The use of history to identify anterior cruciate ligament injuries in the acute trauma setting: the 'LIMP index'

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ABSTRACT

Objective To identify the injury history features reported by patients with anterior cruciate ligament (ACL) injuries and determine whether history may be used to identify patients requiring follow-up appointments from acute trauma services.

Methods Multisite cross-sectional service evaluation using a survey questionnaire design conducted in the UK. The four injury history features investigated were 'leg giving way at the time of injury', 'inability to continue activity immediately following injury', 'marked effusion' and 'pop (heard or felt) at the time of injury'(LIMP).

Results 194 patients with ACL injury were identified, of which 165 (85.5%) attended an acute trauma service. Data on delay was available for 163 (98.8%) of these patients of which 120 (73.6%) had a follow-up appointment arranged. Patients who had a follow-up appointment arranged waited significantly less time for a correct diagnosis (geometric mean 29 vs 198 days; p<0.001) and to see a specialist consultant (geometric mean 61 vs 328 days; p<0.001). Using a referral threshold of any two of the four LIMP injury history features investigated, 95.8% of patients would have had a follow-up appointment arranged.

Conclusions Findings support the value of questioning patients on specific injury history features in identifying patients who may have suffered ACL injury. Using a threshold of two or more of the four LIMP history features investigated would have reduced the percentage of patients inappropriately discharged by 22.2%. Evidence presented suggests that this would significantly reduce the time to diagnosis and specialist consultation minimising the chance of secondary complications.

Key messages

What is already known on this subject?

- A number of published studies have suggested that injury history features may be useful in identifying patients who may have suffered ACL injury and therefore require follow-up However, it is not clear how often patients have all typical features, and therefore, when urgent follow up should be arranged.

What this study adds?

- In this observational questionnaire study, we found that just over half of patients with ACL injured recalled all four typical historical features.
- Patients with an ACL injury reporting fewer typical historical features were less likely to be referred and had longer delays to seeing a specialist.
- To avoid unnecessary delay in referrals of ACL injuries, without overburdening the system, it is proposed that having two or more features of The 'LIMP index' should result in specialist referral.

INTRODUCTION

Anterior cruciate ligament (ACL) injuries are a global problem with an estimated one million injuries occurring annually worldwide [1 p.3], usually resulting from a single traumatic event. Most persons with an ACL injury present initially to an acute trauma service (eg, A&E department; minor injury unit).[2–4] However, the diagnosis of ACL injuries within the trauma setting is challenging as acute pain and swelling often compromise physical examination. Consequently, the reported accuracy of ACL injury diagnosis at initial presentation is low, ranging between 6.8% and 28.2%.[2–8]

It is imperative that patients with ACL injuries are identified in a timely manner as delay to diagnosis is known to increase risk of long term morbidity as a consequence of concomitant meniscal and/or chondral injury.[9–18] Patients with ACL deficient knees are also reported to experience increased pain, reduced function and greater risk of repeated episodes of instability.[19–21] As many ACL injuries are associated with characteristic symptoms at onset, it has been suggested that exploration of injury history will assist in the accurate identification of patients with ACL lesions thereby ensuring appropriate follow-up beyond the trauma environment and enabling earlier diagnosis.[2–4] Previous studies exploring ACL injuries have reported that the majority of patients (74%–90%) present with 'typical' injury histories.[2–4] However, the use of currently defined 'typical' histories to identify patients who have potentially suffered ACL injury is problematic for a number of reasons. Firstly, definitions of what constitutes a 'typical' ACL injury history are inconsistent and as a result, it is not possible for clinicians to discern the most pertinent injury features relevant to ACL injury diagnosis from the research evidence for application in to practice. Secondly, some of the 'typical' history features reported (eg, recurrent episodes of giving way; 1–2 weeks to show improvement in weight bearing) can only be appreciated sometime after initial injury presentation and are therefore unhelpful in the assessment

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of patients presenting acutely. Thirdly, it is evident that a substantial proportion of patients do not report the full complement of features that represent a 'typical' injury history based on those currently defined.

Despite the problems and inconsistencies in the reporting of injury history, four injury features appear to be frequently reported in the literature by patients who have suffered an ACL injury: leg giving way at time of injury; inability to continue activity immediately following injury; acute swelling (effusion) and hearing or feeling a 'pop' at time of injury.[7] In combination, these features may be considered to constitute a 'typical' injury history. However, no identified study has evaluated whether the presence of these features could be used to inform clinical decision making and follow-up referral pathways and whether their incorporation into the assessment of ACL injury will reduce the inappropriate discharge of patients at high risk of ACL injury.

This paper, based on the findings of a multi-centre survey, examines these four key injury history features and reports the number and type of features reported by patients diagnosed with ACL injury. The potential impact of using these history features to improve follow-up rates and reduce time to diagnosis and specialist consultation is also explored.

METHODS

Study design

Multisite cross-sectional service evaluation using a survey questionnaire design.

Subjects

Patients with ACL injuries were prospectively identified and recruited via eight orthopaedic specialist-led knee clinics in five NHS Hospital Trusts located within the West Yorkshire and North Lincolnshire regions of the UK. A 'specialist' was defined as 'a person highly trained in a particular branch of medicine',[22] in this case the management, including surgery, of the ACL deficient knee. Patients were eligible for inclusion in the study if they had attended a specialist led knee clinic and had been diagnosed with a primary ACL injury through clinical examination, MRI scan or arthroscopy. The inclusion of patients diagnosed through specialist clinical examination was justified as evidence suggests that diagnostic accuracy is comparable to MRI.[23] Patients were excluded if they had a multiple ligament injury, a prior history of ACL injury with attendance at a clinic run by an orthopaedic soft tissue knee specialist or if they had undergone ACL reconstructive surgery. Study approval was gained through research and development or clinical governance frameworks at each of the participating hospital trusts and from the humanities, social sciences and health studies research ethics panel at the University of Bradford (ref: EC1554).

Questionnaire

The structured questionnaire contained a series of closed questions and was informed by published literature detailing the causes of delayed diagnosis of ACL injuries and common clinical features. The survey was evaluated for construct and content by three orthopaedic specialists and piloted on 20 patients within a single hospital site (Bradford Royal Infirmary) to assure comprehension and response consistency. Based on feedback, minor phrasing revisions were made.

The final questionnaire explored patient demographics and the four key injury history features identified: leg giving way (knee going out of place); inability to continue activity immediately following injury; marked swelling (effusion) within six hours and pop (heard or felt). Based on an acronym, we refer to these features as the 'LIMP index'. Questions on the date of initial injury, diagnosis and specialist clinic attendance were included as were details of first presentation for medical attention. Where the patient had first attended an A&E or minor injury unit, details on whether the ACL injury was correctly diagnosed at initial attendance and follow-up appointment arrangements were also explored.

Data collection and handling

Data collection took place between April 2013 and September 2014. Questionnaires were completed via a face-to-face interview during the clinic appointment by the attendant health professional within the specialist clinic. To promote consistency in data collection, all clinical sites were visited prior to study commencement to explain the purpose of the research, provide written instructions and answer any questions concerning the study. Medical records were also available at the time of questionnaire completion to minimise patient recall bias (eg, recalling exact date of injury or hospital attendance history). Data from the completed questionnaires were entered into a spreadsheet (Microsoft Excel 2010; Redmond, Washington, USA) and double checked for accuracy at a later date. Delay to diagnosis was recorded as time in days from initial injury to the patient receiving a diagnosis of ACL injury and delay to specialist consultation as the number of days from the date of initial injury to the date of specialist clinic attendance. Where reported dates were inexact, midpoint rules[24 25] were applied to estimate the actual date for purpose of analysis. Specifically, where the month was supplied but not an exact date, the mid date of the month was used. If the date was reported as 'early' or 'late' within a given month, the first or last date of the month was used respectively. In order to allow investigation of the impact of this choice on conclusions drawn from the model, a sensitivity analysis was undertaken with 'early' taken as the 7th of the month and 'late' as the 22nd of the month.

Analysis

Descriptive statistics were used to summarise demographic information, the number and percentage of patients attending acute trauma services, injury characteristics and reported history features.

Normality of data relating to time to diagnosis and specialist consultation was assessed through visual inspection of histograms and similarity of variance was assessed through comparison of standard deviations. Where conditions for parametric testing were not satisfied, log transformation was performed and the normality of data and standard deviations reassessed. Prior to undertaking log transformation all values of 0 days were revalued as 0.5 to ensure that data were not lost.

An independent samples t-test was undertaken where conditions for parametric analysis were met and the Mann-Whitney test where not. Statistical analysis was undertaken using Stata Statistical Software: Release 14 (StataCorp, College Station, Texas). Statistical significance was set at $\alpha=0.05$.

RESULTS

A total of 194 completed questionnaires were returned and included in the analysis. The flow of patients and analysis undertaken are presented in figure 1. No patient meeting the eligibility criteria and approached to participate refused to take part in the study. The mean (SD) age of patients enrolled in the study was 29 (9.3) years. Patient demographic and injury characteristics are

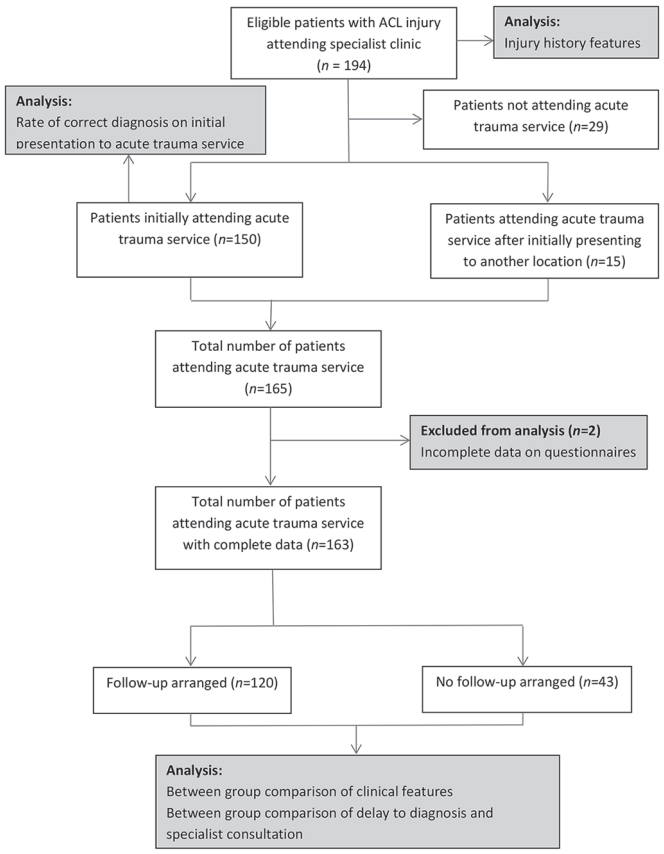

Figure 1 Flow chart of study patients and undertaken analysis.

presented in table 1 and details on the reported injury history features shown in table 2. The number of records available for analysis is reported to indicate where responses were missing from returned questionnaires.

The majority of patients (n=111/192; 57.8%) reported the presence of all four history features at the time of injury. The total number of history features reported by patients at the time of injury is indicated in table 3. Two records were excluded from the analysis due to incomplete LIMP data. The results presented reveal that 95.8% of patients would have been identified using a threshold of at least two of the four 'LIMP index' features.

In total 165 patients (n=165/194; 85.1%) attended an A&E or minor injury unit at some point following their injury, of which 150 patients (n=150/194; 77.3%) presented initially to an acute trauma service. Only 19 patients attending an acute trauma service (n=19/150; 12.7%) were correctly diagnosed with an ACL injury on initial attendance and assessment.

Complete information on delay to diagnosis and specialist consultation was available for 163 (n=163/165; 98.8%) patients who had attended an A&E or minor injury unit. Of these, 120 patients (n=120/163; 73.6%) were referred for a follow-up appointment. Patients who were not referred for a follow-up appointment reported statistically significantly (p=0.003) fewer LIMP features associated with ACL injury (median=3; IQR 3–4) than those where a follow-up appointment was arranged (median=4; IQR 3–4) (figure 2).

Data on delay to diagnosis and specialist consultation were strongly positively skewed and therefore log transformation was undertaken following which conditions for undertaking parametric analysis were satisfied.

Patients who had a follow-up appointment had significantly less delay to diagnosis and specialist consultation than those who did not (table 4; figures 3 and 4). The geometric mean delay in time to diagnosis for patients not referred for follow-up is 6.8 times longer than where follow-up was arranged (95% CI 3.5 to 13.3; p<0.001). The geometric mean time delay to specialist consultation for patients not referred for follow-up is 5.3 times longer than where follow-up was arranged (95% CI 3.2 to 8.9;

Table 1 Patient demographic and injury characteristics (n=194)

Demographic/injury characteristics	Number (%)
Sex	
Male	157 (80.1)
Female	37 (19.9)
Specific incident or injury recalled	
Yes	193 (99.5)
No	1 (0.5)
Injury type	
Contact	60 (31.1)
Non-contact	132 (68.0)
Not sure/ not applicable	2 (1.0)
Activity at time of injury	
Sporting	
Football	114 (58.8)
Rugby	23 (11.9)
Skiing	12 (6.2)
Other sporting	24 (12.4)
Non sporting	20 (10.3)
No recall	1 (0.5)

Table 2 Injury history features in patients with anterior cruciate ligament injury (n=194)

Injury history feature (number of records available for analysis)	Number (%)
Giving way at time of injury (n=193)	
Yes	172 (89.1)
No	15 (7.8)
Not sure	6 (3.1)
Heard/felt pop at the time of injury (n=193)	
Yes	141 (73.1)
No	37 (19.2)
Not sure	15 (7.8)
Able to continue activity immediately (n=194)	
Yes	14 (7.2)
No	175 (90.2)
Not applicable	5 (2.6)
Swelling within 6 hours (n=192)	
Yes	165 (85.9)
No	27 (14.1)

Table 3 Number of LIMP injury history features reported by each patient (n=192)

Number of LIMP injury features* reported	Number (%)	Cumulative percentage
4	111 (57.8)	57.8
3	50 (26.0)	83.9
2	23 (12.0)	95.8
1	7 (3.6)	99.5
0	1 (0.5)	100

*LIMP injury features (leg giving way, inability to continue activity immediately after injury, marked effusion within 6 hours, pop).

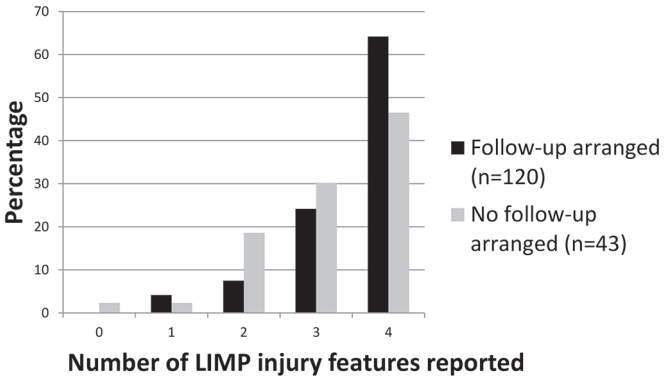

Figure 2 Percentage of patients with ACL injury reporting 0 to 4 LIMP injury features* based on whether follow-up appointment arranged (n=163). *LIMP injury features (leg giving way, inability to continue activity immediately after injury, marked effusion within 6 hours, pop). ACL, anterior cruciate ligament.

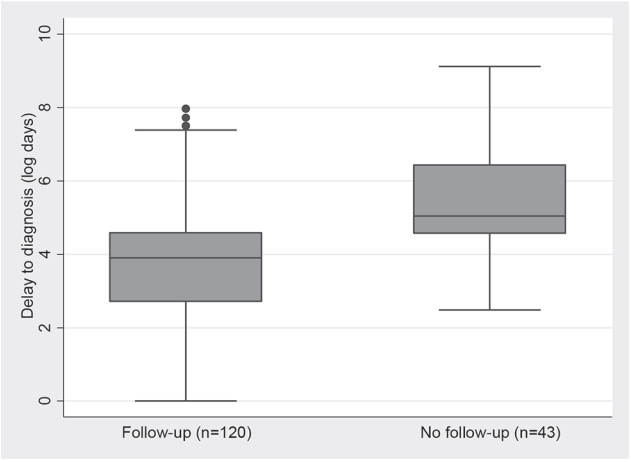

Figure 3 Box-and-whisker plot of delay to diagnosis (log days) by whether follow-up arranged (n=163).

p<0.001). When patients diagnosed with an ACL injury at initial assessment were removed from analysis, between group differences in time to diagnosis and time to see a specialist remained highly significant (table 4). The sensitivity analysis, replacing the dates for 'early' and 'late' presentation with 7th and 22nd, respectively, did not result in any change to geometric mean values.

DISCUSSION

This is the first study to quantify the impact of discharging patients at high risk of ACL injury on subsequent time to diagnosis and specialist consultation. The findings provide a comprehensive insight into the importance of injury history in clinical decision making. The data presented illustrate that while 57.8% of patients reported all four LIMP features, a significant proportion (42.2%) reported three or fewer features. However, only 4.2% patients reported one or no LIMP features investigated suggesting that these features could inform clinical decision making and the identification of patients who would benefit from onward referral to a specialist clinic for review. Importantly, the variation in the type and number of features reported casts doubt over ever defining a 'typical' injury history as stated in previous studies.[2–4]

The rate of correct diagnosis of ACL injury at initial attendance in this study (12.7%) was comparable with values reported previously[2–8] confirming the belief that ACL injury is a challenging diagnosis in the acute stage. Consequently, there is a need to provide clinicians with clear criteria to help identify patients who may have suffered an ACL injury and should be referred for specialist follow-up. With 26.4% of patients in this study with a subsequently confirmed ACL injury being discharged from the acute trauma service after initial attendance, it is clear that current injury assessment practices are unsatisfactory.

The LIMP injury history features investigated in this study were all frequently experienced by patients at a percentage consistent with those previously reported.[7] Statistically significant differences were noted in the number of injury features reported by those patients referred for follow-up and those who were not, however, the magnitude of differences was small. Therefore, while fewer LIMP features were generally reported by patients who were not referred for follow-up, the median number of features reported in this group was still three out of four suggesting that injury history may be useful if appropriately investigated. The importance of injury history does not appear to currently inform clinical decision making within

Table 4 Delay to diagnosis and specialist consultation based on follow-up referral pattern at initial attendance

	Follow-up arranged (n=120 unless stated)*	No follow-up arranged (n=43 unless stated)*	Ratio of Geometric means	p Value
Delay to diagnosis	29 (20 to 42)	198 (117 to 337)	6.8 (3.5 to 13.3)	p<0.001
Delay to diagnosis (removing those diagnosed at initial presentation)	46 (33 to 64) (n=101)	229 (142 to 370) (n=40)	5.0 (2.8 to 9.2)	p<0.001
Delay to specialist consultation	61 (47 to 80)	328 (213 to 503)	5.3 (3.2 to 8.9)	p<0.001
Delay to specialist consultation (removing those diagnosed at initial presentation)	69 (51 to 93) (n=101)	311 (210 to 481) (n=40)	4.5 (2.6 to 7.8)	p<0.001

*Geometric mean values (95% CI) reported. Values reported in days.

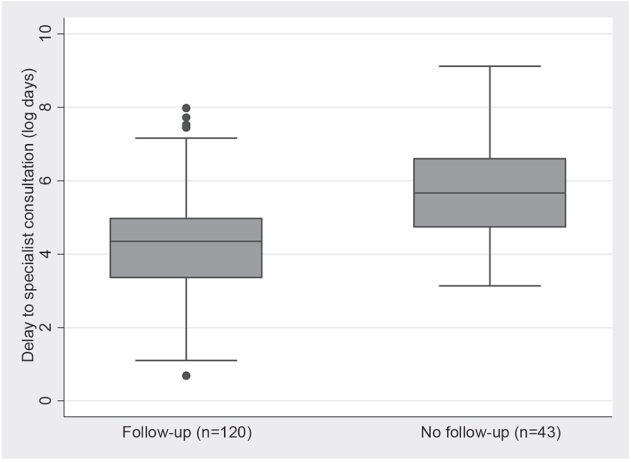

Figure 4 Box-and-whisker plot showing delay to specialist consultation (log days) by whether follow-up arranged (n=163).

the trauma services as all four LIMP features were reported by almost half of patients discharged from hospital care. However, as only 57.6% of patients in the study cohort reported all four LIMP features, a lower follow-up referral threshold would be required if injury history were to be used as a screening tool as part of the injury assessment. In this study, a threshold of three or more LIMP features would have improved follow-up rates by 10.3% compared with current practice but still only identified 83.9% of patients with ACL injury. Using a threshold of two or more LIMP features would have ensured that 95.8% of patients were referred for specialist follow-up and reduced the proportion of patients inappropriately discharged by 22.2%. Although almost all patients would be identified using a threshold of at least one LIMP feature, lowering the referral threshold will result in a corresponding reduction in specificity. While the 'LIMP index' must have a high sensitivity in identifying patients who have potentially suffered an ACL injury, its clinical utility is also dependent upon the specificity of the index (the ability to recognise patients who have not suffered ACL injury). It is not possible to calculate the specificity of the 'LIMP index' from the study cohort as all enrolled patients had a known ACL injury.

The decision to refer patients for follow-up after initial assessment was critical in reducing the time to diagnosis based on geometric mean values (29 days when follow-up arranged, 198 days when discharged without follow-up). Arguably more importantly, patients referred for a follow-up appointment received a specialist appointment at 61 days compared with 328 days for patients discharged without follow-up (geometric mean values) allowing for earlier treatment planning and surgical intervention where indicated. The significantly greater time to diagnosis and to see a specialist after discharge following initial attendance to trauma services remains a matter of concern. A systematic review by Snoeker *et al*[9] confirmed that the risk of sustaining a medial meniscal tear is increased when surgery is delayed more than 12 months, although increased risk is evident at only 5 or 6 months postinjury.[13 17 18] The American Academy of Orthopaedic Surgeons have concluded that there is moderate evidence that, where indicated, ACL reconstruction should take place within 5 months of initial injury to protect the articular cartilage and menisci.[23] The findings presented in this paper suggest that in the UK, a significant proportion of patients remain undiagnosed beyond 5 months postinjury and may therefore be at increased risk of secondary, and preventable, knee pathology as a consequence of inappropriate follow-up referral practices following initial presentation to acute trauma services.

In order to reduce the frequency of ACL injuries being missed we believe the 'LIMP index' may act as a simple and appropriate mnemonic to assist healthcare professionals with differing skill sets and experience working in primary or emergency care settings. The proposed binary (yes/no) 'LIMP index' will allow patients to be triaged for onward referral based on history alone (table 5). From the evidence presented, we suggest that a LIMP score of 2 or more features identified at initial presentation warrants referral for a follow-up assessment and based on the cohort studied should significantly reduce the inappropriate discharge of patients with ACL injuries. Even with a LIMP score of 1 the possibility of ACL injury cannot be completely discounted and onward referral should be considered if the assessing clinician is concerned. A prospective study to validate the clinical application of this index and establish the specificity of the 'LIMP index' is required.

Table 5 Proposed 'LIMP index'

Injury feature	Yes/no
Leg giving way (at the time of injury)	
Inability to continue activity immediately after injury	
Marked effusion (within six hours of injury)	
Pop (either heard or felt at the time of injury)	
LIMP score (number of items marked yes)	**/4**

Strengths

The present study has a number of advantages over previous studies. This was the first study to be undertaken over multiple sites and included 194 patients, a larger sample than previous research. The population covered by the hospital sites was approximately 2.3 million representing 3.65% of the UK population, significantly larger than those studies based on single recruitment sites. The history features investigated were based on simple questions requiring little interpretation therefore permitting maximum use within the acute trauma setting.

Limitations

It should be noted that the presence of the injury features identified in this paper do not confirm whether an ACL injury has been sustained but instead raise the possibility that an ACL injury has been sustained. In order to reduce the number of patients being inappropriately discharged from acute trauma services we believe it is imperative to maintain a high index of suspicion. The threshold LIMP score for onward referral could potentially have significant resource implications as a consequence of an increased number of referrals to follow-up clinics. However, when examined alongside the long term costs to hospitals and patients of delayed or misdiagnosis of ACL injury, we believe these initial resource costs to be negligible, although a detailed prospective economic evaluation is required to confirm this. Further research is also required to determine the history features related to non-ACL knee injuries and establish the specificity of the 'LIMP index'.

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