



Complications following anterior cruciate ligament reconstruction in the English NHS

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ABSTRACT

Unlike the English National Joint Registry (NJR) for arthroplasty, no surgeon driven national database currently exists for ligament surgery in England. Therefore information on outcome and adverse events following anterior cruciate ligament (ACL) surgery is limited to case series. This restricts the ability to make formal recommendations upon surgical care. Prospectively collected data, which is routinely collected on every NHS patient admitted to hospital in England, was analysed to determine national rates of 90-day symptomatic deep venous thrombosis (DVT), pulmonary thromboembolism (PTE) rate, 30-day wound infection and readmission rates following primary ACL reconstruction between March 2008 and February 2010 (13,941 operations, annual incidence 13.5 per 100,000 English population). 90-day DVT and PTE rates were 0.30% (42) and 0.18% (25) respectively. There were no in-hospital deaths. 0.75% (104) of the consecutive patient cohort had a wound complication recorded. 0.25% (35) underwent a further procedure to wash out the infected knee joint and 1.36% (190) were readmitted to an orthopaedic ward within 30 days. This is the first national comprehensive study of the incidence of significant complications following ACL surgery in England. This should allow meaningful interpretation of future baseline data supporting the development of a national ligament registry.

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1. Introduction

Annually, around 100,000 primary anterior cruciate ligament (ACL) reconstructions are performed in the US, with this number increasing [1]. Accurate figures for the frequency of such procedures in English practice do not exist, and there remains little information on the epidemiology of post-operative complications. There is a growing awareness of venous thromboembolism (VTE) following orthopaedic surgery, and there are formal recommendations on thromboprophylaxis from the National Institute for Health and Clinical Effectiveness (NICE) following lower limb arthroplasty [2] but no reliable data exists to allow for informed discussion regarding thrombotic risks following modern endoscopic ligament surgery. Indeed a publication entitled 'Complications of arthroscopic reconstruction of the anterior cruciate ligament' specifically failed to discuss rates of VTE or infection post surgery [3]. The reader may therefore draw the conclusion that thrombotic events or infections following arthroscopic ACL surgery do not represent a clinical problem.

ACL reconstruction performed as a day case (less than 24 h stay) is increasingly being reported in association with accelerated rehabilitation

[4]. Despite this, there have been sporadic reports of VTE complications ranging from documented deep vein thrombosis (DVT) through to fatal pulmonary thromboembolus (PTE) [5]. BASK best practice guidelines state that thromboprophylaxis is unnecessary given the rarity of VTE [6]. This is in no small measure due to the lack of a prospective national database or large series analyses. Our knowledge is confined to individual surgeon case series and highly subjective postal surveys with poor uptake. It is essential for the purposes of making appropriate and informed recommendations on the prevention of complications following ligament surgery that knowledge of relative risk should exist. Moreover, national standard setting, comparison between units, and evidence for future consultant surgeon revalidation are only possible with population-based datasets.

In depth data concerning diagnosis, operation, co-morbidities and post-operative complications is prospectively collected on every NHS patient admitted to hospitals in England (Hospital episode statistics data [HES]) [7]. The risk of VTE following foot/ankle surgery has previously been analysed [8]. From this independent English database we have now analysed data for ACL surgery.

2. Methods

Data for English NHS patients (treated in NHS, private or independent sector treatment hospitals) who underwent planned ACL reconstruction between March 2008 and February 2010 were

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collected from the administrative hospital admissions database (HES data). This was augmented with more recent data from the Secondary Users Service (a system that reports and analyses the latest data from NHS units to support planning and commissioning of healthcare provision) [9]. HES covers all admissions to English hospitals providing care for NHS patients and includes fifteen diagnosis fields (coded using the International Statistical Classification of Diseases and Related Health Problems [10th revision], ICD-10 codes), and fifteen surgical procedure fields (coded using Office of Population, Censuses and Surveys Classification of Surgical Operations and Procedures [4th revision], OPCS-4 codes). Within the system, patients are identified by a pseudonymisation identifier created by the Information Centre for Health and Social Care (ICHSC), in order that independent data analysis providers have no access to patient identifiable information [10]. Records belonging to the same patient (defined using a combination of date of birth, sex and postcode) were linked and the number of days between the index operation and any subsequent orthopaedic re-admission to any NHS hospital was collected. Patients with missing dates of operation were excluded. By employing the appropriate ICD-10 or OPCS codes, complication rates were identified. Rates of PTE, symptomatic DVT and all-cause in-hospital mortality within 90 days were established, even if successfully discharged following the primary procedure. Length of stay and readmission within 30 days of the primary procedure were also analysed. Wound infections and haematomas were grouped as 'wound complications'. In addition, deep wound infection (defined as those who returned to theatre for joint washout) were also analysed independently. Age, sex and Charlson score [11] were recorded for each patient. The Charlson co-morbidity index predicts the one-year mortality for a patient who may have a range of co-morbid conditions. Each condition is assigned with a score of 1, 2, 3 or 6 (Appendix 1) depending on the risk of dying associated with this condition. The combined total score is then used to predict patient-specific overall mortality.

CHKS has approval to re-use HES data with the permission of The Health and Social Care Information Centre [12]. Codes are summarised in Appendix 2. Information about the mechanism of injury, the duration of symptoms, severity of damage and the method of reconstruction was not available, due to the nature of this database.

Provider identification numbers, recorded in the HES database, were used to calculate units' yearly volume of ACL reconstructions. Surgical volume was categorised as high (> 100 cases per year), mid (25–100) or low (>3<25). In addition, funnel plots (produced in MATLAB) were used to compare individual units with the national baseline (mean) for the adverse outcomes (VTE, re-operation, infection and readmission). These plots are recommended as a graphical aid for institutional comparisons in order to compare proportions and assess association between outcome and volume of cases [13]. Control limits create a funnel around the baseline (mean hospital performance) in order to identify statistical outliers. The score confidence interval as described by Wilson was used to create limits [14]. This prevents spurious ranking of institutions into 'league tables.' For each adverse outcome scatter plots of performance, as a percentage, were generated against the number of cases reported (the denominator for the percentage). 'Population' represents the number of ACLs performed during the study period (two years) in the plots. In this analysis there was no risk adjustment. Units performing less than three per year were excluded from the funnel plot to avoid unnecessary low volume clutter.

Odds ratios (OR) and 95% confidence intervals [15] were calculated for rates of post-operative complications using the conditions 'age' (categorised as less than twenty, twenty to 30, 30 to 40, or 40 and over), 'sex', 'Charlson score and co-morbidities', 'length of stay' (less than one day, one-two days, more than two days) and 'hospital provider volume' (low, mid and high volume). For each condition, one category was used as a reference compared to which all other categories were compared. Complications tested were VTE within 90 days, any wound complication within 30 days, re-operation for

Table 1
Demographics of patients undergoing anterior cruciate ligament reconstruction in the English NHS (2008–2010).

	ACL reconstruction (N = 13,941)
Age (years, mean and range)	29.34 (8–83)
Charlson score	
0	13012 (93.3%)
≥ 1	929 (6.7%)
Sex	
Female	2854 (20.5%)
Male	11084 (79.5%)
Missing data	3 (0.0%)
Co-morbidities	
IDDM	25 (0.2%)
NIDDM	38 (0.3%)
RA	5 (0.0%)
Length of stay	
<1 day	2681 (19.2%)
<2 days	11103 (79.6%)
Providers (241 units)	
Minimal volume (62 units)	127 (0.9%)
Low volume (79 units)	2096 (15.0%)
Mid volume (88 units)	8469 (60.7%)
High volume (12 units)	3249 (23.3%)

ACL – anterior cruciate ligament, IDDM – Insulin dependent diabetes mellitus, NIDDM – non-insulin dependent diabetes mellitus, RA – rheumatoid arthritis, Minimal volume – <3 ACLs per year, Low volume – ≥3<25 ACLs per year, Mid volume – ≥25<100 ACLs per year, High volume – ≥100 ACLs per year

deep wound infection within 30 days, and orthopaedic readmission within 30 days. The null hypothesis (OR = 1) was tested using the chi-square test (alpha = 0.05) for a 2 × 2 contingency table (Table 3).

3. Results

Table 1 outlines the patient demographics. A total of 13941 ACL reconstructions were performed in the English NHS in the 24-month study period between 2008 and 2010. Data was recorded at 241 units of which 179 performed more than three ACLs per year (accounting for 99.1% of patients). Mean age was 29.3 years with a range of 8–83.

Fig. 1 displays the spread of cases by age. The majority of patients were fifteen to 45 years of age. Three patients (0.0%) under 10 years old and 47 (0.3%) over 65 years underwent ACL reconstruction.

The spread of inpatient stay is shown in Fig. 2. The majority of patients (79.6%) stayed in hospital for less than two days, although the true day case figure is considerably lower at around 20%. 99% of patients were discharged within four days.

Table 2 summarises the complications identified during the study period as a percentage of the total group. Within 90 days of ACL reconstruction, there were 67 thrombotic (peripheral and central, non fatal PTE) events in 62 patients. There were no deaths recorded.

It can be seen from Fig. 3 that ACL surgery increases the risk of VTE compared with a control group of non-surgical patients, but remains at approximately 25% of lower limb arthroplasty rates. When data was analysed for each unit to create funnel plots, no

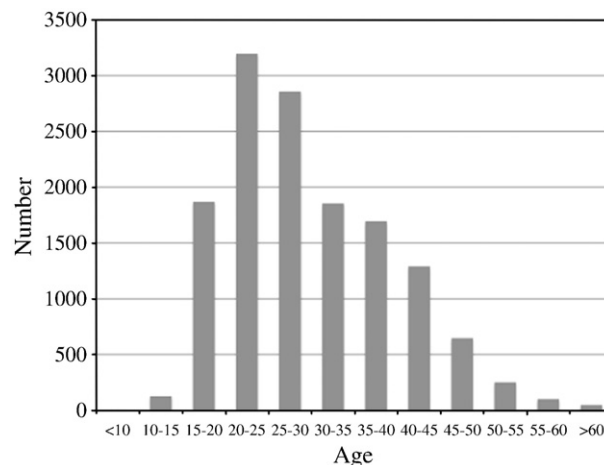


Fig. 1. Age distribution of patients undergoing anterior cruciate ligament reconstruction in the English NHS (2008–2010).

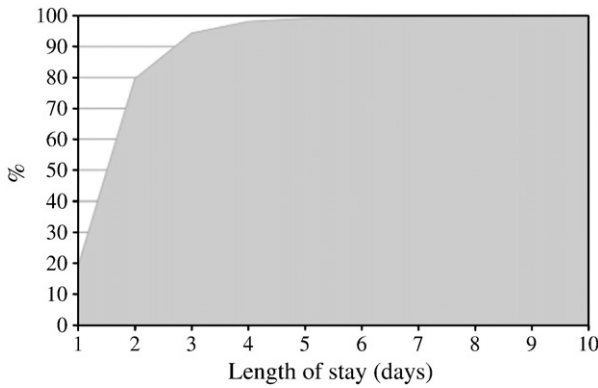


Fig. 2. Length of stay recorded for ACL reconstruction patients in the English NHS (2008–2010).

Table 2

National complication rates following anterior cruciate ligament reconstruction in the English NHS (2008–2010).

Complication	Number of patients (%)
Any wound complication within 30 days	104 (0.75)
RTT for deep infection	35 (0.25)
Orthopaedic readmission within 30 days	190 (1.36)
Readmission with wound complications	82 (0.59)
VTE event within 90 days*	62 (0.44)
DVT	42 (0.30)
PTE	25 (0.18)
Death within 90 days	0

ACL – anterior cruciate ligament, RTT – return to theatre, VTE – venous thromboembolism.

* 5 patients had both DVT and PTE, DVT – deep vein thrombosis, PTE – pulmonary thromboembolism.

outliers were found for VTE rates (Fig. 7). Of the 104 (0.75%) patients who developed a wound complication within 30 days, 35 (0.25%) required a further operation to wash out the infected knee joint. Figs. 4 and 5 display this data in funnel plots for each unit. There are no outlying units for reoperation for infection. However, there is one high volume unit that falls on the 95% confidence limits for wound complications.

Fig. 6 shows one outlier (bold square) for 30-day readmission, with several others close to the 95% confidence line. One hundred ninety patients (1.36%) were readmitted to orthopaedics within 30 days of discharge. Of these, just under half had a wound complication recorded.

Table 3 shows that the risk of a VTE event was significantly higher in patients 40 years old and over (odds ratio (OR) 2.36, 95% confidence intervals (CI) 1.29–4.34, $p = 0.004$), although length of stay and existing co-morbidities did not appear to have an influence. Male sex was a predictor of 30-day readmission (OR = 1.96 (95% CI 1.26–

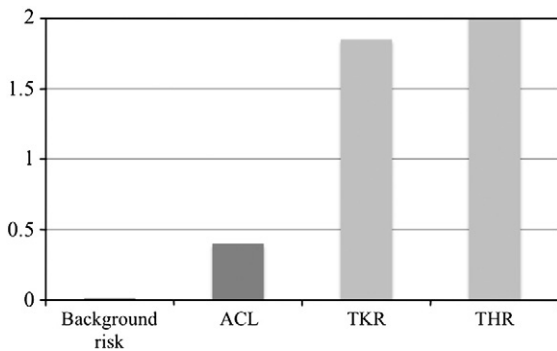


Fig. 3. 90-day VTE rate following ACL reconstruction compared with lower limb arthroplasty and background risk. VTE – venous thromboembolism, ACL – anterior cruciate ligament reconstruction, Background risk in middle-aged, female, non-surgical population [17], TKR- total knee replacement, THR – total hip replacement. VTE risk after THR and TKR [18].

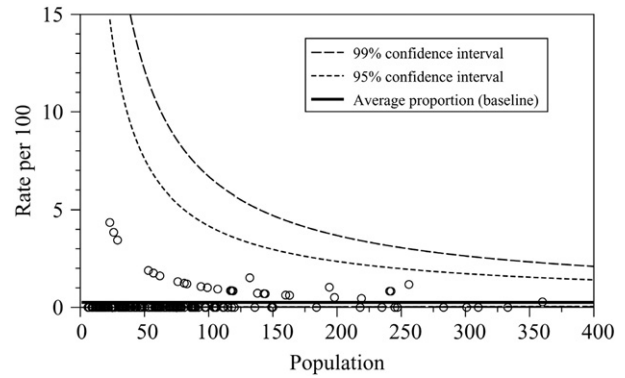


Fig. 4. Funnel plot of 30-day return to theatre for infection following ACL reconstruction in units providing care for English NHS patients.

3.06), inverted from the value in Table 3, showing the OR for females, $p = 0.002$). There were no predictors for 30-day wound complication or reoperation for infection.

4. Discussion

Anterior cruciate ligament reconstruction is considered a safe procedure performed endoscopically with low complication rates. The literature describes revision rates for graft failure and poor tunnel position but little information on infection and VTE [3]. To the best of our knowledge this is the first independent comprehensive report from an English population database for ACL reconstruction. Over the last 2 years (2008–2010), 13,941 primary ACL reconstructions were performed (annual incidence 13.5 per 100,000 English population). The majority of these patients were discharged within two days of surgery. It is a common perception that ACL surgery is a ‘day case’. In

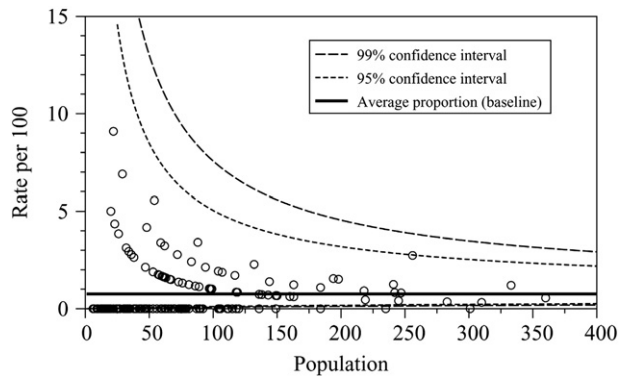


Fig. 5. Funnel plot of 30-day wound complications following ACL reconstruction in units providing care for English NHS patients.

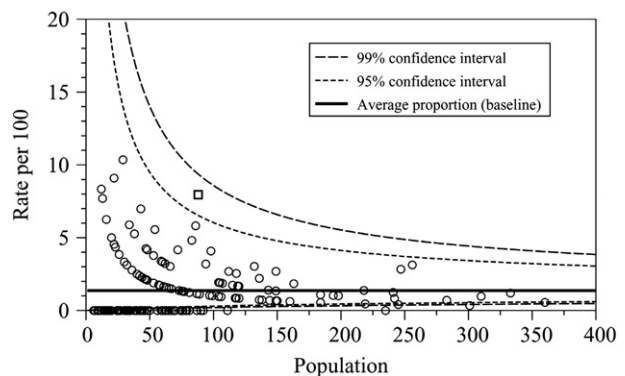


Fig. 6. Funnel plot of 30-day readmission following ACL reconstruction in units providing care for English NHS patients.

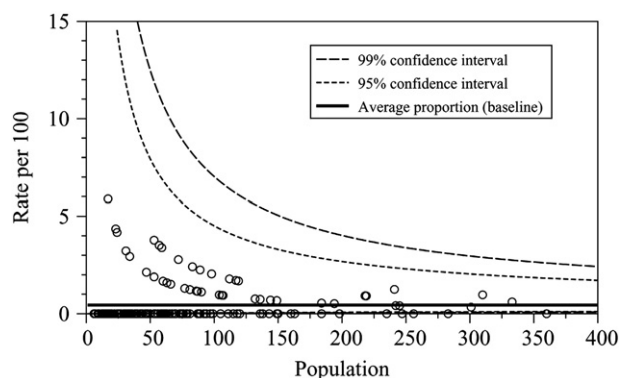


Fig. 7. Funnel plot of 90-day VTE event following ACL reconstruction in units providing care for English NHS patients.

fact, this data shows that only around 20% are true day case procedures in the English NHS.

Rates of wound complications, early re-operation for infection and readmission were low and there were no deaths recorded. Infection is a rare complication after ACL reconstruction and ranges from 0.3% to 1.7%, usually involving bacterial organisms [16]. This can range from superficial surgical site infection and minor wound complications to septic arthritis of the knee with devastating consequences. Lyman et al. [1] looked at complications post surgery and quoted a readmission rate within 90 days of 2.3%. Our 30-day readmission rate was 1.4%. However, there appeared to be more variance from the baseline in this data compared with other complications, with several units in the funnel plots straying towards the upper 95% confidence limits. This data may be important in the future as English NHS Trusts are penalised for every readmission following elective surgery [17]. Our low infection rate combined with low return to theatre figures

reassures and confirms that ACL reconstruction is a clean procedure. Unfortunately, other than infections, we lack data on cause of readmissions. This could suggest that we are underestimating wound complication rates, or simply that patients are presenting other complications that our analysis is unable to capture. Lyman et al. [1] also found that low volume units had significantly higher readmission rates. We found no such association with any of the complications investigated in this study.

There is a commonly held view that ACL surgery is not associated with VTE. This study has demonstrated that patients undergoing ACL reconstruction are at greater risk of VTE when compared with a non-surgical population, but much lower than lower limb arthroplasty patients, and there were no fatal PTEs. Based on a middle-aged, female, non-surgical population, the general background risk of a VTE event was calculated as 0.058 per 1000 person months by Sweetland and colleagues [18]. For a 90-day (3 month) period this is the equivalent of 0.017% risk. VTE rates are therefore 26 times higher than the background risk (0.44%) after ACL reconstruction. Jameson et al. [19] have previously shown that VTE risk (excluding out of hospital fatal PE rate) following lower limb arthroplasty is around 2%, similar to the findings of Sweetland et al, and around 120 times higher than background risk (Fig. 3). It should be noted that over 95% of lower limb arthroplasty patients receive chemical thromboprophylaxis [20]. This data is unknown for ACL surgery, but is likely to be much lower.

Current guidelines from the statement of best practice in primary ACL reconstruction for an isolated rupture, approved by the British Orthopaedic Association, British Association for the Surgery of the Knee and British Orthopaedic Sports Trauma Association state that the risk of DVT following ACL surgery is very low and routine prophylaxis is not indicated [6]. NICE does not currently make any specific recommendations on thromboprophylaxis following ACL surgery, although there is guidance on lower limb elective surgery. This states that patients who undergo lower limb surgery lasting for more than

Table 3
Predictors of outcomes.

	90-day VTE		30-day wound complication		30-day reoperation for infection		30-day readmission	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
Age								
<20	0	–	0.57 (0.24, 1.35)	0.195	1.01 (0.32, 3.13)	0.989	1.16 (0.75, 1.78)	0.509
20–30	Reference		Reference		Reference		Reference	
30–40	1.55 (0.84, 2.85)	0.152	1.12 (0.64, 1.94)	0.688	1.71 (0.77, 3.80)	0.185	1.21 (0.85, 1.73)	0.277
>40	2.36 (1.29, 4.34)	0.004	1.22 (0.66, 2.25)	0.533	1.51 (0.60, 3.85)	0.381	1.06 (0.69, 1.61)	0.794
Charlson score								
0	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
≥1	0.97 (0.35, 2.66)	0.947	0	–	0	–	0.94 (0.52, 1.70)	0.846
Sex								
Female	1.47 (0.84, 2.57)	0.175	0.54 (0.27, 1.08)	0.076	0.50 (0.17, 1.42)	0.184	0.50 (0.32, 0.79)	0.002
Male	Reference		Reference		Reference		Reference	
LOS								
<1 day	0.82 (0.42, 1.60)	0.563	0.66 (0.32, 1.35)	0.248	0.78 (0.29, 2.09)	0.628	0.98 (0.67, 1.44)	0.923
>1 <2 days	Reference		Reference		Reference		Reference	
>2 days	0.63 (0.31, 1.31)	0.213	1.52 (0.91, 2.55)	0.107	1.49 (0.69, 3.18)	0.305	1.14 (0.80, 1.63)	0.464
Provider volume								
Low	0.72 (0.29, 1.77)	0.477	0.97 (0.44, 2.14)	0.937	0.52 (0.14, 1.91)	0.313	1.43 (0.90, 2.29)	0.132
Mid	Reference		Reference		Reference		Reference	
High	1.02 (0.56, 1.85)	0.939	1.15 (0.65, 2.03)	0.625	0.98 (0.45, 2.12)	0.959	1.23 (0.85, 1.78)	0.280

VTE – venous thromboembolism, OR – odds ratio, CI – confidence intervals, P value comparing group of interest with reference group, IDDM – Insulin dependent diabetes mellitus, NIDDM – non-insulin dependent diabetes mellitus, RA – rheumatoid arthritis, Low volume – $\geq 3 < 25$ ACLs per year, Mid volume – $\geq 25 < 100$ ACLs per year, High volume – ≥ 100 ACLs per year.

60 min, including anesthetic time (defined as ‘high risk’), may benefit from thromboembolic prophylaxis and should be offered both chemically and mechanically, although this lacks an evidence base (NICE 2010) [2]. However, there remains limited information on the incidence/risk factors for VTE following ACL surgery. Despite a thorough review of the literature we have found few reports from small case series of the incidence and outcome following symptomatic venous thrombosis after primary ACL surgery [5,21]. Other studies identified risk factors for VTE as being over 40 years of age and an operative duration greater than one hour [22]. Carlson et al. [23] reviewed 3200 cases with only seven reported PTEs, and found that 53% of America Orthopaedic Society for Sports Medicine members used some form of VTE prophylaxis. In this analysis, age over 40 years was the only significant predictor of an increase in VTE risk, but there were no fatal in-hospital PTEs in any group. Statistical testing failed to identify an effect of any other variable on the complications analysed (other than sex on readmission, which is difficult to explain). However, it must be stressed that these adverse events are rare and the statistics in this situation have not been particularly helpful in stratifying risk.

The current knowledge of modern day ligament practice and outcome in England is based upon low uptake postal surveys [4,24]. There are limited, small case series [25–27] outlining case mix, outcome and major complications but there are significant drawbacks to such methods of data collection, such as poor response rates, non-validated questionnaires and a potential bias which can limit any conclusions that may be drawn [28]. They may also lack accurate representation of current practice [24]. In addition to these problems, outcome data derived from small number case series is difficult to interpret, as case selection does not accurately represent the normal burden of clinical practice, and there has been focus placed on surgical technique, timing of surgery and graft choice rather than outcome [25–27].

The most comprehensive data to date is derived from the national databases of Scandinavia. Established in June 2004, the Norwegian first two years recorded 2714 primary ACL reconstructions. Of these, 77% received prophylactic anticoagulation and 5% encountered perioperative complications, ‘most often due to graft failure’ [29]. Interestingly the use of thromboprophylaxis ranged from 17% in Denmark to 78% in Norway but no information on type, duration, or dosage was available [30]. Results from the first two years from the Danish registry looked at 4972 primary ACL reconstructions and quoted a perioperative complication rate of 4.3% [31]. Despite commenting on the use of thromboprophylaxis, there are no published VTE rates in any of the registries, nor was there data available on readmission rates or return to theatre for reoperation. Although these registries provide some insight into potential trends, there is limited information on breakdown of complications.

We accept that there are limitations within this observational study. We have no data on type or duration of the thromboprophylaxis regime. Nor were we able to comment on reasons for readmission other than infection. In addition, the data collection and coding of patients who are diagnosed with DVT as an outpatient may not be entirely accurate, and the figures presented here may in fact be an underestimate of the true 90-day DVT rate. Patients who die at home would not be detected in this analysis, but those who become unwell and subsequently die in hospital after readmission would be included. We acknowledge HES inaccuracies from the past [32], but the system is constantly improving and remains the most accurate means of large scale surgical data collection in England currently.

5. Conclusions

This study has quantified the complication rates for VTE, readmission and infection following ACL surgery from a national database. Infection rates are low with only one outlier for a 30-day reoperation.

Readmission rates vary considerably, with several units having higher than expected rates. Contrary to popular belief there is a real but small risk of VTE following ACL surgery. Whether this justifies thromboprophylaxis remains unanswered, given the lack of any real evidence in the literature for benefit. We believe this data strengthens the argument for a funded prospective ligament registry in the UK.

Supplementary materials related to this article can be found online at doi:10.1016/j.knee.2010.11.011.

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