

Perioperative pain control is important for prevention of venous thromboembolism after around the knee osteotomy

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Research article

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Abstract

Background: Venous thromboembolism (VTE), including deep venous thrombosis (DVT) and pulmonary embolism (PE) are well-known complications after TKA. However, there are few reports about VTEs after around the knee osteotomy (AKO).

Purpose: To investigate the incidence of and risk factors for VTEs after AKO.

Methods: A total 108 AKO cases were assessed in this study. The procedures included open-wedge high tibial osteotomy (OWHTO; n=96), hybrid closed-wedge high tibial osteotomy (CWHTO; n=7), distal femoral osteotomy (DFO; n=2), tibial condylar valgus osteotomy (TCVO; n=2), and double level osteotomy (DLO; n=1). Ultrasonography of the lower extremities was performed for all patients at 1 week after AKO. The incidence of VTEs was investigated, and a logistic regression analysis was performed to determine which patient demographics, pre-operative clinical results and surgical factors were associated with DVT or PE after surgery.

Results: Of the 108 patients who underwent AKO, 29 (26.9%) developed postoperative DVT, but no patients developed PE. The logistic regression analysis identified abrasion chondroplasty (odds ratio [OR], 3.46) and pre-operative pain visual analog scale (VAS; OR, 1.05) as independent predictors of DVT.

Conclusion: The incidence of DVT after AKO is relatively high and preoperative and postoperative pain may induce DVT. Perioperative pain control is important for preventing VTEs.

Introduction

Venous thromboembolic events (VTEs), including deep venous thrombosis (DVT) and pulmonary embolism (PE) are well-known and well-studied complications after total knee arthroplasty (TKA). Several studies have also mentioned VTEs after anterior cruciate ligament reconstruction (ACLR) [1]. In the relevant literature, the reported incidence of VTEs after TKA and ACL reconstruction was 0.36–62.5%[2–4], and 0.5%[1, 6], respectively. The risk factors associated with VTEs after TKA included advanced age (> 70 years), drain use, and delayed ambulation (≥ 72 h) after surgery [4]. The risk factors for VTEs after ACLR included age > 35 years, history of nicotine use, anticoagulant use, concomitant HTO, or concomitant posterior cruciate ligament (PCL) reconstruction [1]. However, there are few reports about VTEs after around the knee osteotomy (AKO). The purpose of this study was to detect the frequency of and risk factors for VTEs after AKO. We hypothesized that the incidence of VTEs would be an intermediate value between the incidence rates of VTEs in TKA and ACLR, and that the risk factors would be high body mass index (BMI), history of nicotine use, bleeding, and increased operation time.

Methods

This cross-sectional study used completely de identified data and was exempt from institutional review board approval. From October 2013 to October 2019, a total 138 cases underwent around the knee

osteotomy (AKO). One hundred eight cases were assessed by ultrasonography of the lower extremities at 1 week after AKO (Fig. 1A, B). The assessment of ultrasonography was performed by professional technician. The study population included 29 men and 79 women. The average age was 60.8 years and the average BMI was 26.5. The procedures included open-wedge high tibial osteotomy (OWHTO; n = 96), hybrid closed-wedge high tibial osteotomy (CWHTO; n = 7), distal femoral osteotomy (DFO; n = 2), tibial condylar valgus osteotomy (TCVO; n = 2), and double level osteotomy (DLO; n = 1). Patients with symptomatic osteoarthritis of the patellofemoral joint and lateral compartment, rheumatoid arthritis, a knee range of movement < 100°, high-grade ligamentous instabilities, or extensive loss or absence of the lateral meniscus were excluded from the study.

Age, sex, body mass index (BMI), and operative side were assessed as patient demographic factors. Smoking, use of female hormone medication, steroids, NSAIDs, anticoagulants, antihypertensive agents and psychotropic agents, and diabetes were assessed as medical comorbidities. A perioperative decrease in hemoglobin level, operation time, concomitant surgery (ACL, meniscus), abrasion chondroplasty, correction angle, rate of infection were assessed as operative variables. Preoperative pain visual analog scale (VAS), knee injury and osteoarthritis outcome score (KOOS) [7] subcategory (Pain, Symptom, ADL, Sports & Recreation activity, QOL), Knee Society score [8], 3-meter timed up and go test (TUG) [9], single leg standing test (SLS; maximum 30 seconds) [10], and the isometric muscle strength of knee extension and flexion measured using an EasyTech Genu Plus®[†] (Firenze, Italy) were assessed as preoperative clinical results.

In all cases, VTEs were detected by ultrasonography of the lower extremities at 1 week after AKO, irrespective of whether they had symptoms of VTEs. The demographics, medical comorbidities, operative variables, and preoperative clinical results were compared between patients with and without VTE. Furthermore, a logistic regression analysis was performed to identify patient demographic factors, medical comorbidities, operative variables, and preoperative clinical results that were associated with DVT or PE after surgery.

Surgical technique and postoperative rehabilitation

All operations were performed or supervised by a single surgeon (K.M.). Prior to the HTO, diagnostic arthroscopy was performed to verify the correct indication. Arthroscopic synovectomy and lateral release were performed if necessary.

If the anterior instability due to ACL injury was noted, a single bundle ACL reconstruction using hamstring tendon was performed. Partial meniscectomy was performed for degenerative tears of the medial meniscus. Suturing of the meniscus was not performed in this study. Abrasion chondroplasty or using 4.0 mm abrader bar was performed for chondral defects of the medial compartment of the knee (Fig. 2), and autologous chondrocyte implantation (ACI) was not performed in this study. According to the recommendations of the AO Expert group [11, 12], biplanar osteotomy was performed in all patients. The angle of open wedge of the tibia during HTO was determined when the weight-bearing line (WBL) ratio

passed through 62.5% of the tibial plateau, which was defined as Fujisawa's point [13], using an alignment rod under intraoperative fluoroscopy. The osteotomy was stabilized using a long-type locking plate (TomoFix, Synthes, Bettlach, Switzerland; or TriS, Olympus Terumo Biomaterials, Tokyo, Japan). An artificial bone graft (OSferion 60; Olympus Terumo Biomaterials) was inserted into the osteotomy gap to start early weight-bearing [14].

Postoperative rehabilitation began the day after surgery, when active and passive range-of-motion exercises and muscle strengthening were started. Range-of-motion training was continued until a maximum flexion angle of at least 130° was obtained within 3 weeks of surgery. Standing exercises were also initiated as soon as possible. One week after surgery, patients were permitted to begin half-weightbearing exercises with walker equipment, and full-weightbearing walking was allowed 2 weeks after surgery. A return to normal sports activities, including jogging, was permitted after verifying bone union at the osteotomy site.

Perioperative anticoagulation therapy

Anticoagulant withdrawal was performed before surgery to minimize the level of intraoperative and postoperative bleeding. In this study, 1 case of was administered prasugrel, aspirin, sarpogrelate, and ethyl icosapentate, respectively. Prasugrel was withdrawn two weeks before surgery. and the other anticoagulants were withdrawn one week before surgery.

All patients were equipped with foot pumps on the unaffected side during the operation, and elastic stockings were put on both lower legs immediately after the operation. All patients continued to take edoxaban at a dosage of 15 mg for 2 weeks from the day after surgery. If the patient was taking a different anticoagulant, then that same anticoagulant was resumed after completing the treatment regimen with edoxaban.

Statistical Analysis

Each individual variable was compared between patients with and without VTE; t-tests were performed as a univariate analysis. P values of < 0.05 were considered to indicate statistical significance in the univariate analysis. A logistic regression analysis was performed, and the resulting odds ratios (ORs) with 95% CIs were calculated for all independent predictors of VTE. P values lower than the specified cutoff of 0.05 were considered statistically significant (SPSS Statistics v26.0; IBM Corporation).

Results

The patient demographics are shown in Table 1. The average age at surgery was 60.8 years, the average BMI was 26.5, 74.1% of the patients were female, and the procedure involved the right knee in 42.6% of the patients. Of the 108 patients who underwent AKO, 29 cases (26.9%) developed postoperative DVT. However, no patients developed PE. Therefore, the comparison of patients with and without VTEs compared patients with and without DVT. The variables tested in the univariate analysis are shown in

Table 2. With regard to the patient demographics, there were no significant differences between patients with and without DVT.

The medical comorbidities that were more common in the DVT group included diabetes requiring medication (19% vs. 3%, $P = 0.006$) (Table 1).

With regard to operative variables, the postoperative anemia group had a higher frequency of DVT (2.6% vs. 2.1%, $P = 0.02$). Concomitant surgery (ACL reconstruction or meniscal repair) and the correction angle during AKO did not significantly affect the development of DVT ($P = 0.49, 0.31$, respectively).

With regard to the preoperative clinical results, the timed up and go test (TUG) and isometric muscle strength of the hamstrings were associated with a higher frequency of DVT (11.3 sec vs. 9.8 sec, $P = 0.04$, 42.5% vs. 56.5%, $P = 0.005$, respectively).

A logistic regression analysis revealed multiple independent predictors of DVT after AKO (Table 3). The variable with the highest OR for DVT was abrasion chondroplasty (OR, 3.46; 95%CI, 1.06–11.30; $P = 0.04$) at the time of AKO. Preoperative pain VAS (OR, 1.05; 95% CI, 1.00-1.11; $P = 0.04$) was another significant independent predictor of DVT.

Discussion

The incidence of DVT after AKO was 26.9% in this study, and the rate was considered to be relatively high, despite the early postoperative evaluation. The rate of DVT after AKO was almost the intermediate value between TKA and ACLR; thus, our hypothesis was confirmed. The incidence of symptomatic VTEs in Asian regions is low in comparison to studies targeting Western populations [5]. The overall rates of symptomatic in-hospital DVT in patients undergoing THA and TKA were 0.21% and 0.36%, respectively. The incidence of VTEs in the study was much lower than that in the present study because the definition of VTEs only included symptomatic VTEs. There were no cases of symptomatic VTEs in this study. Greets reported that the incidence of DVT, which is detected by screening tests, ranges from 42–57% after hip arthroplasty and from 41–85% after knee arthroplasty [15]. Therefore, the incidence of DVT after AKO in this study was comparable to that in previous studies. It was emphasized that VTEs even occurred without symptoms, and an assessment of all patients by ultrasonography of the lower extremities was important to avoid missing VTE.

The logistic regression analysis revealed that the preoperative pain VAS and abrasion chondroplasty were independent predictors of DVT after AKO. Abrasion chondroplasty is a factor that increases postoperative pain; thus, both items were considered to be factors related to pain. It is well-known that the frequency of DVT increased due to immobilization of lower extremity, and that decreased activity due to perioperative pain was considered a risk factor for DVT. Thus, perioperative pain control was considered important for the prevention of VTEs. Many risk factors have been reported to increase the incidence of DVT after total joint arthroplasty, including increasing age, sex (female), obesity, diabetes mellitus, congestive heart failure, a history of VTE, cancer, and immobilization [4, 16, 17, 18]. The indication for AKO was primarily

an active patient, and the average BMI was 26.5, which is relatively low in comparison to Western populations. Thus, fewer risk factors were reported in this study in comparison to previous studies.

No studies have reported a relationship between perioperative clinical results and VTEs. Pearse et al. reported that an early mobilization protocol (beginning to walk less than 24 h after knee replacement) not only resulted in a 30-fold reduction in the risk of postoperative DVT after TKA after adjustment for other risk factors, but also brought about fewer episodes of syncope, less pain, and less need of analgesics, which may be related to psychological preparation [19]. In this study, the timed up and go test of the patients without DVT was significantly shorter in comparison to patients with DVT (9.8 sec vs. 11.3sec; $P = 0.04$; Table 2); thus, the patients without DVT could walk faster than the patients with DVT. It was thought that patients could walk fast because they had less pain and that walking fast prevented immobilization. A similar relationship was considered to exist regarding the single leg standing test and isometric muscle strength results (Table 2). Patients without DVT could stand longer than patients with DVT, and the muscle strength of patients without DVT was stronger than that of patients with DVT. Abrasion chondroplasty was also identified as a risk factor for DVT in this study. The reason for this is obvious: operations that include abrasion chondroplasty are associated with stronger postoperative pain than those without abrasion chondroplasty.

The present study was associated with some limitations. First, the study population was relatively small. Second, the assessment of VTEs by ultrasonography was performed 1 week after surgery; thus, preoperative VTEs were not assessed. VTEs may have developed before surgery in the patients with DVT. Third, several operations were performed for AKO in this study, including OWHTO, CWHTO, DFO, TCVO, and DLO. The degree of invasiveness and the operative time differed for each operation. It will be necessary to evaluate each operation in the future. In the context of these limitations, our results have to be interpreted with caution.

Conclusions

In conclusion, the incidence of DVT after AKO was relatively high (26.9%). and preoperative and postoperative pain may induce DVT. Perioperative pain control is important for the prevention of VTEs, and it is important that all patients undergo an assessment of the lower extremities using ultrasonography in order to avoid missing VTEs.

Abbreviations

VTE Venous thromboembolism; DVT: Deep vein thrombosis; PE: Pulmonary Embolism; AKO: Around the knee osteotomy; TKA: Total Knee Arthroplasty; ACL: Anterior cruciate ligament; OWHTO: open-wedge high tibial osteotomy; CWHTO: closed-wedge high tibial osteotomy ; DFO: distal femoral osteotomy; TCVO: tibial condylar valgus osteotomy; DLO: double level osteotomy

Declarations

Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors. The need for ethics approval was waived by Koshigaya Municipal Hospital IRB since data checking was anonymous (Approval no. 30-5).

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Not applicable.

Authors' contributions

KM – Study design, data collection, statistical analysis, original writing of manuscript, editing manuscript. KY – Literature review, original writing of manuscript, editing

manuscript. ST - Original writing of manuscript, editing manuscript. OR - Editing manuscript. IM - Original writing of manuscript, editing manuscript. All authors have read and approved the manuscript.

Competing interests

The authors declare that they have no competing interests.

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Not applicable.

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Tables

Table 1

Patient demographics

Variable	Average
Age	60.8
Sex (Female, %)	74.1
BMI	26.5
Side (Right, %)	42.6

Table 2

Comparison with and without deep vein thrombosis (DVT) following around the knee osteotomy (AKO)

Variable	Patients With DVT (n=29), %	Patients Without DVT (n=79), %	P Value
Patient demographics			
Sex (Female, %)	76	73	0.80
Age	61.8	60.4	0.58
BMI	26.5	26.6	0.92
Side (Right, %)	48	41	0.48
Medical comorbidities			
Smoking (cigarette / day)	2.4	2.9	0.72
Female hormone (%)	0	1	0.32
Steroid (%)	3	1	0.56
NSAIDs (%)	62	57	0.64
Anticoagulants (%)	7	3	0.40
Antihypertensive (%)	38	43	.064
Diabetes (%)	3	19	0.006**
Psychotropic agents (%)	17	17	0.95
Operative variables			
Anemia ¹	2.6	2.1	0.02*
Operation Time (min)	121.6	128.8	0.31
Concomitant surgery ² (%)	24	18	0.49
Abrasion	69	63	0.58
Correction angle	12.3	11.6	0.31
Infection (%)	3	3	0.82
Pre-operative clinical results			
VAS	61.2	61.8	0.92
KOOS Symptom	54.3	55.5	0.77
KOOS Pain	45.9	47.8	0.62
KOOS ADL	59.4	64.7	0.13

KOOS Sports &Rec	25.7	27.8	0.60
KOOS QOL	28.4	27.5	0.79
KSS ³	65.1	66.8	0.26
TUG ⁴ (Seconds)	11.3	9.8	0.04*
SLS ⁵ (Seconds)	16.4	20.3	0.13
Quadriceps strength (%BW)	94.3	107.4	0.19
Hamstrings strength (%BW)	42.5	56.5	0.005**

*: P<0.05, **: P<0.01,

Anemia¹: difference in hemoglobin levels before and after surgery; Concomitant surgery²: ACL reconstruction, meniscectomy; KSS³: Knee society score; TUG⁴: 3m Timed up and go test; SLS⁵: Single limb standing test (maximum 30 seconds)

Table 3

Logistic regression analysis of the risk factors for deep vein thrombosis following around the knee osteotomy (AKO)

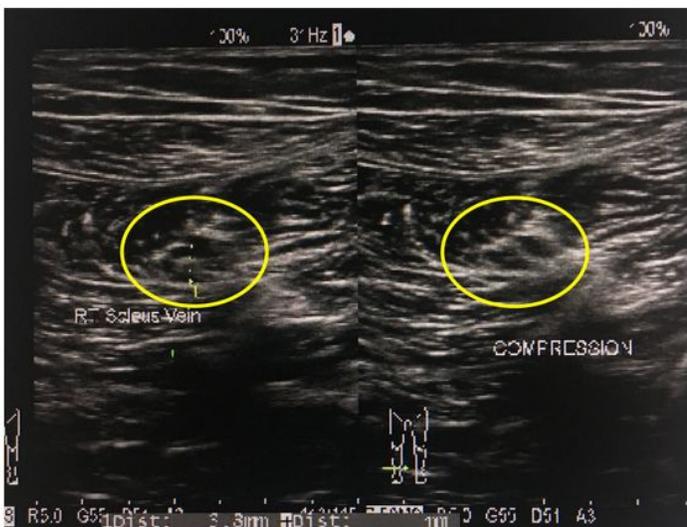
Variable	OR	95% CI	<i>P value</i>
Patient demographics			
Sex (Female, %)	0.34	0.65-1.74	0.21
Age	1.02	0.92-1.13	0.69
BMI	2.36	0.12-46.72	0.57
Side (Right, %)	1.95	0.31-12.38	0.48
Medical comorbidities			
Smoking (cigarette / day)	0.99	0.86-1.13	0.85
Female hormone (%)	0.02	0.01-1.16	0.95
Steroid (%)	0.34	1.01-26.56	0.63
NSAIDs (%)	2.70	0.65-11.21	0.17
Anticoagulants (%)	9.47	0.26-341.28	0.22
Antihypertensive (%)	1.037	0.20-5.43	0.97
Diabetes (%)	0.94	0.20-43.64	0.97
Psychotropic agents (%)	6.19	0.48-80.43	0.16
Operative variables			
Anemia	0.48	0.17-1.02	0.55
Operation Time (min)	0.99	0.96-1.01	0.37
Concomitant surgery (%)	5.91	0.47-75.16	0.17
Abrasion chondroplasty	3.46	1.06-11.30	0.04*
Correction angle	0.85	0.60-1.21	0.38
Infection (%)	3.31	0.54-205.11	0.57
Pre-operative clinical results			
VAS	1.05	1.00-1.11	0.04*
KOOS Symptom	0.98	0.93-1.03	0.43
KOOS Pain	1.02	0.93-1.11	0.64
KOOS ADL	0.95	0.87-1.04	0.24
KOOS Sports &Rec	1.03	0.97-1.09	0.35

KOOS QOL	1.02	0.98-1.08	0.34
KSS	0.96	0.85-1.07	0.44
TUG (Seconds)	1.27	0.90-1.78	0.18
SLS (Seconds)	0.94	0.87-1.02	0.15
Quadriceps strength (%BW)	1.00	0.98-1.02	0.75
Hamstrings strength (%BW)	0.98	0.98-1.02	0.32

*: P<0.05

Figures

A



B

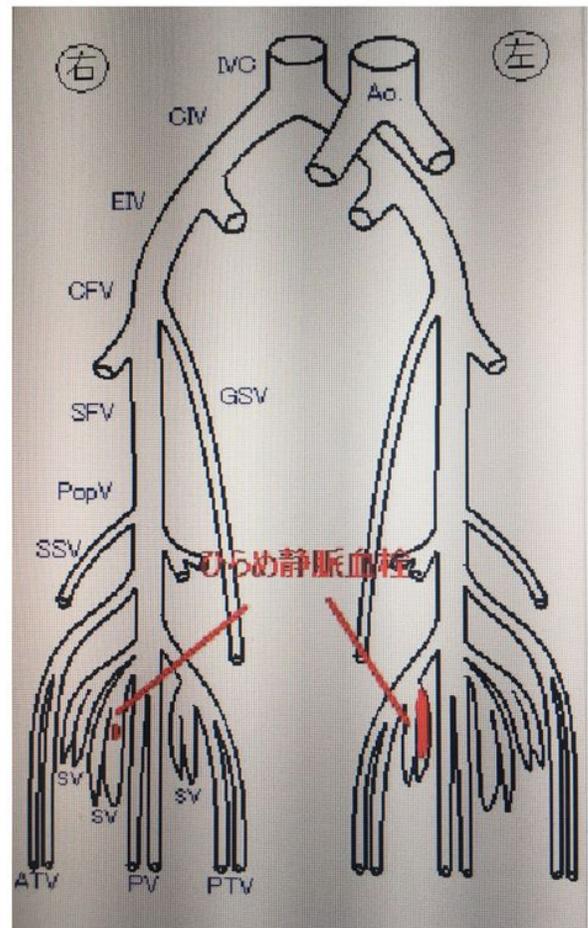


Figure 1

A: Ultrasonography of the lower leg of a 64-year-old woman. The left yellow frame shows a thrombus in the soleus vein. The right yellow frame shows that the thrombus was not flattened by compression. The body mass index (BMI) of the patient was 30, and her preoperative pain VAS was 86. The patient underwent abrasion chondroplasty during open wedge high tibial osteotomy (OWHTO). B: A pattern diagram of deep venous thrombosis (DVT). The red mark indicates DVT. DVT was found not only on the affected side (left) but also on the opposite side.

A



B



Figure 2

A: Abrasion chondroplasty using 4.0mm abrader bar was performed for chondral defects of the medial compartment of the knee. B: Second look after abrasion chondroplasty. Vigorous fibrous cartilage is growing at the site of abrasion chondroplasty.