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# The incidence of venous thromboembolism is low when risk stratification-based thromboprophylaxis is used after fast-track hip and knee arthroplasty

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## Abstract

**Background** The optimal length of thromboprophylaxis after total hip or knee arthroplasty (THA and TKA) is unknown. Fast-track protocols have improved patient care and led to shorter immobilization and length of stay (LOS) after THA and TKA, thereby diminishing venous thromboembolism (VTE) risk. Here, we investigated risk stratification-based thromboprophylaxis after fast-track THA and TKA.

**Methods** A retrospective register study was conducted in two Finnish hospitals using a fast-track protocol for THA and TKA. These hospitals use risk stratification-based planning of thromboprophylaxis, including risk evaluation of patients' personal VTE risk. Patients at low risk received thromboprophylaxis solely during hospitalization, provided this lasted five days or less. All VTEs and clinically relevant bleedings were obtained from Finnish hospital discharge registers between 1 January 2020 and 31 December 2021 to determine VTE incidences and clinically relevant bleedings 90 days after surgery.

**Results** During the study period 3 713 arthroplasties were performed (1 636 THAs and 2 077 TKAs). The 90-day incidence of VTE was 0.7% (CI 0.4 to 0.9), and 25 VTEs occurred within 90 days of surgery. These VTEs comprised 12 pulmonary embolisms and 13 deep vein thromboses, none of which was fatal. The incidence of clinically relevant bleedings ( $n = 57$ ) within 90 days of surgery was 1.5% (CI 1.1 to 1.9). One intracranial bleeding was fatal. The bleedings typically occurred at the operational site.

**Conclusion** Risk stratification-based thromboprophylaxis appears safe for fast-track THA and TKA patients as the incidences of VTEs and clinically relevant bleedings were low.

**Keywords** Risk stratification, Thromboprophylaxis, Venous thromboembolism, Fast-track, Total hip arthroplasty, Total knee arthroplasty

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## Background

Before the use of routine thromboprophylaxis with long inpatient care, 15 to 35% of patients experienced symptomatic VTE after THA or TKA [1]. Routine use of thromboprophylaxis has diminished the incidence of VTE to around 2% within 90 days of surgery [2]. Studies conducted in Denmark after implementation of fast-track THA and TKA found that the incidence of VTE in patients receiving thromboprophylaxis solely during hospitalization, and without the use of previous permanent anticoagulation, was around 0.4% [3–5] if LOS was five days or less. In a Finnish study of unselected fast-track THA and TKA patients, the 90-day incidence of VTE was 0.3% when thromboprophylaxis was administered for 21 to 28 days after THA and 14 days after TKA [6].

The risk factors for VTE are numerous. Patient-related factors include high age, obesity, previously diagnosed VTE, hereditary and acquired thrombophilias, malignancy, varicose veins, and comorbidities that impair everyday life. Surgical factors include extended length of surgery, and perioperative immobilization [7]. Fast-track protocols optimize patient care leading to earlier mobilization and shorter LOS without compromising quality of care [8, 9]. It has been debated whether long thromboprophylaxis is any longer needed for these patients, as the reported incidence of VTEs with thromboprophylaxis used solely during hospitalization is low [3–5].

Around 1 to 3% of THA or TKA patients suffer from bleeding complications within 90 days of surgery [10, 11]. Most of these are operational site bleedings [10]. Since neither VTEs nor bleedings are wanted after surgery, more personalized planning of thromboprophylaxis is warranted to balance between the occurrence of these two potential side effects [12].

Recommendations on the length of thromboprophylaxis after THA and TKA differ according to the pharmacological agents used and/or length of thromboprophylaxis [2]. Most of these recommendations, which are mainly based on surgery type and do not include individual VTE risk assessment, advise longer thromboprophylaxis after THA than TKA [1, 13]. The European guidelines on perioperative venous thromboembolism prophylaxis for day surgery and fast-track surgery by the European Society of Anaesthesiology and Intensive Care (ESAIC) first published in 2018 seems to be the only recommendation that considers the care protocol used for THA and TKA to be one of the decisive factors associated with the length of thromboprophylaxis [14]. An update of these guidelines were published in 2024 [15]. According to the first edition of the ESAIC guidelines, the use of thromboprophylaxis solely during hospitalization can be used after fast-track THA and TKA for selected patients, if LOS is five days or less. In the updated 2024 version of these guidelines, it is stated that

thromboprophylaxis only during hospitalization can be used after fast-track hip and knee arthroplasty, if LOS is five or less and functional discharge criteria are used [15]. Both guidelines emphasize the importance of the individual risk factor-based planning of thromboprophylaxis [14, 15]. These guidelines are based on studies reporting results of VTE incidences among Danish fast-track THA and TKA patients [4, 5, 16–18].

We conducted a registry study to determine the incidences of VTEs and clinically relevant bleeding within 90 days after fast-track THA and TKA in patients who followed a risk stratification-based thromboprophylaxis protocol outlined in the European guidelines on perioperative venous thromboembolism prophylaxis for day surgery and fast-track surgery.

## Methods

All primary hip and knee arthroplasties performed in two Finnish teaching hospitals (Kuopio University hospital, Kuopio and Hospital Nova, Jyväskylä) between 1 January 2020 and 31 December 2021 were identified from the Finnish Arthroplasty register (FAR), using the following NOMESCO codes for hip and knee arthroplasties: NFB30, NFB40, NFB50, NFB60, NFB99, NGB20, NGB30, NGB40 and NGB50 (Appendix I). Both hospitals perform arthroplasties using fast-track protocol.

The fast-track protocols used in these two hospitals consist of the provision of consistent information on early mobilization, discharge criteria, and opioid-sparing pain relief. Anesthesia is carried out with low-dose opioid-free spinal anesthesia or intra-venous anesthesia, and local anesthesia is used to ensure postoperative pain relief. No drains or catheters that could inhibit mobilization on the day of the surgery are used. Patients receive at least one dose of tranexamic acid to stabilize clotting during the operation. Discharge home is preferred and occurs when patients are able to get into and out of bed and a chair independently, walk 40 m and, if needed, ascend and descend stairs, dress and undress themselves, take care of their personal hygiene, and have a support person available to them.

Thromboprophylaxis is planned based on the patient's risk factors for VTE. Length of thromboprophylaxis is determined based on major and minor risk factors (Table 1) as outlined in the European guidelines on perioperative venous thromboembolism prophylaxis for day surgery and fast-track surgery published by ESAIC in 2018 and updated in 2024 [14, 15]. The risk stratification is performed before surgery and revised as needed after surgery. Patients with no major risk factors or at most two minor risk factors are considered to have low risk for VTE. Patients with a low risk for VTE receive thromboprophylaxis solely during hospitalization if LOS is five days or less. Patients with a higher VTE risk receive

**Table 1** Risk factor

Major risk	Minor risk
Active cancer or in treatment for cancer	Age > 60 years
Previous venous thromboembolism	Body mass index > 40
Venous thromboembolism in 1st degree family members	Immobilization before surgery (non-walking, 4 days)
Operation time > 120 min	Chronic venous insufficiency
Hereditary clotting disorder	

thromboprophylaxis ranging from 10 to 14 days and for up to 4 weeks if their VTE risk is very high.

In patients using permanent potent anticoagulation, the medicine was discontinued a few days before surgery. Bridging therapy was used if necessary, and patients were transitioned back to their regular anticoagulation regimen as soon as was possible.

The FAR data were combined with the data from the Finnish Hospital Discharge Register (FHDR) to identify all venous thromboembolisms (VTE) and clinically relevant bleedings according to the ICD-10 diagnosis codes, 10th revision [19]. All non-traumatic bleedings documented in the FHDR were classified as clinically relevant, as their inclusion in the FHDR likely indicated the need for additional medical attention following surgery. This definition follows the definition of major bleeding in clinical investigations of antihemostatic medicinal products in surgical patients [12]. All patients aged at least 18 years on the day of surgery were included in the study. Length of stay (LOS) was defined as number of nights spent in the hospital before discharge home. Causes of deaths within 90 days of surgery were obtained from Statistics Finland.

Due to the low number ( $N=42$ ) of bilateral total hip or knee arthroplasties operated under the same anesthesia (BTHA or BTKA), these operations were excluded from this study.

### Statistics

Descriptive statistics are presented as means (SD), medians (IQR) or counts (%). Incidence was estimated with an exact 95% confidence interval (CI) based on a Poisson distribution. Risks of venous thromboembolism and bleedings after fast-track hip and knee arthroplasty were analyzed using multivariate logistic regression analysis. Analyses were performed with Stata 15.1 (StataCorp LP; College Station, Texas, USA).

### Ethics

Ethics approval was granted by the National Institute for Health and Welfare (protocol number: Dnro: THL/1089/5.05.00/2019) and Statistics Finland (Protocol number: Dnro: TK/2800/07.03.00/2022).

**Table 2** Basic demographics of the fast-track total joint arthroplasty patients

	THA	TKA	Total
Number of operations, N (%)	1636 (44)	2077 (56)	3713 (100)
Patients, N (%)	1552 (44)	1945 (56)	3497 (100)
Women, N (%)	904 (55)	1270 (61)	2174 (59)
Age, mean (SD)	68 (11)	68 (10)	68 (10)
Diagnosis, N (%)			
OA	1353 (83)	1902 (92)	3255 (88)
RA	6 (0)	43 (2)	49 (1)
Other	277 (17)	132 (6)	409 (11)
Side operated			
Right	903 (55)	1071 (52)	1974 (53)
Left	727 (44)	970 (47)	1697 (46)

THA=total hip arthroplasty, TKA=total knee arthroplasty, OA=osteoarthritis, RA=rheumatoid arthritis

**Table 3** Venous thromboembolism

	THA	TKA	All
Pulmonary Embolism, N (%)	10 (83.3)	2 (16.7)	12 (100)
Incidence of PE % (95% CI)	0.6 (0.2 to 1)	0.1 (0.0 to 0.2)	0.3 (0.1 to 0.5)
Deep venous thrombosis (%)	4 (30.8)	9 (69.2)	13 (100)
Incidence of DVT, % (95% CI)	0.2 (0.0 to 0.5)	0.4 (0.2 to 0.7)	0.4 (0.2 to 0.5)
Venous thromboembolism, N (%)	14 (56)	11 (44)	25 (100)
Incidence of VTE, % (95% CI)	0.9 (0.4 to 1.3)	0.5 (0.2 to 0.8)	0.7 (0.4 to 0.9)

THA=total hip arthroplasty, TKA=total knee arthroplasty, N=number, PE=pulmonary embolism, CI=confidence interval, DVT=Deep venous thrombosis and VTE=venous thromboembolism

### Results

During the study period from January 1st, 2020, to December 31st, 2021, 3 497 patients underwent 3 713 THAs or TKAs. Of these operations, 88% were due to osteoarthritis. Of all THAs and TKAs, 59% were performed on females and 56% were TKAs. Mean LOS was 2 days (SD 1). Of all the 3 713 arthroplasties performed, 93.3% had a LOS of five days or less. For more demographic data, see Table 2.

The incidence of venous thromboembolism (VTE) was 0.7% (CI 0.4 to 0.9) during the first 90 days after the operation and comprised 12 pulmonary embolisms (PE) and 13 deep venous thromboses (DVT). PE incidence was 0.3% (CI 0.2 to 0.6) and DVT incidence 0.4% (CI 0.2 to 0.6). Most of these venous thromboembolisms occurred after THA (Table 3). Two of these patients suffered from Covid-19 infections during the same period. No deaths due to a VTE occurred.

A total of 57 clinically relevant bleedings were reported after these operations. Most occurred after TKA (54%) and the most common site of bleeding was the operational site, which accounted for 37 (65%) of these bleedings. (Table 4). The incidence of clinically relevant bleeding complications was 1.5% (CI 1.1 to 1.9) during

**Table 4** Clinically relevant bleedings after fast-track hip and knee arthroplasty

	THA	TKA	All
Bleeding, N (%)	26 (46)	31 (54)	57(100)
Incidence of bleedings, % (95% CI)	1.6 (1.0 to 2.2)	1.5 (1.0 to 2.1)	1.5 (1.1 to 1.9)
Operational site bleedings, N (%)	15 (40.5)	22 (59.5)	37 (100)
Incidence of operational site bleedings, % (95% CI)	0.9 (0.5 to 1.4)	1.0 (0.6 to 1.5)	1.0 (0.7 to 1.3)
Gastrointestinal bleedings N (%)	6 (50)	6 (50)	12 (100)
Incidence of gastrointestinal bleedings, % (95% CI)	0.4 (0.1 to 0.7)	0.1 (0.0 to 0.3)	0.3 (0.1 to 0.5)
Non-traumatic intracranial bleedings, N (%)	3 (75.0)	1 (25.0)	4 (100)
Incidence of non-traumatic intracranial bleedings, % (95% CI)	0.2 (0.0 to 0.4)	0.1 (0.0 to 0.1)	0.1 (0.0 to 0.2)
Bleeding elsewhere, N (%)	2 (50)	2 (50)	4 (100)
Incidence of bleeding elsewhere, % (95% CI)	0.1 (0.0 to 0.3)	0.1 (0.0 to 0.2)	0.1 (0.0 to 0.2)

THA=total hip arthroplasty, TKA=total knee arthroplasty, f/m=female/male, N=number and CI=confidence interval

**Table 5** Multivariate logistic regression analysis for venous thromboembolism and clinically relevant bleedings after fast-track THA and TKA

	Venous thromboembolism OR (95% CI)	P-value	Bleedings OR (95% CI)	P-value
Male sex	1.05 (0.48 to 2.30)	0.90	1.20 (0.71 to 2.03)	0.50
Age	1.01 (0.97 to 1.05)	0.67	0.99 (0.97 to 1.02)	0.49
Arthroplasty				
THA	1 (Reference)		1 (Reference)	
TKA	1.12 (0.51 to 2.64)	0.24	1.39 (0.80 to 2.41)	0.24
Diagnosis				
OA	1 (Reference)		1 (Reference)	
Others	1.34 (0.45 to 3.96)	0.60	1.22 (0.57 to 2.61)	0.62

THA=total hip arthroplasty, TKA=total knee arthroplasty, OR=Odds ratio and OA=Osteoarthritis

the first 90 days after surgery. One death due to non-traumatic intracranial bleeding occurred during the 90-day follow-up period, and hence the incidence of bleeding-related deaths was 0.03% (CI 0.00 to 0.08).

In the multivariate regression analysis of VTE and clinically relevant bleeding risks, none of the variables – age, sex, operation type or indication for surgery – emerged as explanatory factors for either outcome (Table 5).

### Discussion

We found a low incidence of VTE and clinically relevant bleeding among unselected fast-track THA and TKA patients with risk stratification-based

thromboprophylaxis. Most of patients had a LOS of five days or less. In a multivariate logistic regression analysis, age, sex, operation type, and indication for surgery were not explanatory factors for risk of VTE or clinically relevant bleeding.

In 2011, Husted et al. [3] reported on 1 977 fast-track patients who had received thromboprophylaxis solely during hospitalization after fast-track THA and TKA. Patients with preoperative use of anticoagulants were excluded. During their study period, LOS shortened from over 7 days to 3 days, and hence the operated patients received much shorter thromboprophylaxis than published recommendations [1, 20]. In their study, Husted et al. reported a 90-day incidence of deep venous thromboembolism (DVT) of 0.51% for THA, 0.6% for TKA, and 0% for BTKA. The incidences of pulmonary embolism (PE) were also low: 0% for THA, 0.3% for TKA, and 0% for BTKA in their study. Later, Jørgensen et al. [5] studied unilateral fast-track THA and TKA operations. In their study, 4 924 THAs and TKAs were performed on 4 718 patients without permanent anticoagulation, and 4 659 patients with a LOS of 5 days or less received thromboprophylaxis solely during hospitalization. The incidence of VTE was 0.41%. Petersen et al. [4] published a follow-up study with a median length of thromboprophylaxis of 2 days. The incidence of VTE in their study was 0.4%. The hospitals included in these previous Danish studies used the same fast-track protocol as that used in the two hospitals in the present study. Although the VTE incidence was lower in these studies than that in our study, we included all patients with or without permanent use of preoperative anticoagulation. We consider it an advantage of our study that we report the true incidence of fast-track THA and TKA patients, as our sample was not selected with respect to previous anticoagulant use.

A previous Finnish study reported a VTE incidence of 0.3% in the first 90 days after fast-track THA and TKA with long thromboprophylaxis (10–14 days after TKA and 21–28 days after THA) [6]. Compared to this finding, the present incidence of VTE, although higher, is nevertheless low. Further studies are needed to determine the distribution of VTEs between low VTE-risk patients without thromboprophylaxis after discharge and high VTE-risk patients with longer thromboprophylaxis.

Risk stratification-based planning of thromboprophylaxis started during the Covid-19 pandemic. It had been reported that the Covid-19 infection could increase the risk of thrombosis, especially if hospital care was needed [21, 22]. The use of anticoagulants was encouraged for hospitalized Covid-19 patients to diminish this increased risk [22]. Two of the arthroplasty patients in our study had a diagnosed coronavirus infection leading to hospital care during the 90-day follow-up period. These two patients did not experience a VTE.

Post-operative bleedings are clearly unwanted. Although they are seldom serious, they cause patients discomfort and unease as well as increase the use of healthcare services. The incidences of bleedings after THA and TKA vary between 1 and 3% [10]. Comparison of bleeding complications after THA and TKA is difficult due to the lack of a unanimous definition. We have previously reported the incidence of clinically relevant bleedings in Finnish fast-track THA and TKA patients with longer thromboprophylaxis lasting 10 to 14 days for TKAs and 21 to 28 days for THAs. The incidence of 90-day postoperative clinically relevant bleedings was 1% [10]. The incidence of clinically relevant bleedings in the present study was on approximately the same level (1.5%). Over 60% of these clinically relevant bleedings occurred at the operational site in both studies. In both studies, potent anticoagulants were discontinued before surgery. The continued use of aspirin may have influenced the incidence of clinically relevant bleedings. However, accurately determining aspirin use in a register study is challenging, as it can be purchased over the counter and is therefore not recorded in any official register. More studies are needed to specify the distribution of bleedings related to the length of thromboprophylaxis.

We found that age, sex, type of surgery, or indication for surgery were not significant risk factors for VTE or clinically relevant bleeding. Evidence suggests that age, sex, and type of surgery can influence VTE risk, with increased age, female sex, and TKA identified as risk factors for VTE [23, 24]. However, our study results are supported by a French study on enhanced recovery hip and knee arthroplasties, where age and sex were not found to be risk factors for VTE or bleeding [11]. Early mobilization reduces the risk of VTE following THA and TKA [24]. The beneficial effects of same-day mobilization, along with advancements in patient care, may explain why age, sex, type of surgery, or surgical indication did not emerge as significant risk factors for VTE or clinically relevant bleeding. Additionally, the limited number of patients in our study may have reduced the power to detect significant risk factors due to the low incidence of VTE and clinically relevant bleeding.

A limitation of our study is that the exact number of patients receiving thromboprophylaxis solely during hospitalization cannot be determined, as the length of planned thromboprophylaxis is not recorded in the FAR. According to our protocol patients with one major or at least two minor risk factors for VTE receive thromboprophylaxis for a minimum of 10 days. Unfortunately, in a register study, it is not possible to identify all patient-related risk factors for VTE—for example whether a patient's 1st degree relative has had a VTE: However, we know that 93.3% of the present patients in this study had a LOS of five days or less. This suggests that most of the operated

patients would likely have received thromboprophylaxis only during hospitalization if LOS was the sole criterion for determining the duration of thromboprophylaxis.

Moreover, our research setting is pragmatic and informative about the real-life situation. This study includes confounding factors, such as unknown aspirin use, the deviation of permanent anticoagulation users from the risk stratification-based thromboprophylaxis protocol, and the inability to determine the exact number of patients receiving thromboprophylaxis only during hospitalization in a registry study. The use of aspirin and potent anticoagulants can influence the incidence of clinically significant bleeding complications by enhancing or prolonging bleeding through more effective inhibition of coagulation. A key strength of our study is that, unlike previous studies that excluded permanent anticoagulation users, it provides real-life insights into the patients we care for. Thus, a strength of this study is that it presents results on an unselected consecutive sample of fast-track THA and TKA patients operated on during the selected study period.

The accuracy of our study relies, of course, on the quality of the registers used. Both the Finnish Arthroplasty register (FAR) and Finnish hospital discharge register (FHDR) are maintained by the Finnish National Institute for Health and Welfare. Over 95% of the arthroplasties performed were reported to the FAR, indicating good coverage [25]. We also know that the completeness of the FHDR is good: more than 95% of all discharges have been found to be filed in it [26]. In a study conducted in 2018, Turpo et al. found that the compatibility of these two registers was good [27]. Statistics Finland maintains a register on the causes of death. This register has a level of completeness of 99% [28]. The accuracy of our study also depends on adherence to the risk stratification-based thromboprophylaxis protocol. Both study hospitals have exclusively used this protocol as their thromboprophylaxis regimen since its implementation in fast-track THA and TKA. In 2022, the national guidelines were updated to align with the same VTE risk stratification protocol [27].

## Conclusion

This study shows that risk stratification-based planning of thromboprophylaxis after fast-track THA and TKA can be considered safe. The occurrence of VTE and clinically relevant bleedings appear to be the same as those reported after long thromboprophylaxis. However, to improve planning of thromboprophylaxis after fast-track THA and TKA, further studies on VTE and bleedings among high- and low-risk patients are needed.

## Appendix I NOMESCO codes – Finnish version

NFB30. Primary total prosthetic replacement of hip joint not using cement.

NFB40. Primary total prosthetic replacement of hip joint using hybrid technique.

NFB50. Primary total prosthetic replacement of hip joint using cement.

NFB60. Demanding prosthetic replacement of hip joint.

NFB99. Other primary prosthetic replacement of hip joint.

NGB20. Primary total prosthetic replacement of knee joint without patellar part–sliding prosthesis.

NGB30. Primary total prosthetic replacement of knee joint without patellar part–connected prosthesis.

NGB40. Primary total prosthetic replacement of knee joint with patellar part–sliding prosthesis.

NGB50. Primary total prosthetic replacement of knee joint with patellar part–connected prosthesis.

### Abbreviations

THA	Total hip arthroplasty
TKA	Total knee arthroplasty
LOS	Length of stay
VTE	Venous thromboembolism
CI	Confidence interval
ESAIC	European society of anaesthesiology and intensive care
FAR	Finnish arthroplasty register
NOMESCO	Nordic medico-statistical committee
FHDR	Finnish hospital discharge register
ICD-10	International classification of diseases, tenth revision
BTHA	Bilateral hip arthroplasty operated under same anesthesia
BTKA	Bilateral knee arthroplasty operated under same anesthesia
SD	Standard deviation
IQR	Interquartile range
PE	Pulmonary embolism
DVT	Deep vein thrombosis

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### Author contributions

A.M., K.P., J.H., H.K., A.K. and J.P. contributed to the conception and design of the study, critical analyses of the data, interpretation of the findings, and critical revision of the manuscript. All authors read and approved the final manuscript.

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### Data availability

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

### Declarations

#### Ethical approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and approved by the National Institute for Health and Welfare (protocol number: Dnro: THL/1089/5.05.00/2019) and Statistics Finland (protocol number: Dnro: TK/2800/07.03.00/2022). As this study is based on data from Finnish national

health and/or social care registers, specific informed consent from participants was not required, as permitted by Finnish legislation (Act on the Secondary Use of Health and Social Data (552/2019). All data were anonymized before analysis to ensure participant confidentiality.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

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