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Research Article

Comparison of clinical outcomes of enoxaparin and aspirin for postoperative venous thromboembolism prophylaxis in hip fractures

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ABSTRACT

Objective: The risk of symptomatic venous thromboembolism (VTE) following hip fracture surgery is estimated at 1%-6%, necessitating effective prophylactic measures. While aspirin has been widely used in total hip and knee arthroplasty due to its comparable efficacy, reduced bleeding risk, and cost-effectiveness, its role in trauma patients remains under-researched. This study aims to evaluate the efficacy and safety of aspirin and enoxaparin for VTE prophylaxis in hip fracture patients.

Methods: This two-center, retrospective study analyzed 306 adult patients who underwent hip fracture surgery between 2019 and 2023. Patients were divided into 2 groups: the aspirin group (81 mg twice daily) and the enoxaparin group (40 mg subcutaneous once daily), both receiving prophylaxis for 4 weeks postoperatively. Demographics, comorbidities, surgical details, and clinical outcomes—including major bleeding events, symptomatic VTE (deep vein thrombosis and pulmonary embolism), periprosthetic joint infection (PJI), blood transfusion requirements, and 90-day mortality—were recorded. Statistical analyses were performed using Pearson chi-square and independent *t*-tests, with significance set at $P < .05$.

Results: The aspirin group (n=136) and enoxaparin group (n=170) had mean ages of 67.66 ± 19.67 and 63.42 ± 19.71 years, respectively. Hemoglobin decrease was significantly lower in the aspirin group (1.75 ± 1.07 g/dL vs. 2.73 ± 1.56 g/dL, $P=.001$). In addition, the amount of postoperative blood transfusion was statistically significantly lower in the aspirin group compared to in the enoxaparin group (0.89 vs. 1.31 units, respectively, $P=.034$). There was no significant difference in mean hospital stay (6.84 vs. 6.65 days, $P=.751$). The incidence of major bleeding was higher in the enoxaparin group (3.7% (n=5) vs. 5.3% (n=9)), though not statistically significant ($P=.789$). Symptomatic VTE occurred in 3.7% (n=5) of the aspirin group and 5.3% (n=9) of the enoxaparin group ($P=.453$). Periprosthetic joint infection was observed in 2 patients in the enoxaparin group but none in the aspirin group ($P=.447$). Mortality within 90 days was lower in the aspirin group (8.8% (n=12) vs. 15.9% (n=27)), but the difference was not statistically significant ($P=.066$).

Conclusion: This study suggests that aspirin appears to be a reasonable alternative to enoxaparin for VTE prophylaxis in hip fracture patients, demonstrating comparable efficacy with a lower blood transfusion requirement and similar rates of major bleeding and symptomatic VTE. Given its affordability, ease of administration, and favorable safety profile, aspirin appears to be a reasonable and cost-effective alternative for high-risk trauma patients.

Level of Evidence: Level III, Therapeutic Study.

Introduction

The incidence of symptomatic venous thromboembolism (VTE) after surgeries for hip fractures is reported to be 1%-6%.[1] To mitigate this risk, mechanical and pharmacological prophylaxis methods are employed. Guidelines from the American Academy of Orthopedic Surgeons (AAOS),[2] the American College of Chest Physicians (ACCP),[3] the National Institute for Health and Clinical Excellence (NICE),[4] and the International Consensus Meeting - VTE have offered varied recommendations on VTE prophylaxis.[5] In the recent 2 decades, aspirin has been reported as a potential alternative option for VTE prophylaxis after total knee arthroplasty and total hip arthroplasty (THA) due to its comparable effectiveness to other pharmacological agents, reduced bleeding risk, oral administration convenience, and low cost.[5] However, the Orthopaedic Trauma Association has highlighted the lack of high-quality evidence and wide variability in VTE prevention for fracture patients.[6] Although recent studies with large populations including trauma patients have been reported,[7] current guidelines for VTE prophylaxis in orthopedic trauma are mostly based on data from arthroplasty and elderly hip fracture patients, which limits their relevance to the broader trauma population.[8] Despite strong data in elective arthroplasty, limited evidence exists for trauma cases, where bleeding risk and comorbidities differ.

This study aims to compare the clinical outcomes of aspirin and enoxaparin in VTE prophylaxis among hip fracture patients to evaluate their efficacy.

Materials and methods

In this retrospective, two-center study, 306 adult patients who underwent surgery for hip fractures

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between 2019 and 2023 were included, provided that they had complete datasets and uninterrupted postoperative follow-up. Surgeries performed by 2 experienced orthopedic surgeons in 2 different centers were included in the study. Ethics committee approval was obtained for the study on 28/04/2023 from İstanbul Medipol University Non-Interventional Clinical Research Ethics Committee Presidency (decision no: E-10840098-772.02-2769). Written informed consent was obtained from all patients. Collected patients' data were divided into 2 groups according to the use of chemoprophylactic agents for VTE prophylaxis after hip fracture surgery. Patients who were given 81 mg aspirin twice daily after surgery constituted the aspirin group, while patients who were given enoxaparin 40 mg SC once daily after surgery constituted the enoxaparin group. Aspirin was administered at 81 mg twice daily, a regimen shown to be effective in arthroplasty literature[9] and consistent with the dosing used in the Pulmonary Embolism Prevention trial.[8] As recommended by the ACCP, enoxaparin 40 mg subcutaneously once daily is the preferred prophylactic regimen for these patients.[10] Patients in each group received the same chemoprophylactic agent at the same dose throughout their hospital stay and for 4 weeks after surgery. To standardize patient data collected from 2 different centers, the same surgical protocols, but different types of chemoprophylaxis were applied. Demographic data of the patients (age, gender, body mass index [BMI], Charlson Comorbidity Index [CCI]), type of surgery, type of anesthesia, length of stay, preoperative and latest hemoglobin results during hospital stay were collected. Major bleeding events (MBEs), symptomatic VTE (pulmonary embolism [PE] and deep vein thrombosis [DVT]), periprosthetic joint infection (PJI), blood transfusion, and mortality were recorded within 90 days after the trauma. A 90-day surveillance window is widely adopted in VTE research, as most postoperative thromboembolic events occur within this period, and it captures both early and delayed complications relevant to orthopedic surgery.[3,11] Pulmonary embolism and DVT screening were not performed routinely in asymptomatic patients. Standardized algorithms were used for symptomatic VTE diagnosis. For this purpose, computerized tomography-angiography and Doppler ultrasonography were used for symptomatic patients.[12] Major bleeding criteria were accepted as the need for 2 or more units of blood transfusion, intracranial bleeding, gastrointestinal bleeding, and hematoma formation requiring drainage in the operating room.[13] The International Consensus Meeting criteria were accepted for the diagnosis of PJI.[14]

In all patients, the surgeon and anesthesiologist preferred spinal/regional anesthesia. However, general anesthesia was applied to patients who could not undergo regional anesthesia for any reason (failure of regional anesthesia, patient preference, etc.). Hemiarthroplasty or THA was applied to patients diagnosed with femoral neck fracture. This decision (hemi- or total) was made by the surgeon according to the patient's age and activity level. All patients who underwent arthroplasty were operated on with a posterior approach in the lateral decubitus position. Bleeding control was applied at every stage of the surgery. Care was taken to close the external rotator muscles and fascia in accordance with their anatomy. No drains were used in the patients. Proximal femoral nail and intramedullary nails (IMNs) were applied in intertrochanteric and subtrochanteric fractures. All patients were prepared in the lateral decubitus position. Fracture fixation was performed after reduction was achieved under fluoroscopy. No drains were used in the patients. All patients walked with weight bearing as tolerated from the first postoperative day. All patients were given training on in-bed exercises during their hospitalization and postoperative period. All patients walked with weight bearing as tolerated from the first postoperative day. Mechanical prophylaxis was not applied, as all patients were eligible for pharmacologic thromboprophylaxis, and current guidelines recommend mechanical methods only when anticoagulation is contraindicated or as an adjunct in high-risk cases.[3]

Patients with severe hepatic and renal failure, patients with hemorrhagic disease and/or a history of major bleeding, patients with a platelet count below 100 000 cells (10^3/uL), patients with aspirin allergy, patients using Coumadin (warfarin) and direct oral anticoagulant drugs, and patients with conditions causing hypercoagulability were excluded from the study.

Data were analyzed using IBM SPSS v29.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov–Smirnov test was used to assess the normality of data distribution. Categorical variables were analyzed using the Pearson chi-square test and Fisher's exact test. Independent sample *t*-test and Mann–Whitney *U*-tests were applied for parametric and non-parametric variables. Quantitative variables were presented as mean ± SD, and qualitative variables were expressed as numbers (n), frequencies, or proportions. A $P < .05$ value was accepted for statistical significance. Post-hoc power analysis was conducted for both continuous and binary outcomes.

Power analysis results

Postoperative hemoglobin decrease and transfusion requirements were outcomes with adequate statistical power. Specifically, hemoglobin decrease demonstrated a large effect size with an achieved power of 100%, and transfusion requirements also reached sufficient power to detect between-group differences. By contrast, outcomes with lower event rates—such as symptomatic VTE, MBEs, PJI, and 90-day mortality—were underpowered, limiting the ability to identify statistically significant differences despite observable trends. These distinctions between adequately powered and underpowered outcomes are now explicitly noted to guide interpretation.

Results

A total of 306 patients were included in the study. Of these, 136 patients were in the aspirin group (mean age=67.66 ± 19.67) and 170 patients were in the enoxaparin group (mean age=63.42 ± 19.71) (Table 1). In the aspirin group, a total of 68 patients (50%) underwent arthroplasty, including 66 hemiarthroplasties (48.5%) and 2 total hip arthroplasties (1.5%). In the enoxaparin group, arthroplasty was performed in 40 patients (23.5%), consisting of 36 hemiarthroplasties (21.1%) and 4 THAs (2.4%).

Hemoglobin decrease was statistically significantly lower in the aspirin group compared to the enoxaparin group (1.75 ± 1.07 g/dL and 2.73 ± 1.56 g/dL, respectively, $P=.001$). The calculated effect size

HIGHLIGHTS

- Venous thromboembolism after hip fractures is a preventable, life-threatening complication.
- Although the literature recommends venous thromboembolism (VTE) prophylaxis after hip fractures, there is no clear and definite consensus.
- In this study, low-dose aspirin was associated with fewer blood transfusions and was comparable to enoxaparin in preventing VTE after hip fractures.
- Although the , a large randomized trial (PREVENT CLOT trial[7]) published in 2023[7], including orthopedic trauma patients, showed that aspirin is non-inferior to low-molecular-weight heparin, further studies focusing specifically on hip fractures are needed.

Table 1. Characteristics and complications of the patients according to the prophylaxis method subgroup

		Aspirin (n=136)	Enoksaparin (n=170)	*P*
Age (years) (Mean ± SD)[a]		67.66 ± 19.67	63.42 ± 19.71	.083
Sex[c], n (%)	Male	39.3 (n=53)	38.2 (n=65)	.906
	Female	60.7 (n=82)	61.8 (n=105)	
Smoking status[c], n (%)	Non-smoker	91.9 (n=124)	80.6 (n=137)	.005*
	Smoker	8.1 (n=11)	19.4 (n=33)	
Mean body mass index[a]	kg/m²	28.04 ± 5.45	26.75 ± 5.98	.106
Charlson Comorbidity Index[a]		6.62 ± 4.08	4.84 ± 2.03	.001*
Diagnosis[c], n (%)	Femoral neck fracture	71.3 (n=97)	53.5 (n=91)	.001*
	Pertrochanteric fracture	21.3 (n=29)	41.8 (n=71)	
	Subtrochanteric fracture	2.9 (n=4)	0 (n=0)	
	Other	4.4 (n=6)	4.7 (n=8)	
Type of surgery[c], n (%)	PFN	38.2 (n=52)	62.4 (n=106)	.001*
	Non-PFN osteosynthesis	11.8 (n=16)	14.1 (n=24)	
	Hemiarthroplasty	48.5 (n=66)	21.2 (n=36)	
	Total hip arthroplasty	1.5 (n=2)	2.4 (n=4)	
Anesthesia type[c], n (%)	General	75 (n=102)	41.2 (n=70)	.001*
	Regional	25 (n=34)	58.8 (n=100)	
Major bleeding[d], n (%)	No	96.3 (n=131)	94.1 (n=160)	.434
	Yes	3.7 (n=5)	5.9 (n=10)	
Venous thromboembolism[d], n (%)	No	96.3 (n=131)	94.7 (n=161)	.589
	Yes	3.7 (n=5)	5.3 (n=9)	
Periprosthetic joint infection[d], n (%)	No	100.0 (n=136)	98.8 (n=168)	.505
	Yes	0	1.2 (n=2)	
Death[d], n (%)	No	91.2 (n=124)	84.1 (n=143)	.084
	Yes	8.8 (n=12)	15.9 (n=27)	
Perioperative hemoglobin change[a]	g/dL	1.75 ± 1.07	2.73 ± 1.56	.001*
Blood transfussion[b]	Units	0.89 ± 1.26	1.31 ± 1.96	.034*
Length of hospital stay[b]	Days	6.84 ± 4.95	6.65 ± 5.10	.751

PFN, proximal femoral nail. For statistical analyses ; a : Independent Samples T-test, b : Mann-Whitney U test, c : Chi-Square Test, d : Fisher's Exact Test. * : statistically significant

(Cohen's *d*=0.72) yielded an achieved power of 100%, indicating that the study was well-powered to detect this difference. The decrease in hemoglobin levels in patients who underwent osteosynthesis (2.01 g/dL ± 1.27) was lower than in patients who underwent arthroplasty (2.48 g/dL ± 1.52) (*P*=.016). In addition, the amount of postoperative blood transfusion was statistically significantly lower in the aspirin group compared to in the enoxaparin group (0.88 vs. 1.31 units, respectively, *P*=.034). The calculated effect size (Cohen's *d*=0.26) yielded an achieved power of 58%, indicating that the study is prone to a type 2 mistake risk for this analysis (Table 2). The mean hospital stay was 6.84 ± 5 days in the aspirin group and 6.65 ± 5.1 days in the enoxaparin group (*P*=.751).

Major bleeding events were detected in 5 patients (3.7%) in the aspirin group and 10 patients (5.9%) in the enoxaparin group. Although MBEs were more common in the enoxaparin group, no statistically significant difference was observed between the 2 groups (*P*=.789).

Symptomatic VTE was observed in 5 patients (3.7%) in the aspirin group and 9 patients (5.3%) in the enoxaparin group. Symptomatic VTE was less common in the aspirin group; however, no statistically significant difference was observed between the groups (*P*=.453).

Two patients were diagnosed with PJI in the enoxaparin group, whereas no PJI was identified in the aspirin group (*P*=.447). Death within 90 days after surgery was seen in 12 patients (8.8%) who received aspirin, and in 27 patients (15.9%) who received enoxaparin (*P*=.066). Although the mortality rate was higher in the enoxaparin group, no significant difference was found between the 2 groups (*P*=.066). All data of the groups are detailed in Table 1.

Table 2. Power analysis of key results

	Cohen's *d*	Power (%)
Decrease in hemoglobin levels	0.72	100
Amount of blood transfusion	0.26	58

Discussion

This study demonstrated comparable VTE prevention efficacy between aspirin and enoxaparin after hip fracture surgery. Patients who receive aspirin have a slight decrease in postoperative hemoglobin levels, and hence their blood transfusion rate was lower compared to patients who receive enoxaparin.

The risk of symptomatic VTE in patients with hip fractures is reported to be 1%-6% according to the literature.[1,15] Patients with hip fractures are considered high-risk patients for developing VTE.[16] The goals of VTE prophylaxis in these patients are to prevent fatal PE and to reduce the incidence of post-VTE morbidity, both of which contribute to in-hospital and 1-year mortality rates.[17] Despite widespread awareness of the benefits of thromboprophylaxis, the optimal VTE prophylaxis method for hip fractures remained controversial.[18]

In the last 2 decades, the use of aspirin for VTE prophylaxis has gained momentum, especially in the total (Total Joint Arthroplasty) TJA literature. In a recent survey among members of the American Association of Hip and Knee Surgery, 86% of participants stated that aspirin was the preferred agent for preventing VTE.[2] Numerous studies have supported the use of aspirin for VTE prophylaxis after primary TJA[19,20] and revision TJA.[21]

Indeed, almost all clinical practice guidelines such as AAOS, ACCP, NICE, and ICM-VTE guidelines, strongly recommend the use of aspirin for VTE prophylaxis in patients undergoing TJA.[3-5] The AAOS safely recommends the use of aspirin after hip fractures.[22] The ACCP guidelines recommend aspirin for VTE prophylaxis for at least 2 weeks in patients with hip fractures with strong evidence (Grade 1B).[3] This convergence between AAOS and ACCP resulted in the inclusion of aspirin as an acceptable prophylactic option within the Surgical Care Improvement Project VTE quality measure in 2014, which resolved a longstanding debate regarding VTE prophylaxis that has persisted for over a decade.[23] On the other hand, NICE still recommends the use of low-molecular-weight heparin after hip fractures.[4] Recently, the ICM-VTE[5] guideline recommended that aspirin can be used safely for chemoprophylaxis of VTE after hip fractures.

Recent studies have demonstrated that aspirin significantly reduces VTE rates in patients undergoing surgery after hip fractures.[8,24] In addition, a recent meta-analysis examining 49 409 hip fracture patients from 19 studies examined the use of direct oral anticoagulants, low-molecular-weight heparin, and aspirin after hip fractures and reported that aspirin had a similar effect as other groups in preventing VTE events.[25] Another meta-analysis comparing the effectiveness of rivaroxaban and aspirin in preventing symptomatic VTE in patients undergoing arthroplasty after hip fracture included 5133 patients from 7 studies and reported no significant difference between the 2 groups. It was reported that aspirin was as effective as rivaroxaban in preventing symptomatic VTE in this group of patients.[26]

There are many studies on the ideal dose and duration of aspirin in VTE prophylaxis. Aspirin has been recommended primarily for patients at low risk for VTE, 325 mg twice a day by AAOS in 2008.[22] However, studies published later reported that low-dose aspirin was similarly effective as high doses.[27] Recent literature has demonstrated that low-dose aspirin (75-100 mg BID) has similar protection regarding cardiovascular and cerebrovascular events to high-dose aspirin (2 × 325 mg).[28] Similarly, in a double-blind randomized cohort of 13 356 patients undergoing hip fracture surgery, low-dose aspirin (160 mg daily) was reported to be sufficient to prevent VTE compared to the placebo group.[8] Although ICM-VTE[5] does not specify a clear dose for aspirin use after hip fractures, they state that aspirin is safe. A systematic review of 11 studies with various dosing regimens concluded that aspirin may reduce VTE with a lower risk of bleeding complications.[20] Furthermore, low-dose aspirin is associated with lower bleeding rates than high-dose aspirin, and it has been reported that low-dose aspirin use may potentially reduce gastrointestinal toxicity.[29] This study supports the safe use of low-dose (81 mg BID) aspirin in higher-risk patients, in line with the literature.

It is known that patients with hip fractures are generally fragile due to their advanced age and comorbid medical conditions, and these patients are taking a large number of patented anticoagulants and are therefore more prone to bleeding.[8,30] In fact, recent data have shown that the majority of hip fracture patients are older and tend to have prolonged elimination half-lives of direct oral anticoagulants, with approximately 50% of patients still having therapeutic levels at the time of surgery.[31] The incidence of both bleeding and thromboembolic events increases sharply with advanced age.[32] It is important to establish a balance between bleeding and VTE risk in these fragile elderly patients. Potent anticoagulants such as enoxaparin, warfarin, and direct oral anticoagulants increase bleeding risk, decrease hemoglobin, and increase the need for blood transfusion.[33] It is known that blood transfusion causes immunomodulation,[34]which indirectly increases PJI risk, increases blood loss transfusion rates, treatment costs, morbidity,[35] and may also cause unnecessary use of limited blood bank resources.[36] Aspirin provides balanced modest VTE prophylaxis by acting on the arterial and venous systems at different stages of the coagulation cascade.[37] Although some studies reported that aspirin and other anticoagulants gave similar results in terms of MBEs.[7,24] In a meta-analysis examining the efficacy of thromboprophylactic agents after hip fractures in 18 163 patients, it was reported that aspirin increased the risk of bleeding less compared to other anticoagulant agents.[25] Numerous studies have shown that aspirin has a lower bleeding risk compared to other potent anticoagulants.[38] In this study, although not statistically significant, aspirin was found to cause fewer MBEs compared to enoxaparin. Major bleeding events were seen in 3.7% of the aspirin group, while this rate was 5.9% in the enoxaparin group. It was also found that blood transfusion rates during and after surgery were statistically lower in the aspirin group (P=.034). Considering that the elderly patient group is prone to bleeding due to accompanying medical problems, aspirin is an optimal agent for VTE prophylaxis in elderly patients with hip fractures and would also be beneficial in terms of optimizing bleeding risk. When considering the decrease in hemoglobin levels in the aspirin group, which was significantly lower compared to the enoxaparin group in this study, it supports that aspirin use causes less bleeding.

There are also studies examining the effects of anticoagulants used after hip fractures on mortality. Accordingly, in a double-blind randomized study including 13 356 patients, it was reported that aspirin (n=6679) alone after hip fractures did not increase all-cause mortality (DVT, pulmonary thromboembolism (PTE), major bleeding, etc.) compared to placebo (n=6677).[8] In the PREVENT CLOT randomized cohort investigating the effects of prophylactic anticoagulant use in trauma patients (n=12 211), mortality was reported as 0.78% in the aspirin group (n=6101) and 0.73% in the low molecular weight heparin(LMWH group), with no significant statistical difference.[7] In this study, the CCI was higher in the aspirin group (P=.001). This suggests that patients receiving aspirin had more comorbidities than those receiving enoxaparin. However, the mortality rate was lower in the aspirin group (n=12, 8.8%) than in the enoxaparin group (n=27, 15.9%), although it was not statistically significant (P=.066). These results suggest that aspirin appears safe and comparably effective with its balanced effect on VTE and bleeding risk in fragile patients with multiple comorbidities.

This study has several limitations:

- Although each group contains 170 and 135 patients, respectively, the number of patients is still small.
- Given the absence of routine VTE screening, subclinical or asymptomatic thromboembolic events could have been missed.
- Retrospective design of the study, potential selection bias, lack of American Society of Anesthesiologists Physical Status Classification System (ASA)score data, absence of multivariable adjustments, differences in CCI, type of anesthesia, and fracture type may have caused heterogeneity between the groups and may have affected the results.
- Differences in surgical techniques (arthroplasty vs. intramedullary nailing) may inherently influence perioperative blood loss. However, the presence of both arthroplasty and IMN procedures in each treatment group strengthens the generalizability of these findings, allowing the choice of anticoagulant to be recommended independently of the surgical procedure performed.

- Different surgeons with different expertise and surgical techniques made the groups more heterogeneous. However, evaluating the effectiveness of aspirin and enoxaparin by including all fracture types and surgical methods may be accepted as strengths in terms of reflecting daily practice.
- Although the study was adequately powered to detect a clinically meaningful difference in postoperative hemoglobin levels, it was underpowered to identify significant differences in low-frequency adverse outcomes such as venous thromboembolism, major bleeding, and mortality due to the low incidence of these events. In order to standardize anticoagulant therapy in different types of surgery in these patient groups, further studies with sufficiently large sample groups to represent each group are recommended.
- A further limitation is the lack of multivariate analysis, which prevents adjustment for confounders. The imbalance in comorbidities between groups may also have influenced the findings.

This study demonstrated that aspirin appears to be a reasonable alternative to enoxaparin for VTE prophylaxis in patients undergoing surgery for hip fractures. Blood transfusion rates are lower in patients who receive aspirin. Although aspirin appears to be a viable option to enoxaparin, further studies with adequately powered sample sizes representing each surgical subgroup are warranted to standardize anticoagulant therapy across different types of surgery in these high-risk trauma populations. Although the PREVENT CLOT trial,[7] a large randomized trial published in 2023 involving orthopedic trauma patients, showed that aspirin is non-inferior to low-molecular-weight heparin, further studies focusing specifically on hip fractures are needed.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Artificial Intelligence Usage Statement: The authors declared that no Artificial Intelligence tool was used in the preparation of the manuscript.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of İstanbul Medipol University (Approval No.: E-10840098-772.02-2769; Date: 28/04/2023).

Informed Consent: Verbal informed consent was obtained from the patients who agreed to take part in the study.

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References

1. MacDonald DRW, Neilly D, Schneider PS, et al. Venous thromboembolism in hip fracture patients: a subanalysis of the FAITH and HEALTH trials. *J Orthop Trauma*. 2020;34(3)(suppl 3):S70-S75. [CrossRef]
2. Abdel MP, Berry DJ. Current practice trends in primary hip and knee arthroplasties among members of the American Association of Hip and Knee Surgeons: a long-term update. *J Arthroplasty*. 2019;34(7S):S24-S27. [CrossRef]
3. Falck-Ytter Y, Francis CW, Johanson NA, et al. Prevention of VTE in orthopedic surgery patients: antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest*. 2012;141(2)(suppl):e278S-e325S. [CrossRef]
4. National Institute for Health and Care Excellence. Clinical guidelines. In: *Venous Thromboembolism in over 16s: Reducing the Risk of Hospitalacquired Deep Vein Thrombosis or Pulmonary Embolism*. National Institute for Health and Care Excellence, London; 2018.
5. The ICM-VTE Hip & Knee Delegates. Recommendations from the ICM-VTE: hip & knee. *J Bone Joint Surg Am*. 2022;104(suppl 1):180-231. [CrossRef]
6. Sagi HC, Ahn J, Ciesla D, et al. Venous thromboembolism prophylaxis in orthopaedic trauma patients: a survey of OTA member practice patterns and OTA expert panel recommendations. *J Orthop Trauma*. 2015;29(10):e355-e362. [CrossRef]
7. Major Extremity Trauma Research Consortium (METRC), O'Toole RV, Stein DM, et al. Aspirin or low-molecular-weight heparin for thromboprophylaxis after a fracture. *N Engl J Med*. 2023;388(3):203-213. [CrossRef]
8. Prevention of pulmonary embolism and deep vein thrombosis with low dose aspirin: pulmonary Embolism Prevention (PEP) trial. *Lancet*. 2000 April 15;355(9212):1295-1302. [CrossRef]
9. Parvizi J, Huang R, Restrepo C, et al. Low-dose aspirin is effective chemoprophylaxis against clinically important venous thromboembolism following total joint arthroplasty: a preliminary analysis. *J Bone Joint Surg Am*. 2017;99(2):91-98. [CrossRef]
10. Farfan M, Bautista M, Bonilla G, et al. Worldwide adherence to ACCP guidelines for thromboprophylaxis after major orthopedic surgery: a systematic review of the literature and meta-analysis. *Thromb Res*. 2016;141:163-170. [CrossRef]
11. Lieberman JR, Bell JA. Venous thromboembolic prophylaxis after total hip and knee arthroplasty. *J Bone Joint Surg Am*. 2021;103(16):1556-1564. [CrossRef]
12. Konstantinides SV, Meyer G, Becattini C, et al. 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS). *Eur Heart J*. 2020;41(4):543-603. [CrossRef]
13. Schulman S, Angerås U, Bergqvist D, et al. Definition of major bleeding in clinical investigations of antihemostatic medicinal products in surgical patients. *J Thromb Haemost*. 2010;8(1):202-204. [CrossRef]
14. Parvizi J, Tan TL, Goswami K, et al. The 2018 definition of periprosthetic hip and knee infection: an evidence-based and validated criteria. *J Arthroplasty*. 2018;33(5):1309-1314.e2. [CrossRef]
15. Pedersen AB, Ehrenstein V, Szépligeti SK, et al. Excess risk of venous thromboembolism in hip fracture patients and the prognostic impact of comorbidity. *Osteoporos Int*. 2017;28(12):3421-3430. [CrossRef]
16. Parvizi J, Huang R, Rezapoor M, et al. Individualized risk model for venous thromboembolism after total joint arthroplasty. *J Arthroplasty*. 2016;31(9)(suppl):180-186. [CrossRef]
17. Downey C, Kelly M, Quinlan JF. Changing trends in the mortality rate at 1-year post hip fracture - a systematic review. *World J Orthop*. 2019;10(3):166-175. [CrossRef]
18. Scottish Intercollegiate Guidelines Network. Management of hip fracture in older people: a national clinical guideline [Internet]; 2009. Edinburgh, United Kingdom: Scottish Intercollegiate Guidelines Network. https://pdf4pro.com/view/part-of-nhs- quality-improvement-scotland-67a27.html. Accessed February 13, 2020.
19. Uzel K, Azboy İ, Parvizi J. Venous thromboembolism in orthopedic surgery: global guidelines. *Acta Orthop Traumatol Turc*. 2023;57(5):192-203. [CrossRef]
20. Flevas DA, Megaloikonomos PD, Dimopoulos L, et al. Thromboembolism prophylaxis in orthopaedics: an update. *EFORT Open Rev*. 2018;3(4):136-148. [CrossRef]
21. Yılmaz MK, Abbaszadeh A, Restrepo C, et al. Aspirin is an effective prophylaxis for venous thromboembolism after revision hip and knee arthroplasty. *J Arthroplasty*. 2024;39(9S2):S385-S390. [CrossRef]
22. Members of 2007 and 2011 AAOS Guideline Development Work Groups on PE/VTED Prophylaxis, Mont M, Jacobs J, et al. Preventing venous thromboembolic disease in patients undergoing elective total hip and knee arthroplasty. *J Bone Joint Surg Am*. 2012;94(8):673-674. [CrossRef]
23. Callaghan JJ, Dorr LD, Engh GA, et al. Prophylaxis for thromboembolic disease: recommendations from the American College of Chest Physicians – Are they appropriate for orthopaedic surgery? *J Arthroplasty*. 2005;20(3):273-274. [CrossRef]
24. Huang Q, Xing SX, Zeng Y, et al. Comparison of the efficacy and safety of aspirin and Rivaroxaban following enoxaparin treatment for prevention of venous thromboembolism after hip fracture surgery. *Orthop Surg*. 2019;11(5):886-894. [CrossRef]
25. Negm AM, Yamaura L, Clarke A, et al. Effectiveness of thromboprophylaxis agents following hip fracture: a systematic review and network meta-analysis. *JB JS Open Access*. 2023;8(4):e23.00064. [CrossRef]
26. Hu B, Jiang L, Tang H, et al. Rivaroxaban versus aspirin in prevention of venous thromboembolism following total joint arthroplasty or hip fracture surgery: a meta-analysis. *J Orthop Surg Res*. 2021;16(1):135. [CrossRef]
27. Azboy I, Groff H, Goswami K, et al. Low-dose aspirin is adequate for venous thromboembolism prevention following total joint arthroplasty: a systematic review. *J Arthroplasty*. 2020;35(3):886-892. [CrossRef]
28. Eikelboom JW, Hirsh J, Spencer FA, et al. Antiplatelet drugs: antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest*. 2012;141(2)(suppl):e89S-e119S. [CrossRef]
29. Serebruany VL, Steinhubl SR, Berger PB, et al. Analysis of risk of bleeding complications after different doses of aspirin in 192,036 patients enrolled in 31 randomized controlled trials. *Am J Cardiol*. 2005;95(10):1218-1222. [CrossRef]
30. Borges FK, Bhandari M, Guerra-Farfan E. Accelerated surgery versus standard care in hip fracture (HIP ATTACK): an international, randomised, controlled trial. *Lancet*. 2020;395(10225):698-708. [CrossRef]
31. Viktil KK, Lehre I, Ranhoff AH, et al. Serum concentrations and elimination rates of direct-acting oral anticoagulants (DOACs) in older hip fracture patients

hospitalized for surgery: a pilot study. *Drugs Aging*. 2019;36(1):65-71. [CrossRef]
32. Torn M, Bollen WLEM, Van Der Meer FJM, et al. Risks of oral anticoagulant therapy with increasing age. *Arch Intern Med*. 2005;165(13):1527-1532. [CrossRef]
33. Gosch M, Jacobs M, Bail H, et al. Outcome of older hip fracture patients on anticoagulation: a comparison of vitamin K-antagonists and Factor Xa inhibitors. *Arch Orthop Trauma Surg*. 2021;141(4):637-643. [CrossRef]
34. Delaney M, Wendel S, Bercovitz RS, et al. Transfusion reactions: prevention, diagnosis, and treatment. *Lancet*. 2016;388(10061):2825-2836. [CrossRef]
35. Teng Z, Zhu Y, Liu Y, et al. Restrictive blood transfusion strategies and associated infection in orthopedic patients: a meta-analysis of 8 randomized controlled trials. *Sci Rep*. 2015;5(1):13421. [CrossRef]
36. WHO. Global status report on blood safety and availability. Available at: www.who.int/worldblooddonorday/media/who_blood_safety_factsheet_2011.pdf. Accessed January 17, 2021. *Fact sheet;* 279:1-173.
37. Undas A, Brummel-Ziedins K, Mann KG. Why does aspirin decrease the risk of venous thromboembolism? On old and novel antithrombotic effects of acetyl salicylic acid. *J Thromb Haemost*. 2014;12(11):1776-1787. [CrossRef]
38. Azboy I, Barrack R, Thomas AM, et al. Aspirin and the prevention of venous thromboembolism following total joint arthroplasty: commonly asked questions. *Bone Joint J*. 2017;99-B(11):1420-1430. [CrossRef]