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Early morbidity after simultaneous and staged bilateral total knee arthroplasty

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Abstract
Purpose The aim of this nationwide study was to investigate the early morbidity after bilateral simultaneous and staged total knee arthroplasty (TKA) in order to clarify potential benefits of a well-established fast-track regime.
Methods The Danish National Patient Registry was searched for all bilateral simultaneous and staged TKA procedures from 2010 to 2011. The staged procedures were defined as two separate procedures done within 0–6 months or within 7–18 months.
Results A total of 157 patients had bilateral simultaneous TKA, 346 patients had bilateral staged TKA within 0–6 months and 292 patients had bilateral staged TKA within 7–18 months. The median length of stay in hospital (LOS) was 4 days (interquartile range, IQR: 3) after bilateral simultaneous TKA versus cumulated LOS of 6 days (IQR: 3) in both of the bilateral staged groups ($p < 0.001$). There were no deaths after bilateral simultaneous TKA versus three deaths (0.9 and 1.0 %) in each of the bilateral staged groups within 90 days of surgery (n.s.). The total readmission rate within 30 days of surgery was lower after bilateral simultaneous TKA (7 %, CI 4.0–12.0) and bilateral staged TKA within 0–6 months (9 %, CI 6.4–12.4) compared with 14 % (CI 11.5–20.1) after bilateral staged TKA within 7–18 months.
Conclusions The results from this nationwide study indicate that bilateral simultaneous TKA can safely be performed in a fast-track set-up.
Level of evidence Therapeutic study, Level III.

Keywords Bilateral · Total knee arthroplasty · Simultaneous · Staged · Fast-track · Morbidity · Nationwide · Mortality

Introduction

A substantial proportion of patients with knee osteoarthritis require bilateral total knee arthroplasty (TKA), which is usually done in two stages within months or years of each other. Alternatively, both knee arthroplasties can be performed under one anaesthesia as a bilateral simultaneous TKA. Potential advantages such as reduction in costs, total rehabilitation time and total length of stay in hospital (LOS) have led to an increasing number of bilateral simultaneous procedures [2, 3, 13, 21, 25, 30, 32]. However, a meta-analysis, a Swedish register study and American retrospective register studies found increased mortality [2, 24, 30] and morbidity, with pulmonary embolism and cardiac complications as the major complications, after bilateral simultaneous TKA compared with the bilateral staged TKA [2, 17, 23, 24, 30]. In contrast, results from the New Zealand National Joint Registry and a recent American register study indicated no difference in mortality and complications between simultaneous and staged procedures [1, 3]. Furthermore, a Danish single-centre fast-track study on bilateral simultaneous TKA and two Korean studies found no increase in mortality and

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complications after bilateral simultaneous TKA, when compared with unilateral TKA procedures [7, 12, 29].

Consequently, there are no evidence-based guidelines regarding the optimal choice between one- or two-stage bilateral operations and clinical practise varies between individual surgeons and individual departments. There are few systematic reports on outcome after bilateral simultaneous and staged TKA on a nationwide basis [3, 30], and no previous reports have investigated the two-stage procedures in time intervals. To our knowledge, no previous study has examined the safety aspects of bilateral simultaneous TKA on a nationwide basis with in a well-established fast-track setting despite the favourable outcomes reported after fast-track unilateral TKA as well as after bilateral simultaneous total hip arthroplasty [4, 7, 9, 14, 16, 27]. The aim of this nationwide study was to investigate the early morbidity after bilateral simultaneous and staged total knee arthroplasty (TKA) in order to clarify potential benefits of a well-established fast-track regime [5]. Our hypothesis was that the bilateral simultaneous procedure in selected patients was safe and associated with similar or lower morbidity compared with the bilateral staged procedure, when performed in a fast-track setting.

Materials and methods

The Danish National Patient Registry (DNPR) [15] was searched for all bilateral simultaneous and staged TKA procedures in Denmark from 1 January 2010 to 31 June 2011. A total of 157 patients underwent bilateral simultaneous TKA in 16 departments, 346 patients underwent bilateral staged TKA within 0–6 months in 40 departments and 292 patients underwent bilateral staged TKA within 7–18 months in 34 departments in Denmark. The mean age was 64.0 years (36–82) in the bilateral simultaneous TKA group compared with 66.3 years (42–90) in the bilateral staged TKA (0–6 months) group ($p = 0.002$) and 66.7 (35–88) in the bilateral staged TKA (7–18 months) group ($p = 0.005$).

DNPR registers all hospital admissions (lack of reporting precludes reimbursement) including diagnoses and surgical procedures from any Danish hospital, allowing information on LOS and readmissions within 30 days. Because all hospitals have to report to DNPR to receive diagnosis-related group (DRG) payment, a 100 % follow-up regarding readmissions is possible. However, DNPR registers no information about preoperative morbidity, clinical scores or perioperative details, such as the types of implants or the use of tourniquet. The simultaneous procedure was defined as a bilateral TKA under the same anaesthesia and the bilateral staged procedure as a TKA on each side as two separate procedures—either within 0–6 months or within 7–18 months. We chose this subdivision as we assumed that most patients with bilateral knee osteoarthritis requiring surgery would be scheduled either for a bilateral simultaneous or for a bilateral staged procedure with the second stage done within 6 months. Furthermore, we wanted to investigate how many patients with bilateral knee osteoarthritis waited more than 6 months for the second stage surgery and the outcome of this group. Regarding the bilateral simultaneous TKA, the normal procedure in Denmark is that the same surgeon does both knees sequentially under the same anaesthesia. This could not be investigated or confirmed in the present study as such information is not registered in the DNPR.

LOS was defined as the number of postoperative nights in hospital (including transfer to other departments) until discharge. Readmission rate was defined as total number of readmissions/total number of procedures. The patients' notes were examined thoroughly to ascertain reasons for readmission. Readmission criteria were overnight stay in hospital. The following reasons for readmissions were surgery related: deep venous thrombosis (DVT) and DVT suspicion but not found, pulmonary embolus (PE), possible wound infection (return to the operating theatre, treatment with antibiotics only, no treatment), wound sequelae (including rupture and return to operating theatre and oozing), cardiac problems (including acute myocardial infarction (AMI) and any type of arrhythmia), abdominal complications (including gastric ulcer, constipation, gastritis, ileus, rectal bleeding and melaena), anaemia, erysipelas, pneumonia, urinary tract complications (including urinary tract infection and renal insufficiency), need of rehabilitation (including pain), surgical sequelae (other conditions related to surgery) and medical sequelae (including dehydration, opioid-related side effects and oedema) [9, 14]. Only one readmission (kidney stone) was found obviously unrelated to surgery and excluded. Mortality was obtained through The Central Office of Civil Registration (CPR) based upon all citizens' unique social security number. Patients dying ≤90 days of surgery had their medical files examined to determine cause of death. Death of unknown cause was defined as surgery related in order not to underestimate the mortality rate.

Regarding the 30-day readmission rate and the 90-day mortality rate, there were two follow-up periods after bilateral staged TKA and the rates are accumulated, while there was only 1 follow-up period after bilateral simultaneous TKA.

Eight high-volume departments in this study are dedicated fast-track departments, but the fast-track protocol is widely implemented in Denmark [5]. Fast-track surgery is defined as the synergistic, beneficent effect on convalescence achieved by adding multimodal evidence-based care principles and combining these with optimised logistics.

Fast-track surgery has yielded quicker functional recovery, reduced morbidity, decreased length of convalescence, increased satisfaction and—as a secondary gain—reduced hospital costs [4, 10].

No approval was needed from the Ethics Committee as this was a non-interventional study. Permission was acquired from the Danish Data Protection Agency and the Danish National Board of Health to request medical records in case of readmissions. The study was not registered at Clinical Trials.gov as it is a retrospective quality control study.

Statistical analysis

The data were tested for normal distribution using Q–Q plots and histograms. Medians with interquartile ranges (IQR) were reported for skewed data, means with ranges were reported for normally distributed data, and proportions were expressed as percentages with 95 % confidence intervals (CI). For normally distributed data, overall comparison was performed using one-way ANOVA where differences were found significant pair-wise independent samples *t* test was used. The data that were not normally distributed were compared using Kruskal–Wallis test and where significant differences were found pair-wise two-sample Wilcoxon rank-sum (Mann–Whitney) *U* test was used. Proportions were compared using the Pearson chi-squared test. When comparing related samples Wilcoxon signed-rank test was used for not normally distributed data, and the McNemar test was used for proportions. Statistical analyses were made using SPSS version 20 (IBM Corporation, Armonk, NY). A p value ≤ 0.05 was considered to be statistically significant.

Results

The median total LOS after bilateral simultaneous TKA (4 days) was shorter compared with the cumulated LOS of 6 days in both bilateral staged groups ($p < 0.001$) (Table 1). Readmission rates and detailed lists of 30-day readmissions and reasons across the different surgical subgroups are shown in Tables 1, 2, 3 and 4.

There were no deaths ≤90 days postoperatively after bilateral simultaneous TKA compared with three deaths in both of the bilateral staged groups. One patient died of pneumonia 71 days postoperatively (170 days after the first stage procedure) and 2 patients died of unknown causes in their own homes 15 and 42 days postoperatively (125 and 166 days after the first stage) after bilateral staged TKA within 0–6 months. After bilateral staged TKA within 7–18 months, 1 patient died of pulmonary embolism 4 days postoperatively (267 days after the first stage) and 2 patients died of unknown causes in their own homes 83 and 71 days postoperatively (413 and 337 days after the first stage).

When comparing outcomes after the first and second stage within the bilateral staged TKA (0–6 months) group,

Table 1 Surgical subgroups and related outcome

	Bilateral simultaneous TKA	Bilateral staged TKA within 0–6 months	Bilateral staged TKA within 7–18 months
N	157	346	282
Mean age (SD) (range)	64.0 (8.2) (36–82)	66.3 (9.3) (42–90)	66.7 (9.2) (35–88)
Gender (% female)	52.9	50.0	65.8
Median LOS (IQR)	4 (3)	6 (3)	6 (3)
Mean LOS (range)	4.4 (1–25)	6.8 (2–40)	7.0 (2–51)
30 days readmission rate (%) (*n* and CI)	7.0 (11) (4.0–12.0)	9.0 (31) (6.4–12.4)	14.0 (41) (11.5–20.1)
90 days mortality rate (%) (*n* and CI)	0 (0–2.4)	0.9 (3) (0.3–2.5)	1.0 (3) (0.4–3.2)

Mean age in years

SD standard deviation, *IQR* interquartile range, *LOS* length of stay in days, *CI* 95 % confidence interval, *n* number of readmissions/deaths

Table 2 Readmissions ≤30 days after bilateral simultaneous TKA

Readmissions ≤30 days $n = 11$ (7 %)	Reason for readmission	Comments
Surgically related $n = 5$ (45.5 %)	Infection (3)	All needed reoperation
	Wound complications (2)	Wound oozing (2)
Medically related $n = 6$ (54.5 %)	Abdominal complications (3)	Constipation (2)
		Gastritis (1)
	Urinary retention (1)	
	Pulmonary embolism (1)	
	Rehabilitation, including pain (1)	

Table 3 Readmissions ≤30 days after bilateral staged TKA within 0–6 months

Readmissions ≤30 days $n = 31$ (9 %)	Reason for readmission	Comments
Surgically related $n = 9$ (29.0 %)	Infection (2)	Two treated with oral antibiotics
	Infection suspected, but not found (3)	
	Wound complications (4)	Wound oozing (3)
		Wound rupture and needed revision (1)
Medically related $n = 22$ (71.0 %)	DVT (1)	
	DVT suspected, but not found (9)	
	Cardiac complications (4)	Arrhythmia (3)
		Angina pectoris (1)
	Abdominal complications (2)	Ileus (1)
		Melaena (1)
	Urinary tract infection (1)	
	Rehabilitation, including pain (1)	
	Other medical complications (4)	Opioid-related side effects (1)
		Oedema (1)
		Dehydration (1)
		Erysipelas (1)

DVT deep venous thrombosis

Table 4 Readmissions ≤30 days after bilateral staged TKA within 7–18 months

Readmissions ≤30 days $n = 41$ (14 %)	Reason for readmission	Comments
Surgically related $n = 20$ (48.8 %)	Infection (5)	Reoperated (5)
	Infection suspected, but not found (11)	
	Wound complications (1)	Wound rupture and reoperated (1)
	Other surgical complications (2)	Peroneus nerve palsy (1)
		Infection in the other knee (1)
Medically related $n = 21$ (51.2 %)	DVT (1)	
	DVT suspected, but not found (9)	
	Cardiac complications (2)	Angina pectoris (1)
		Arrhythmia (1)
	Abdominal complications (4)	Constipation (1)
		Gastric ulcer (1)
		Rectal bleeding (1)
	Renal insufficiency (1)	
	Pneumonia (1)	
	Anaemia (1)	
	Rehabilitation, including pain (2)	
	Other medical complications (1)	Dehydration (1)

DVT deep venous thrombosis

we found the same median LOS of 3 days and the 30-day readmission rate was 5.2 % after the first stage compared with 4.0 % after the second stage (n.s.). Within the bilateral staged TKA (7–18 months) group, the median LOS was also 3 days after the first and second stage and the 30-day readmission rate was 7.9 % after the first stage compared with 5.8 % after the second stage (n.s.).

A histogram showing the overall time course between the staged procedures is shown in Fig. 1. The mean time interval between surgeries was 117.5 days (range 17–180) in the bilateral staged TKA (0–6 months) group and 281.0 days (range 181–491) in the bilateral staged TKA (6–18 months) group.

Discussion

The most important findings in this nationwide descriptive study are the low complication rate (≤30 days readmission rate 7 %) after the bilateral simultaneous TKA, and the fact

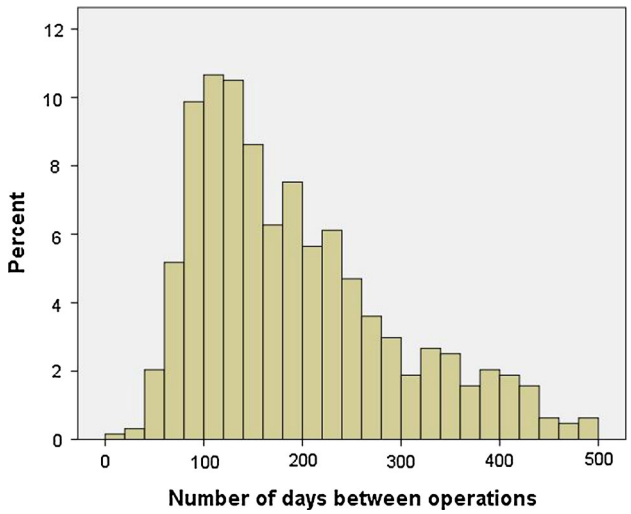

Fig. 1 Histogram showing the overall time course between the bilateral staged TKA procedures

that no patient died ≤90 days postoperatively in this group. Similar promising low mortality- and complication rates after bilateral simultaneous TKA were found in a Danish single-centre fast-track study [7] and in two Korean retrospective studies [12, 29]. However, most previous studies found increased in-hospital mortality or/and increased number of complications after bilateral simultaneous TKA compared with a staged bilateral procedure [2, 17, 23, 24, 30], but the perioperative care programme in these studies may not have been adjusted to the fast-track methodology, which otherwise may reduce LOS as well as morbidity and mortality [10, 16, 27].

The 90-day mortality rates of 0.9 and 1.0 % after bilateral staged TKA in this study were higher than the average 90-day mortality rate of 0.4 % after unilateral TKA in Denmark [9, 31]. The explanation hereto may be that the healthiest patients with bilateral osteoarthritis are selected for a simultaneous procedure, while the remaining patients are offered the staged procedure. Consequently, the average preoperative general health condition among the patients in the bilateral staged groups might be worse than among patients undergoing bilateral simultaneous or unilateral procedures. Unfortunately, we do not have specific information on preoperative morbidity in our study but the question is whether the fast-track set-up per se may reduce morbidity even in high-risk patients [4, 9, 10, 14, 16, 27]. Memtsoudis et al. [20] also found higher complication rates after the bilateral staged procedure compared with bilateral simultaneous and unilateral procedures, but they only state in-hospital complications and in-hospital mortality.

In this study, the median LOS was 4 days after bilateral simultaneous TKA and the cumulative total LOS after bilateral staged TKA was 6 days, where the LOS includes transfer to other hospital departments. In contrast to the American register studies [2, 13, 17, 20, 21], patients are discharged to their own homes and not to rehabilitation units after surgery in Denmark. Our findings on the LOS are comparable to recent fast-track studies on both unilateral and bilateral TKA as well as bilateral THA and show that a fast-track protocol is widely adhered to in Denmark [7, 9, 14, 16].

Readmissions were found using the Danish National Patient Registry (DNPR) which allows a complete postoperative registration of complications with a 30-day follow-up. We provided detailed analyses of surgical versus medical readmissions in order to define future strategies for improvement of care after bilateral simultaneous and staged TKA [9, 11]. The major reasons for readmission were suspicion of infection or DVT, but none were verified during the readmission. This suggests that the future focus should be on patient information at discharge and extended follow-up in the outpatient clinic. The cumulative readmission rate after bilateral staged TKA within 7–18 months of 14 % was higher than after bilateral staged TKA within 0–6 months (9 %). However, this was mainly due to a higher number of readmissions due to unverified suspicion of infection (3.7 vs. 0.9 %). This type of readmission may be influenced by many confounders outside hospital, such as health care logistics, experience and availability of general practitioners, availability of outpatient clinics. Thus, the explanation for the difference in readmission rates between the bilateral staged groups is uncertain and should be a subject for future studies.

According to a recent consensus paper, it is generally accepted that patients with few comorbidities and especially without heart disease can be offered the bilateral simultaneous procedure [18]. We assume that the patients in the bilateral simultaneous TKA group in our study were selected after these criteria, but no specific information was available. However, the slightly younger age of the patients in the bilateral simultaneous group, which is correlated to lower rates of comorbidities, suggests that these patients have been selected [22]. Our findings are further supported by the study by Meehan et al. [17] where there were fewer diabetics and morbidly obese among the patients undergoing bilateral simultaneous surgery and in the study by Memtsoudis et al. [20] where patients with bilateral procedures were generally younger and had fewer comorbidities compared with unilateral TKA.

The bilateral simultaneous procedures in our study were performed in fewer different departments (16) than the staged procedures (40 and 34). 73.2 % of the bilateral simultaneous procedures were performed in four dedicated fast-track departments [6] and 50 % were performed in a single department [7]. This skewness shows that the bilateral simultaneous procedures are mainly done by high-volume surgeons in high-volume departments with a

standardised set-up appropriate for the simultaneous procedure probably influencing the positive outcome after bilateral simultaneous TKA in our study.

Our assumption that most of the patients with bilateral staged procedures would be scheduled for the second stage surgery at the 3-month postoperative check in the outpatient clinic—seemed to be correct. However, we also found that the majority of bilateral staged patients are having the second procedure done within 90–250 days after the first stage, which is valuable knowledge in terms of planning future studies. The median time between first and second stage surgery in our study (5.6 months) differs from the findings of Ichii et al. [8] with a median of 12.5 months between the operations.

The lack of information about preoperative morbidity of the patients is the major limitation of this nationwide register study. Unfortunately, there is no reliable source of this information as the value of specific diagnoses codes for medical diseases in the DNPR is limited [28]. Thus, although important with regard to interpreting whether there was preoperative selection of patients (which is very probable), we do not believe that the lack of details on comorbidity weakens our results regarding incidence and types of postoperative morbidity after these procedures. Other limitations are the lack of information about the types of implants used and clinical scores of the patients, which is not registered in the DNPR [15] and therefore not obtainable—although this would hardly affect morbidity or mortality. Although this study may be limited by a relatively small number of performed procedures during the study period, we believe that this is preferable compared with studies which include a large number of procedures during a longer time period, as it reduces the influence of changes in perioperative care and therefore gives a more reliable picture of postoperative morbidity according to current practise. This is especially important considering the effect of the implementation of fast-track principles on, for example LOS after TKA in Denmark [5], and the number of patients in our study represent the production nationwide in Denmark and thus present the setting for an entire nation. In this context, we believe that our method of combining the complete 90-day follow-up through the DNPR with detailed information through the medical charts outweighs the limitations of a limited sample size. In our opinion, this provides a more reliable picture of postoperative morbidity compared with previous studies which may have more patients due to longer study periods [12, 17, 19], but consequently rely on diagnostic codes regarding postoperative morbidity [17, 19], which may be of limited value [26]. Finally, the follow-up period of 30 days for readmissions gives no information about potential late surgical complications such as low-grade infections and aseptic loosening which can occur several years after surgery. However, the primary focus of this study was to provide information about safety and early complications leading to readmission after bilateral TKA surgery on a nationwide basis.

The results from this nationwide study provide new information about bilateral simultaneous and staged TKA in relation to the fast-track protocol. This information is of clinical importance in order to optimise the perioperative set-up in orthopaedic departments in many countries, but also in the day-to-day clinical practise of counselling patients with bilateral knee arthritis prior to bilateral TKA surgery.

Conclusion

The results from this nationwide study indicate that low morbidity and mortality can be expected after bilateral simultaneous TKA, when patients are selected and operated in a fast-track setting. However, a prospective randomised controlled study or a detailed prospective multicentre study with a fast-track protocol is necessary to determine whether the bilateral simultaneous or the bilateral staged procedure gives the safest outcome regarding morbidity and mortality in the patient without serious comorbidity.

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Conflict of interest None.

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