series	GI tract bleeding (2.0%), superficial infection (2.0%), manipulation under anesthesia (2.0%)
Berger et al.[4]	111	UKA and TKA	Case series	Symptomatic anemia requiring blood transfusion (0.9%), GI bleeding (0.9%), DVT (0.9%), wound complications (1.8%), manipulation under anesthesia (0.9%), GI bleeding (0.9%)
Berger et al.[6]	150	THA	Case series	Stress fracture (0.7%), pneumonia (1.4%), dehydration (0.7%), anemia (0.7%), pain (0.7%), leg swelling (0.7%), urinary tract infection (0.7%), fall (0.7%), medication reaction (0.7%), hypotension (0.7%)
Dorr et al.[13]	69	THA	Case series	1 revision after fracture during surgery (1.5%)
Dervin et al.[12]	24	UKA	Case series	Dislocation (4.2%), arthrotomy after persistent wound leakage (4.2%)
Chen and Berger [10]	87	THA	Case series	Infection (1.1%)
Cross and Berger [11]	105	UKA	Case series	Infection (1.0%)
Gondusky et al.[15]	160	UKA	Case series	Reoperation (1.3%), hematoma (0.6%), wound drainage (0.6%), fatigue and urinary tract infection (0.6%)
den Hartog et al.[16]	27	THA	Case series	Seroma formation (3.7%)
Kolisek et al.[26]	128	TKA	Case controlled	Developed drop foot (1.6%), manipulation under anesthesia (3.2%), iatrogenic ligament deficiency (1.6%), revisions (3.2%)
Kort et al.[27]	40	UKA	Case controlled	Manipulation under anesthesia (5%)

	Readmission (rate)	Prolonged hospital stay	FU	CASP score
	None	4 patients (3.4%) intraoperative fracture, atelectasis, monitoring after ECG changes	90 days	8
	3 patients (6.0%) e.g. GI tract bleeding, superficial infection, manipulation under anesthesia	2 patients (4.0%) not willing to go home, nausea/vomiting/orthostatic hypotension	3 months	10
	4 patients (3.6%) e.g. anemia, GI bleeding, DVT.	7 patients (6.3%) e.g. difficulty with pain control, chest pain workup for myocardial infarction, which was negative, fear to go home, PONV	3 months	10
	1 patient (0.7%) periprosthetic fracture	None	3 months	10
	None	16 patients (26.3%) e.g. hypotension, dizziness, nausea, infection, home problems	6 months	9
	2 patients (8.4%) e.g. arthrotomy, revision	NA	2.4 years	9
	1 patient (1.1%) infection one-stage revision	1 patient (1.1%) unable to complete PT elements	1 year	10
	1 patient (1.0%) infection	None	3 months	11
	1 patient (0.6%)	None	1 year	9
	1 patient (3.7%)	3 patients (11,1%) nausea and/or dizziness	3 months	10
	4 patients (4.6%) e.g. manipulation under anesthesia, revision	None	24 months	7
	1 patient (5%) manipulation under anesthesia	3 patients (15%) e.g. fear to go home and pain	3 months	10

Table 1. Continued.

Author(s)	N	Arthroplasty	Study design	AEs
Lovald et al.[28]	5.401	TKA	Case series	NA**
Lovald et al.[30]	102.684	TKA	Case controlled	DVT (4.8%), dislocation (1.1%), loosening (2.1%), infection (4.5%), mortality (2.4%), pain in joint (46,3%), revision (2.1%), stiffness (8.2%), mechanical complication (3.4%), wound (1.1%)

Table 2. Expert opinion and literature based patient selection criteria for OJA.

Inclusion criteria	*Expert opinion*
General	Able and willing to participate, understanding the OJA protocol and care must be provided during the first postoperative days.
Exclusion criteria	
General	None
Cardiology	Coumarin-derivative usage based on atrial fibrillation or prosthetic valve, bridging anticoagulation, NYHA classification[14] III or IV.
Pulmonology	Lung fibrosis, emphysema, carcinoma, pulmonary hypertension or embolism.
Internal medicine	Extensive edema, chronic usage of prednisolone, severe renal function disorders, DM type I.
Geriatrics	History of (frequent) falling in the past three months, cognitive function disorders (e.g. history of delirium, dementia, memory difficulties), need for additional inpatient rehabilitation, polypharmacy and/or substance abuse.
Urology	Pre-existing voiding difficulties, preoperative use of urologic medication.
Neurology	Severe mobility disorders (e.g. loss function due to cerebrovascular accident, Parkinson, peripheral neurologic function disorders).
Psychiatry	No criteria were given.

Patient selection criteria

According to recent literature, patients, who are able and willing to participate, with a low ASA classification (<III), undergoing primary arthroplasty, age <75 and with support at home during the first postoperative days are eligible candidates for OJA. Patients with a high ASA classification (>II), bleeding disorders, poorly controlled and/or severe cardiac (e.g. heart failure, arrhythmia) or pulmonary (e.g. embolism, respiratory failure) comorbidities, uncontrolled DM (type I or II), a high BMI (>30 m2/kg), chronic opioid consumption, functional neurological impairments, dependent functional status, chronic/end-stage renal disease and/or reduced preoperative cognitive capacity should be excluded from OJA.

Readmission (rate)	Prolonged hospital stay	FU	CASP score
NA**	NA*	1 year	8
1.6% (not further specified)	NA*	2 years	9

Expert opinion

All medical specialists agreed and participated. Table 2 presents an overview of expert opinion-based patient selection criteria per given discipline.

Discussion

The most important finding of the present study was that an extensive and well-conducted patient selection procedure is needed to perform safe and effective OJA with acceptable clinical outcome. Despite OJA being increasingly applied in daily orthopaedic practice, general consensus on patient selection criteria is lacking. It is known that comorbidities can predispose patients to increased AEs, readmission rates and increased length of hospital stay [7, 28, 30]. Patient selection seems to be crucial in the prevention of AEs and readmissions [4, 15]. This selection for OJA patients was previously studied by Lovald et al. [28, 30]. In the latest series [28], outpatient and short-stay TKA patients were analysed as one cohort. These results are of major interest in patient selection; however, the selection criteria for outpatient TKA were not described. In addition, the question remains whether outpatient TKA resulted in comparable outcome as the short-stay group, since enhanced recovery pathways are increasingly applied as the standard care for arthroplasty [22]. In previous series [30], standardized 3–4 night's hospitalization were compared with outpatient, shortened or extended stay. Unfortunately, the inclusion and exclusion criteria for outpatient TKA were not reported. On the other hand, the results showed that outpatient TKA improved more in terms of functioning, quality of life and short-term outcomes including lower incidence of knee pain and stiffness. Despite there were no significant differences found between groups, awareness for potential increase of postoperative complications in outpatient and short-stay TKA was suggested. When implementing an outpatient surgery pathway for hip and/or knee arthroplasty, surgeons need to consider proper patient selection criteria to prevent AEs and readmissions while ensuring the quality of care, to maintain patient

satisfaction and function with a reduction in length of stay. A limitation of the present study is the methodological quality of the included studies. There are no multicentre randomized controlled trials comparing the conventional with the outpatient pathway. In order to create general applicable patient selection criteria with a multidisciplinary approach, the expert opinions were reviewed. Besides the presented differences between THA and TKA risk factors for OJA, literature is inconclusive to establish specific patient selection criteria for either hip- or knee arthroplasty. The presented results provide a basis for patient selection criteria in daily practice, but on the other hand highlighting the need for further development of these criteria.

Further research needs to identify the patients who will do well with the outpatient procedure and those who will do better with the more traditional care. Today, this twopronged type of clinical "pathway" research is essential for patients and healthcare systems worldwide.

Conclusion

In this review, an evidence and expert opinion-based summary of patient selection criteria are presented to prevent prolonged hospital stay, AEs and readmissions following OJA. These criteria can be useful when selecting patients for OJA. With a change in mindset, literature-based protocols and patient selection criteria, outpatient hip and knee arthroplasty can be applied in daily orthopaedic practice while ensuring patients' safety.

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Compliance with ethical standards

Conflict of interest
One of the authors (NK) is a paid consultant for Zimmer-Biomet. The other authors declare that they have no conflict of interest. No financial support was received for this study.

References

1. Aasvang EK, Luna IE, Kehlet H (2015) Challenges in postdischarge function and recovery: the case of fast-track hip and knee arthroplasty. Br J Anaesth 115(6):861–866
2. Aynardi M, Post Z, Ong A, Orozco F, Sukin DC (2014) Outpatient surgery as a means of cost reduction in total hip arthroplasty: a case-control study. HSS J 10(3):252–255
3. Bass AR, Rodriguez T, Hyun G, Santiago FG, Kim JI, Woller SC, Gage BF (2015) Myocardial ischaemia after hip and knee arthroplasty: incidence and risk factors. Int Orthop 39(10):2011–2016
4. Berger RA, Kusuma SK, Sanders SA, Thill ES, Sporer SM (2009) The feasibility and perioperative complications of outpatient knee arthroplasty. Clin Orthop Relat Res 467(6):1443–1449
5. Berger RA, Sanders S, Gerlinger T, Della Valle C, Jacobs JJ, Rosenberg AG (2005) Outpatient total knee arthroplasty with a minimally invasive technique. J Arthroplasty 20:33–38
6. Berger RA, Sanders SA, Thill ES, Sporer SM, Della Valle C (2009) Newer anesthesia and rehabilitation protocols enable outpatient hip replacement in selected patients. Clin Orthop Relat Res 467(6):1424–1430
7. Callaghan JJ, Pugely A, Liu S, Noiseux N, Willenborg M, Peck D (2015) Measuring rapid recovery program outcomes: are all patients candidates for rapid recovery. J Arthroplasty 30(4):531–532
8. Critical Appraisal Skills Programme (CASP) (2014) CASP Checklists Oxford. www.casp-uk.net/
9. Castoro C, Bertinato L, Baccaglini U, Drace CA, McKee M (2007) European observatory on health systems and policies; day surgery: making it happen. World Health Organization. www.euro.who.int
10. Chen D, Berger RA (2013) Outpatient minimally invasive total hip arthroplasty via a modified Watson-Jones approach: technique and results. Instr Course Lect 62:229–236
11. Cross MB, Berger R (2014) Feasibility and safety of performing outpatient unicompartmental knee arthroplasty. Int Orthop 38(2):443–447
12. Dervin GF, Madden SM, Crawford-Newton BA, Lane AT, Evans HC (2012) Outpatient unicompartment knee arthroplasty with indwelling femoral nerve catheter. J Arthroplasty 27(6):1159–1165
13. Dorr LD, Thomas DJ, Zhu J, Dastane M, Chao L, Long WT (2010) Outpatient total hip arthroplasty. J Arthroplasty 25(4):501–506
14. Genth S, Zotz R, Darius H, Treese N, Sigmund M, Hanrath P, Meyer J (1996) Comparison of NYHA classification with cardiopulmonary function in patients with chronic heart failure. Z Kardiol 85(6):428–434
15. Gondusky JS, Choi L, Khalaf N, Patel J, Barnett S, Gorab R (2014) Day of surgery discharge after unicompartmental knee Knee Surg Sports Traumatol Arthrosc 1 3 arthroplasty: an effective perioperative pathway. J Arthroplasty 29(3):516–519
16. den Hartog YM, Mathijssen NM, Vehmeijer SB (2015) Total hip arthroplasty in an outpatient setting in 27 selected patients. Acta Orthop 86(6):667–670
17. Healy WL, Iorio R, Ko J, Appleby D, Lemos DW (2002) Impact of cost reduction programs on short-term patient outcome and hospital cost of total knee arthroplasty. J Bone Joint Surg (Am) 84:348–353
18. Husted H, Holm G, Jacobsen S (2008) Predictors of length of stay and patient satisfaction after hip and knee replacement surgery: fast-track experience in 712 patients. Acta Orthop 79:168–173
19. Husted H, Lunn TH, Troelsen A, Gaarn-Larsen L, Kristensen BB, Kehlet H (2011) Why still in hospital after fast-track hip and knee arthroplasty? Acta Orthop 82(6):679–684

20. Ibrahim MS, Khan MA, Nizam I, Haddad FS (2013) Peri-operative interventions producing better functional outcomes and enhanced recovery following total hip and knee arthroplasty: an evidence-based review. BMC Med 11:37
21. Kallio PJ, Nolan J, Olsen AC, Breakwell S, Topp R, Pagel PS (2015) Anesthesia preoperative clinic referral for elevated Hba1c reduces complication rate in diabetic patients undergoing total joint arthroplasty. Anesth Pain Med 5(3):e24376
22. Kehlet H, Jørgensen CC (2015) Rapid recovery after hip and knee arthroplasty—A transatlantic gap? J Arthroplasty 30(12):2380
23. Kehlet H, Thienpont E (2013) Fast-track knee arthroplasty—status and future challenges. Knee 20(1):29–33
24. Kerkhoffs GMMJ, Servien E, Dunn W, Dahm D, Bramer JAM, Haverkamp D (2012) The influence of obesity on the complication rate and outcome of total knee arthroplasty: a meta-analysis and systematic literature review. J Bone Joint Surg (Am) 94(20):1839–1844
25. Kerr DR, Kohan L (2008) 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 79:174–183
26. Kolisek FR, McGrath MS, Jessup NM, Monesmith EA, Mont MA (2009) Comparison of outpatient versus inpatient total knee arthroplasty. Clin Orthop Relat Res 467(6):1438–1442
27. Kort NP, Bemelmans YFL, Schotanus MGM (2015) Outpatient surgery for unicompartmental knee arthroplasty is effective and safe. KSSTA. doi:10.1007/s00167-015-3680-y
28. Lovald ST, Ong KL, Lau EC, Joshi GP, Kurtz SM, Malkani AL (2014) Patient selection in outpatient and short-stay total knee arthroplasty. J Surg Orthop Adv 23(1):2–8
29. Lovald ST, Ong KL, Lau EC, Joshi GP, Kurtz SM, Malkani AL (2015) Patient selection in short stay total hip arthroplasty for Medicare patients. J Arthroplasty 30(12):2086–2091
30. Lovald ST, Ong KL, Malkani AL, Lau EC, Schmier JK, Kurtz SM, Manley MT (2014) Complications, mortality, and costs for outpatient and short-stay total knee arthroplasty patients in comparison to standard-stay patients. J Arthroplasty 29(3):510–515
31. Nadelson MR, Sanders RD, Avidan MS (2014) Perioperative cognitive trajectory in adults. Br J Anaesth 112(3):440–451
32. Nederlandse Orthopedie Vereniging (NOV). Guideline: total hip arthroplasty. www.richtlijnendatabase.nl
33. Nederlandse Orthopedie Vereniging (NOV). Guideline: total knee arthroplasty. www.richtlijnendatabase.nl
34. Pivec R, Issa K, Naziri Qais, Kapadia Bhaveen H, Bonutti Peter M, Mont Michael A (2014) Opioid use prior to total hip arthroplasty leads to worse clinical outcomes. Int Orthop 38(6):1159–1165
35. Price AJ, Webb J, Topf H, Dodd CA, Goodfellow JW, Murray DW (2001) Oxford Hip and Knee Group. Rapid recovery after oxford unicompartmental arthroplasty through a short incision. J Arthroplasty 16(8):970–976
36. Schotanus MGM, Bemelmans YFL, Jansen J, v.d. Kuy H, Kort NP (2015) No advantage of adrenaline in the local infiltration analgesia mixture during total knee arthroplasty. KSSTA. doi:10.1007/s00167-015-3723-4
37. Schotanus MGM, van Dun B, Kort NP (2014) Fast-track total knee arthroplasty in a patient with Parkinson's disease. In: Nederlands Tijdschrift Voor Orthopaedie. www.ntv-orthopaedie.nl
38. Thienpont E, Lavand'homme P, Kehlet H (2015) The constraints on day-case total knee arthroplasty: the fastest fast track. Bone Joint J 97(10):40–44
39. Warth LC, Pugely AJ, Martin CT, Gao Y, Callaghan JJ (2015) Total joint arthroplasty in patients with chronic renal disease: Is it worth the risk? J Arthroplasty 30(9):51–54

CHAPTER 9

PHYSICAL ACTIVITY AFTER OUTPATIENT SURGERY AND ENHANCED RECOVERY FOR TOTAL KNEE ARTHROPLASTY. PROSPECTIVE CASE-CONTROLLED STUDY.

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Abstract

Purpose and hypothesis The purpose of this study was to 'objectively' measure improvement of physical activity with the use of an activity monitor between patients who followed an enhanced recovery- or outpatient surgery pathway after total knee arthroplasty (TKA). It was hypothesized that both pathways will have comparable physical activity after TKA at 6-week follow-up.

Methods This prospective observational comparative case study was designed to investigate activity parameters (e.g. physical activity, number of steps, sit–stand transfers) of two different pathways after 6 weeks with the use of a non-invasive triaxial accelerometer activity monitor. This study included 20 patients with a mean age of 65.5 years (SD 6.1) undergoing TKA who were allocated to follow one of the two pathways: enhanced recovery (n = 10) or outpatient surgery (n = 10). Patients were monitored for 4 days pre-, 4 days during and 4 days after 5 weeks postoperatively. Patient-reported outcome measures (PROMs) and range of knee motion were obtained pre- and 6 weeks postoperatively.

Results The activity parameters recovered steeply during the first 4 postoperative days and continued to improve within both pathways (n.s.). Preoperative and during the first 4 days and 5 weeks postoperative, activity parameters were comparable (n.s.) between both pathways but did not reach preoperative levels of physical activity and range of motion (n.s.). PROMs improved within each pathway, and no difference between both pathways was observed (n.s.).

Conclusions This study demonstrates that the early physical activity parameters of patients after TKA, following the outpatient surgery pathway, were similar to patients who followed the standard enhanced recovery pathway. The activity monitor is an added value for a more detailed and objective analysis of the physical performance in patients after TKA.

Keywords Outpatient surgery; Day care surgery; Enhanced recovery; Fast track; Pathway; Total knee arthroplasty; Physical activity; Activity monitor; Accelerometer

Introduction

Enhanced recovery pathways and the further development to outpatient surgery (OS) pathways should focus on reduction of surgical stress, postoperative nausea, vomiting (PONV) and pain [12, 14, 15, 32]. With this optimisation, a reduction in the length of hospital stay (LoS) can be possible [16]. Recent literature supports early discharge on the day of surgery [1, 5, 6, 9, 17, 18]. Together with patient-based selection criteria, a change in mindset and a multidisciplinary approach, OS pathways are as safe and efficient as conventional pathways, in terms of readmissions and complications [18, 19]. Nevertheless, the physical activity of patients in the early postoperative phase is still unclear. A more accurate and objective measure of actual physical activity would therefore be useful for predicting performance in patients with specific activity levels. This includes creating reference data, verifying compliance to rehabilitation protocols, objectify outcome and to better manage patient expectations. Furthermore, it creates the possibility to provide activity-based biofeedback to motivate patients. In addition to patient-reported outcome measures (PROMs), acceleration-based gait analysis has been accepted as an objective measurement of functional and clinical outcome in arthroplasty patients [2]. Results have shown that physical function after total knee arthroplasty (TKA), significantly improved within one year postoperative in terms of gait, sit-to-stand and block step-up transfers. These results were found after TKA in an enhanced recovery pathway (ERP), but data on activity after OS TKA are lacking. This single surgeon, comparative case study was designed to investigate clinical outcomes after TKA following an OS pathway compared to the standard ERP, which brings us to the following research questions; first, is there a difference in physical activity of daily life between ERP and OS as assessed with a non-invasive triaxial accelerometer-based Activity Monitor (AM) and secondly, is there a difference in clinical outcome between ERP and OS patients as assessed with PROMs and knee range of motion (RoM). This is the first study to evaluate the physical activity during the early postoperative phase in patients undergoing TKA following an OS pathway. It was hypothesized that there would be no difference in physical activity PROMs and RoM between both pathways.

Materials and methods

Between April 2014 and December 2015, twenty patients gave consent to participate in this prospective observational comparative case study. This study was performed in compliance with the Helsinki Declaration of 1975, as revised in 2000, and was approved by the Institutional Review Board (IRB: Zuyderland-Zuyd, Heerlen, The Netherlands, IRB Nr. 16N33). Patients with disabling unilateral moderate-severe osteoarthritis, who

were able and willing to follow instructions and return to the outpatient clinic for follow-up evaluations, were eligible for inclusion in the study. Patients with previous knee surgery (except for arthroscopic meniscectomy), active or recently treated infections and patients who were wheelchair-bound were excluded from the study. Included patients were not randomly selected for one of the two pathways, 10 patients followed ERP and 10 other patients followed the OS pathway [18]. There were no bilateral cases. Allocation of patients for the OS pathway was performed by the operating surgeon (NK) and based on the following criteria: no severe cardiologic, pulmonary and/or internal diseases, no additional treatment pre-, periand postoperative needed (e.g. medication adjustment in diabetes mellitus, bridging anticoagulation), patients can be discharged to home environment, able to understand and willing to participate in the OS pathway [18]. Pre-, peri- and postoperative protocols were previously described in detail [18]. A further optimisation of the RR pathway, as the standard pathway for arthroplasty, resulted in similar protocols regarding the use of dexamethasone and tranexamic acid within the conventional (ERP) and OS pathways in this study. Knee flexion as a discharge criterion is no longer applied. The differences between pathways are summarized in Table 1. The clinical reports and patient information were identical in both groups as well as the pain protocol [7]. No adrenaline was used during local infiltration analgesia (LIA) in the OS pathway, since it was shown that adrenaline could be omitted from the LIA mixture [32]. All TKA procedures were performed by one experienced knee surgeon (NK), performing a minimum of 150 TKA procedures annually. Patients were operated with the use of Patient Specific Guides (Signature, Zimmer Biomet, Warsaw, IN, USA) for the implantation of the cemented Vanguard CR TKA IN, USA). Baseline conditions and operative data are summarised in Table 2.

Table 1. Differences between pathways pre-, peri- and postoperative care.

	ERP	**OS**
Preoperative		
Admission	Night before/day of surgery	Day of surgery
Planned discharge	<3 days postoperative	Day of admission
Perioperative		
Prophylactic antibiotics	I.v.	I.v. and oral
Adrenaline in LIA mixture	Yes	No
Postoperative		
First mobilization	<6hrs	<4hrs
Compression bandages	24hrs postoperative	8hrs postoperative, first 4 days postoperative elastic bandage

Table 2. Patient characteristics and operative data presented as mean (±SD) or absolute numbers for both pathways.

	ERP	OS	p-value
Patient characteristics			
Age (years) at index surgery	66.9 (7.9)	64.1 (3.5)	n.s.
Male/ female	5/5	8/2	n.s.
BMI kg/m²	29.2 (6.0)	27.7 (4.7)	n.s.
ASA, I/II/III	2/8/0	3/7/0	n.s.
Operative data			
Blood loss, mL	237.5 (106.1)	233.3 (136.9)	n.s.
OR time, min	65.8 (13.8)	58.8 (18.9)	n.s.

Outcome

Physical activity in the daily life of patients was measured in a non-invasive way using triaxial accelerometer (GC Dataconcepts LLC, Waveland, USA). The AM was attached onto the lateral side of the non-affected upper leg. Based on previously published principles [27, 28], raw accelerometer data were post-processed and analysed using self-developed algorithms for feature detection and activity classification written in Matlab (MATLAB R2010a, The Mathworks Inc., Natick, Massachusetts, USA) [25]. More detailed information of the AM and its clinical application are described in a previous study [34]. Activity parameters calculated were the daily number of events (counts) and total time (duration) spent sitting or lying (inactive), standing, walking or cycling (active) and the number of steps and sit–stand transfers. In addition to these quantitative parameters, qualitative aspects of activities could also be calculated, such as walking cadence (steps/min), time-wise distribution of walking bouts (e.g. number walking bouts consisting of less or more than an amount of steps), sitting and standing. Physical activity was measured for four consecutive days [13, 26]. The AM was worn only during waking hours with a minimum of 8 h a day and removed at night and during showering. The daily physical activity was measured at three time points. First, patients wore the monitor during four days before surgery until the day of surgery. During the surgery hours, the AM data were extracted. Second, once the surgery was completed, the AM was returned to the patients and they wore the sensor until the fourth postoperative day. Within the first 4–6 h after surgery, the patient started with early mobilization (Table 2). Patients following the OS pathway were discharged later the same day, while the ERP patients were evaluated twice a day to check whether they met discharge criteria (e.g. safe mobilization, able to climb stairs and able to perform sit–stand transfers, adequate pain/ PONV control). The third activity assessment was during the 6th postoperative week and again measured for four consecutive days. The time between hospital admission and discharge and the time between the start of anaesthesia until the first mobilization were recorded in hours in the patient's clinical report. PROMs were obtained pre- and 6 weeks

postoperative including the Dutch validated Oxford Knee Score (OKS; 12–60, 12 being the best outcome) [10], Western Ontario and McMaster Universities Arthritis Index (WOMAC; 0–100, 100 being the best outcome) [29] and the Euro-Qol-5D (EQ-5D; 0–1, 1 indicates the best health state) [3]. Experienced pain was measured by a Numerical Rating Scale (NRS, 0–10, 10 being 'worst pain'). All PROMs were conducted prior to the outpatient visit. Active measures of flexion and extension were determined using a digital inclinometer (MicroFET 5, Hoggan Health Industries, Salt Lake City, USA) with a high level of accuracy. The RoM of the operated leg was measured twice, and the average value was used [36, 37]. RoM was obtained pre-, 1 and 6 weeks postoperative.

Statistical analysis

All statistical analysis was done with use of SPSS version 17.0 for windows (Inc., Chicago, IL). Statistically significant differences between both groups were analysed with nonparametric Mann–Whitney U test, since the group sizes were small. Chi-square test was used for categorical variables. *P* values were considered to be statistically significant at $p \leq 0.05$ for all analysis. This study was carried out in an attempt to predict an appropriate sample size to design a full-scale research project. A minimum pilot trial sample size per arm of 10 patients is appropriate [35].

Results

No patients were lost to follow-up. At 6-week follow-up, all physical activity parameters were comparable between both groups (Fig. 1; Table 3). Looking at the preoperative activity levels and longitudinally also at the direct postoperative days (Fig. 1), groups were statistically comparable showing equal amounts of preoperative activity and matching recovery profiles in all activity parameters with no group difference (n.s.). Activity recovers steeply during the first 4 postoperative days and continues to improve towards the 6-week assessment when it remains below preoperative levels. As expected, the overall mean LoS was statistically significant different ($p \leq 0.000$) in favour of the OS pathway. The ERP patients were discharged after a mean of 52:30 h (range, 25:12–97:12) compared to a mean discharge of 9:30 h (range, 8:20–12:06) in the OS pathway. Early mobilization was not different between both groups (n.s.). Patients mobilized within a mean of 4:06 h (range, 1:15–6:37) and 3:11 h (range, 2:10–4:22) for, respectively, the ERP and OS pathway. One patient in the ERP pathway was not able to mobilize <4 h postoperative due to loss of sensibility, and the first mobilization was postponed. At 6 weeks postoperatively, mean (±SD) PROMs improved within each pathway compared to preoperative values. No statistically significant or clinically relevant differences for the PROMs and RoM were found between both pathways (Table 4).

Figure 1. Mean daily Physical Activity (A), sit-stand transfers (B), amount of steps (C) and cadans (D) (*vertical axis*) before and after TKA. Preoperative (Pre OR), day of surgery (DoS) up to postoperative day (PoD) 3 and 6th week postoperative (*horizontal axis*) for the ERP (white-bars) and OS pathway (black-bars). Standard deviations are displayed with whiskers.

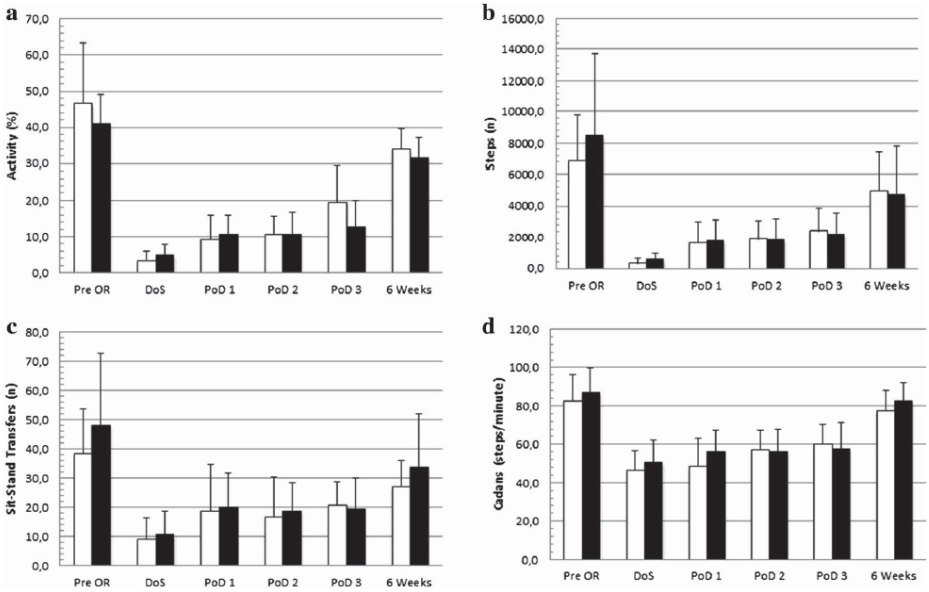

Table 3. Mean amount of average daily activity (e.g. walking, standing, cycling) in minutes (min) with percentage (%) of the total physical activity during the 6th postoperative week for both pathways.

	ERP	OS	P-value
Physical Activity, min (%)	253.9 (33.5)	221.4 (31.5)	n.s.
Walking, min (%)	81.8 (10.6)	80.5 (11.5)	n.s.
Standing, min (%)	170.3 (22.6)	131.7 (18.9)	n.s.
Cycling, min (%)	1.8 (0.3)	9.2 (1.1)	n.s.
Sitting, min (%)	509.3 (66.5)	404.4 (68.5)	n.s.

Table 4. Mean (±SD) pre- and 6-wks postoperative PROMs and RoM for both pathways.

		ERP	OS	*p-value*
OKS	**Pre**	34.8 (7.6)	32.0 (10.3)	n.s.
	6-wks	25.4 (1.8)	29.0 (8.2)	n.s.
WOMAC	**Pre**	49.0 (14.8)	49.2 (25.7)	n.s.
	6-wks	70.8 (11.9)	76.7 (18.1)	n.s.
EQ-5D	**Pre**	0.79 (0.04)	0.63 (0.24)	n.s.
	6-wks	0.87 (0.10)	0.75 (0.26)	n.s.
NRS-pain	**Pre**	4.7 (1.6)	5.2 (2.5)	n.s.
	6-wks	2.6 (2.1)	2.6 (2.2)	n.s.
RoM	**Pre**	120.6 (11.3)	115.9 (24.0)	n.s.
	6-wks	104.3 (17.2)	106.2 (20.0)	n.s.

Discussion

The most important finding of the present study was that OS was not inferior but equal compared to ERP regarding physical activity of daily life, PROMs and RoM as it was hypothesized. Both groups did not reach preoperative levels of physical activity during the 6th postoperative week. Physical activity after TKA has a positive impact on the early recovery and length of stay after arthroplasty [4, 7, 20, 21, 30]. At this moment, there are no data to suggest the effect of OS on early postoperative physical activity after TKA. In this study, OS was not clearly superior to ERP with respect to physical activity directly after TKA during the first week and 6th postoperative week. Both groups in this study improved with comparable physical activity at a minimum 6 weeks follow-up. It has been stated that PROMs represent the best subjective measurement of clinical outcome [31]. Studies have shown that patients who followed enhanced recovery pathways after arthroplasty were as satisfied or even more satisfied compared to patients who followed conventional pathways, with regard to the PROMs at 3, 4 and 12 months postoperative [11, 22–24]. However, there is no single best outcome measurement tool after TKA. Beside the positive results of PROMs on enhanced recovery pathways, various scores are not capturing the changes due to a lack of power of the scores as averse to a lack of change (e.g. floor and ceiling effects) [8]. For example, pain during the early recovery phase can conceal the functional changes [33]. The PROMs in this study failed to detect subjective changes after an early rehabilitation period of 6 weeks. In order to characterize the objective changes in physical activity after TKA in detail, the AM was used to capture changes over time and to detect potential objective differences (e.g. activity, steps, sit–stand transfers, cadence) between both pathways during the early recovery phase [2,

8]. Minimal information exists regarding the physical activity after TKA in an OS setting. Early experience with OS in patients operated for unicompartmental knee arthroplasty (UKA) showed promising results in terms of safety and efficiency [18]. Recently, Krenk et al. [20] reported on 20 patients operated for TKA and total hip arthroplasty (THA) following an enhanced recovery pathway. They found similar results in the postoperative physical activity in patients who were discharged after a mean of 2.6 days. However, with a substantial difference, this study captured changes within the early recovery phase up to 6 weeks postoperative compared to 6 days postoperative. Furthermore, patients in the OS pathway were compared with patients who followed the ERP as a control group. When comparing these pathways, both groups experienced a drop in physical activity during the first postoperative days after TKA, with a comparable improvement at 6 weeks postoperative. A particular strength of this study is the assessment of physical activity over three time points, which allows a more detailed analysis of the activity of the different parameters into the early recovery phase. After hospital discharge, patients need to be encouraged to do their daily exercises in their home environment. With the use of the AM, we were able to objectively monitor if patients were physically active in their home environment during the first week and 6th postoperative week. On the other hand, this study and the results of Krenk et al. [20] demonstrate the need for follow-up beyond 6 weeks postoperative. This is of interest and needs attention in further research. Finally, this study does have some limitations. The most important limitation was the limited number of patients and power of this study. Nevertheless, this study was carried out in order to evaluate the daily physical activity in patients following OS after TKA, in an attempt to predict an appropriate sample size to design a performance of a full-scale research project [35]. A possible mismatch in the study could be the potential selection bias. Patients were not individually randomly selected for one of the two pathways due to practical and financial consideration (e.g. limited number of AMs). Even though medical comorbidities in both pathways were comparable, it resulted in equal physical activity up to six weeks postoperative. After surgery, patients did not change from one pathway to another.

Conclusions

This study demonstrates that the early physical activity parameters of patients undergoing TKA in the OS pathway were similar to patients who followed the standard ERP. Measurement with the AM is an added value for a more detailed and objective analysis of the physical activity during the early recovery phase in patients after TKA and provides more insight information rather than PROMs alone.

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Compliance with ethical standards

Conflict of interest
No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References

1. Berger RA, Kusuma SK, Sanders SA et al (2009) The feasibility and perioperative complications of outpatient knee arthroplasty. Clin Orthop Relat Res 467(6):1443–1449
2. Bolink SA, Grimm B, Heyligers IC (2015) Patient-reported outcome measures versus inertial performance-based outcome measures: a prospective study in patients undergoing primary total knee arthroplasty. Knee 22(6):618–623
3. Brooks R (1996) EuroQol: the current state of play. Health Policy 37(1):53–72
4. Brosseau L, Milne S, Wells G et al (2004) Efficacy of continuous passive motion following total knee arthroplasty: a meta-analysis. J Rheumatol 31:2251–2264
5. Cross MB, Berger R (2014) Feasibility and safety of performing outpatient unicompartmental knee arthroplasty. Int Orthop 38(2):443–447
6. Dervin F, Madden SM, Crawford-Newton BA et al (2012) Outpatient unicompartment knee arthroplasty with indwelling femoral nerve catheter. J Arthroplasty 27(6):1159–1165
7. Gerber LH (1990) Exercise and arthritis. Bull Rheum Dis 39(6):1–9
8. Giesinger K, Hamilton DF, Jost B et al (2014) Comparative responsiveness of outcome measures for total knee arthroplasty. Osteoarthritis Cartilage 22(2):184–189
9. Gondusky JS, Choi L, Khalaf N et al (2014) Day of surgery discharge after unicompartmental knee arthroplasty: an effective perioperative pathway. J Arthroplasty 29(3):516–519
10. Haverkamp D, Breugem SJ, Sierevelt IN et al (2005) Translation and validation of the Dutch version of the Oxford 12-item knee questionnaire for knee arthroplasty. Acta Orthop 76(3):347–352
11. Husted H, Hansen HC, Holm G et al (2006) Accelerated versus conventional hospital stay in total hip and knee arthroplasty III: patient satisfaction. Ugeskr Laeger 168(22):2148–2151
12. Husted H, Lunn HT, Troelsen A et al (2011) Why still in hospital after fast-track hip and knee arthroplasty? Acta Orthop 82:679–684
13. Kang M, Hart PD, Kim Y (2012) Establishing a threshold for the number of missing days using 7 d pedometer data. Physiol Meas 33(11):1877–1885
14. Kehlet H, Wilmore DW (2002) Multimodal strategies to improve surgical outcome. Am J Surg 183:630–641
15. Kehlet H, Dahl JB (2003) Anaesthesia, surgery, and challenges in postoperative recovery. Lancet 362:1921–1928
16. Kehlet H, Andersen LØ (2011) Local infiltration analgesia in joint replacement: the evidence and recommendations for clinical practice. Acta Anaesthesiol Scand 55:778–784
17. Kolisek FR, McGrath MS, Jessup NM et al (2009) Comparison of outpatient versus inpatient total knee arthroplasty. Clin Orthop Relat Res 467(6):1438–1442
18. Kort NP, Bemelmans YFL, Schotanus MGM (2015) Outpatient surgery for unicompartmental knee arthroplasty is effective and safe. Knee Surg Sports Traumatol Arthrosc. doi:10.1007/s00167-015-3680-y
19. Kort NP, Bemelmans YFL, van der Kuy PHM et al (2016) Patient selection criteria for outpatient joint arthroplasty. Knee Surg Sports Traumatol Arthrosc. doi:10.1007/s00167-016-4140-z
20. Krenk L, Jennum P, Kehlet H (2014) Postoperative sleep disturbances after zolpidem treatment in fast-track hip and knee replacement. J Clin Sleep Med 10(3):321–326
21. Labraca NS, Castro-Sánchez AM, Matarán-Peñarrocha GA et al (2014) Benefits of starting rehabilitation within 24 h of primary total knee arthroplasty: randomized clinical trial. Clin Rehabil 25(6):557–566

22. Larsen K, Hvass KE, Hansen TB et al (2008) Effectiveness of accelerated perioperative care and rehabilitation intervention compared to current intervention after hip and knee arthroplasty. A before-after trial of 247 patients with a 3 month follow-up. BMC Musculoskelet Disord 9:59
23. Larsen K, Sørensen OG, Hansen TB et al (2008) Accelerated perioperative care and rehabilitation intervention for hip and knee replacement is effective: a randomized clinical trial involving 87 patients with 3 months of follow-up. Acta Orthop 79(2):149–159
24. Larsen K, Hansen TB, Søballe K, Kehlet H (2012) Patientreported outcome after fast-track knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 20(6):1128–1135
25. Lipperts M, Senden R, van Asten W et al (2012) Validation of a low cost activity monitor for orthopaedic patients. J Bone Joint Surg 94:235
26. Masse LC, Fuemmeler BF, Anderson CB et al (2005) Accelerometer data reduction: a comparison of four reduction algorithms on select outcome variables. Med Sci Sports Exerc 37(11):544–554
27. Mathie MJ, Celler BG, Lovell NH et al (2004) Classification of basic daily movements using a triaxial accelerometer. Med Biol Eng Comput 42(5):679–687
28. Preece SJ, Goulermas JY, Kenney LP et al (2009) Activity identification using body-mountedsensors—a review of classification techniques. Physiol Meas 30(4):R1–33
29. Roorda LD, Jones CA, Waltz M et al (2004) Satisfactory cross cultural equivalence of the Dutch WOMAC in patients with hip osteoarthritis waiting for arthroplasty. Ann Rheum Dis 63(1):36–42
30. Racunica TL, Teichtahl AJ, Wang Y et al (2007) Effect of physical activity on articular knee joint structures in community-based adults. Arthritis Rheum 57(7):1261–1268
31. Rolfson O, Malchau H, Wang Y et al (2015) The use of patientreported outcomes after routine arthroplasty: beyond the whys and ifs. J Bone Joint Surg 97-B(5):578–581
32. Schotanus MGM, Bemelmans YFL, van der Kuy PHM et al (2015) No advantage of adrenaline in the local infiltration analgesia mixture during total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. doi:10.1007/s00167-015-3723-4
33. Terwee CB, van der Slikke RM, van Lummel RW et al (2006) Self-reported physical functioning was more influenced by pain than performance-based physical functioning in knee-osteoarthritis patients. J Clin Epidemiol 59(7):724–731
34. Verlaan L, Bolink SA, Van Laarhoven SN et al (2015) Accelerometer-based physical activity monitoring in patients with knee osteoarthritis: objective and ambulatory assessment of actual physical activity during daily life circumstances. Open Biomed Eng J 23(9):157–163
35. Whitehead AL, Julious SA, Cooper CL, Campbell MJ (2016) Estimating the sample size for a pilot randomised trial to minimise the overall trial sample size for the external pilot and main trial for a continuous outcome variable. Stat Methods Med Res 25(3):1057–1073
36. de Winter AF, Heemskerk MAMB, Terwee CB et al (2004) Interobserver reproducibility of measurements of range of motion in patients with shoulder pain using a digital inclinometer. BMC Musculoskelet Disord 5(1):18
37. Yaikwawongs N, Limpaphayom N, Wilairatana V (2009) Reliability of digital compass goniometer in knee joint range of motion measurement. J Med Assoc Thai 92(4):517–522

CHAPTER 10

IMPROVED HEALTH-RELATED QUALITY OF LIFE AFTER KNEE ARTHROPLASTY FOLLOWING AN OUTPATIENT SURGERY PATHWAY: AN OBSERVATIONAL COMPARATIVE CASE STUDY.

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Abstract

Purpose Enhanced recovery pathways after knee arthroplasty have been introduced worldwide with positive results. The present study investigated the improvements of health-related quality of life and functional outcome in patients operated for knee arthroplasty who followed an Outpatient Surgery (OS) or Enhanced Recovery (ER) pathway.

Methods We reviewed our institutional database of 361 consecutive patients undergoing knee arthroplasty (total and partial) who followed either the OS-pathway (n=94; 26.1%) or ER-pathway (n=267; 73.9%). Recorded outcomes included 4 different patient reported outcome measures (PROMs; EuroQol-5D (both index and VAS), Oxford Knee Score, Western Ontario and McMaster Universities Arthritis Index and the Pain-Numerical Rating Scale) obtained pre-and during the 3-and 12-months postoperative follow-up.

Results 93 patients (99%) in the OS-group were discharged on the day of surgery as scheduled, whereas in the ER-group 70% of the patients were discharged < 3 days postoperatively. At 12-month follow-up, the EQ-5D (both index and VAS) and other PROMs improved significantly ($p < 0.000$) within each pathway. There were no significant differences between both pathways.

Conclusion One year after knee arthroplasty, patients who were included in an Outpatient Surgery pathway had comparable quality of life and PROMs as patients operated in an Enhanced Recovery pathway.

Keywords Quality of life; Clinical pathways; Outpatient surgery; Knee arthroplasty; Clinical outcome

Introduction

Modification of a selected number of literature-based protocols, used together, can be implemented in a care pathway. Such optimisation is also known as 'outpatient joint arthroplasty', a multimodal clinical pathway based on well-defined patient selection criteria [1-3] with the focus on discharge on the day of surgery while ensuring patients' safety [1,4-8] and cost reduction [9,10,11]. Results have shown that quality of life after TKA, significantly improved within one year postoperative [11]. Although, these results were found after TKA in an enhanced recovery pathway, results during the early postoperative phase have shown that patients following the outpatient joint arthroplasty pathway were satisfied with sufficient physical activity [8,12,13]. Data on the quality of life after outpatient surgery on the long term are lacking. This is the first study to evaluate the quality of life during the long postoperative phase in patients undergoing knee arthroplasty following an outpatient surgery (OS) pathway compared to the standard enhanced recovery pathway (ERP) as measured with the EQ-5D and other patient reported outcome measures (PROMs). It was hypothesized that there would be no difference in quality of life between both pathways 1-yr after knee arthroplasty.

Materials and Methods

This comparative case study reviewed a consecutive series of patients (n=361) operated for knee arthroplasty (total and partial), with the use of patient specific instruments (Signature, Zimmer-Biomet, Warsaw INC) by one experienced knee surgeon (NK). Patients were operated between January 2014 and June 2015. Allocation of patients for the OS pathway or ERP was performed based on previous described selection criteria [14]. Pre-, peri- and postoperative protocols were described in detail in previous study for OS [8]. A further optimisation of the ERP resulted in similar protocols, regarding the use of Dexamethasone, Tranexamic acid (both perioperative). Knee flexion as a discharge criterion is no longer applied. The differences between both pathways are summarized in Table 1.The clinical reports and patient information were identical in both groups as well as the pain protocol [8]. No adrenaline was used during local infiltration analgesia (LIA) in the OS pathway, since it was shown that adrenaline could be omitted from the LIA-mixture [14].

Table 1. Differences between both pathways extracted for pre-, peri- and postoperative care and discharge criteria.

	Enhanced Recovery Pathway	**Outpatient Surgery Pathway**
Preoperative		
Admission	Night before/day of operation	Day of operation
Planned discharge	<3 days postoperative	Day of admission
Perioperative		
Antibiotics prophylactic	I.v.	I.v. and oral
Postoperative		
First mobilization	<6hrs	<4hrs
Compression bandages	24hrs postoperative	8hrs postoperative, first 4 days postoperative elastic bandage

Prior to each outpatient visit (preoperative, 3- and 12-months postoperative) patients filled out 4 different Patient reported outcome measures (PROMs) as standard control in our department for knee arthroplasty patients. PROMs included the EuroQol-5D (EQ-5D; 0 to 1, 1 indicates the best health state) [15], Oxford Knee Score (OKS; 12 to 60, 12 being the best outcome) [16] and the Western Ontario and McMaster Universities Arthritis Index (WOMAC; 0 to 100, 100 being the best outcome) [17]. Experienced pain was measured by a Numerical Rating Scale (NRS, 0 to 10, 10 being 'worst pain'). This study was validated and approved by the Independent Review Board (METC Z, Heerlen, the Netherlands; IRB-nr.16N194) and registered online at the Dutch Trial Register (www.trialregister.nl).

Statistical analysis

SPSS Version 17.0 for windows (Inc., Chicago, IL) was used. Standard descriptive statistics were used to describe the patient demographic data and baseline characteristics. Fisher's exact test was used to test differences of proportions. Students T-tests were performed on the baseline conditions for significant interactions. A mixed model (GLMM) approach was used to take into account the repeated-measures design of the study, to cope with any missing data being collected during the pre-, 3- and 12-months postoperative follow-up and to cope with the wide range of a possible variation in relation to the time-frame the data was collected [18]. The GLMM contained fixed variables, to estimate the effect of the different pathways and age on the trend of the PROMs (dependent variables). For all analyses, a p-value was considered to be statistically significant at $P \leq 0.05$.

Results

94 cases (26.1%) followed the outpatient surgery pathway (OS), while 267 patients (73.9%) followed the protocols of an enhanced recovery pathway (ERP). Baseline and operative data are presented in Table 2. 93 patients (99%) in the OS pathway were discharged on the day of surgery as scheduled, whereas in the ERP pathway 70% of the patients were discharged < 3 days postoperatively. One patient in the OS pathway had prolonged hospital stay because not fulfilling the discharge criteria walking stairs. The first day postoperative the patient was discharged. At 12-month follow-up, the EQ-5D (both index and VAS), the OKS, WOMAC and NRS-pain score improved significantly ($p < 0.000$) within each pathway. There were no significant differences between both pathways. Outcome measures data are summarized in Table 3.

Table 2. Baseline and operative data presented as mean (± SD) or absolute numbers for both groups.

	ERP (n=267)	OS (n=94)	p-value
Age (years) at index surgery	68.4 (9.0)	63.4 (8.0)	0.033
Gender, Male/ female	94/173	49/45	0.005
BMI, kg/m²	29.49 (5.05)	28.25 (3.68)	n.s.
ASA, ≤II / >II	253/14	94/0	0.025
Implant, TKA/UKA	230/37	51/43	0.022

Table 3. Mean (SD) and p-values are presented for the PROMs for both groups for each different follow-up visits tested with a generalized linear mixed model (GLMM).

		ERP Mean	ERP SD	OS Mean	OS SD	p-value GLMM
EQ-5D (Index)	**Pre**	0.77	0.06	0.80	0.07	
	3-months	0.85	0.10	0.86	0.10	
	12-months	0.88	0.10	0.85	0.08	n.s.
EQ-5D (VAS)	**Pre**	62.5	18.5	66.4	19.4	
	3-months	73.5	16.8	79.8	11.7	
	12-months	73.6	17.2	82.5	13.1	n.s.
OKS	**Pre**	36.9	7.7	34.8	8.0	
	3-months	25.9	8.1	23.6	7.5	
	12-months	21.3	7.2	19.2	5.8	n.s.
WOMAC	**Pre**	58.8	23.6	64.3	21.8	
	3-months	78.1	18.5	81.7	16.7	
	12-months	83.7	16.6	89.5	11.6	n.s.

Discussion

The most important findings of the present study were that preselected patients who followed the outpatient knee arthroplasty pathway have comparable quality of life and PROMs as patients who followed the conventional pathway. Other studies showed that enhanced recovery pathways were as satisfying or even more satisfied compared to conventional pathways regarding the PROMS [19]. Increased PROMS were reported by Larsen et al. [11,20,21] at 3, 4 and 12 months postoperative. They reported that early mobilization, a nurse-led organization and optimisation of the preoperative education were a possible reason for these improved PROMs [11,20,21]. Our preoperative education and postoperative organization was unchanged. Therefore, a possible explanation for our results could be the strict patient selection criteria to select patients into one of the two clinical pathways. Besides, the results of Larson et al. were found after TKA in an enhanced recovery pathway [11,20,21], data after outpatient surgery are lacking. Hoorntje et al. [12] recently published their case-controlled study regarding the presence of symptoms of anxiety and depression, by means of the Hospital Anxiety and Depression Scale (HADS) in patients operated after UKA. They found that at the first postoperative day, the median HADS score was significantly ($p=0.02$) lower in the OS group compared to the ERP group and that patients in the OS group were significantly more satisfied (NRS satisfaction score, $p=0.03$) without any differences between both groups at 3-month follow-up [12] Pain relief and improved function are one of the principal aims of arthroplasty, thus it was expected that PROMs would improve significantly after knee arthroplasty. Due to aging and associated health issues, decreased selfrated health scores could be a logic consequence. However, the EQ-5D was still significantly better than the preoperative value but not different between both pathways. This shows that the possible problems associated with the knee arthritis alone, determine partially the overall health score. In the present study a wide range of PROMs were used to measure pre- and postoperative outcome after knee arthroplasty in preselected patients following ERP or OS. PROMs are a subjective measurement of clinical outcome after arthroplasty [22]. The used PROMs in this study did not capturing changes over time due to a lack of sensitivity to change of these scores [23]. Nonetheless, PROMs remain inherently subjective, prone to an individual's interpretation and perception of function [22,24]. A more accurate and objective measure to validate patient clinical outcome after knee arthroplasty is highly sought. In addition to PROMs, acceleration-based gait analysis has been accepted as an objective measurement of functional and clinical outcome in arthroplasty patients [25]. Recent results have shown that the physical activity parameters of patients after TKA, following the outpatient surgery pathway, were similar to patients who followed the standard enhanced recovery pathway [13]. Acceleration-based gait analysis provides more insight information rather

than PROMs alone. A potential criticism in the study was the significant differences in baseline condition. To ensure a proper comparison, both groups should be equal (e.g. age, gender and ASA classification). On the other hand, our primary goal was to compare two pathways in which different patient selection criteria were used. Practical applicability of simplified protocols and new techniques are progressive. Although, these optimisations are associated with initial costs, they will reduce costs for the long term [26]. Firstly there must be an investment in training, knowledge and adjustments to daily practice for the surgeon, nurse and physiotherapist [27]. Good cooperation between these professionals and patients are necessary. All disciplines should be informed about, and involved in the whole process. Together with well-defined patient-based selection criteria, a change in mind set and a multidisciplinary approach, OS pathways are as safe and efficient as conventional pathways, in terms of readmissions, complications [8,14] and clinical outcome [12,13].

Conclusion

With the present study, we are able to conclude that patients, who are selected according to strict criteria for inclusion in an outpatient knee arthroplasty pathway, have comparable quality of life and PROMs as patients operated in a conventional enhanced recovery pathway.

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Author's contribution
Martijn G.M. Schotanus, designed the study, gathered and analysed all the data, wrote the initial draft of the manuscript and managed the study. Yoeri F.L. Bemelmans ensured the accuracy of the data, analyzed the data, wrote and revised the manuscript. Nanne P. Kort, conceived the study and revised the manuscript.

Conflict of interest
No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article. One author (Nanne P. Kort) is a paid consultant for Zimmer-Biomet, Europe. The other authors certify that they have no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.

References

1. Berger RA, Kusuma SK, Sanders SA, Thill ES, Sporer SM (2009) The feasibility and perioperative complications of outpatient knee arthroplasty. Clin Orthop Relat Res 467: 1443-1449
2. Kort NP, Bemelmans YF, van der Kuy PH, Jansen J, Schotanus MG (2016) Patient selection criteria for outpatient joint arthroplasty. Knee Surg Sports Traumatol Arthrosc. [Ahead of Print]
3. Lovald S, Ong K, Lau E, Joshi G, Kurtz S, et al. (2014) Patient selection in outpatient and short-stay total knee arthroplasty. J Surg Orthop Adv 23:2-8
4. Chen D, Berger RA (2013) Outpatient minimally invasive total hip arthroplasty via a modified Watson-Jones approach: technique and results. Instr Course Lect 62: 229-236
5. Cross MB, Berger R (2014) Feasibility and safety of performing outpatient unicompartmental knee arthroplasty. Int Orthop 38: 443-447
6. Gondusky JS, Choi L, Khalaf N, Patel J, Barnett S, et al. (2014) Day of surgery discharge after unicompartmental knee arthroplasty: an effective perioperative pathway. J Arthroplasty 29: 516-519
7. Kolisek FR, McGrath MS, Jessup NM, Monesmith EA, Mont MA (2009) Comparison of outpatient vs. inpatient total knee arthroplasty. Clin Orthop Relat Res 467: 1438-1442
8. Kort NP, Bemelmans YFL, Schotanus MGM (2015) Outpatient surgery for unicompartmental knee arthroplasty is effective and safe. Knee Surg Sports Traumatol Arthrosc. [Ahead of Print]
9. Aynardi M, Post Z, Ong A, Orozco F, Sukin DC (2014) Outpatient surgery as a means of cost reduction in total hip arthroplasty: a case control study. HSS J 10: 252-255
10. Bertin KC (2005) Minimally invasive outpatient total hip arthroplasty: a financial analysis. Clin Orthop Relat Res 435:154-163
11. Larsen K, Hansen TB, Søballe K, Kehlet H (2012) Patient-reported outcome after fast-track knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 20: 1128-1135
12. Hoorntje A, Koenraadt KL, Boevé MB, van Geenen RC (2017) Outpatient unicompartmental knee arthroplasty: who is afraid of outpatient surgery? Knee Surg Sports Traumatol Arthrosc 25: 759-766
13. Schotanus MG, Bemelmans YF, Grimm B, Heyligers IC, Kort NP (2016) Physical activity after outpatient surgery and enhanced recovery for total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. [Ahead of Print]
14. Schotanus MG, Bemelmans YF, van der Kuy PH, Jansen J, Kort NP (2015) No advantage of adrenaline in the local infiltration analgesia mixture during total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. [Ahead of Print]
15. Brooks R (1996) EuroQol: the current state of play. Health Policy 37:53-72
16. Haverkamp D, Breugem SJ, Sierevelt IN, Blankevoort L, van Dijk CN (2005) Translation and validation of the Dutch version of the Oxford 12-item knee questionnaire for knee arthroplasty. Acta Orthop 76: 347-352
17. Roorda LD, Jones CA, Waltz M, Lankhorst GJ, Bouter LM, et al. (2004) Satisfactory cross cultural equivalence of the Dutch WOMAC in patients with hip osteoarthritis waiting for arthroplasty. Ann Rheum Dis 63:36-42
18. DeSouza CM, Legedza AT, Sankoh AJ (2009) An overview of practical approaches for handling missing data in clinical trials. J Biopharm Stat 19: 1055-1073
19. Husted H, Hansen HC, Holm G, Bach-Dal C, Rud K, et al. (2006) Accelerated versus conventional hospital stay in total hip and knee arthroplasty III patient satisfaction. Ugeskr Laeger 168: 2148-2151

20. Larsen K, Hvass KE, Hansen TB, Thomsen PB, Søballe K (2008) Effectiveness of accelerated perioperative care and rehabilitation intervention compared to current intervention after hip and knee arthroplasty. A before-after trial of 247 patients with a 3-month followup. BMC Musculoskelet Disord 9: 59
21. Larsen K, Sørensen OG, Hansen TB, Thomsen PB, Søballe K (2008) Accelerated perioperative care and rehabilitation intervention for hip and knee replacement is effective: a randomized clinical trial involving 87 patients with 3 months of follow-up. Acta Orthop 79: 149-159
22. Rolfson O, Malchau H (2015) The use of patient-reported outcomes after routine arthroplasty. Beyond the whys and ifs. Bone Joint J 97: 578-581
23. Giesinger K, Hamilton DF, Jost B, Holzner B, Giesinger JM (2014) Comparative responsiveness of outcome measures for total knee arthroplasty. Osteoarthritis Cartilage 22: 184-189
24. Hossain FS, Konan S, Patel S, Rodriguez-Merchan EC, Haddad FS (2015) The assessment of outcome after total knee arthroplasty: are we there yet? Bone Joint J 97: 3-9
25. Bolink SA, Grimm B, Heyligers IC (2015) Patient-reported outcome measures versus inertial performance-based outcome measures: a prospective study in patients undergoing primary total knee arthroplasty. Knee 22: 618-623
26. Larsen K, Hansen TB, Thomsen PB, Christiansen T, Søballe K (2009) Cost-effectiveness of accelerated perioperative care and rehabilitation after total hip and knee arthroplasty. J Bone Joint Surg Am 91: 761-772
27. Kehlet H, Thienpont E (2013) Fast-track knee arthroplasty-status and future challenges. Knee 20: 29-33

CHAPTER 11

GENERAL DISCUSSION AND VALORISATION

General discussion

Arthroplasty surgeries are globally increasingly performed due to ageing of the population and higher demands of functional capabilities in (working) life [1,2]. Cost-effectiveness and maximum functional recovery after surgery is therefore of increasing importance. To satisfy this higher volume and high-demanding expectations, the outcomes after surgery should ideally be evaluated and adjusted according to most recent literature. The improvement of healthcare is an ongoing process, rather than an one-way optimisation process, which should be initiated by the complete multi-disciplinary team (e.g. orthopaedic surgeon, physiotherapists, anaesthesiologists, hospital pharmacist, nurses, hospital managers, scrub nurses, operation room planners, physician assistants) involved in the orthopaedic care regarding hip and knee arthroplasty. It holds an indispensable role to optimise outcomes after surgery, with a possible reduction of costs of the complete pre-, peri- and postoperative procedure [3]. A combination of an optimised arthroplasty pathway to reduce side-effects and/or (S) AEs, and shortened LOS, will eventually contribute to a sustainable social-economic solution for this increasing demand [4].

The conduction of a perioperative arthroplasty pathway is done by further elaboration of the steps included in this pathway. As presented in part 1, several protocol optimisations led to improvement of patient preoperative information, more adequate perioperative blood management to prevent for blood transfusions, low postoperative amount of urinary retentions with omission of urinary catheters and acceptable pain scores to mobilize patients early after surgery. This step-wise work process is needed to cope with potential setbacks. It is not only the protocol itself which makes an optimisation effective and successful. The ongoing process towards the 'perfect' protocol is of even more importance. To incorporate the protocol in the current work processes, the involvement of all stakeholders is crucial. As, for example, orthopaedic surgeons and anaesthesiologists, need to step over traditions within the care of arthroplasty patients to reduce morbidity, mortality and costs [5]. In this matter, cost reduction is not only based on LOS, but it is also found by the introduction and optimisation of clinical protocols. For example, by implementing TXA, a tremendous decrease in postoperative blood transfusions was found. These transfusions are not only expensive but can potentially increase (S)AEs (e.g. thromboembolic events, infections), which also contribute to higher costs [6,7]. The same results are found after implementation of LIA in knee arthroplasty surgery. It decreased postoperative pain scores and makes it possible for patients to mobilize early after surgery, which improves outcomes and decreases LOS [8-11].

When the fast-track pathway is enrolled as daily clinical practice, a further development of the pathway could lead to outpatient joint arthroplasty (OJA). The ultimate goal of OJA is not the discharge itself on the day of surgery, but rather the ambition towards perfection of the pre-, peri- and postoperative process which leads to the ability to safely discharge patients on the day of surgery, while maintaining or even improving patient satisfaction. During the past decades, OJA pathways are increasingly implemented, with success [12-14]. As most of the papers included the rather healthier and younger patients, the selection process of patients is of crucial importance [15,16]. Valuable information is stated in this thesis regarding the role of patient selection for these OJA pathways. The selection criteria are paramount to prevent for these (S)AEs and thus readmissions. Future research should focus on more precise criteria to extended OJA to daily practice and provide a choice for our patients (fast-track or OJA). These selection criteria are not solely based on medical conditions (or arguments), but also patient's wishes are of (even more) importance. Several studies highlighted the preoperative education towards, for example, discharge on the day of surgery. One of the main reasons for discharge on the day of surgery is fear [17,18,19]. To prevent these delayed discharges, this fear has to be allayed. In first place by providing adequate information before surgery, for the patient as well as their relatives/caregivers. Adequate information on forehand can adjust postoperative expectations [20,21] and create the basics for preoperative preparation of their home-situation.

After surgery, patients should be monitored closely to prevent for (S)AEs and/or readmissions. Future research holds an important role to optimise this monitoring. These days, several steps are already made towards better understanding and optimising the patients' recovery after discharge, laid out in digital solutions (e.g. applications, smart-watches, health-care information systems, tele-rehabilitation) but need further evidence-based support for implementation in daily practice [22,23].

To connect the patients' needs, medical interventions and the in-hospital logistical process, a case manager or project leader should ideally be appointed. It is of paramount importance to appoint a project leader which has substantive knowledge of the arthroplasty operation itself in first place, but more importantly, has insight in the complete patient 'journey' regarding the arthroplasty surgery. A physician assistant (PA), a specially trained healthcare professional (e.g. former physiotherapist, nurse, scrub nurse) who is certified to provide low complex medical services without direct supervision, can fulfil this position [24]. The PA has knowledge and experience with this process and is able to oversee the different stages during the patients' journey. Potentially, it will reduce the surgeon's workload by taking over the work regarding the evidence-based drafting and implementation of the perioperative protocols. As a clinically trained healthcare professional, the PA is able to

consult and debate the content of these protocols and processes with other healthcare professionals (e.g. physicians, nurses, planners, anaesthesiologists, hospital pharmacist, and other medical specialists). Furthermore, a point of contact is necessary as most of the process optimisations are accompanied by contrariety. In case of a setback, or adverse result of an optimisation, a project leader should be contacted to solve the arose problem. The 'plan-do-check-act' (PDCA) circle provides a tool for the basic principles of the optimisation. This optimisation process starts by outlining and analysing the current situation regarding clinical results (e.g. LOS, patient satisfaction, complication and readmission rate). Main reasons for the current (prolonged) LOS should be outlined. For example, statistics on pain scores, number of patients with PONV, early mobilisation success percentages, orthostatic intolerance, wound complications, urinary status etc. must be mapped. An analysis on the logistical process, the pathway from first contact preoperatively to last outpatient visit postoperatively, should be made, in order to streamline patients' journey in-hospital.

A profound analysis on patients' needs and wishes regarding the perioperative process should be done in order to create 'mind-set' towards patient involvement in the perioperative treatment rather than a professional imposed process. In order to draw the 'plan' of optimisation, with its goal to improve the in-hospital process for patients and compromising the risk of peri- and direct postoperative complications. With an adequate 'plan', the elaboration of the current evidence-based protocols should be made and implemented to the pathway itself. Comparing the current protocols with the state-of-the-art in the latest literature. This process is time consuming, in which a PA plays an important role as the connector in a guiding role between the patient and the multidisciplinary health-care professional team, reporting to the orthopaedic surgeon. Contrary evidence statements exist, for example as outlined in chapter 3 several types of administrations, time regimens and dosages can be used for TXA implementation [25-28]. The drafted protocols should be discussed, chosen and approved by all professionals within the team in order to create a supportive base. Without compliance, these optimised protocols are destined to fail, as the effectiveness depends on the practical usage.

When the newly designed protocols are finished and ready to be implemented, the step 'do' takes effect. To create awareness of these novel protocols, communication towards all involved health-care professionals is paramount. Possible options to accomplish this are; (oral) presentations on the workplace with Q and A opportunities, (digital) update of the protocol database, issue a newsletter and/or subject-oriented training courses for several stakeholders (e.g. physiotherapists, nurses, planners), distribute new evidence-base insights and most important, provide evidence on the data extracted from their own patients population (ideally as published results).

An indispensable role is held for the surgeon and PA; they are the representatives of the newly addressed workflow and should be on the ward, operation room, post anaesthetic care unit (PACU) and the outpatient clinic to answers questions and guide colleagues through the implementation process. After the implementation of the newly designed protocols, the evaluation should take place as outlined in this thesis on several topics within the clinical pathway. In first place, results regarding patient's clinical data should be gathered and monitored on those subjects whom delay or negatively influence the patients' journey (e.g. pain experience, PONV, urinary retention, wound complications, early mobilization). Secondly, adequate and repeatedly review of the literature should be done. To adjust the implemented protocols, the multi-disciplinary team should collaborate and provide regular consultation to adjust when deemed appropriate, which includes the final 'act' step of the PDCA circle.

Final remark

By optimising the pre-, peri- and postoperative protocols, clinical pathways for hip and knee arthroplasty successfully resulted in well-established concepts such as fast-track surgery and OJA. With the aims of improving postoperative recovery in terms of lower morbidity and mortality with comparable or even improved PROMs and thus patient satisfaction. These improvements consist of evidence-based treatment modalities which are based on the reduction of surgical stress response and with an additional optimised logistical process. But most important, tailored information to the patient is crucial. Especially when implementing an OJA pathway, patients preoperative planning is of paramount importance. Patients need to know and understand the process to create the correct mind-set for discharge on the day of surgery to their home-environment. Future research strategies should focus on a further evaluation of safety (e.g. (S)AEs, readmission rate) and efficacy (e.g. pain management, blood management, early mobilization, discharge criteria) aspects of OJA, substantiated with evidence-based patient selection criteria with as major goal improving patients healthcare and satisfaction while reducing healthcare costs.

References

1. O'Neill TW, McCabe PS, McBeth J (2018) Update on the epidemiology, risk factors and disease outcomes of osteoarthritis. Best Pract Res Clin Rheumatol. 32(2):312-326
2. Kurtz S, Ong K, Lau E, Mowat F, Halpern M (2007) Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am. 89(4):780-5
3. Vendittoli PA, Pellei K, Desmeules F, Massé V, Loubert C, Lavigne M, Fafard J, Fortier LP (2019) Enhanced recovery short-stay hip and knee joint replacement program improves patients outcomes while reducing hospital costs. Orthop Traumatol Surg Res. 105(7):1237-1243
4. Husted H, Hansen HC, Holm G, Bach-Dal C, Rud K, Andersen KL, Kehlet H (2010) What determines length of stay after total hip and knee arthroplasty? A nationwide study in Denmark. Arch Orthop Trauma Surg. 130(2):263-8
5. Husted H, Gromov K, Malchau H, Freiberg A, Gebuhr P, Troelsen A (2014) Traditions and myths in hip and knee arthroplasty. Acta Orthop. 85(6):548-55
6. Jiang T, Song K, Yao Y, Pan P, Jiang Q (2019) Perioperative allogenic blood transfusion increases the incidence of postoperative deep vein thrombosis in total knee and hip arthroplasty. J Orthop Surg Res. 14(1):235
7. Kim JL, Park JH, Han SB, Cho IY, Jang KM (2017) Allogeneic Blood Transfusion Is a Significant Risk Factor for Surgical-Site Infection Following Total Hip and Knee Arthroplasty: A Meta-Analysis. J Arthroplasty. 32(1):320–325
8. Kerr DR, Kohan L (2008) Local infiltration analgesia: a tech-nique for the control of acute postoperative pain following knee and hip surgery a case study of 325 patients. Acta Orthopaedica 79:174–183
9. Vendittoli PA, Makinen P, Drolet P, Lavigne M, Fallaha M, Guertin MC, Varin F (2006) A multimodal analgesia protocol for total knee arthroplasty. A randomized, controlled study. J Bone Joint Surg Am 88:282–289
10. Andersen LØ, Husted H, Kristensen BB, Otte KS, Gaarn-Larsen L, Kehlet H (2010) Analgesic efficacy of intracapsular and intra-articular local anaesthesia for knee arthroplasty. Anaesthesia 65:904–912
11. Andersen LØ, Husted H, Otte KS, Kristensen BB, Kehlet H (2008) High-volume infiltration analgesia in total knee arthro-plasty: a randomized, double-blind, placebo-controlled trial. Acta Anaesthesiol Scand 52:1331–1335
12. Pollock M, Somerville L, Firth A, Lanting B (2016) Outpatient Total Hip Arthroplasty, Total Knee Arthroplasty, and Unicompartmental Knee Arthroplasty: A Systematic Review of the Literature. JBJS Rev. 4(12):01874474-201612000-00004
13. Hoffmann JD, Kusnezov NA, Dunn JC, Zarkadis NJ, et al. (2018) The Shift to Same-Day Outpatient Joint Arthroplasty: A Systematic Review. J Arthroplasty 33(4):1265-1274
14. Jaibaji M, Volpin A, Haddad FS, Konan S (2020) Is Outpatient Arthroplasty Safe? A Systematic Review. J Arthroplasty http://doi:10.1016/j.arth.2020.02.022
15. Meneghini RM, Ziemba-Davis M, Ishmael MK, Kuzma AL, Caccavallo P (2017) Safe Selection of Outpatient Joint Arthroplasty Patients With Medical Risk Stratification: the "Outpatient Arthroplasty Risk Assessment Score". J Arthroplasty. 32(8):2325-2331
16. Moore MG, Brigati DP, Crijns TJ, Vetter TR, Schultz WR, Bozic KJ. Enhanced Selection of Candidates for Same-Day and Outpatient Total Knee Arthroplasty. J Arthroplasty. 2020 Mar;35(3):628-632
17. Berger RA, Kusuma SK, Sanders SA, Thill ES, Sporer SM (2009) The feasibility and perioperative complications of outpatient knee arthroplasty. Clin Orthop Relat Res 467(6):1443–1449

18. Berger RA, Sanders S, Gerlinger T, Della Valle C, Jacobs JJ, Rosenberg AG (2005) Outpatient total knee arthroplasty with a minimally invasive technique. J Arthroplasty 20:33–38
19. Dorr LD, Thomas DJ, Zhu J, Dastane M, Chao L, Long WT (2010) Outpatient total hip arthroplasty. J Arthroplasty 25(4):501–506
20. Tilbury C, Haanstra TM, Leichtenberg CS, et al. (2016) Unfulfilled expectations after total hip and knee arthroplasty surgery: there is a need for better preoperative patient information and education. J Arthroplasty 31(10): 2139-2145
21. Walker JA (2007) What is the effect of preoperative information on patient satisfaction? Br J Nurs 16(1): 27-32
22. Wang X, Hunter DJ, Vesentini G, Pozzobon D, Ferreira ML (2019) Technology-assisted rehabilitation following total knee or hip replacement for people with osteoarthritis: a systematic review and meta-analysis. BMC Musculoskelet Disord. 20(1):506
23. Berton A, Longo UG, Candela V, Fioravanti S, Giannone L, Arcangeli V, et al. (2020) Virtual Reality, Augmented Reality, Gamification, and Telerehabilitation: Psychological Impact on Orthopedic Patients' Rehabilitation. J Clin Med. 7;9(8):2567
24. van den Brink GTWJ, Kouwen AJ, Hooker RS, Vermeulen H, Laurant MGH (2019) An activity analysis of Dutch hospital-based physician assistants and nurse practitioners. Hum Resour Health. 2019 Oct 29;17(1):78.
25. Fillingham YA, Ramkumar DB, Jevsevar DS, et al. (2018) The Safety of Tranexamic Acid in Total Joint Arthroplasty: A Direct Meta-Analysis. J Arthroplasty. 33(10):3070–3082.e1
26. Fillingham YA, Ramkumar DB, Jevsevar DS, et al. (2018) The Efficacy of Tranexamic Acid in Total Knee Arthroplasty: A Network Meta-Analysis. J Arthroplasty. 33(10):3090–3098.e1
27. Wang N, Xiong X, Xu L, et al. (2019) Transfusions and cost-benefit of oral versus intravenous tranexamic acid in primary total hip arthroplasty: A meta-analysis of randomized controlled trials. Medicine. 98(17):e15279
28. Xiong H, Liu Y, Zeng Y, Wu Y, Shen B (2018) The efficacy and safety of combined administration of intravenous and topical tranexamic acid in primary total knee arthroplasty: a meta-analysis of randomized controlled trials. BMC Musculoskelet Disord. 19(1):321

Valorisation

Scientific innovations in healthcare only apply when the innovation itself is implemented into daily practice. The shift from scientific research towards newly designed clinical protocols used in future practice, holds an indispensable role during the innovation process. Sharing the current knowledge will ultimately increase the supportive base for these innovations. Valorisation is the supply of knowledge for different stakeholders within the clinical pathways, not only consisting of the healthcare staff, but also companies, governments and human society. This chapter attempts to discuss the medical, social and financial value of this thesis.

Globally, rising healthcare costs are one of the most important challenges we face in the upcoming years. In orthopaedic care, especially the rise of hip and knee arthroplasty procedures to be performed on a global scale, demands critical analysis and distribution of healthcare resources. Innovations within the orthopaedic care should therefore not only focus on patient related outcomes (e.g. safety and efficacy) but also on reducing costs to maintain a sustainable and 'financial healthy' healthcare system. Care pathways are essential and play a major role in this challenge. Over the past decades, research has shown that LOS after hip and/or knee arthroplasty can be decreased by implementing an evidence-based clinical pathway. With the introduction of so-called OJA pathways, an even larger reduction is possible, and patients can be discharged on the day of surgery to their home-environment. The main challenge is to maintain the patient's safety during the process of reduction of LOS. For example, when the fast-discharging protocol results in a higher readmission rate, it will lead to an opposite effect and thereby the number of (S)AEs and costs will only be higher.

Besides the potential financial positive side-effects, the needs and wishes for patients to recover in their own environment could be encountered. In future, the organisation of postoperative care after arthroplasty surgery following an OJA pathway needs to be further developed. Adaptation of the patients' needs and wishes are of primary importance to ensure that patients experience outpatient joint arthroplasty as an added value. The implementation of OJA should meet the need and expectations of patients. The role of the patient, in close contact with their relatives and/or caregivers, should be put first in the implementation process. For some patients, rapid discharge is desirable. The transition of hospital care to home could increase patient satisfaction. Whereas other patients feel safer in the hospital after surgery and require several days in the hospital. The differences between patients must be weighed in the decision for short (outpatient) or regular (several

days) hospital stay. Ideally, patients who are operated, decide after the operation, in close consultation with the ward doctor (personified by a physician assistant for example) and/or operating surgeon, when to leave the hospital according to preoperatively instructed discharge criteria.

Future research should focus on a thorough clinical pathway for fast-track and outpatient hip and knee arthroplasty. By examining the different entities within these clinical pathways, a further improvement in the outcomes after surgery can be achieved. In particular precise patient selection criteria will provide an evidence-based foundation for implementation of these clinical pathways to daily practice. More insights in the postoperative experiences and needs for care should be gathered. These new insights, directly after discharge, will lead to a more patients' tailored care. To streamline this ongoing process and evidence-based discussion, peer collaboration between all the involved health-care professionals, led by a project manager (e.g. physician assistant), is of paramount importance.

CHAPTER 12

SUMMARY, NEDERLANDSE SAMENVATTING

Summary

On a global scale, hip and knee arthroplasty surgeries as treatment for end-stage osteoarthritis are increasingly performed, making these operations one of the most performed and successful orthopaedic surgeries. Improvement of outcomes after these surgeries is not solely based on the surgical procedure itself. In the past decades, the introduction of so-called clinical pathways improved postoperative outcomes in terms of safety and efficacy. Making it nowadays possible to discharge patients faster (within 2 days), and in selected populations even on the day of surgery. A clinical pathway consists of a combination of pre-, peri- and postoperative protocols, which form the patients' process (or journey) throughout their surgical procedure. Ideally, these protocols are the result of a multi-disciplinary approach (e.g. orthopaedic surgeon, physiotherapists, anaesthesiologists, hospital pharmacist, nurses, hospital managers, scrub nurses, operation room planners, physician assistants) and is completely based on the latest scientific evidence. This thesis examined several crucial components of these enhanced recovery pathways in the first place and adds new insights in outpatient joint arthroplasty pathways.

Part one start with addressing and examination of several keystones in the formation of an enhanced recovery pathway for hip and knee arthroplasty.

As preoperative information influences postoperative outcomes (in terms of satisfaction, by addressing expectations), type and form of provided information is paramount. In **chapter 2** the patients' experiences on the usage of an information brochure handed out to knee arthroplasty patients were investigated. Within this brief qualitative study, patients reported to be satisfied with the provided information brochure, making this an adequate method to prepare patients for surgery. Although patients reported no need for digital forms of information (e.g. websites, applications), the debate on these types of information sources will continue in future due to the digitization within society.

After hip and knee arthroplasty, the need for postoperative blood transfusions rise up to 20%. The potential side effects of blood transfusions and the increased risks of complications after these transfusions (e.g. postoperative joint infection) make it undesirable. The introduction of tranexamic acid (TXA) reduced these numbers significantly. In **chapter 3** the current TXA protocol (combining oral and intravenous administration) was retrospectively examined by investigating the transfusion rates in a large cohort of 5205 hip and knee arthroplasty patients. Only 0.9% of the patients received perioperative allogenic blood transfusions. Several clinical factors (e.g. age, body-mass index, American Society of Anaesthesiologists score, duration of surgery,

type of arthroplasty, estimated blood loss, perioperative Hb levels and length of stay) were statistically significant different between transfused and non-transfused patients. The incidence of thromboembolic adverse events (e.g. deep vein thrombosis/lung embolism) was acceptable low.

One of the major issues for prolonged hospital stay and/or delayed mobilization is severe postoperative pain. Multi-modal pain modalities are conducted to control postoperative pain which makes the patient able to mobilize hours after surgery, reduce (opioid) pain medication and thereby effectuate early discharge. The introduction of local infiltration analgesia (LIA) in knee arthroplasty is the most considerable contributor to adequate pain control after surgery. Several methods are described, with variety of analgesics used in the mixture of LIA. **Chapter 4** examined, via a randomized controlled trial, the effect of adrenaline in the LIA mixture. The postoperative pain scores and opioid consumption did not differ between patients who received LIA with or without adrenaline. To prevent for possible adrenaline-related side effects and maintaining the analgesic effect, omission of adrenaline from the LIA mixture is eligible.

Postoperative urinary retention (POUR) is a challenging condition after hip and knee arthroplasty surgery. It requires preventive measures, adequate monitoring and precise treatment if it does occur. **Chapter 5** presents the results of a retrospective investigation of 803 patients, which showed 12.9% incidence of POUR after implementation of a nurse-led bladder scan protocol. Patients characteristics and bladder volumes at different time-point throughout the surgical process (pre-, peri- and postoperative) were analysed, showing >200ml of bladder volume directly after surgery as a risk factor for POUR.

Part two continues with safety and efficacy evaluations of outpatient joint arthroplasty (OJA).

When introducing newly designed methods and treatment protocols, a pilot or case-controlled study can be conducted. **Chapter 6** presents results of the first consecutive patients undergoing unicompartmental knee arthroplasty in an outpatient pathway. The outcomes, regarding safety (e.g. (serious) adverse events, readmissions) and efficacy (e.g. postoperative pain scores, postoperative nausea and vomiting (PONV), successful discharge on day of surgery) were compared with patients following the standard inpatient pathway. Postoperative pain was the most common reason for prolonged hospital stay for patients in the outpatient pathway group. Nevertheless, 85% of the patients went home on the day of surgery. Regarding efficacy, no significant differences were found for postoperative pain scores, numbers of patients with PONV and opiate usage during the first 2 days. Regarding safety, no differences were found

between outpatient and inpatients patients in terms of (serious) adverse events and/or readmission. Patient reported outcome measures (PROMs) improved equally between both groups.

With the increased application of OJA pathways globally, evidence is growing. **Chapter 7** shows the results of a systematic review with meta-analysis on studies comparing OJA with standard inpatient pathways in terms of safety and efficacy (e.g. (S)AEs, readmissions, successful same day discharge rates, PROMs and costs). A total of 41 studies met the inclusion criteria and were methodologically assessed. In general, patients who followed the outpatients pathway were younger, had a lower BMI and ASA class when compared with patients who followed the inpatient pathway. No statistically significant differences between outpatients and inpatients were found regarding the overall complication and readmission rates, and improvement in PROMs. OJA resulted in an average cost reduction of $6.797,02. Therefore, OJA pathways are as safe and effective as inpatient pathways in selected populations, with a potential reduction of costs. Considerable risk of bias in the majority of studies was found and should be taken into account.

As outlined in the above-mentioned chapter, current literature mostly exists of papers including a selected group of patients for OJA pathways. In general, the younger and healthier patients are selected, since it is considered to be safer when starting with these OJA pathways. Adequate selection of patients for OJA is important to prevent for (serious) adverse events and readmissions. **Chapter 8** reviewed the literature on these patient selection criteria and additional expert opinion-based selection criteria were established by interviewing different medical specialists. The described evidence-based patient selection criteria, supplemented with expert opinions, provide a basis for outpatient joint arthroplasty and can be useful when selecting patients.

After discharge, patients need to be physical active to prevent for complications (e.g. thrombo-embolic events) and to start the rehabilitation process. **Chapter 9** examined patients' physical activity during the first 6 weeks postoperative, comparing OJA with inpatient TKA surgery. Data was obtained with usage of an activity monitor. The activity parameters recovered steeply during the first 4 postoperative days and continued to improve within both pathways. No differences were found between both pathways regarding physical activity, both cohorts of patients did not reach preoperative levels at 5 weeks postoperative. This study demonstrates that the early physical activity parameters of patients after TKA recover independently of the clinical pathway (inpatient vs. outpatient) they were treated in.

The further development and usage of OJA pathways can only be justified if it doesn't lead to increased complications and readmissions, which has been outlined in the previous chapters, but also maintains PROMs after surgery. **Chapter 10** examined the PROMs after knee arthroplasty surgery between in- and outpatients by assessing health-related quality of life (EuroQol-5D) and functional outcome (Oxford Knee Score, Western Ontario and McMaster Universities Arthritis Index and the Pain-Numerical Rating Scale). A total of 361 consecutive patients undergoing knee arthroplasty (total and partial) who followed either the OJA pathway (n=94; 26.1%) or standard inpatient pathway (n=267; 73.9%) were analysed preoperative, and at 3 and 12-months follow up. At one year postoperative, patients in both pathways improved equally, which confirms that type of pathway does not influence PROMs, regarding quality of life or functional outcome, after knee arthroplasty surgery.

In conclusion, this thesis provides several pre-, peri-, and postoperative protocols, which optimise current treatment strategies in hip and knee arthroplasty patients, elaborated in two parts describing fast-track and OJA protocols.

Recommendation for future research

- High-quality trials (including randomized-controlled trials) comparing fast-track surgery with OJA.
- In-depth analysis and drafting of precise patient selection criteria for roll out OJA pathways to general orthopaedic practice in hip and knee arthroplasty surgery.
- Exploring the patients experience, perspective and recommendations for OJA pathways.
- Examination of the exact (non-)cost-effectiveness of OJA pathways.

Nederlandse samenvatting

Als behandeling van eindstadium artrose, zal de vraag naar heup- en kniegewricht vervangende chirurgie de komende jaren wereldwijd stijgen. De uitkomst van deze behandeling is niet alleen gebaseerd op de operatie zelf, maar vooral ook op het gehele zorgproces rondom deze operatie. Dit zorgproces wordt beschreven in klinische zorgpaden en hebben de laatste jaren toenemende aandacht gekregen. Een klinisch zorgpad bestaat uit een aaneenschakeling van, op aangetoonde en wetenschappelijk bewezen, pre-, peri- en postoperatieve protocollen. Idealiter zijn deze protocollen het resultaat van een multidisciplinaire samenwerking, waarvan de invulling wordt vormgegeven door o.a. de orthopedisch chirurg, fysiotherapeut, anesthesioloog, verpleegkundige, managers, operatieassistenten, planners en physician assistant. Door het optimaliseren van deze zorgpaden, verbeteren de klinische uitkomstmaten in termen van ziekenhuis opnameduur, postoperatieve pijnbeleving, vroegtijdige mobilisatie, reductie van complicaties en heropnames (fast-track surgery). Als gevolg van deze optimalisaties, is het voor vooraf geselcteerde patiënten zelfs mogelijk om in dagbehandeling geopereerd te worden (outpatient joint arthroplasty). In dit proefschrift worden verschillende specifieke onderdelen van deze klinische zorgpaden voor heup- en knieprotheses onderzocht, met een verdere verdieping naar dagbehandeling.

In ***Deel 1*** van dit proefschrift worden de verschillende optimalisatiestappen van een fast-track surgery zorgpad uiteengezet.

Het preoperatief correct informeren van patiënten zorgt voor een hogere patiënt tevredenheid. Dit maakt dat de manier waarop dit gebeurt essentieel. In **hoofdstuk 2** worden de resultaten weergegeven van een kwalitatieve studie naar de patiëntervaringen met het gebruik van een brochure over de knieprothese operatie. Patiënten geven aan dat het gebruik van deze brochure aan te raden is en dat zij naar tevredenheid zijn voorgelicht. Er werden enkele punten van optimalisatie genoemd (o.a. vorm, weergave). Ondanks dat patiënten in deze studie geen behoefte rapporteerde aan digitale vormen van informatie (o.a. apps, websites), blijft dit naar de toekomst toe een punt van discussie gezien de digitalisering van onze samenleving en steeds jongere populatie knieprothese patiënten.

Eén van de grootste uitdagingen tijdens een heup- of knieprothese operatie, is het beperken van bloedverlies en daarmee postoperatieve bloedtransfusies. De potentiele bijwerkingen van bloedtransfusies kunnen ingrijpend zijn (o.a. transfusiereactie, verhoogde kans op een postoperatieve wondinfectie). Door de introductie van tranexaminezuur zien wij een forse reductie in het aantal bloedtransfusies na de

operatie. In **hoofdstuk 3** worden de resultaten weergegeven van een perioperatief tranexaminezuur protocol voor heup- en knieprothese operaties. In een cohort van 5205 patiënten, welke preoperatief (oraal) en perioperatief (intraveneus) tranexaminezuur kregen toegediend, werd een bloedtransfusie percentage van 0.9% gevonden, afgezet tegen een transfusie percentage die in de huidige literatuur zelfs oploopt tot 20%. Verschillende klinische factoren waren statistisch significant verschillend tussen getransfundeerde en niet-getransfundeerde patiënten (o.a. leeftijd, body-mass index, American Society of Anaesthesiologists score, duur van de operatie, type prothese, geschat bloedverlies, perioperatieve hemoglobinegehalte en ligduur). Er werd een lage incidentie van trombo-embolische events (o.a. diep veneuze trombose/longembolie) gezien.

Een van de meest gerapporteerde redenen voor een verlengde ziekenhuis opname, is postoperatieve pijn. Protocollen waarin het gebruik van opiaten beperkt wordt, zijn opgesteld om postoperatieve pijn te verminderen zonder de nadelige bijwerkingen van opioïden (o.a. PONV). Dit maakt mede een vroegtijdige mobilisatie na de operatie mogelijk en bespoedigt het ontslag. Lokale infiltratie anesthesie (LIA) in knieprothese chirurgie is een van de meest effectieve methoden om direct postoperatieve pijn te verminderen. Verschillende methodieken zijn beschreven met een verscheidenheid aan analgetica in de injectievloeistof. **Hoofdstuk 4** presenteert de resultaten van een gerandomiseerde klinische trial over het effect van adrenaline in deze injectievloeistof. Er werden twee groepen vergeleken (ropivacaïne met en zonder toevoeging van adrenaline). De postoperatieve pijn scores waren niet verschillend tussen beide groepen, evenals het postoperatieve gebruik van opiaten. Concluderend kunnen we zeggen dat adrenaline niet bijdraagd aan de effectiviteit van LIA met ropivacaïne bij knieprotheses, en dus niet toegevoegd hoeft te worden aan de LIA injectievloeistof.

Postoperatieve urineretentie is een veelvoorkomende complicatie na een heup- of knieprothese operatie. Een bladder scan protocol zorgt voor een adequate monitoring van urine volume en, in geval van urineretentie, vroegtijdige behandeling. **Hoofdstuk 5** beschrijft een retrospectieve studie waarbij de resultaten van de implementatie van een bladder scan protocol, in een cohort van 803 heup- of knieprothese patiënten. Een lage incidentie (12.9%) van urineretenties werd gevonden in deze populatie. Verschillende patiënt karakteristieken werden geanalyseerd. Patiënten met een blaasvolume van meer dan 200ml direct na de operatie zijn 'at risk' voor de ontwikkeling van postoperatieve urineretentie.

Deel 2 van dit proefschrift richt zich op de verdere uitwerking van dagbehandeling voor heup- en knieprothese operaties, waarbij de focus ligt op veiligheid en effectiviteit.

Hoofdstuk 6 presenteert de resultaten van de eerste patiënten die een hemiknieprothese operatie hebben ondergaan in een dagbehandeling zorgpad. Uitkomsten betreffende veiligheid (o.a. complicaties, heropnames) en effectiviteit (o.a. pijnscores, aantal patiënten ontslagen op dag van operatie) werden vergeleken met patiënten behandeld met het standaard zorgpad (enkele dagen opname). 85% van de in opzet dagbehandeling patiënten ging daadwerkelijk op de dag van de operatie naar huis. Postoperatieve pijn was de meest gerapporteerde reden voor falen van dagbehandeling. Er werden geen statistisch significante verschillen gevonden tussen beide groepen patiënten in veiligheid en effectiviteit.

Wereldwijd is er een groei van het aantal patiënten dat een heup- of knieprothese operatie ondergaat in dagbehandeling. **Hoofdstuk 7** toont de resultaten van een systematische review en meta-analysis over dagbehandeling voor heup- en knieprothese welke vergeleken worden met de standaard fast-track zorgpaden. Als uitkomstmaten werd gekeken naar veiligheid en effectiviteit (o.a. complicatie risico, heropnames, succes percentage ontslag op dag van operatie, PROMs en kosten). In totaal werden 41 studies methodologisch beoordeeld en meegenomen in de analyse. Er werd een laag tot gemiddeld bias risico gevonden, waarbij het grootste deel van de studies retrospectief van aard zijn. Over het algemeen wordt gezien dat de patiëntenpopulatie die in dagbehandeling een heup- of knieprothese operatie ondergaat jonger is met een lagere ASA score en BMI. Over het algemeen werden er geen statistisch significante verschillen gevonden voor het aantal complicaties, heropnames en PROMs. Voor patienten die een heupprothese in dagbheandeling kregen, werden minder complicaties gerapporteerd. Dagbehandeling resulteerde in een gemiddelde kostenreductie van $6.797,02. Het lijkt erop dat dagbehandeling, voor een selecte groep patiënten, veilig en effectief is met behoud van patiënt tevredenheid met een mogelijke kostenbesparing.

Zoals in het vorige hoofdstuk beschreven, is het toepassen van dagbehandeling voornamelijk onderzocht in selectieve patiëntengroepen van vooral jongere en gezondere patiënten als onderzoekpopulatie. Ter preventie van complicaties en heropnames is het van cruciaal belang om criteria te hanteren waarop patiënten geselecteerd worden. **Hoofdstuk 8** presenteert de resultaten van een literatuurstudie en expert opinie naar selectie criteria voor dagbehandeling heup- en knieprothese operaties. Verschillende selectie criteria werden beschreven, aangevuld met meningen van verschillende medisch specialisten. Deze criteria vormen de basis voor verder onderzoek en de implementatie van dagbehandeling voor heup- en knieprothesiologie.

Om complicaties te voorkomen is het van belang dat patiënten na de operatie fysiek actief zijn. **Hoofdstuk 9** geeft de resultaten weer van een vergelijkende studie naar fysieke activiteit tussen patiënten die in dagbehandeling een knieprothese kregen, vergeleken met patiënten in het standaard fast-track zorgpad. Data werden verzameld

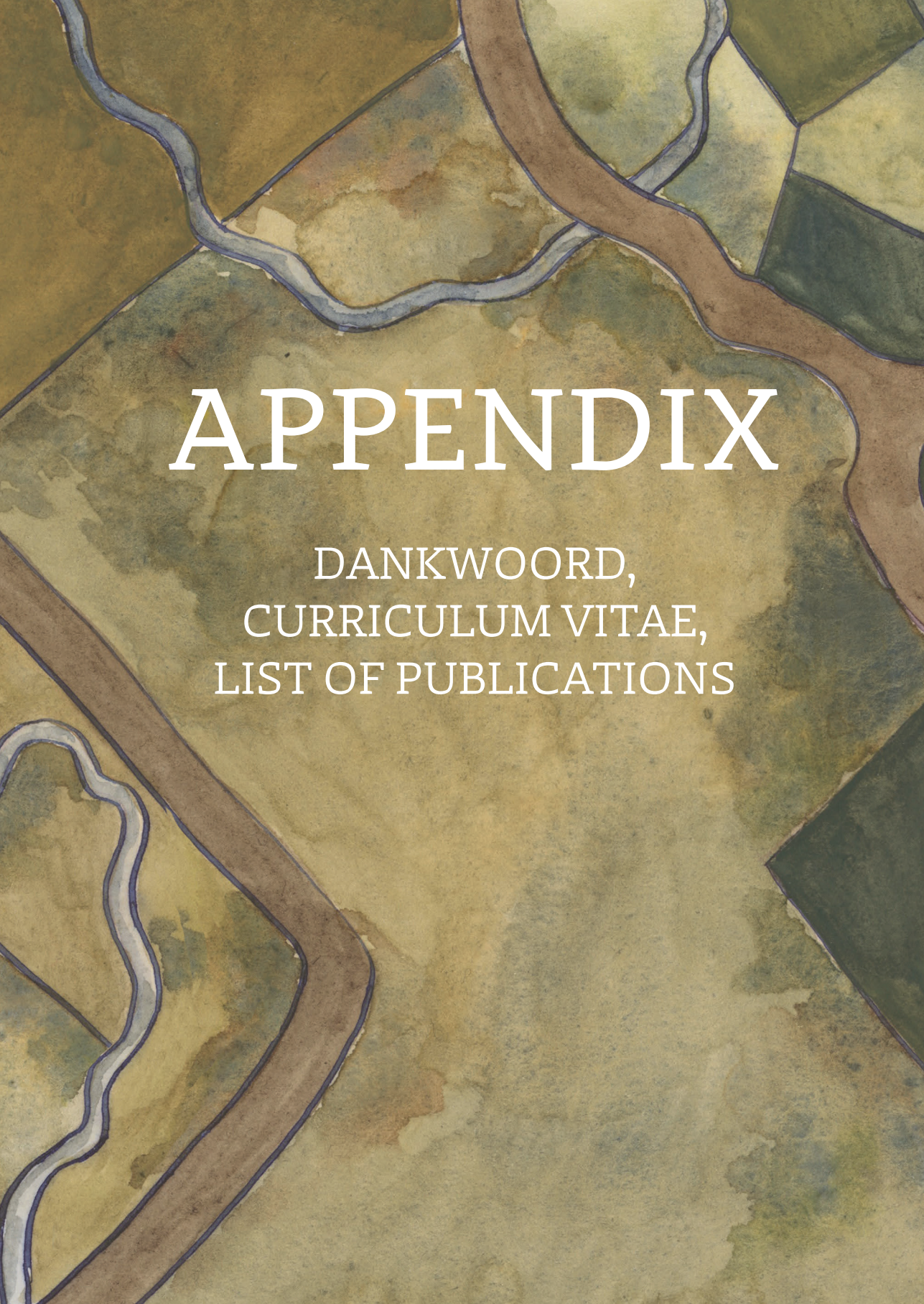
middels een activity monitor. Er werden geen statistisch significante verschillen gezien in fysieke activiteit tussen dagbehandeling en fast-track patiënten. Beide cohorten haalde na 6 weken niet het fysieke activiteitniveau van voor de operatie. Deze studie laat daarmee zien dat fysieke activiteit in de direct postoperatieve fase na een knieprothese vergelijkbaar is tussen dagbehandeling en fast-track patiënten.

De verdere ontwikkeling en inzet van dagbehandeling voor heup- en knieprothesiologie kan alleen worden gerechtvaardigd wanneer dit niet leidt tot een toename van complicaties, heropnames of een invloed heeft op patiënt tevredenheid. In **hoofdstuk 10** wordt de invloed van dagbehandeling op patiënt gerapporteerde uitkomsten (PROMs) vergeleken met een standaard fast-track zorgpad bij knieprothese patiënten. Kwaliteit van leven en functionele uitkomsten werden vergeleken door middel van vragenlijsten (EuroQol-5D, Oxford Knee Score, Western Ontario and McMaster Universities Arthritis Index and the Pain-Numerical Rating Scale). In totaal werd de data van 361 patiënten (n=94 dagbehandeling, 26.1%) geanalyseerd voor en op twee momenten na de operatie (3 en 12 maanden postoperatief). De verbetering van kwaliteit van leven en functionele uitkomstmaten waren gelijk tussen dagbehandeling en fast-track patiënten en laat daarmee zien dat het type zorgpad de PROMs na de operatie niet beïnvloedt.

Concluderend wordt in dit proefschrift een overzicht gegeven van de pre-, peri- en postoperatieve protocollen die de basis kunnen vormen voor fast-track zorgpaden. Daarnaast worden er diverse studies gepresenteerd over de doorontwikkeling naar dagbehandeling voor heup- en knieprotheses en de veiligheid en effectiviteit hiervan.

Aanbevelingen voor toekomstig wetenschappelijk onderzoek

- Kwalitatief hoge klinische trials die fast-track zorgpaden vergelijken met dagbehandeling, met als doel meer inzicht te krijgen in de veiligheid en effectiviteit van dagbehandeling.
- Verdere ontwikkelingen en diepgaand onderzoek naar de selectiecriteria voor dagbehandeling, met als doel het reduceren van complicaties en heropnames, en daarbij waarborgen van de patiënt tevredenheid.
- Analyseren van patiënt ervaringen, perspectieven en aanbevelingen voor dagbehandeling, met als doel het verder door ontwikkelen van het zorgpad vanuit patiënt perspectief.
- Economische analyse naar inzet van dagbehandeling binnen de Nederlandse gezondheidszorg.



APPENDIX

DANKWOORD, CURRICULUM VITAE, LIST OF PUBLICATIONS

APPENDIX

DANKWOORD

Dankwoord

Het doen van wetenschappelijk onderzoek is teamwork en een proefschrift ontstaat niet zonder hulp van anderen. Daarom wil ik iedereen bedanken die geholpen heeft in de totstandkoming van dit proefschrift en een aantal in het bijzonder;

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APPENDIX

CURRICULUM VITAE

Curriculum Vitae

Yoeri Bemelmans was born on the 21st of March 1990 in Geleen, the Netherlands as the second son in a family of 3 children. After graduation from higher general secondary school in 2007, he studied Fysiotherapie at Hogeschool Zuyd in Heerlen, the Netherlands. After graduation in 2011, he worked several years as a physiotherapist in primary care, nursing homes and hospital setting respectively. During this work experience, he became more interested in orthopaedic surgery and traumatology. In 2013, he became resident physician assistant at the department of orthopaedic surgery and traumatology of the Orbis Medical Centre. During these years of training and after graduation in 2017 at the HAN in Nijmegen, the Netherlands, he increasingly performed scientific research. In the autumn of 2019, the foundation of this PhD thesis was laid. Currently he works as physician assistant in orthopaedic surgery and traumatology at the Zuyderland Medical Centre, Sittard-Geleen and Heerlen, the Netherlands. Together with his beloved Vanity, daughter Sophie (2017) and son Oliver (2020) he lives at Hommerich (Gulpen, the Netherlands).

APPENDIX

LIST OF PUBLICATIONS

List of publications

1. Schotanus MGM, **Bemelmans YFL**, van der Kuy PH, Jansen J, Kort NP (2017) No advantage of adrenaline in the local infiltration analgesia mixture during total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 25(9):2778-2783.
2. Kort NP, **Bemelmans YFL**, Schotanus MGM (2017) Outpatient surgery for unicompartmental knee arthroplasty is effective and safe. Knee Surg Sports Traumatol Arthrosc. 25(9):2659-2667.
3. Schotanus MGM, **Bemelmans YFL**, Grimm B, Heyligers IC, Kort NP (2017) Physical activity after outpatient surgery and enhanced recovery for total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 25(11):3366-3371.
4. Kort NP, **Bemelmans YFL**, van der Kuy PH, Jansen J, Schotanus MGM (2017) Patient selection criteria for outpatient joint arthroplasty. Clinical review. Knee Surg Sports Traumatol Arthrosc. 25(9):2668-2675.
5. Schotanus MGM, **Bemelmans YFL**, Kort NP (2017) Quality of life after total knee arthroplasty; inpatient vs. outpatient. Journal of Clinical Trials. 7:327.
6. Kort NP, **Bemelmans YFL**, Schotanus MGM (2018) Low incidence of postoperative urinary retention after implementation of a nurse-led bladder scan protocol. Eur J Orthop Surg Traumatol. 28(2):283-289.
7. Thijs E, Schotanus MGM, **Bemelmans YFL**, Kort NP (2019) Reduced opiate use after total knee arthroplasty using computer-assisted cryotherapy. Knee Surg Sports Traumatol Arthrosc. 27(4):1204-1212.
8. **Bemelmans YFL**, Heitink MV, Hendrickx RPM (2020) Diagnose in beeld: Een man met blaren na een knieprothese. Nederlands Tijdschrift voor Geneekunde. 164:D4876.
9. Keulen MHF, Asselberghs S, **Bemelmans YFL**, Hendrickx RPM, Schotanus MGM, Boonen B (2020) Reasons for unsuccessful same-day discharge following outpatient hip and knee arthroplasty: five and a half years' experience from a single institution. Journal of Arthroplasty. 35(9):2327-2334.e1.
10. **Bemelmans YFL**, van Haaren EH, Hendrickx RPM, Boonen B, Schotanus MGM (2021) Low blood transfusion rate after implementation of tranexamic acid for fast-track hip- and knee arthroplasty. Acta Orthopaedica Belgica. 87, 9-16.
11. **Bemelmans YFL**, Keulen MHF, Heymans M, van Haaren EH, Boonen B, van Rhijn LW, Schotanus MGM (2021) Safety and efficacy of outpatient hip and knee arthroplasty. A systematic review with meta-analysis. Archives of Orthopaedic and Trauma Surgery. doi: 10.1007/s00402-021-03811-5. Online ahead of print.

12. **Bemelmans YFL**, Heijkens B, Kleynen M, van Haaren EH, Schotanus MGM (2020) Patients' experiences on information brochure in knee arthroplasty. A brief qualitative study. International Journal of Orthopaedic and Trauma Nursing. 100836.
13. Kalaai S, **Bemelmans YFL**, Scholtes M, Boonen B, van Haaren EH, Schotanus MGM (2021) A short-term radiological and clinical comparison between the bi-cruciate and cruciate retaining total knee arthroplasty. A retrospective case-controlled study. Journal of Clinical Orthopaedics and Trauma. 18:144-149.