Does Anterior Cruciate Ligament Reconstruction Increase Venous Thromboembolism Risk Compared to Knee Meniscectomy Under Arthroscopy?

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Research Article

Keywords: Arthroscopic knee surgery, Venous thrombosis, Anterior cruciate ligament reconstruction, Meniscectomy

Posted Date: November 16th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-1074505/v1>

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Abstract

Background: This study compared the incidence of postoperative venous thromboembolism (VTE) between meniscectomy and anterior cruciate ligament reconstruction (ACLR) under arthroscopy and determined whether ACLR increases the VTE risk compared to meniscectomy.

Methods: A retrospective study including 468 patients, ranging in age from 18 to 70 years, was divided into an ACLR group and a meniscectomy group according to the intervention procedures.

All patients routinely received VTE screening by venous ultrasonography in postoperative week 2 and then clinical follow-up at 4 and 6 weeks post surgery. The incidence of VTE was calculated and clinical factors such as age, sex, body mass index (BMI), smoking, concomitant procedure, Caprini score, and duration of tourniquet were evaluated in relation to the risk factors for VTE.

Results: A total of 341 patients who underwent arthroscopic ACLR or meniscectomy were available for analysis. Of these, 130 (38.1%) received ACLR, and 211 (61.9%) received meniscectomy. There was no pulmonary embolism (PE) or femoral deep vein thrombosis (DVT) reported in either group. Fourteen patients (10.8%) developed VTE in the ACL group compared to 17 (8.1%) in the meniscectomy group, with no significant difference ($P=0.397$). Among these patients, 4 (3.1%) patients in the ACL reconstruction group and 3 (1.4%) patients in the meniscectomy group had DVT confirmed by ultrasound Doppler ($P>0.05$). Age was shown to be the only independent risk factor for the development of VTE postoperatively ($p=0.027$). ACLR had a tendency ($OR=3.129$) to increase the risk of VTE but failed to reach statistical significance ($p = 0.052$). ACLR had a tendency ($OR=3.129$) to increase the risk of VTE but failed to reach statistical significance ($p = 0.052$).

Conclusion: The incidence of VTE after ACLR and meniscectomy within 6 weeks post surgery was 10.8% and 8.1%, respectively. Age was the only independent risk factor for the development of VTE postoperatively.

Background

Knee arthroscopy is used for the treatment of many kinds of knee injuries, with over 5 million patients undergoing it globally every year [1]. Knee arthroscopic surgery is minimally invasive and safe with a relatively low risk of venous thromboembolism (VTE) [2]. A previous meta-analysis found an overall rate of deep vein thrombosis (DVT) of 9.9% [3]. Two recent studies with large populations reported rates of DVT of 0.46% and rates of pulmonary embolism from 0.05–0.11% [4, 5].

With new technological developments and extensions of the indications for knee arthroscopic surgery, some arthroscopic procedures make use of a tourniquet for a longer time during the operation, which will result in an increased risk of DVT [6]. One recent study also showed that different procedures under arthroscopy might affect the VTE risk after surgery [7]. For example, anterior cruciate ligament reconstruction (ACLR), as the most important and common surgical procedure in knee sports medicine,

may increase the risk of VTE due to the complexity of its procedure[8–10]. One early study even showed that 41.2% of patients had DVT confirmed by magnetic resonance venography after ACLR [10], while subsequent studies published inconsistent results [11–17]. Compared with ACLR, meniscectomy, as one of the most common knee arthroscopic surgeries, is simple and usually considered to have a lower risk of VTE. However, specific data on the risk of VTE after knee meniscectomy are limited.

Therefore, we performed a population-based, historical cohort study to estimate the incidence of VTE after arthroscopic meniscectomy (a simple knee surgery) and ACLR (a relatively complex surgery) and to determine whether ACLR will increase the VTE risk compared to knee meniscectomy.

Methods

A retrospective study of prospectively collected clinical data including 468 patients, ranging in age from 18 to 70 years, undergoing ACLR or meniscectomy surgery was performed at our hospital from October 2018 to October 2019. Patients meeting one of the following criteria were excluded from the study: unwillingness to give written informed consent; bilateral knee surgeries; concomitant other ligament reconstruction; multiple ligament reconstructions or repair; a history of DVT or pulmonary embolism(PE); ongoing treatment with anticoagulant therapy; a history of cerebrovascular accident in the past 6 months; or severe renal or hepatic failure. Any other cause of immobility and follow-up less than 3 months were also excluded. All patients were routinely screened for VTE with compression venous duplex ultrasonography. Clinical data including date of birth, sex, weight, height, smoking, etc. were recorded pre-surgery.

According to the intervention procedures, the patients included were divided into two groups (the ACLR group and the meniscectomy group). In the ACLR group, all patients received primary ACL reconstruction, including single bundle and double bundle reconstruction; concomitant simple procedures, including simple debridement, partial meniscectomy, and simple meniscal repair (1 or 2 sutures), were permitted. In the meniscectomy group, all patients mainly received meniscectomy, including partial meniscectomy, subtotal meniscectomy and total meniscectomy; concomitant simple procedures, including simple debridement, removal of loose bodies, and chondroplasty, were also allowed. All surgeries were performed by the same team under general anaesthesia with a tourniquet inflated to 250 to 300 mmHg. No intra-articular drain was inserted in either group. All concomitant treatments, operative time, Caprini score [18] and tourniquet time were recorded.

No brace or knee immobilizer was used postoperatively for any patient. Patients started full weight bearing and physiotherapy, including active motion exercises, ankle pump exercise and thigh muscle strengthening, on the first postoperative day. Patients were encouraged to move as much as possible. No limitations were placed on motion or ambulatory status, except for the patients who underwent meniscal repair during the operation. These patients limited their knee to 0° of extension for 6 weeks when walking with full weight but were allowed knee flexion without loading. A pain protocol with nonsteroidal anti-inflammatory drugs (NSAIDs) was followed, and patients were allowed to use opioid drugs according to

their pain scores. Physiotherapy was continued for 3 months. Patients were discharged from the hospital at 1 or 2 days post operation. No anticoagulant and no compression stockings were used.

All patients routinely received follow-up for clinical assessments at 2, 4 and 6 weeks after surgery. All patients routinely received compression venous duplex ultrasonography in the outpatient clinic 2 weeks after surgery. A standardized protocol for compression venous duplex ultrasonography was applied for both legs [19]. Patients were asked whether they had any clinical signs or symptoms of VTE after the operation. At any other time, any patients found to have a clinical suspicion of VTE, including disproportionate levels of swelling, calf or thigh pain not consistent with the surgery, and/or respiratory symptoms, were investigated with appropriate imaging in the form of an ultrasound Doppler scan and/or computed tomography pulmonary angiogram by our hospital. Once radiologically confirmed as cases of VTE, appropriate treatment dose anticoagulation was commenced. Any patients found to have VTE were analysed to identify any possible risk factors, including surgical procedure, age, sex (male), body mass index (BMI), smoking, concomitant surgery, Caprini score and tourniquet time.

The primary measure was the incidence of major VTE, including DVT (total, proximal, and distal), PE, or both, up to 6 weeks post discharge. Proximal DVT was defined as VTE of the popliteal or common femoral vein. Distal DVT was defined as VTE located in the distal part of the popliteal vein, including the tibial vein and peroneal vein. The second measure was the total incidence of total VTE.

Statistical Analysis

The independent-samples t-test was used to compare outcomes with a normal distribution or the Mann–Whitney U test was used when the data were not normally distributed. The chi-square and Fisher exact tests were used to compare categorical variables between the 2 treatment groups. Binary logistic regression was performed to identify significant independent predictors, and the resulting odds ratios (ORs) with 95% confidence intervals (CIs) were calculated for all independent predictors of VTE and DVT for both groups. Statistical significance was set at $P < 0.05$ for all analyses, and all statistical analyses were performed using SPSS Version 22 (IBM).

A power analysis was performed with PASS (version 6) based on the acceptable level of significance, expected effect size, and underlying event rate of the population in previously published work. To detect a 10% difference between the two groups with 80% power and a p value of less than 0.05, 100 patients per group were required to reach a sufficiently narrow confidence interval (CI).

Results

During the 1-year period of study, 468 arthroscopic ACLR or meniscectomy procedures were performed at our institution. A total of 127 patients were excluded after applying the inclusion criteria. The remaining 341 patients who underwent arthroscopic ACLR or meniscectomy were available for analysis. The baseline characteristics and potential risk factors for these patients are listed in Table 1. There were 186 men (54.5%) and 155 women (45.5%), with a mean age of 36.67 ± 13.30 . The average patient BMI was

24.43±12.67 kg/m². Of these, 130 (38.1%) received ACLR, and 211 (61.9%) received meniscectomy. There was no difference in BMI or smoking between the treatment groups, while there were significant differences regarding sex ratio, age, Caprini score, concomitant surgery, tourniquet time and operative time (p<0.01). The detailed characteristics of the patients are shown in Table 1.

Table 1
Baseline characteristics of the patients

Characteristic	ACLR group (n= 130)	Meniscectomy group (n= 211)	P value
Male sex, n (%)	90(69.2)	96(45.5)	<0.001
Age, y, mean ± SD	29.46±8.53	41.10±13.77	<0.001
BMI, kg/m ² , mean ± SD	23.96±3.69	23.66±3.01	0.528
Smoking, n (%)	20(15.4)	31(14.7)	0.862
Caprini score, mean ± SD	2.32±0.60	2.89±0.91	<0.001
Concomitant surgery, n (%)	88(67.7)	69(32.7)	<0.001
Tourniquet time, min, mean ± SD	61.554±23.60	31.39±15.62	<0.001
Operative time, min, mean ± SD	76.59±25.60	43.56±17.86	<0.001
ACLR, anterior cruciate ligament reconstruction; BMI, body mass index;SD, standard deviation			

There was no PE or femoral DVT reported in either group. The overall incidence of major VTE was 7 of 341 patients (2.05%) within the 6-week follow-up; 4 of the 7 patients (57.1%) were nonsymptomatic. DVT was detected in 6 cases at two weeks after surgery and in 1 case at week 4. Among the 7 patients who suffered from DVT, 4 (3.1%) patients in the ACL reconstruction group and 3 (1.4%) patients in the meniscectomy group had confirmed DVT (P >0.05). In the 4 patients with DVT who underwent ACL reconstruction, all DVTs were detected in the distal DVT regions (3 in the posterior tibial veins, 1 in the peroneal vein). In the 3 patients with DVT who underwent meniscectomy, there was 1 popliteal DVT and 2 distal DVTs (1 in the peroneal vein, 1 in the posterior tibial vein and peroneal vein).

The overall incidence of nonmajor VTE was 24 of 341 patients (7.04%) within the 6-week follow-up. In the ACL reconstruction group, VTE in the venous calf of the plexus leg muscle was found in 10 (7.7%) patients, and VTE in the meniscectomy group was found in 14 (6.6%) patients by ultrasonography (P=0.711). In total, 14 patients developed VTE in the first cohort and 17 patients in the second cohort, with no significant difference (10.8% vs. 8.1%; P=0.397). The detailed results are shown in Table 2.

Table 2
The incidence of VTE after ACL reconstruction and meniscectomy

Outcome	ACLR group (n= 130)	Meniscectomy group (n= 211)	P value
Total VTE, n (%)	14(10.8)	17(8.1)	0.397
Major VTE, n (%)	4(3.1)	3(1.4)	0.513 ^a
Proximal DVT, n (%)	0	1(0.5)	1.000 [*]
Distal DVT, n (%)	4(3.1)	2(0.9)	0.304 ^a
PE, n (%)	0	0	-
Other VTE, n (%)	10(7.7)	14(6.6)	0.711
VTE, venous thromboembolism; DVT, deep vein thrombosis; PE, pulmonary embolism; ACLR, anterior cruciate ligament reconstruction; * Fisher's test; ^a Continuity correction test			

A binary multivariate logistic regression analysis was used to evaluate the associations between VTE, DVT and clinical characteristics. ACLR (yes or no), sex (male or not), smoking (yes or no) and concomitant surgery (yes or no) were included as categorical variables and age, BMI, Caprini score and tourniquet time were included as continuous variables. Surgical time was deleted before the logistic regression analysis for collinearity with tourniquet time (both tolerance: 0.18, VIF: 56.463, 55.870, respectively). The multivariate regression determined that age was the only independent risk factor ($p = 0.27$, OR 1.061 [CI 1.007-1.118] for an increased risk of developing VTE following knee arthroscopic surgery (Table 3). ACLR was associated with an odds ratio of 3.129 [CI 0.991-9.877] for the development of VTE compared to meniscectomy but it was not statistically significant ($p = 0.052$). No risk factor remained statistically significant for developing major VTE during the study period (all $p > 0.05$).

Table 3 Multivariate logistic regression analysis for associations between patient characteristics and VTE

Patient characteristics	Total VTE		Major VTE	
	P value	OR [95% CI]	P value	OR [95% CI]
ACLR vs. Meniscectomy	0.052	3.129 [0.991-9.877]	0.173	5.056 [0.492-51.939]
Age	0.027	1.061[1.007-1.118]	0.393	1.046 [0.943-1.161]
Sex (male)	0.679	1.205 [0.498-2.919]	0.487	1.942 [0.299-12.595]
BMI	0.223	1.078 [0.955-1.216]	0.581	1.069 [0.844-1.353]
Smoking	0.346	0.522 [0.135-2.018]	0.880	0.816 [0.059-11.239]
Concomitant surgery	0.563	0.783 [0.342-1.794]	0.887	0.888[0.174-4.541]
Caprini score	0.372	1.396 [0.671-2.906]	0.493	1.629 [0.404-6.564]
Tourniquet time	0.120	1.015 [0.996-1.034]	0.251	1.020[0.986-1.056]

ACLR, anterior cruciate ligament reconstruction; VTE, venous thromboembolism; OR, odds ratio; BMI, body mass index

Discussion

The principal findings of this study are that the incidence of total VTE was 10.8% and 8.1% in ACL reconstruction and meniscectomy, respectively, without a significant difference. DVT by using duplex ultrasound within 6 weeks after ACLR and meniscectomy was 3.1% and 1.4%, respectively. Age was shown to be the only independent risk factor for the development of VTE postoperatively ($p=0.027$), and no risk factor was detected for major VTE. ACLR had a tendency (OR 3.129, CI 0.991-9.877) to increase the risk of the development of VTE but it failed to reach statistical significance ($p = 0.052$).

The reported incidence of VTE after ACLR varies in the existing literature. Oshiba H et al.[11] found that the incidence of DVT after ACL reconstruction detected by ultrasonography on postoperative Day 7 was 6.3% (16/256). Dong et al. [12] reported that the incidence of DVT in Chinese patients was 12.1% within 7 days of 282 ACL surgeries. Ye et al. [13] studied 171 patients with an overall DVT incidence of 14% by venography. Marieke C et al. [14] conducted a prospective cohort study and found a 9% incidence of asymptomatic proximal or distal DVT, whereas 4% of patients were symptomatic. Based on these findings, they suggested that prophylactic measures for DVT should be considered after arthroscopic ACLR to decrease the incidence of DVT, especially when risk factors are present [11–14], consistent with the French Society of Anaesthesia and Intensive Care [20].

However, several investigations with large cohorts of patients undergoing ACLR have reported inconsistent results. Jameson et al. [15] found the rate of symptomatic VTE to be approximately 0.44% (0.30% DVT and 0.18% PE) in 13,941 patients undergoing ACL reconstruction. Forlenza EM et al. [16]

reported that the incidence of VTE was 1.01% and 1.22% at 30 and 90 days, respectively, in 11,977 patients undergoing ACLR and recorded in the Humana administrative claims database in Indiana. Gaskill et al. [21] reported that the incidence of VTE was 0.53% after 16,558 ACL reconstructions performed and recorded in the Military Health Care System (MHS) database in the United States. Schmitz et al. [22] reported that the incidence of VTE was 0.4% in a cohort consisting of 26,014 primary and revision ACLR obtained from the Swedish Knee Ligament Register in Sweden. These authors recommended against the routine use of thromboprophylaxis, which is in accordance with the American guidelines and Swedish surgeons [17, 23].

In our study, all patients received duplex ultrasound scans after the operation, and the incidence of DVTs by duplex ultrasound after ACL reconstruction was 3.1%, which is close to the incidence in Oshiba H et al. [11] and Marieke C et al. studies [14] but lower than that reported by Dong et al. [12] and Ye et al. [13]. This might be because 67.4% of patients underwent reconstruction of the medial and lateral collateral ligament and posterior cruciate ligament at the same time in Dong et al.'s study [12]. In Ye et al.'s study, DVT was detected by venography, which might be more sensitive to the diagnosis of VTE than the ultrasound used in our study. The reported incidence of DVT/VTE in several large cohorts [15, 16, 21, 22] was significantly lower than in these studies [11–14] and in our study, which can be mostly explained by the study design and whether screening of VTE is performed for all patients. The data for these large cohorts are generally from local and national databases and are obtained via ICD codes. Therefore, the accuracy of the information related to ICD codes should be queried, and the incidence of asymptomatic VTE cannot be accurately recorded in these health care systems. Moreover, the data from local and national databases are usually reported by patients, and not all patients undergo VTE screening after surgery. In fact, higher rates of VTE are usually reported with the use of prospective diagnostic screening, which was performed in our study and several other studies [11–14] with a higher reported incidence of VTE.

Compared to ACLR, meniscectomy has been considered to have a lower risk of VTE because of its simplicity and its relatively shorter surgical time. In one recently published review [24], major VTE (symptomatic VTE, DVT and PE) was reported in 4.75% of patients who received ACL reconstruction without prophylaxis and 0.72% of patients who received simple knee arthroscopic surgery (similar to meniscectomy); the rate of VTE was 8.0% in patients who received ACL reconstruction and 1.96% in patients who received simple knee arthroscopic surgery. However, another investigation with a cohort of 12,595 patients reported conflicting results: the VTE rate after ligament reconstruction was 0.16%, while that after meniscectomy was 0.56% ACLR [25]. In our study, the incidence of DVT and all VTE were similar between the patients who received ACL reconstruction and the patients who received meniscectomy, without significant differences. This could be why we failed to detect a statistically significant difference despite ACLR having a tendency to increase the risk of the development of VTE compared to meniscectomy.

Age as a risk factor for VTE has been previously reported in several series of patients undergoing knee arthroscopic surgeries. Oshiba H et al.[11] found that patients aged ≥ 30 years have a higher risk of

developing VTE. Ye et al. [13] reported that female patients and those aged 35 years were at a higher risk for VTE, and they recommended routine thromboprophylaxis in these patients. In several studies with large cohorts, Jameson et al. [15] found that age over 40 years was associated with an increased VTE risk; no additional risk factors were reported. Forlenza EM et al. [16] reported risk factors including age $\geq$ 45, inpatient surgery, COPD, tobacco use and concurrent PCL reconstruction, meniscal transplant or osteochondral allograft. Gaskill et al. [21] reported that increased odds of VTE were identified in patients aged 35 years and over with a history of nicotine use, anticoagulant use, concomitant HTO, or concomitant PCL reconstruction. Schmitz et al. [22] reported that the only significant risk factor for VTE after surgery was age. In our study, multivariate logistic regression determined that age was the only independent risk factor for an increased risk of developing VTE following knee arthroscopic surgery, which is similar to the findings of the studies mentioned above.

Our study has some limitations. First, the retrospective design limited our assessment of the true effect of surgical intervention on the risk of VTE. Second, the number of ACL reconstruction patients was relatively small. The power analysis showed that 100 patients per group was sufficient to reach a sufficiently narrow confidence interval, but a study with a larger number of patients would increase its clinical importance. In our study, a tendency for an increased risk of VTE was found, so a much larger number of included patients may strengthen the statistical significance. Third, the incidence of VTE in this study was mainly identified at two weeks after surgery by duplex ultrasound. DVT might develop in patients after they are discharged. All patients received follow-up for clinical assessments, but asymptomatic DVT might be neglected. Therefore, the true overall incidence of DVT after ACL reconstruction is probably slightly higher than that shown in this study. Finally, contraceptive and NSAID use in our study by female patients was not recorded, and this may have an overall effect on the final incidence of DVT [26, 27].

Conclusion

The incidence of VTE after ACL reconstruction and meniscectomy detected by duplex ultrasound within 6 weeks post surgery was 10.8% and 8.1%, respectively. Age was shown to be the only independent risk factor for the development of VTE postoperatively. ACL reconstruction had a tendency to increase the risk of VTE compared to meniscectomy. Other prospective, large-sample studies are needed to confirm our results.

Abbreviations

VTE: venous thromboembolism; ACLR: anterior cruciate ligament reconstruction; BMI: body mass index; PE: pulmonary embolism; DVT: deep vein thrombosis

Declarations

Acknowledgements

Nothing.

Authors' contributions

LPC and PL carried out the follow-up evaluations for all patients and equally contributed to the writing. LH and TX participatory designed the study and were responsible for analysis and interpretation of the data. ZJ initiated the study, provided suggestions for the study and critically reviewed the manuscript. All authors read and approved the final manuscript.

Funding

No funding was received to assist with the preparation of this manuscript.

Availability of data and materials

All data generated or analysed during this study are included in this published article.

Ethics approval and consent to participate

The study protocol was approved by the Human Ethics Committee for Medical Research at Sichuan University in accordance with the Declaration of Helsinki.

Consent for publication

All patients provided informed consent prior to enrolment in the study.

Competing interests

The authors declare that they have no competing interests.

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