Archives of Orthopaedic and Trauma Surgery (2019) 139:167–171
https://doi.org/10.1007/s00402-018-3045-3

ORTHOPAEDIC SURGERY

Mechanical thromboprophylaxis would suffice after total knee arthroplasties in Asian patients?

Young-Hoo Kim[1] · V. Anil[1] · Ashwini Gaurav[1] · Jang-Won Park[2] · Jun-Shik Kim[2]

Received: 30 July 2018 / Published online: 8 October 2018

Abstract

Purpose Our prospective study evaluated the incidence and location of deep vein thrombosis (DVT), the risk factors for PE and the natural history of DVT after TKA in patients who have received only mechanical compression device without having any chemical thromboprophylaxis or therapeutic treatment.

Methods We studied 408 consecutive patients (691 knees) who underwent primary TKA; 283 patients had one-stage bilateral TKAs and 125 had unilateral TKAs. Coagulation assays, the full blood count and blood typing tests, and serum chemical profiles were undertaken in all patients on three separate occasions. Molecular genetic testing was performed preoperatively to detect the genetic traits involving DVT. Bilateral simultaneous or unilateral venograms were carried out at 6 or 7 days after operation. Perfusion lung scanning was undertaken before and at 7 or 8 days after operation.

Results In the 691 venograms in 408 patients, only 4 knees (0.6%) were positive for fresh thrombi. In the 4 knees with DVT, thrombi were located in the calf veins. We observed factor V Leiden mutation, antithrombin-III level, and prothrombin promoter G20210A mutation were absent in all patients. We saw no relationship between DVT and coagulation or thrombophilic data. No pulmonary embolism (PE) occurred as shown by negative perfusion lung scan and absence of symptoms.

Conclusion We concluded that the combinations of absent thrombophilic polymorphisms with low clinical prothrombotic risk factors led to low prevalence of DVT and virtually absent PE after TKA in the current series of patients, who had received mechanical compression device only without chemical thromboprophylaxis.

Keywords Prevalence deep vein thrombosis · Pulmonary embolism · Total knee arthroplasty · Chemical thromboprophylaxis · Mechanical compression device

Introduction

The occurrence of postoperative deep vein thrombosis (DVT) after total knee arthroplasty (TKA) is a well-known serious complication. The reported prevalence of DVT varied from 24 to 60% in early studies in Caucasians [1, 2]. However, currently the prevalence of DVT without prophylaxis in Caucasians was around 4–6% [3]. The prevalence of DVT depends on various factors and differs between each ethnic group of patients. Among the Asian patients, it has been reported that low levels of Factor V Leiden, fibrinogen, factor VII C and VIII C, and lifestyle and diet have been postulated as reasons for lower prevalence of DVT [4–7].

There are two types of thromboprophylaxis. One is using a chemical thromboprophylaxis and the other is using a mechanical compression device. It has been reported that using chemical thromboprophylaxis such as low molecular weight heparin (LMWH) and warfarin led to reduced the prevalence of the DVT to 15–20% [8–10]. The major concern with LMWH and warfarin is the bleeding risk which is as high as 3–7% [10, 11]. Mechanical compression devices have been reported to be less effective in reducing the prevalence of DVT compared to chemical thromboprophylaxis, but there is no risk of bleeding complication [12–14].

The purpose of this prospective study was to (1) evaluate the incidence and location of DVT, (2) identify risk factors for DVT and PE and, (3) follow the natural history of DVT after TKA in patients who have received only mechanical

✉ Young-Hoo Kim
younghookim@ewha.ac.kr

[1] The Joint Replacement Center, Seoul Metropolitan SeoNam Hospital, #20, Sinjeongipen 1-ro, YangCheon-Gu, Seoul 08040, Republic of Korea

[2] The Joint Replacement Center, Ewha Womans University MokDong Hospital, Seoul, Republic of Korea

compression device without having any chemical thromboprophylaxis or therapeutic treatment.

Materials and methods

From September 2015 to March 2018, a total of 408 consecutive patients (691 knees) underwent primary TKR. Of these 283 patients (566 knees) underwent bilateral simultaneous sequential TKAs and 125 patients (125 knees) underwent primary unilateral TKAs. All patients received mechanical compression only for the prevention of DVT. Patients were excluded if they had a previous history of DVT, chronic venous insufficiency, stroke, varicose veins, malignancy, renal insufficiency, recent myocardial infarction, and heart failure. Additionally, if they were taking oral contraceptives, or on steroidal/hormonal/ anticoagulant drugs for any medical condition were excluded from the study. The study protocol, including the consent forms, was approved by the institutional review board at our institution. (IRB number: 2012-08). All patients provided informed consent.

There were 363 women and 45 men with a mean age of 70.14 ± 7.7 years (range 48–94 years) at the time of surgery. All patients had osteoarthritis of knees. The preponderance of female patients (89%) in our study might be attributed to the inherent bow leg deformity, habitual squatting and yoga position. Mean weight was 64 ± 10 kg (range 49–110 kg) and mean height was 153 ± 7 cm (range 145–180 cm). Mean BMI was 27 ± 10 kg/m^2 (range 23–34 kg/m^2). All patients were asked to discontinue taking aspirin-containing compounds and any other antiplatelet medications 14 days before hospital admission.

All operations were performed by the senior author with tourniquet inflation to 250 mm Hg under spinal anaesthesia. An anterior midline skin incision was made between 12 and 15 cm long with a medial parapatellar capsular incision. Nine millimeters of tibial bone was resected with a 3° posterior tibial slope. An anterior cortical reference was used for the AP cut of the distal femur. Femoral component rotation was determined by three reference axes: (1) the transepicondylar axis; (2) the midtrochlear (Whiteside line); and (3) 3° of external rotation relative to the posterior aspect of the condyles. Ligamentous balance was established first in knee extension and then in knee flexion with use of a tensor. All implants were posterior cruciate substituting prosthesis (Optetrak Logic knee prosthesis; Exactech, Gainesville, Florida). All implants were cemented after pulsed lavage irrigation, drying, and pressurization of vacuum-mixed cement using a Palacos cement (Zimmer Biomet, Warsaw, Indiana). Suction drains were placed in the wound and removed after 48 h. Intra-operative blood loss was tabulated from the volume of blood in suction drains and weighing the swabs used. Post-operative blood loss was assessed by measuring wound drainage in the hemovac.

All patients were administered a dose of 1 g tranexamic acid intravenously 15 min before skin incision was made and another dose of 1 g tranexamic acid was administered intravenously 20 min before the tourniquet was deflated of the second knee (in bilateral TKAs). The mean total tourniquet time was 37 min (range 35–45 min).

Patients were on bed rest for the first 1 postoperative day and were allowed to stand on the second post-operative day and then progressed to full weight bearing activity with crutches as tolerated. They were advised to use crutches for 4 weeks and to use a cane thereafter that as needed.

For prophylaxis against DVT and pulmonary embolism (PE), a DVT-3000 impulse system (DS, Maref, Gunpo, Republic of Korea) was used on both legs and thighs for all patients post-operatively. Mechanical compression was started on the day of operation and continued for 10–14 days after the operation. We applied continuous mechanical pneumatic compression 4 h two times a day. We used sleeves with three circumferential air chambers running the distance from ankle to thigh. The DVT-3000 provides bilateral and graded sequential compression with fixed cycling rate. The pneumatic compression cycle was set at 12 s with a pressure of 40–45 mm Hg applied for 60 cycles per hour. All of these patients were compliant to use DVT-3000 impulse system. Patients were followed at 3 months, 1 year and 2–3 years thereafter. Mean follow-up was 2.3 years (range 2–4 years).

Coagulation assays (platelet count, prothrombin time, partial thromboplastin time, fibrogen, antithrombin III and factor VIII), a full blood count, blood typing, serum chemical profile tests were performed in all patients on three separate occasions: on the day before operation, on the 2nd or 3rd postoperative day and on the 6th or 7th postoperative day. All of these patients received sonogram first and additional venograms to improve the detection rate of thrombi using technetium-99 m-macroaggregated albumin (TcMAA) performed on post-operative day 7 or 8. Sonogram in suspected DVT focuses primarily on the femoral and popliteal vein. Tc MAA in suspected DVT focuses on the both distal and proximal femoral veins.

The criterion for diagnosing DVT was filling defect in a deep vein of defects surrounded by a narrow rim of contrast material. Any readmission to a hospital for thromboembolic complications was recorded. Both before and after surgery, all patients underwent electrocardiogram and chest radiography, and serial measurement of blood gases and serum enzymes were performed. All of patients had pre-operative and post-operative perfusion lung scans using a standardized technique. Results of preoperative examinations were compared with those of examinations conducted 7 or 8 days after surgery to detect new PE. Ventilation lung scanning

and computerized tomographic (CT) lung scanning were performed only when perfusion lung scans were positive.

Statistical analysis

Statistical analysis was performed using the Student's *t* test or Wilcoxon nonparametric test, χ^2 and Fisher's exact tests, and the Mann–Whitney *U* test. All statistical calculation was performed using SPSS version 20.0 for Windows (IBM Corp). A *p* value of <0.05 was considered to be significant.

Results

After surgery, out of the 691 venograms of lower extremities in the 408 patients in the current series, only 4 knees (0.6%) were positive for DVT. Four patients with DVT were women, and thrombi were located in calf veins in the single leg of each patient (Table 1). We observed no complications related to venograms. Preop-and postoperative laboratory data, age and bone mass index were statistically not different ($p<0.05$) between patients with or without DVT. DVT occurred in the 4 patients with bilateral TKAs. All of these 4 DVTs were asymptomatic. Pre-and post-operative perfusion lung scans revealed no evidence of PE in any patients. We saw no relationship between DVT and coagulation or thrombophilic data (Table 2). We observed a relationship between DVT and factor V Leiden mutation, antithrombin-III level, and prothrombin promoter G20210A mutation. Factor V Leiden mutation and prothrombin promoter G20210A mutation were absent in all patients in the current series. Antithrombin-III level was normal in all patients. No patient was readmitted related to DVT. We found that administration of tranexamic acid did not increase the risk of DVT.

Table 1 Sites of thrombi in knees

Site	Bilateral TKA	Unilateral TKA
Knees with no thrombi	562 Knees (99%)	125 Knees (100%)
Knees with thrombi	4 Knees (0.3%)	0 Knee (0%)
Calf veins	4 Knees (0.7%)	0 Knee (0%)

TKA total knee arthroplasties

Discussion

The literature review suggests that the prevalence of DVT in Asian patients is variable. Fujita et al. [15] reported an incidence of 48.6% in 138 patients after TKA. Ko et al. [16] reported the incidence of DVT was 31% in 58 Japanese TKA patients. Sudo et al. [17] reported the incidence of DVT was 4% in 25 Japanese TKA patients. Park et al. [18] reported the incidence of DVT and PE was 4% and 1.3%, respectively, after studying 375 Korean patients with TKAs. Lee et al. [19, 20] studied the National Claim registry of Korea and reported the countrywide incidence of DVT to be 0.22% in the TKA patients.

Kim et al. [21] reported an incidence of DVT of 6.6% among 1434 Korean patients who underwent TKA using mechanical compression devices postoperatively. Nagase et al. [22] reported the prevalence of post-operative PE after the use of mechanical prophylaxis alone was 0.66% and 0.40% after combined use of fondaparinux and mechanical prophylaxis in patients with THA or TKA. Kanchanabatet al. [23] performed a metanalysis on the rate of DVT after orthopaedic surgery in Asian patients without thromboprophylaxis. They found very low prevalence of DVT and no fatal PE in Asian patients. After their extensive analysis of DVT in their Korean patients, Kim et al. [20, 24, 25] found a low prevalence of DVT and PE after TKA. They reported that the absence of thrombophilic polymorphisms, particularly

Table 2 Prevalence of deep vein thrombosis after TKA in Asian patients

Authors	Country	Number of patients	Prevalence
Dhillon et al. [16]	Malaysia	34	76.3%
Fujita et al. [17]	Japan	138	48.6%
Koet et al. [18]	Japan	58	31%
Sudo et al. [19]	Japan	25	4%
Park et al. [20]	Korea	375	4%
Jain et al. [3]	India	46	0%
Lee et al. [21]	Korea	National Claim Registry of Korea	0.22%
Kim et al. [23]	Korea	1,434	6.6%
Nagase et al. [24]	Japan	27,542 (THA or TKA)	0.4%
Kim et al. [26–28]	Korea	735	27.2% (No any prophylaxis)
Kim et al. (current study)	Korea	408	0.6%

factor V Leiden mutation, antithrombin-III deficiency, and prothrombin promoter G20210A mutation, signalled a low incidence of DVT and PE. In the current series, we found very low prevalence of DVT (0.6%) and no PE. This finding concurs with the findings of Lee et al. [19] and Nagase et al. [22].

Kim et al. [26] reported that tranexamic acid did not increase the risk of thromboembolism after bilateral simultaneous total knee arthroplasties in Asian population. We concur with their findings.

Although the results of this study suggest that chemical thromboprophylaxis is not needed in Asian population, only a large prospective randomized control trial would be able to answer this question. Further prospective randomized controlled studies are needed whether the routine chemical thromboprophylaxis should be avoided or not [27, 28].

There are some limitations in our study. First, the present study has not addressed the subjective knee score and objective clinical findings of the patient after TKA, as the main purpose of this study was to evaluate the incidence of DVT after TKAs without DVT chemical thromboprophylaxis. Second, the current series, no patients with morbid obesity, preponderance of women and good preoperative range of knee motion: these factors might limit general applicability to other patients or practice settings. On the other hand, the patients in this series engaged in heavy labor activities such as farming, squatting, and lifting.

The findings of the current study demonstrated that the rate of DVT and PE was very low in this patient cohort, who had received mechanical compression device only without chemical thromboprophylaxis after TKA.

Funding There is no funding source.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article contains studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Hull RD, Raskob GE (1986) Prophylaxis of venous thromboembolic disease following hip and knee surgery. J Bone Joint Surg Am 68:146
2. McKenna R, Bachmann F, Kaushal SP, Galante JO (1976) Thromboembolic disease in patients undergoing total knee replacement. J Bone Joint Surg Am 58:928
3. Falck-Ytter Y, Francis CW, Johanson NA, Curley C, Dahl OE, Schulman S, Ortel TL, Pauker SG, Colwell CW Jr. (2012) Prevention of VTE in orthopedic surgery patients: antithrombotic, therapy and prevention of thrombosis, 9th edition: American College of chest physicians Evidence-based Clinical Practice Guidelines. Chest 141:e278S
4. Lee WS, Kim KI, Lee HJ, Kyung HS, Seo SS (2013) The incidence of pulmonary embolism and deep vein thrombosis after knee arthroplasty in Asians remains low-A meta-analysis. Clin Orthop Relat Res 471:1523
5. Spencer FA, Emery C, Joffe SW, Pacifico L, Lessard D, Reed G, Gore JM, Goldberg RJ (2009) Incidence rates, clinical profile, and outcomes of patients with venous thromboembolism. The Worcester DVT study. J Thromb Thrombolysis 28:401
6. Dowling NF, Austin H, Dilley A, Whitsett C, Evatt BL, Hooper WC (2003) The epidemiology of venous thromboembolism in Caucasians and African-Americans: the GATE Study. J Thromb Haemost 1:80
7. Leizorovicz A, Turpie AGG, Cohen AT, Wong L, Yoo MC, Dans A, SMART Study Group (2005) Epidemiology of venous thromboembolism in Asian patients undergoing major orthopedic surgery without thromboprophylaxis. The SMART study. J Thromb Haemost 3:28
8. Lewis CG, Inneh IA, Schutzer SF, Grady-Benson J (2014) Evaluation of the first-generation AAOS clinical guidelines on the prophylaxis of venous thromboembolic events in patients undergoing total joint arthroplasty: experience with 3289 patients from single institution. J Bone Joint Surg Am 96:1327
9. Pulmonary Embolism Prevention (PEP) Trial collaborative Group (2000) Prevention of pulmonary embolism and deep vein thrombosis with low dose aspirin: pulmonary Embolism Prevention (PEP) trial. Lancet 355:1295
10. Lieberman JR, Pensak MJ (2013) Prevention of venous thromboembolic disease after total hip and knee arthroplasty. J Bone Joint Surg Am 95:1801
11. Hull RD, Yusen RD, Bergqvist D (2009) State-of-the-art review: Assessing the safety profiles of new anticoagulants for major orthopedic surgery thromboprophylaxis. Clin Appl Thromb Hemost 15:377
12. Sakai T, Izumi M, Kumagai K, Kidera K, Yamaguchi T, Asahara T, Kozuru H, Jiuchi Y, Mawatari M, Osaki M, Motokawa S, Migita K (2016) Effects of a foot pump on the incidence of deep vein thrombosis after total knee arthroplasty in patients given edoxaban. A randomized controlled study. Medicine 95:e2247
13. Colwell CW Jr., Froimson MI, Anseth SD, Giori NJ, Hamilton WG, Barrack RL, Buehler KC, Mont MA, Padgett DE, Pulido PA, Barmes CL (2014) A mobile compression device for thrombosis prevention in hip and knee arthroplasty. J Bone Joint Surg Am 96:177
14. Westrich GH, Sculco TP (1996) Prophylaxis against deep venous thrombosis after total knee arthroplasty. Pneumatic plantar compression and aspirin compared with aspirin alone. J Bone Joint Surg Am 78:826
15. Fujita S, Hirota S, Oda T, Kato Y, Tsukamoto Y, Fuji T (2000) Deep venous thrombosis after total hip or total knee arthroplasty in patients in Japan. Clin Orthop Relat Res 375:168
16. Ko PS, Chan WF, Siu TH, Cheng A, Lee OB, Lam JJ (2003) Duplex ultrasonography after total hip or knee arthroplasty. Int Orthop 27:168
17. Sudo A, Sano T, Horikawa K, Yamakawa T, Shi D, Uchida A (2003) The incidence of deep vein thrombosis after hip and knee arthroplasties in Japanese patients: a prospective study. J Orthop Surg (Hong Kong) 11:174
18. Park SH, Ahn JH, Park YB, Lee SG, Yim SJ (2016) Incidences of deep vein thrombosis and pulmonary embolism after total knee arthroplasty using a mechanical compression device with and without low-molecular-weight heparin. Knee Surg Relat Res 28:213

19. Lee SY, Ro DH, Chung CY, Lee KM, Kwon SS, Sung KH, Park MS (2015) Incidence of deep vein thrombosis after major lower limb orthopedic surgery: analysis of a nationwide claim registry. Yonsei Med J 56:139
20. Kim Y-H, Kim JS (2002) Incidence and natural history of deep-vein thrombosis after total knee arthroplasty. A prospective, randomised study. J Bone Joint Surg Br 84:566
21. Kim K-I, Cho K-Y, Jin W, Khurana SS, Bae D-K (2011) Recent Korean perspective of deep vein thrombosis after total knee arthroplasty. J Arthroplasty 26:1112
22. Nagase Y, Yasunaga H, Horiguchi H, Hashimoto H, Shoda N, Kadono Y, Matsuda S, Nakamura K, Tanaka S (2011) Risk factors for pulmonary embolism and the effects of fondaparinux after total hip and knee arthroplasty: a retrospective observational study with use of a national database in Japan. J Bone Joint Surg Am 93:e146
23. Kanchanabat B, Stapanavatr W, Meknavin S, Soorapanth C, Sumanasrethakul C, Kanchanasuttirak P (2011) Systematic review and meta-analysis on the rate of postoperative venous thromboembolism in orthopaedic surgery in Asian patients without thromboprophylaxis. Br J Surg 98:1356
24. Kim YH, Yoo JH, Kim JS (2007) Factors leading to decreased rates of deep vein thrombosis and pulmonary embolism after total knee arthroplasty. J Arthroplasty 22:974
25. Kim YH (1990) The incidence of deep vein thrombosis after cementless and cemented knee replacement. J Bone Joint Surg Br 72:779
26. Kim Y-H, Park J-W, Kim J-S, Seo D-H (2018) Does tranexamic acid increase the risk of thromboembolism after bilateral simultaneous total knee arthroplasties in Asian population? Arch Orthop Trauma Surg 138:83
27. Warwick D (2012) Prevention of venous thromboembolism in total knee and hip replacement. Circulation 125:2151
28. Mayer A, Schuster P, Fink B (2017) A comparison of apixaban and dabigatran etexilate for thromboprophylaxis following hip and knee replacement surgery. Arch Orthop Trauma Srug 137:797