Incidence of Symptomatic Venous Thromboembolism in Proximal Hamstring Repair

A Prospective Cohort Study

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Background: Surgical repair of proximal hamstring avulsion injuries can enable the return to preinjury levels of sporting function and minimize the risk of recurrence in both professional and recreational athletes. While venous thromboembolism (VTE) is a recognized complication of surgical repair, the incidence thereof is poorly reported in the literature.

Purpose/Hypothesis: To report the incidence of symptomatic VTE after proximal hamstring avulsion repair and assess the efficacy of our thromboprophylaxis protocol. It was hypothesized that the incidence of VTE after proximal hamstring avulsion repair is low and that aspirin is an adequate choice of chemical prophylaxis.

Study Design: Cohort study; Level of evidence, 2.

Methods: We performed a prospective cohort study of 2 groups of patients who underwent proximal hamstring avulsion (partial and complete) repair between 2000 to 2020 with different thromboprophylaxis protocols. No patients were routinely screened for VTEs, and VTE was investigated only if clinically indicated. Prospectively collected data included demographics, the mechanism and sport that caused injury, use of bracing, and clinical diagnosis of deep vein thrombosis (DVT) or pulmonary embolism (PE). The first cohort (n = 380) was given mechanical prophylaxis in the form of compression stockings for 6 weeks postoperatively. The second cohort (n = 600) was given compression stockings and aspirin 150 mg once daily routinely, or prophylactic low–molecular weight heparin in high-risk individuals, until the 6-week follow-up. Patients in both cohorts underwent early mobilization after surgery; a hinged knee brace locked at 60° to 120° was provided if the tendon repair was under significant tension. The surgical technique and rehabilitation protocol remained consistent throughout the study.

Results: The overall incidence of symptomatic VTE was 0.51%. A total of 5 patients developed symptomatic VTEs (3 DVTs, 2 PEs) in the first cohort, and no patients developed symptomatic VTEs in the second cohort (1.32% vs 0%; $P = .0048$).

Conclusion: The incidence of symptomatic VTE after proximal hamstring avulsion repairs was extremely low. A combination of aspirin, early mobilization despite bracing, compression stockings, and good hydration was an effective thromboprophylaxis strategy.

Keywords: proximal hamstrings; repair; venous thromboembolism; deep vein thrombosis

Proximal hamstring injuries are common in professional athletes, accounting for 12% to 26% of all sporting-related injuries.[2,5,9] They occur through explosive eccentric contraction, with simultaneous hip flexion and knee extension.[1] In addition, these injuries are increasingly identified in the aging population, as people are remaining physically active as they age.[8,9,17] This may also occur due to falls or slippages, which result in eccentric contraction at the degenerative proximal tendon interface. Diagnosis is largely based upon clinical examination and magnetic resonance imaging (MRI) findings, with a wide spectrum of pathologies including low-energy strains, partial tears of the musculotendinous junction, and complete avulsion injuries from higher-energy trauma. These injuries may be managed nonoperatively through physiotherapy or surgically repaired, dependent on the grade of injury and

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patients' physical demands. In the professional athlete, these are potentially career-altering injuries[15,25] and in the elderly, they can lead to increased morbidity and reduced muscle strength.[8,12,15]

Surgery of any description, particularly of the lower limbs, carries an increased risk venous thromboembolism (VTE) including deep vein thrombosis (DVT) and pulmonary emboli (PE).[4] These are potentially life-threatening complications, but precautions can be taken to mitigate against them. VTE risk factors include personal history of VTE, malignancy, increased age, high body mass index (BMI), prolonged lower limb immobilization, blood coagulopathy disorders, smoking, and the use of oral contraceptives or hormone replacement therapy. For patients undergoing surgical repair, depending on the tension upon the repair, a period of immobilization with bracing may be prescribed to protect the repair while healing tissue forms,[25] which may increase the risk of DVT or PE. VTE prophylaxis can be categorized into mechanical prophylaxis or chemical prophylaxis (chemoprophylaxis).[20] Mechanical prophylaxis includes compression stockings and calf-compression devices,[19] while chemoprophylaxis includes anticoagulation medications such as aspirin, low–molecular weight heparin (LMWH), and/or direct oral anticoagulants such as rivaroxaban or apixaban.[7,20] The risk of VTE must be balanced with the risk of postoperative bleeding because of the close proximity of the sciatic nerve to the proximal hamstring insertion site, which could cause nerve compression from hematoma formation or intraneural bleeding.

VTE rates are widely reported for a majority of orthopaedic lower-limb pathologies. However, there is a paucity and considerable variability in the reporting of its incidence in proximal hamstring injuries. Studies have reported an incidence as low as 0.68% to as high as 6.9%, but with inconsistent reporting and low patient numbers, further studies would benefit the literature.[8,13,21]

The aims of this study were to report the incidence of symptomatic VTE after repair of proximal hamstring avulsion repair and assess the efficacy of our thromboprophylaxis protocol. We hypothesized that the incidence of symptomatic VTE after proximal hamstring avulsion repair is lower than previously reported and that aspirin may be used as an effective form of thromboprophylaxis.

METHODS

This prospective cohort study included 980 patients with complete or partial proximal hamstring avulsion injuries who underwent operative repair between 2000 and 2020 at a single institution. All procedures were performed by the senior author (F.S.H.) as part of his regular surgical practice. Because we used anonymized data, research ethics committee approval was not required for this study.

Within our institution, patients undergoing repair of proximal hamstring avulsion injuries were anecdotally recognized to have VTE complications by the senior author, which prompted the change in our postoperative VTE prophylaxis. The first cohort of 380 patients, who underwent surgery between 2000 and 2010, were prescribed mechanical prophylaxis alone in the form of compression stockings, with no routine chemical prophylaxis. The second cohort of 600 patients, who underwent surgery between 2011 to 2020, were prescribed compression stockings with the addition of aspirin 150 mg once daily used routinely in all patients until the 6-week follow-up. Any patients deemed to be of higher risk (age >60 years, known thrombophilia, obesity, personal history of VTE, use of an estrogen-containing contraceptive or hormone replacement therapy, smoking, history of malignancy) were prescribed prophylactic dose LMWH in place of aspirin. In both cohorts, patients were mobilized with partial weightbearing from postoperative day 1, began early rehabilitation exercise, and maintained good hydration. The use of postoperative bracing was based on intraoperative assessment of the tension through the hamstring repair with flexion and extension. If applied, the brace was restricted to 60° to 120° of knee flexion.

Data were prospectively compiled by a clinical research nurse, including demographics, method of injury and sporting activity, whether they had a brace postoperatively, and any clinical diagnosis of postoperative DVT or PE. Diagnosis of hamstring avulsion was made on MRI findings, which were used to differentiate the site and degree of injury. Both complete and partial avulsion injuries from the ischial tuberosity were repaired with debridement of the damaged tendon and reattachment to its osseous bed using suture anchors (5.5-mm HEALIX Suture Anchors; DePuy Synthes). Throughout the series, the operative technique and subsequent rehabilitation protocols remained consistent in both groups.

Patients were not routinely screened for VTE unless any abnormal findings were identified on their MRI scan or if patients had recently flown from abroad to the clinic. Any patients found to have clinical suspicion of VTE, including disproportionate levels of swelling, calf or thigh pain not consistent with surgery, and/or respiratory symptoms, were investigated with appropriate imaging in the form of an ultrasound Doppler scan and/or computed tomography pulmonary angiogram. In radiologically confirmed cases of

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TABLE 1
Demographics and Baseline Data Between the Study Cohorts[a]

	Cohort 1: Mechanical Prophylaxis Alone (n = 380)	Cohort 2: Mechanical and Chemical Prophylaxis (n = 600)	*P* Value
Age, y	29 ± 6.7	27 ± 5.2	.64
Sex, male:female	287:93	479:121	.21
BMI, kg/m^2	28.3 ± 4.9	27.9 ± 3.7	.35
Days from injury to surgery	29 (3-84)	22 (4-84)	.12
Postoperative bracing	355 (93.4)	278 (46.3)	**.01**

[a]Data are reported as n (%), mean ± SD, or median (range). Bolded *P* value indicates statistically significant difference between groups ($P < .05$). BMI, body mass index.

VTE, appropriate treatment dose anticoagulation was commenced. Any patients found to have a VTE were analyzed to identify any risk factors including family history of VTE, age, female sex, high BMI, smoking, use of oral contraceptives, and immobility.

The independent-samples *t* test was used to compare outcomes with a normal distribution, and the chi-square test was used to compare categorical variables between the 2 treatment groups. The Mann-Whitney *U* test was used to compare continuous variables that were not normally distributed. Continuous variables found to be normally distributed were displayed with the mean and standard deviation, while the median and range were presented for variables found not to follow a normal distribution. Statistical significance was set at a $P < .05$ for all analyses, and all statistical analyses were performed using SPSS Version 21 (IBM).

RESULTS

The overall male-to-female ratio of the 980 study patients was 3:1, and 65% of patients were either professional or competitive athletes. Across all patients, both recreational and professional, soccer (39%), rugby (18%), and running (11%) comprised the 3 most common sporting activities in which the injuries were sustained. The demographic and baseline data between the 2 study cohorts are displayed in Table 1. There was a significant difference between the first and second cohorts in the percentage of patients who received postoperative bracing (93.4% vs 46.3%; $P = .01$).

In the first cohort, 38 patients (10%) underwent radiological investigation for VTE due to clinical suspicion. A total of 5 patients developed symptomatic VTE in the first cohort compared with no patients in the second cohort (1.32% vs 0%; $P = .0048$). Three patients (0.79%) were found to have DVTs, and 2 additional patients (0.53%) developed PEs. Of the 5 patients who developed symptomatic VTE, 4 were female, and 1 was male; all patients were aged >50 years. None of the patients were professional athletes. In these patients, identified risk factors for VTE included BMI ≥30 kg/m^2 (all patients), history of smoking (n = 3), and active hormone replacement therapy (n = 2). In addition, all 5 patients were relatively inactive pre- and postoperatively and failed to attend physiotherapy in the first 2 weeks postoperatively.

In the second cohort, 40 patients (6.67%) underwent a Doppler scan, but no patients (0%) showed a DVT. Two patients were found to have a small vessel occlusion, which did not require treatment. There were no symptomatic PEs among this cohort. There were no postoperative bleeding complications as a result of anticoagulation with aspirin or LMWH.

Our overall incidence of clinically symptomatic VTE in this study was 0.51%. The incidence of VTE in the first cohort prescribed mechanical prophylaxis alone was 1.32% (n = 380); in the second cohort, prescribed mechanical and chemical prophylaxis was 0% (n = 600). There was a statistically significant difference in thrombosis between the 2 groups ($P = .0048$; chi-square test). There were no incidences of postoperative hematoma causing sciatic nerve compression or exploration in this study.

DISCUSSION

In this study, the incidence of symptomatic VTE after proximal hamstring avulsion repair was found to be 0.51% across a total of 980 patients. The use of aspirin (150 mg) once daily until the 6-week follow-up, in addition to compression stockings and early mobilization, resulted in a statistically significant reduction in symptomatic VTE as opposed to compression stockings and early mobilization alone (0% vs 1.32%; $P = .0048$). No adverse bleeding events were found with aspirin use.

Proximal hamstring injuries are common in professional athletes and increasingly identified in older recreational athletes. In both instances, operative repair of both complete and incomplete avulsions of the proximal hamstrings demonstrated improved functional outcomes, return to preinjury level of sport, and decreased recurrence rates.[6,8,9,21] The relative rarity of this injury in the wider population leads to a paucity of data in the literature, including the incidence of VTEs, particularly in relation to other orthopaedic lower limb injuries in which this information is widely documented.

Engler et al[13] reported a 6.9% incidence in their retrospective case series of 144 complete proximal hamstring ruptures, with 10 patients developing symptomatic DVTs, of which 5 were diagnosed preoperatively and 5 postoperatively. In the postoperative cohort, patients were prescribed either aspirin 325 mg twice daily or Enoxaparin 40 mg once daily. They noted a change in surgeon preference in 2017, switching aspirin to Apixaban 2.5 mg twice daily in low-risk individuals. In the postoperative cases, a number of risk factors were identified: The mean age of these patients was 48.3 years (range, 29-64 years); 1 patient was a smoker; 1 patient had factor V Leiden; 1 patient was taking oral contraceptives; 1 patient had a family history of DVT; and 1 patient had a long flight 4 days before surgery. They did not

report any bleeding complications as a result of chemical prophylaxis. Comparatively, our prospective series included larger cohorts and has shown a significantly lower overall incidence of symptomatic VTE (0.51%), while patients taking aspirin were found to have no DVTs or PEs.

Sarimo et al[21] evaluated outcomes of 41 patients with complete proximal hamstring avulsions who underwent operative repair. In all patients, their management included suture anchors, toe-touch weightbearing for up to 3 weeks postoperatively, and no use of casts or bracing. There was no mention of chemical or mechanical thromboprophylaxis use; however, they encouraged early mobilization (light pool work 3 weeks postoperatively). They predominantly evaluated functional outcomes after surgery but reported 1 patient who developed a DVT. That said, there was no further information regarding this patient. Their VTE rate was 2.4%, which while better than Engler et al,[13] remained higher than that reported in our study.

Bodendorfer et al[8] performed a meta-analysis of outcomes in proximal hamstring avulsion injuries. A total of 22 studies with 767 operatively managed patients were included, with a range of clinical outcomes recorded. Their study reported a total of 5 DVTs (0.68%) in patients who underwent surgery, but these were not deemed statistically significant. However, their study contained some limitations: VTE events were not consistently reported in every study included in their meta-analysis; in patients who developed a DVT, no further information on their demographics or risk factors was provided; and no information regarding postoperative thromboprophylaxis was provided. Yet, the meta-analysis includes a high number of patients and incidence of DVT that are consistent with our study. Although Bodendorfer et al found a statistically insignificant DVT rate, we believe VTE is a rare but major complication and is thus clinically significant. The risk of VTE is reduced with aspirin (or LMWH in high-risk treatment groups); therefore, we believe it should be considered clinically significant and highlighted in the literature.

Our incidence of 0.51% is consistent with other lower-limb injuries reported in the literature. The postoperative reduction in mobility through bracing is similarly seen in anterior cruciate ligament (ACL) reconstructions (ACLRs), quadriceps or patellar tendon repairs, and lower-limb fractures immobilized in plaster. A Cochrane review analyzing VTE rates in 6 randomized controlled trials with 2924 patients who had at least 1 week of lower-limb immobilization reported a symptomatic DVT rate of 2.1% in patients who did not receive chemical prophylaxis, and 0.8% in those who received LMWH.[26] This is in line with our study in which 1.32% developed symptomatic VTEs with no chemical prophylaxis, whereas with chemical prophylaxis no patients (0%) developed a symptomatic VTE. We utilized postoperative bracing throughout our study. However, there was a statistically significant difference (93.4% vs 46.3%; $P = .01$) in the use of bracing between the 2 cohorts, which could have a confounding effect. However, as a significant proportion of the chemical prophylaxis cohort (46.3%) also underwent bracing and yet no patients developed a symptomatic VTE, we believe this is a limited confounder.

Two large cohort studies place the incidence of VTE after ACLR in the range of 0.4% to 0.53%.[14,16] Kraus Schmitz et al[16] performed a cohort study of 26,014 ACLRs in the Swedish National Knee Ligament Register and identified 89 VTEs (0.4%), with the only significant risk factor being an age >40 years ($P < .001$). Gaskill et al[14] performed a cohort study of 16,558 ACLRs in the Department of Defense Medical Data Repository and identified 87 VTEs (0.53%), and they similarly concluded that the main risk factors were age >35 years ($P = .003$) with a history of nicotine use ($P = .014$). Both studies concluded that routine use of chemical prophylaxis is not required with ACLR, unless intrinsic risk factors are present, particularly increasing age. The patient demographics between ACL ruptures and proximal hamstring ruptures are similar, and our comparable symptomatic VTE rate of 0.51% seen in more elderly patients in our series who did not receive chemical prophylaxis is in line with the literature reported for ACL ruptures.

A VTE rate of 2.5% has been reported in quadriceps tendon repairs, which undergo similar postoperative restrictions to hamstring repair, with a period of weightbearing as tolerated and immobility in an extension brace.[10] This higher incidence may be attributed to the etiology of quadriceps tendon ruptures, as they are more frequently seen in middle-aged or older patients[11]; occur through indirect or direct trauma; can occur bilaterally; or may occur spontaneously in predisposing conditions such as rheumatoid arthritis, diabetes, or renal failure.[22] These comorbidities, particularly increased age, which is shown to be a significant risk factor for VTE in hamstring repairs, may lead to a greater disposition for VTEs.

It is difficult to compare VTE rates with lower-limb trauma due to confounding factors, particularly the higher energy involved in these injuries, more invasive surgical repair, presence of fat emboli, and much wider patient demographic. Tibial plateau and shaft fractures are often immobilized in an above-knee cast or splint to prevent knee mobility and restrict weightbearing. In these fractures, the incidence of postoperative proximal DVT is much higher, reported at 4.5% and 4.6%, respectively.[24] However, in ankle fractures, this rate is much lower, with 1 study reporting 0.28% and 0.21% for DVT and PE, respectively,[23] suggesting that routine anticoagulation may not be required. Unlike tibial fractures, ankle fractures are immobilized in below-knee splints, so knee flexion can still occur, and this may be an important factor in DVT prevention. In proximal hamstring avulsion repair, early mobilization and our use of bracing, which allows a range of 60° to 120° of movement, may help vascular venous return and reduce the risk of VTE.

With such low rates of VTE, the need for anticoagulation remains debatable; however, DVTs and PEs are potentially fatal complications, and consideration to minimize any risk must be given. Conversely, bleeding risks with anticoagulation must be considered, as the sciatic nerve is a prominent structure in the approach with an intimate relationship to the hamstring origin. As such, any bleeding may cause nerve compression. Aspirin is a safe, reversible,

and low-cost anticoagulant, which in our study has shown to be an effective thromboprophylactic medication and importantly has not caused any bleeding complications. LMWH and direct oral anticoagulants are associated with potentially higher bleeding rates, are not easily reversible, remain expensive, and are not shown to have any superiority in VTE prevention relative to aspirin.[3,18] Our patient cohort underwent a change in protocol midway through this study, with patients initially receiving only mechanical prophylaxis and routine use of bracing. Subsequent to the senior author's change in preference, patients were then started on aspirin postoperatively, or LMWH in higher-risk individuals, with increasingly less use of bracing. All symptomatic VTEs identified in our study occurred in patients in the first protocol, with no symptomatic VTEs occurring in patients receiving aspirin. Engler et al,[13] in their study, used Apixaban, which is a more expensive and irreversible anticoagulant, with higher bleeding risk. We suggest that the routine use of aspirin is an adequate choice of prophylaxis in low-risk individuals, as shown in our series and as widely used in others.[2]

The 5 patients who developed symptomatic DVTs or PEs in our study were higher-risk individuals and represent a demographic not routinely seen with these injuries. They were all aged $\geq$50 years and had high BMI. These patients were generally less mobile and did not attend postoperative physiotherapy in the first 2 weeks. In addition, 3 were smokers, and 2 were on hormone replacement therapy. They had no personal or family history of VTE. All patients received mechanical prophylaxis and postoperative knee bracing. Collectively, these patients had a number of significant risk factors for developing VTE and would be considered higher risk in our revised protocol; thus, they would have had anticoagulation with either aspirin or LMWH to potentially reduce the risk of VTE.

There are several limitations to be appreciated when interpreting these findings. First, patients were not prospectively randomized into each cohort. Patients were allocated to their treatment groups based on the date of their surgery as the surgeon transitioned from mechanical prophylaxis to both chemical and mechanical prophylaxis to reduce the risk of VTE. Second, we did not perform routine VTE screening, but only investigated if clinically indicated; therefore, only symptomatic VTEs would be identified and the true incidence may be higher than reported. Third, the overall infrequency of VTEs leads to limited statistical analysis, whereas large database studies would provide more accurate results as seen in the National Ligament Registry analyses for ACLRs.[14,16] Fourth, the level of activity or competition of patients was not recorded prospectively, which may have allowed greater analysis and differentiation between different patient demographics. Fifth, although the surgical technique and postoperative rehabilitation remained consistent, as they are sequential cohorts over a 20-year period, the surgery may have become more proficient, and subsequent rehabilitation subtly increased in intensity. Sixth, the use of bracing has decreased over time with a statistically significant difference between the 2 cohorts, which may be a confounding factor. We do not believe this is a main contributing factor as no patients developed a VTE in the second cohort despite 46.3% of patients receiving a brace. Finally, our population included competitive or professional athletes, which in their own regard will inevitably have lower risk factors for VTE, and may also have enhanced recovery programs through increased physiotherapy services. This does not necessarily represent the general population.

CONCLUSION

In this study, the incidence of symptomatic VTE in patients undergoing proximal hamstring avulsion repair was 0.51%. The combination of early mobilization despite bracing, mechanical prophylaxis with compression stockings, and chemical prophylaxis with aspirin or LMWH for high-risk patients decreased the risk of VTE postoperatively.

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