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Incidence of Deep Vein Thrombosis and its Effects on Clinical Outcome after Opening Wedge High Tibial Osteotomy

-A Comparison with Total Knee Arthroplasty-

개방형 근위경골절골술 이후 심부 정맥 혈전증의 발생율과 임상적 영향

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박 지 수

Abstract

Incidence of Deep Vein Thrombosis and its Effects on Clinical Outcome after Opening Wedge High Tibial Osteotomy

-A Comparison with Total Knee Arthroplasty-

Jisu Park

Department of Clinical Medical Sciences

The Graduate School

Seoul National University

Medial opening high tibial osteotomy (OWHTO) is being used to treat knee osteoarthritis in relatively young patients with varus deformity. Among many possible complications following high tibial osteotomy (HTO), deep vein thrombosis (DVT) has potentials to develop to more life-threatening issues like pulmonary thromboembolism (PTE). Incidence of DVT after total knee arthroplasty (TKA) is known as 41-85%. In case of DVT after HTO,

it is relatively less studied. The incidence and pattern of DVT formation following HTO was compared to TKA. DVT occurred in 65.6% of TKA patients, and it was statistically significantly less in HTO group in which 45.2% occurrence was recorded (p=0.027). Although more patients had DVT in TKA group, more DVT patients in HTO group presented symptom (9.5% vs. 1.1%, p=0.002). There was no statistically significant difference in the location of DVT (p=0.671). According to our results, distal DVT was not less prone to have symptom. Clinical outcome was also compared between DVT and non-DVT group in HTO patients, and there was no statistically significant difference. Because routine postoperative DVT screening was done by CT angiography, DVT could be detected in early stage and proper management could be done. It might be the reason why there was no difference in clinical outcomes. There are guidelines including chemoprophylaxis and mechanical prophylaxis for deep vein thrombosis after joint replacement surgery. However, there is no consensus about the chemoprophylaxis in HTO. We should pay attention to the occurrence of DVT after HTO, and proper management should be done in early stage. However, in terms of routine postoperative evaluation and chemoprophylaxis of DVT, further research must be done.

Keyword: Knee joint, Osteoarthritis, Opening wedge high tibial osteotomy, Total knee arthroplasty, Deep vein thrombosis, Pulmonary thromboembolism

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Introduction

Medial opening high tibial osteotomy (OWHTO) is being used to treat knee osteoarthritis in relatively young patients with varus deformity. Many complications have been documented after high tibial osteotomy (HTO), such as infection, bleeding, skin problem, nerve palsy, and so on. However, since patients who undergo HTO is relatively young and healthy, these possible complications seem less conspicuous. In the same context, not so much attention have been paid on deep vein thrombosis (DVT) after HTO although DVT has potentials to develop to more life-threatening issues like pulmonary thromboembolism (PTE). Various clinical symptoms like pain, swelling and redness suggest the existence of DVT, but these signs are nonspecific, making the DVT be easily neglected in postoperative situation (1).

Although less frequent than total knee arthroplasty (TKA), DVT could occur even after arthroscopic surgery and there are reports that it led to more serious complications (2, 3). Based on some results of the study on the TKA patients, DVT could arise on the contralateral knee in TKA patient. It implies that orthopaedic surgery itself could be a risk of DVT. However, not so many works have been done for HTO (4).

Incidence of DVT after TKA is reported as 41-85% (5). Literatures about the incidence of DVT after HTO, especially medial opening HTO, are few and there is no single study comparing DVT

occurrence and pattern between HTO and TKA (4).

The purpose of this study was largely threefold. First, we would like to find out the incidence and pattern of DVT after HTO, and compare them to TKA done in the same institution, on the same period. Second, we would like to analyze the factors related to the DVT occurrence after HTO. Lastly, we would like to see if there is a difference in short-term clinical outcome according to the occurrence of the DVT in HTO patients.

Methods

From July 2015 to January 2019, patients who underwent medial OWHTO and TKA due to osteoarthritis of the knee were reviewed. Of these, patients who had history of infection, fracture or any other surgery to the ipsilateral knee, history of inflammatory arthritis, underlying medical condition like renal dysfunction, or history of DVT were excluded. 130 patients with 132 knees were reviewed in this research. 42 cases were medial OWHTO and 90 cases were TKA. 1 patient each underwent HTO and TKA bilaterally, but not on a single hospital stay; 1st patient had 5 months of interval and the other patient had 9 months between each procedures. Patients' characteristics were significantly different between HTO and TKA groups (Table 1). There were more male patients in HTO compared to TKA, and it was statistically significant (33.3% vs. 16.7%, p=0.031). HTO group was composed of relatively younger (58.43 vs. 71.67, p=0.000), taller (157.74 vs. 154.58, p=0.042) and heavier (70.06 vs. 63.36, p=0.006) patients. Body mass index (BMI) was higher in HTO group (27.95 vs. 26.47, p=0.031). Most of the HTO cases were carried out by spinal anesthesia whereas only a few cases of TKA used spinal anesthesia (88.1% vs. 10%, p=0.000). Operation time and tourniquet time were both shorter in TKA group (106.45 vs. 92.53, p=0.005; 91.64 vs. 60.69, p=0.000). HTO patients were hospitalized for approximately 1 week, and TKA patients' hospital stay was approximately 2 weeks (6.38 vs. 13.66, p=0.000). Proportion of patients

who took medication for anticoagulation purpose because of their underlying medical condition was comparable in both groups (p=0.114).

DVT was diagnosed with CT angiography on postoperative 4th day, and it was performed in all patients in this research with or without symptoms. The location of the DVT was also noted and divided into proximal and distal DVT (Figure 1, 2). DVT formed at popliteal level and proximal to it was classified as proximal DVT, and distal to it was classified as distal DVT (6). IKDC score was used for evaluating clinical outcomes of HTO patients, and they were measured twice, postoperative 6 months and 1 year. The study protocol was approved by our institutional review board.

For each procedure, the surgeon's technique remained the same throughout the study period: TKA, modified gap technique; HTO, medial opening wedge osteotomy with plate-and-screw fixation.

In TKA group, knee ROM was started at postoperative 2nd day after removing drain using CPM machine and gradual ambulation was started. There was no restriction to the extent of the weight load after surgery.

Also in HTO group, knee ROM was started at postoperative 2nd day after removing drain using CPM machine. ACL brace was applied for 6-8 weeks without limitation of ROM. Only partial weight bearing was allowed for that period.

Chemoprophylaxis for DVT was not done in both TKA and HTO groups. Pneumatic pump was applied routinely after operations in both groups. When DVT confirmed, treatment was stratified based on the location and the symptom. Proximal DVT was treated regardless of symptom and symptomatic distal DVT was also treated. Oral administration of rivaroxaban (Xaralto) for 3 months was the routine protocol for DVT treatment.

Results

DVT occurred in 65.6% of TKA patients, and it was statistically significantly less in HTO group in which 45.2% occurrence was recorded (Table 2, p=0.027). Although more patients had DVT in TKA group, more DVT patients in HTO group presented symptom (9.5% vs. 1.1%, p=0.002). There was no statistically significant difference in the location of DVT (Table 3, p=0.671). Only 1 TKA case had PTE (1.1%) and it also had asymptomatic proximal DVT.

When compared DVT group to non-occurring group, in HTO patients, statistical significance was found only in weight and BMI (Weight 64.56 vs. 74.60, p=0.012, BMI 26.80 vs. 28.90, p=0.035). DVT group was lighter (Table 4). Also, weight was the only statistically significant factor in logistic regression (p=0.025). Additional analysis was done in DVT group focusing on the presence of the symptom. There were no statistically significantly different factors between symptomatic and asymptomatic DVT groups.

There was no statistical significance in the presence of the symptom depending on the location of the DVT (p=0.436).

IKDC was collected in 20 and 23 patients who underwent HTO on postoperative 6 months and 1 year, respectively. We couldn't find any statistical significance on both 6 months and 1 year comparing DVT and non-DVT group (IKDC 6 months p=0.939; IKDC 1 year p=0.147). Also, no statistical significance was found in the clinical score

according to the presence of DVT symptom (IKDC 6 months p=0.634; IKDC 1 year p=0.639).

Discussion

There was a statistically significant difference in occurrence of DVT between HTO and TKA (45.2% vs. 65.6%, p=0.027). Because we conducted routine postoperative evaluation of DVT by CT angiography, this was the result of including of both symptomatic and asymptomatic DVT. The incidence of DVT following TKA is known as 41-85% (5). In case of HTO, 41% of DVT occurrence has been reported (7). Our results were quite similar to the previous reports. Although TKA seems to be more prone to have DVT, there has been no single study comparing the DVT incidence after both procedures directly. Interesting finding was the fact that even though TKA group had more DVT, more symptomatic DVT occurred in HTO group. Confined to the symptomatic DVT, the incidence was 1.1% in TKA group and 9.5% in HTO group (Table 2). Although not much reported, the incidence of the symptomatic DVT after HTO has been reported as 1.4-9.7% (7-10). Only small portion of patients with DVT had symptom in our research, and it was consistent with other reports (7). In terms of symptomatic DVT, HTO was more “risky” procedure compared to TKA.

In order to understand these difference, we need to take a close look to the surgical procedures and anatomy of the neurovascular bundle around the knee. TKA is replacing damaged cartilage to prosthesis. Significant amounts of resected bones are removed during the procedures. Although TKA is considered more invasive surgery

than HTO, basically it's filling as much as being cut. On the other hand, after HTO, especially medial OWHTO, surgical site becomes "overstuffed". Neurovascular bundle could become stretched as a result.

Neurovascular bundle is located just behind the proximal tibia at osteotomy level in HTO. According to cadaveric angiographic study done by Darnis et al., mean distance between the posterior cortex of the proximal tibia and popliteal vessels is 11.7mm in 90 flexion (11). According to other reports, popliteal vessels are protected by a thin muscular layer and the distance to the proximal tibia is 0.5-1.0cm (12). Also, this level is where popliteal vessels trifurcate and it leads to the limited mobility of posterior vessels (12). Because of these anatomical factors, posterior structure can be damaged when using instrument such as hohmann retractor. Unlike TKA, this kind of retractor can directly violate vessels which lie just behind the tibia.

Virchow's triad, which is comprised of venous stasis, hypercoagulability, and endothelial injury is associated with the formation of thrombosis (13). Among them, venous stasis and hypercoagulability are global problem. Endothelial injury is rather focal problem compared to the others. There are some reports about the DVT due to vascular injury after traumatic sports injury of athletes (14). Direct vascular injury can cause DVT. But would the cause of DVT be the determinant factor of whether it would have symptom or not is not known.

Not all DVTs have symptom. As mentioned, only small portion of patients with DVT showed symptom (7). Study about which DVT wound present symptom is scarce. Yamashita et al. reported about the clinical characteristics and long-term outcomes of asymptomatic lower extremity DVT. According to the study, hypercoagulative status in cancer patients might be associated with high risk for symptomatic venous thromboembolism (VTE), resulting in the potential benefit of anticoagulants in patients with active cancer (15). However, study focused on the orthopaedic field is still absent. Our results that DVT after HTO had more symptom compared to TKA might give a clue. DVT arisen from the direct injury of vessels may be "malignant" and may have more potentials of becoming symptomatic.

In TKA, most of the procedures are done at the joint line level. On the other hand, joint itself is not compromised in case of HTO. The main stage, proximal tibia, is located distal to the knee joint. Therefore, our original assumption was that more distal DVT would occur in HTO compared to TKA. Although not statistically significant, proportion of distal DVT was higher in HTO (94.7% vs. 87.7%, p=0.671). Usually, distal DVT is known to have less clinical significance (16-19). It is known not to extend to proximal site and to be often asymptomatic (20, 21). However, according to our results, distal DVT was not less prone to have symptom (p=0.436). The reason most distal DVT is commonly thought to be less clinically significant is that it usually do not extend to proximal site and

develop into PTE (20). PTE occurred in only 1 case, and it was proximal DVT patient. Although not significant, it was a consistent result to many other researches that proximal DVT is more prone to develop to PTE (6). However in terms of symptom of DVT itself, clinical importance of distal DVT cannot be ignored.

Rehabilitation protocols were different between HTO and TKA. Both TKA and HTO patients started knee CPM at postoperative 2nd day. However, the amount of weight load was more carefully increased in HTO in order to protect the osteotomy site. Full weight bearing was allowed in TKA patient on postoperative 2nd day. Immobilization is a known risk factor of DVT and it is related to the venous stasis of Virchow's triad. Too protective action should be avoided in order to prevent DVT formation. Early rehabilitation is now being emphasized in effort to reduce DVT occurrence after orthopaedic surgery (20, 22).

In HTO, patients were lighter in DVT group compared to non-occurrence group (Table 4). Generally, heaviness is known as a risk factor of developing DVT after TKA. It is not clear why the opposite trend has been shown. One possible explanation is that because lighter patients had less soft tissue protection, the vessels might have been more directly damaged by the procedures. In order to prove this however, further prospective research is needed. We tried to find if there were risk factors of DVT being symptomatic in HTO group, but none of the factors showed statistical significance.

American College of Chest Physicians (ACCP) and the American Academy of Orthopedic Surgeons (AAOS) suggested guideline including chemoprophylaxis and mechanical prophylaxis after joint replacement surgery (20, 22). In Asian populations, the incidence of DVT is relatively low (17, 23, 24). DVT prophylaxis by drug has a risk of bleeding issue. Because many reports show lower incidence of DVT after TKA even without chemoprophylaxis in Asian patients, routine chemoprophylaxis after TKA is still debatable (25). Bang et al. published 2nd edition of practice guideline for thrombosis in Korean population (26). In this guideline, for patients who undergo major orthopaedic surgery with advanced age, pharmacological prophylaxis is recommended. However, there is no mention about HTO and this guideline is not specific to orthopaedics. Although there have been some efforts to use chemoprophylaxis in HTO (27, 28), no consensus has yet been made. About postoperative DVT evaluation, AAOS guideline does not recommend routine evaluation after TKA. In case of HTO, no guideline has been accomplished so far. As mentioned above, DVT incidence after TKA is low in Asian populations. But when it comes to DVT after HTO, especially symptomatic DVT, there is no study specific to Asian populations. In Western populations, symptomatic DVT after HTO is known to be 1.4-9.7% (7-10). Considering 9.5% of incidence in our study, unlike TKA, incidence of symptomatic DVT after HTO in Asian populations may not be lower than Western populations. In these context, chemoprophylaxis and routine postoperative DVT evaluation might

have a role in Asian populations after HTO, but further larger research is necessary.

Clinical outcomes checked on postoperative 6 months and 1 year showed no difference regardless of the presence of DVT. Also, it was irrelevant whether DVT had symptom or not. This result might be interpreted that presence of DVT has no effect on the clinical outcome. However, we should consider that all symptomatic DVT could be successfully treated because of early detection. DVT formation is started perioperatively and most of it is known to be formed before postoperative 3^{rd}-4^{th} day (10, 29, 30). Hence, our protocol of checking DVT on postoperative 4^{th} day by CT angiography could detect almost all events. If we could compare with the patients whose DVT left untreated, more interesting results would have been achieved.

Our results that there was no difference in clinical outcome regardless of the presence of the DVT may suggest routine chemoprophylaxis is not necessary in HTO (4). However, in terms of early detection and management of the DVT, routine postoperative evaluation may have its role. Further works would be necessary to determine the prophylaxis and screening guideline but attention must be paid to the occurrence of DVT after HTO since the clinical symptoms of the DVT are nonspecific (1).

Our research has several limitations. First, it was a retrospective analysis. Second, the number of each group was small. Third, the

demographic factors of both groups were significantly different. Patients' characteristics were different in many ways. There were more female patients in TKA group, and they were older, shorter and lighter. However, because the indications of TKA and HTO are significantly different, perfect matching of demographic factors of both groups might not be possible nor necessary. Our goal was to analyze the incidence and pattern of DVT following HTO in comparison to TKA as it is relatively well studied. Age, which is the main demographic factor, is the indication itself. Some demographic differences of both groups might be taken for granted.

Conclusion

The incidence of symptomatic DVT was higher in patients who underwent HTO than TKA although the incidence of total DVT was lower. More distal DVT was found in HTO but there was no statistically significant difference in the location of DVT between two groups. In HTO group, lighter patients had more DVT. There was no difference in clinical outcome at postoperative 6 months and 1 year according to the presence of DVT but we should pay attention to the occurrence of DVT after HTO, and proper management should be done in early stage. However, in terms of routine postoperative evaluation and chemoprophylaxis of DVT, further research must be done.

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Table 1. Demographic factors

	HTO	TKA	p-value
Age	58.43 (42-69)	71.67 (55-84)	0.000[a]
Sex (M : F)	14 : 28	15 : 75	0.031[b]
Height	157.74 (139.6-174.8)	154.58 (132.3-178.0)	0.042[a]
Weight	70.06 (50.5-103.8)	63.36 (48.7-95.2)	0.006[a]
BMI	27.95 (23.1-38.1)	26.47 (20.9-44.8)	0.031[a]
Discharge date	6.38 (3-31)	13.66 (8-23)	0.000[a]
Operation time	106.45 (43-192)	92.53 (67-183)	0.005[a]
Tourniquet time	91.64 (43-141)	60.69 (42-133)	0.000[a]
Anesthesia type (Spinal : General)	37 : 5	9 : 81	0.000[b]
Medication (O : X)	6 : 36	24 : 60	0.114[b]

[a]Significance was determined with student's t-test.

[b]Significance was determined with Pearson's Chi-square test.

Table 2. Incidence of total, symptomatic DVT, and PTE

	HTO	TKA	p-value
DVT	19 / 42 (45.2%)	59 / 90 (65.6%)	0.027[a]
Symptomatic DVT	4 / 42 (9.5%)	1 / 90 (1.1%)	0.035[b]
PTE	0 / 42 (0%)	1 / 90 (1.1%)	1.000[b]

[a]Significance was determined with Pearson's Chi-square test.
[b]Significance was determined with Fisher's exact test.

Table 3. Proportion of proximal and distal DVT

	HTO	TKA	p-value
Proximal	1 (5.3%)	7 (12.3%)	0.671[a]
Distal	18 (94.7%)	50 (87.7%)	

[a]Significance was determined with Fisher's exact test.

Table 4. Demographic factors of DVT and non-DVT group in HTO patients

	No DVT	DVT	p-value
Age	57.04 (42-67)	60.11 (46-69)	0.143[a]
Sex (M : F)	10 : 13	4 : 15	0.191[b]
Height	160.01 (139.6-174.6)	155.00 (139.6-174.8)	0.076[a]
Weight	74.60 (53.5-103.8)	64.56 (50.5-79.0)	0.012[a]
BMI	28.90 (23.1-38.1)	26.80 (23.6-31.2)	0.035[a]
Discharge date	5.83 (3-10)	7.05 (4-31)	0.343[a]
Operation time	104.74 (43-192)	108.53 (54-173)	0.721[a]
Tourniquet time	93.35 (43-141)	89.58 (54-130)	0.662[a]
Anesthesia type (Spinal : General)	20 : 3	17 : 2	1.000[b]
Medication (O : X)	4 : 19	2 : 17	0.673[b]

[a]Significance was determined with student's t-test.

[b]Significance was determined with Fisher's exact test.

Table 5. Clinical outcomes in patients with and without DVT following HTO

Postoperative day	IKDC		
	DVT	No DVT	p-value[a]
6 months	61.5	61.9	0.939
1 year	41.6	47.2	0.147

[a]Significance was determined with student's t-test.

Table 6. Clinical outcomes in patients according to the symptom of DVT following HTO

Postoperative day	IKDC		
	Symptomatic DVT	Asymptomatic DVT	p-value[a]
6 months	57.50	63.14	0.664
1 year	49.00	46.00	0.676

[a]Significance was determined with student's t-test.

Figure 1. Postoperative CT angiography shows occlusion of right common femoral vein in patient with symptomatic DVT following HTO

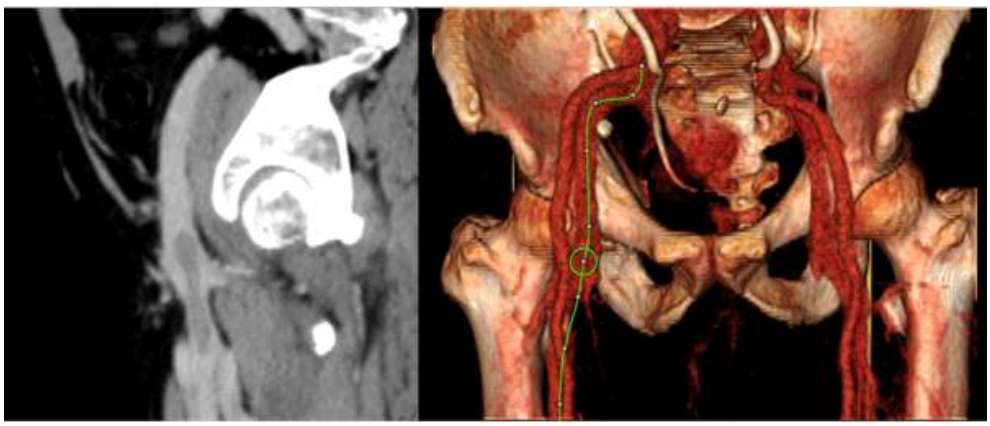
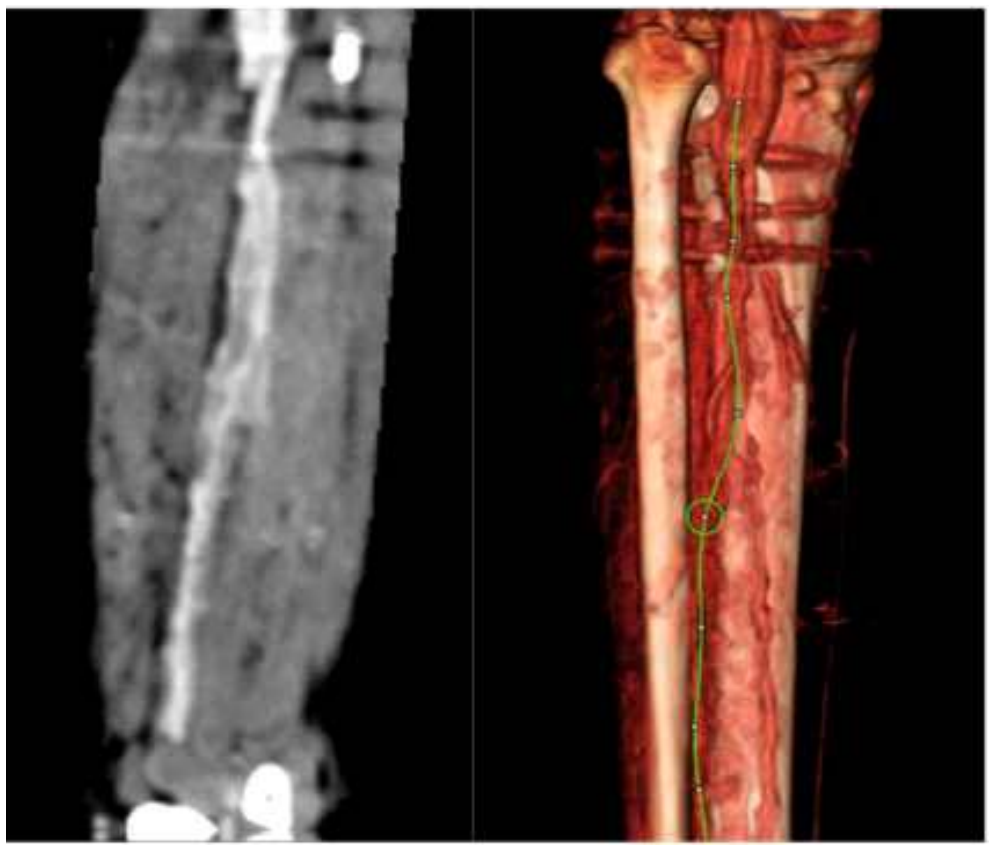


Figure 2. Postoperative CT angiography shows occlusion of left peroneal vein in patient with asymptomatic DVT following HTO



국 문 초 록

개방형 근위경골절골술 이후 심부 정맥 혈전증의 발생율과 임상적 영향

-슬관절전치환술과의 비교-

박 지 수

서울대학교

대학원

임상의과학과

내측 개방형 근위경골절골술은 내반변형이 있는 비교적 젊은 슬관절 골관절염 환자에서 주로 사용되는 수술방법이다. 근위경골절골술 이후 발생할 수 있는 여러 합병증들 중, 심부 정맥 혈전증은 폐색전증과 같이 보다 위중한 문제로 발전할 가능성이 있다. 슬관절전치환술 이후 심부 정맥 혈전증의 발생률은 41-85%로 알려져 있으나, 근위경골절골술 이후의 발생률에 대해서는 많은 연구가 이루어져 있지 않다. 이번 연구에서는 근위경골절골술 이후 발생하는 심부 정맥 혈전증의 발생률과 패턴을 슬관절전치환술 이후 발생하는 경우와 비교하고자 하였다. 슬관절전치환술 이후 심부 정맥 혈전증의 발생률은 65.6%인데 비해

근위경골절골술 이후에는 45.2%의 발생률이 측정되었으며 이 차이는 통계적으로 유의했다 (p=0.027). 비록 슬관절전치환술에서 심부 정맥 혈전증의 발생률이 더 높았으나, 근위경골절골술의 경우에서 증상이 있는 심부 정맥 혈전증의 발생률은 더 높았다 (9.5% vs. 1.1%, p=0.002). 심부 정맥 혈전증의 발생 위치는 양군에서 통계적으로 유의한 차이가 없었다 (p=0.671). 이번 연구 결과에 따르면, 원위부의 발생하는 심부 정맥 혈전증이 임상적으로 증상을 덜 일으키지는 않았다.
근위경골절골술 환자들 중에서 심부 정맥 혈전증이 생긴 환자와 생기지 않은 환자들 간의 임상 결과에 대한 분석도 이루어졌으나 통계적으로 유의한 결과는 보이지 않았다. 이번 연구에서는 모든 환자들에 대해 CT 혈관조영술로 심부 정맥 혈전증 스크리닝을 시행하였기 때문에 수술 후 발생하는 심부 정맥 혈전증의 대다수가 조기에 진단되어 적절한 치료가 이루어질 수 있었을 것이라 생각된다. 따라서 심부 정맥 혈전증의 유무가 임상적 결과에는 영향을 미치지 않았을 수 있었을 것이라 추정해볼 수 있다. 관절 치환술 이후에는 심부 정맥 혈전증의 화학적 및 기계적 예방에 대한 지침들이 제안되어 있지만 근위경골절골술의 경우에는 이에 대한 합의가 이루어져 있지 않다. 근위경골절골술 이후 발생하는 심부 정맥 혈전증의 경우, 증상이 있을 가능성이 슬관절전치환술에 비해 더 높기 때문에 그 발생에 대해 주의를 기울여야 하고 조기에 적절한 조치가 이루어져야 한다. 하지만 근위경골절골술 이후 모든 환자들에 대해서 심부 정맥 혈전증 검사 및 화학적 예방이 이루어져야할 지에 대해서는 추가적인 연구가 이루어져야 하겠다.

주요어: 슬관절, 골관절염, 개방형 근위경골절골술, 슬관절전치환술, 심부 정맥 혈전증, 폐색전증

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