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Characteristics of inpatient anterior cruciate ligament reconstructions and concomitant injuries

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Abstract
Purpose The purpose of this epidemiologic study was to quantify the incidence, expense, and concomitant injuries for anterior cruciate ligament reconstruction (ACLR) procedures in the USA from 2003 to 2011 that required an inpatient stay. It was hypothesized that the relative reported rates of concomitant knee injuries would be greater with the MCL and menisci compared to all other concomitant knee injuries.
Methods The National Inpatient Sample from 2003 to 2011 was retrospectively sampled using ICD-9-CM codes to identify ACLR patients and to extrapolate national averages.
Results Between the years of 2003–2011, an average of 9,037 ± 1,728 inpatient hospitalization included ACLRs, of which 4,252 ± 1,824 were primarily due to the ACLR. Inpatient visits primarily due to ACLR involved an average hospitalization of 1.7 ± 0.2 days and cost $30,118 ± 9,066 per patient. Knee injuries that were commonly reported along with inpatient ACLRs included medial meniscus damage (18.1 %), lateral meniscus damage (16.8 %), collateral ligament repairs (12.3 %), and medial collateral ligament strains (6.9 %). Prevalence of meniscus injuries was consistent across years, but MCL-related injuries increased over time.
Conclusions ACLR-related inpatient hospitalizations account for approximately 7.1 % of the total ACLRs performed annually in the USA. Inpatient ACLR procedures continue to decrease in frequency; however, the mean cost per patient increased. Meniscus and collateral ligament injuries were the most commonly reported concomitant knee injuries. The clinical relevance of this investigation is that it informs, on a large clinical cohort of patients, the current state of incidence and expense for ACLR surgeries in an inpatient setting.

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Introduction

Injuries to the anterior cruciate ligament (ACL) are highly prevalent, with an estimated 250,000 per year in the USA [13]. In the USA annually, there are 127,000 anterior cruciate ligament reconstructive (ACLR) procedures [15]. The estimated cost of per procedure and rehabilitation is $17,000 [11], which results in approximately $2 billion per year spent on ACLRs. ACL injuries commonly occur in an athletic setting during tasks that involve rapid deceleration and/or change of direction [4, 9, 20, 21]. As many as one in fifty female athletes sustain a knee injury per year [22]. ACL ruptures are especially prevalent in high school- and college-level female athletes as they are four to six times more likely to experience injury than their male counterparts [3, 4, 30].

The ACL is the primary passive restraint to anterior tibial translation in the knee, as it resists up to 87 % of this force [6]. The ACL also serves as a secondary restrain to knee abduction and internal tibial rotations [5]. Athletes with poor neuromuscular control exhibit motion patterns consistent with the kinematics that would directly load ACL [8, 12]. These patterns can place abnormal loads on the ACL that lead to rupture as 70 % of ACL injuries occur in non-contact scenarios [4, 20]. Specifically, increased knee abduction during landing phase of a drop vertical jump has been prospectively identified as a leading predictive risk factor for ACL injury [12]. This abduction load at the knee may lead to abnormal loading in the medial and lateral compartments of the tibiofemoral joint. Accordingly, the MCL, which is the primary passive resistor to knee abduction [5, 6, 25], experienced concomitant failure in over 30 % of ACL injuries [17, 25].

Rupture of the ACL creates instability at the knee that can alter kinematics [28] and tibiofemoral contact [1, 2]. The changes lead to abnormal loading of the knee and produce a long-term prognosis of increased risk for osteoarthritis patients [1, 24]. To restore joint stability, ACLRs are the most common procedure performed in patients who wish to regain a physically active lifestyle [28, 29]. Currently, the gold standard for ACLRs is an arthroscopic outpatient procedure that implants a bone–patellar tendon–bone or hamstrings tendon autograft [19]. However, ACL ruptures are often accompanied by additional, concomitant, catastrophic knee injuries [17, 18, 25]. These cases may require multiple surgical procedures and necessitate inpatient hospital admittance.

Prior to the mid-1990s, ACLR was an inpatient procedure with an average hospitalization of 2–3 days; however, surgical advancements allowed ACLRs to become less invasive, and they have since shifted to outpatient operations [14, 16]. Outpatient ACLRs have lead to reduced cost and enhanced patient satisfaction as by 1995 inpatient ACLRs averaged approximately 300 % of the cost of comparable outpatient procedures [14]. However, the current state of inpatient ACLRs has not been quantified by any recent investigation, which has left a gap in knowledge as to how prevalent and expensive this procedure is relative to modern medical treatment.

Though multiple investigations have tried to quantify the incidence rate [3], expenditure [11], and reconstruction incidence [15] for ACL injuries, to our knowledge, the incidence of ACL tears that result in inpatient hospitalization has not been reported. The purpose of this epidemiologic study is to quantify the incidence, expense, and concomitant injuries for ACLR procedures in the USA from 2003 to 2011 that required an inpatient stay. It was hypothesized that the relative reported rates of concomitant knee injuries would be greater with the MCL and menisci compared to all other concomitant knee injuries.

Materials and methods

The source of the data utilized in this investigation was the Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP), and Agency for Healthcare Research and Quality (www.hcup-us.ahrq.gov/nisoverview.jsp) [10]. The NIS was developed in 1988 to provide the largest all-payer inpatient care database in the USA. This database includes an annual survey of inpatient hospital visits accumulated from over 1,500 medical centres across 45 US states that provides unidentified, patient-specific data relative to hospital admittance, diagnoses and procedures performed, patient expenditures, and patient demographics. The NIS provides a 20 % stratified sample of US community hospitals that can be extrapolated into national estimates. The present study analysed the NIS database to determine the incidence of inpatient ACLR procedures from 2003 to 2011.

The NIS database was analysed on a patient-by-patient basis for the 8 years included in this study. Patients were included in this study if their NIS data exhibited International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) or procedure codes were relevant to ACL injury. Specifically, patients were included in the present study if their NIS data exhibited the diagnosis code for an old disruption of ACL (717.83) or a sprain

of cruciate ligament of the knee (844.2), or the procedure code for ACLR (81.45). All data were retrieved and analysed using MATLAB code (version 2012a, The MathWorks, Inc., MA).

Once patients with ACLR diagnoses and procedures were isolated, the remaining patient population was statistically evaluated using custom MATLAB code. Annual means and standard deviations were calculated for all continuous variables (age, length of stay, number of procedures, and total charge). Relative frequencies were calculated for all categorical variables (gender and race). Additionally, a list of all additional ICD-9-CM and procedure codes that corresponded with ACL patients was compiled to evaluate injuries and operations that are frequently concomitant with ACLR. Due to the comprehensive nature of the coding database and multitude of corresponding codes reported for inpatient stays, additional codes were only incorporated if they occurred in >1.0 % of ACLR patients for a given year. Approval for the study was received by the Institutional Review Board of Cincinnati Children's Hospital Medical Center.

Though the NIS provides a comprehensive database, it is not inclusive of all medical centre data in the USA. Annually the NIS reports on approximately 8 million inpatient hospitalizations from a diversity of medical centres. HCUP estimates that approximately 40 million inpatient hospitalizations occur each year in the USA. Software available on the HCUP website (http://www.hcup-us.ahrq.gov/) was used to extrapolate national averages for the entire inpatient ACLR population based on the stratified NIS database. HCUP software was also utilized to estimate national averages for the subset of patients whose primary reason for inpatient hospitalization was ACLR. Patient data within the NIS are stratified by hospital based on geographic region, urban/rural location, teaching status, bed size, and ownership. This stratification of data is used to create accurate estimates for geographic regions that are weighted relative to the number of hospitals from each stratum contained within a desired area.

Statistical analysis

Analysis of variance (ANOVA) and Student's *t* tests were used to determine differences between incidence percentages in categorical variables. All statistics were calculated in MATLAB using built-in functions. Statistical significance was determined at alpha <0.05.

Results

Annually, the NIS database reported an average of 1,344 ± 374 ACLR procedures that required inpatient hospital admittance, with an average cost, as calculated from the annual means, of $45,040 per patient (Table 1). With the exception of 2010, the annual number of inpatient ACLR procedures documented by the NIS declined between each year from 2003 to 2011. However, average expenditures per patient increased annually across all years. NIS patients had a mean hospital admittance of 4.0 days, with an average of 3.0 procedures were performed. From 2003 to 2011, the average number of procedures per patient increased by 0.7 and the average hospitalization increased by 2.7 days. Mean patient age, as calculated from annual NIS means, was 35.8 years. Inpatient ACLR procedures were more common among males (61.3 ± 1.7 %) than females (38.8 ± 1.7 %; $P < 0.01$). The breakdown of injuries by ethnicity is also displayed in Table 1.

Extrapolation of the NIS data to a national average indicated an average of 9,037 ± 1,728 inpatient ACLR procedures per year (Table 2), which accounts for approximately 7.1 ± 1.4 % of the estimated 127,000 ACLR performed annually in the USA [15]. The extrapolated national average was also gender specific (males = 60.0 ± 1.1 %, females = 38.8 ± 1.2 %, $P < 0.01$). ACLRs were significantly more prevalent between the ages of 18–44 than in any other age group (54.7 ± 5.9 %, $P < 0.01$).

Extrapolation of the NIS data into a national average for patients whose primary cause hospitalization was ACLR indicated a mean of 4,252 ± 1,824 annual procedures at a cost of $30,118 ± 9,066 per patient (Table 3). Annually, inpatient ACLRs where the ACLR is the primary reason for hospitalization generated a mean national expense of $115,631,936 ± 26,288,717 and accounted for approximately 3.4 ± 1.4 % of all ACLR procedures in the USA [15]. The incidence of patients primarily admitted for ACLRs decreased by 5,523 patients from 2003 to 2011, whereas the cost per patient increased by $20,675 (Fig. 1). Annual aggregate national patient charges for inpatient hospitalization primarily due to ACLR fluctuated between years, but decreased overall by $90,134,894 from 2003 to 2011. Patients admitted primarily due to ACLR had an average length of stay of 1.7 ± 0.2 days, which was consistent between years. This population subset again demonstrated a male gender bias (58.1 ± 2.3 %, annual range 55.2–61.8 %, $P < 0.01$) and was again more prevalent in the 17–44 age range than any other group (61.0 ± 5.6 %, annual range 53.1–69.1 %, $P < 0.01$).

According to the collected NIS subset, approximately 65.5 ± 3.7 % of ACLR inpatient admittance involved primary ACL ruptures, while 34.7 ± 3.5 % identified old disruptions of the ACL. The most commonly reported concomitant injury was "close fracture of C1-C4 with unspecified spinal cord injury", as it appeared in 29.3 ± 5.8 % of cases (Table 4). The most commonly reported concomitant knee-related injury was

Table 1 Patient demographics calculated directly from the NIS data subset for all reported inpatient ACLR cases from 2003 to 2011

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Procedures	1,963	1,828	1,435	1,233	1,223	1,223	1,038	1,099	929
Age	32.5 ± 14.0	32.8 ± 14.2	34.4 ± 16.8	35.2 ± 16.6	35.1 ± 16.5	37.3 ± 17.5	37.0 ± 18.1	38.5 ± 18.4	39.6 ± 18.1
Length of stay	2.6 ± 4.7	2.8 ± 4.2	3.6 ± 6.1	3.7 ± 5.3	3.7 ± 5.5	3.9 ± 5.7	4.4 ± 7.6	5.8 ± 10.3	5.3 ± 7.0
Operations per patient	2.6 ± 1.6	2.6 ± 1.7	2.8 ± 2.4	2.9 ± 2.4	2.8 ± 2.3	3.1 ± 2.6	3.1 ± 2.6	3.5 ± 3.6	3.3 ± 3.0
Cost per patient	$27,266 ± 31,371	$25,629 ± 27,167	$32,373 ± 60,277	$36,394 ± 41,988	$38,044 ± 43,123	$44,897 ± 47,463	$55,942 ± 74,359	$72,259 ± 105,678	$72,559 ± 89,733
Gender									
Male	1,197 (62.1 %)	1,062 (59.7 %)	844 (60.5 %)	767 (62.7 %)	769 (63.8 %)	709 (58.4 %)	633 (62.2 %)	657 (60.1 %)	569 (61.9 %)
Female	731 (37.9 %)	718 (40.3 %)	551 (39.5 %)	456 (37.3 %)	437 (36.2 %)	505 (41.6 %)	385 (37.8 %)	437 (40.0 %)	350 (38.1 %)
Race									
Caucasian	1,077 (74.2 %)	929 (70.8 %)	732 (69.9 %)	619 (69.7 %)	578 (66.2 %)	623 (68.3 %)	576 (67.1 %)	581 (62.5 %)	530 (64.5 %)
African	163 (11.2 %)	145 (11.1 %)	117 (11.2 %)	99 (11.2 %)	121 (13.9 %)	119 (13.2 %)	125 (14.6 %)	159 (17.1 %)	124 (15.1 %)
Hispanic	140 (9.7 %)	161 (12.3 %)	115 (11.0 %)	123 (13.9 %)	132 (15.1 %)	101 (11.2 %)	104 (12.1 %)	119 (12.8 %)	116 (14.1 %)
Asian	32 (2.2 %)	19 (1.5 %)	14 (1.3 %)	<10 (0.9 %)	<10 (1.0 %)	16 (1.8 %)	19 (2.2 %)	14 (1.5 %)	17 (2.1 %)
Other	39 (2.7 %)	58 (4.4 %)	69 (6.6 %)	39 (4.4 %)	33 (3.8 %)	45 (5.0 %)	35 (4.1 %)	57 (6.1 %)	35 (4.3 %)

Length of stay is reported in days hospitalized. Age is reported in years

Table 2 National averages extrapolated from the NIS for all inpatient hospitalizations that involved ACLRs from 2003 to 2011

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Procedures	12,051	11,486	9,638	8,640	8,404	8,560	7,761	7,972	6,827
Age									
1–17	1,731 (14.4 %)	1,598 (13.9 %)	1,651 (17.1 %)	1,075 (12.4 %)	946 (11.3 %)	967 (11.3 %)	799 (10.3 %)	897 (11.3 %)	636 (9.3 %)
18–44	7,693 (63.8 %)	7,159 (62.3 %)	4,987 (51.7 %)	4,882 (56.5 %)	4,885 (58.1 %)	4,474 (52.3 %)	4,059 (52.3 %)	3,863 (48.5 %)	3,194 (46.8 %)
45–64	2,019 (16.8 %)	2,157 (18.8 %)	2,192 (22.7 %)	1,919 (22.2 %)	1,803 (21.5 %)	2,270 (26.5 %)	1,968 (25.4 %)	2,280 (28.6 %)	2,192 (32.1 %)
65–84	459 (3.8 %)	430 (3.7 %)	582 (6.0 %)	686 (7.9 %)	595 (7.1 %)	689 (8.1 %)	651 (8.4 %)	698 (8.8 %)	626 (9.2 %)
85+	82 (0.7 %)	84 (0.7 %)	150 (1.6 %)	74 (0.9 %)	143 (1.7 %)	142 (1.7 %)	174 (2.2 %)	212 (2.7 %)	149 (2.2 %)
Gender									
Male	7,353 (61.0 %)	6,748 (58.8 %)	5,625 (58.4 %)	5,280 (61.1 %)	5,124 (61.0 %)	5,061 (59.1 %)	4,710 (60.7 %)	4,706 (59.0 %)	4,129 (60.5 %)
Female	4,499 (37.3 %)	4,502 (39.2 %)	3,793 (39.4 %)	3,294 (38.1 %)	3,189 (37.9 %)	3,4,5,6 (40.4 %)	2,928 (37.7 %)	3,242 (40.7 %)	2,632 (38.6 %)

Table 3 Estimated national averages extrapolated from the NIS database for patients whose primary cause for inpatient hospital admittance was ACL injury or ACLR

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Procedures	7,478	6,632	5,018	4,062	3,893	3,516	3,067	2,646	1,955
Length of stay	1.5	1.6	1.7	1.8	1.7	1.7	1.8	2.0	1.9
Cost per patient	$23,501	$20,080	$21,392	$24,684	$25,465	$32,408	$39,642	$39,716	$44,176
National charges	$17,55,06,012	$13,32,50,234	$10,74,57,208	$10,02,29,082	$9,94,37,564	$11,39,46,528	$12,08,65,906	$10,46,23,773	$8,53,71,118
Age									
1–17	1,285 (17.2 %)	1,211 (18.3 %)	1,298 (25.9 %)	731 (18.0 %)	717 (18.4 %)	605 (17.2 %)	527 (17.2 %)	603 (22.8 %)	375 (19.2 %)
18–44	5,164 (69.1 %)	4,379 (66.0 %)	2,666 (53.1 %)	2,607 (64.2 %)	2,531 (65.0 %)	2,181 (62.0 %)	1,812 (59.1 %)	1,446 (54.6 %)	1,093 (55.9 %)
45–64	864 (11.6 %)	878 (13.2 %)	836 (16.7 %)	599 (14.8 %)	508 (13.1 %)	634 (18.0 %)	477 (15.6 %)	460 (17.4 %)	364 (18.6 %)
65–84	79 (17.2 %)	92 (1.4 %)	126 (2.5 %)	116 (2.9 %)	97 (2.5 %)	53 (1.5 %)	129 (4.2 %)	78 (2.9 %)	77 (4.0 %)
85+	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)
Gender									
Male	4,417 (59.1 %)	3,716 (56.0 %)	2,771 (55.2 %)	2,437 (60.0 %)	2,405 (61.8 %)	1,995 (56.8 %)	1,736 (56.6 %)	1,599 (60.5 %)	1,113 (57.0 %)
Female	2,885 (38.6 %)	2,689 (40.5 %)	2,048 (40.8 %)	1,586 (39.1 %)	1,424 (36.6 %)	1,483 (42.2 %)	1,224 (39.9 %)	1,022 (38.7 %)	781 (40.0 %)

Length of stay is reported in days hospitalized. Age is reported in years

a "tear of the medial cartilage or meniscus of the knee" (18.1 ± 1.5 % of cases) followed by "tear of lateral cartilage or meniscus of knee" (16.8 ± 1.1 % of cases). The difference in the prevalence of meniscus injuries between the medial and lateral sides was statistically significant ($P = 0.04$). "Collateral ligament repairs" were less frequent ($P < 0.01$), documented in 12.3 ± 2.3 % of cases. However, when combined with "sprain of medial collateral ligament of the knee", collateral ligament damage significantly became the most commonly reported concomitant injury with inpatient ACLR procedures (19.2 ± 6.7 % of cases), though there was no statistical difference compared to the incidence of medial meniscus injuries ($P = 0.50$). Additional unspecified knee repairs and knee arthroscopy were performed in 14.6 ± 0.7 and 17.8 ± 4.8 % of ACLR cases, respectively.

The incidence of meniscus injuries was consistent between years for both the medial (range 15.9–19.1 %) and lateral (range 15.5–19.0 %) sides (Fig. 2). The combined incidence of collateral ligament repairs and strains increased by 18.4 % between 2003 and 2011. Frequency of additional knee repairs was consistent between years (range 13.3–15.6 %), while additional knee arthroscopies decreased by 16.8 % from 2003 to 2011.

Discussion

The most important finding of this study is that while the annual incidence of inpatient ACLRs has decreased, the cost of these hospitalizations has increased as inpatient cases more frequently involve complex, multi-ligament injuries. The purpose of this epidemiologic study was to quantify the incidence, expense, and concomitant injuries for ACLR procedures in the USA from 2003 to 2011 that required an inpatient stay. This investigation is clinically relevant as it informs, on a large clinical cohort of patients, the current state of incidence and expense for ACLR surgeries in an inpatient setting. It was found that inpatient ACLRs comprise a minority of ACLR procedures as they account for only approximately 7.1 % of procedures performed annually. However, as conservative estimates place surgical costs for outpatient, autograft ACLR procedures at $4,872 [23], as evidenced in the current data set inpatient ACLRs, are significantly more expensive. Between the years of 2003–2011, the average per patient charge of an inpatient stay that was primarily due to an ACLR was 618 % greater than outpatient ACLRs. Previous studies have indicated that inpatient ACLRs have an average expense three times greater than the equivalent outpatient procedures [14]. The increased cost ratio in the present study is likely due to the combination of multiple procedures that accompany the majority of present-day inpatient

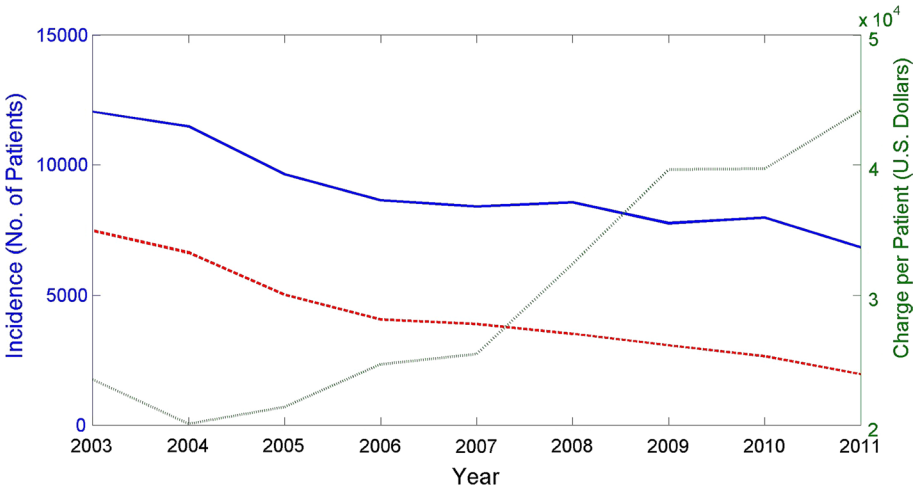

Fig. 1 Incidence of inpatient ACLR and charges per patient across time. The change in per-patient cost (*dotted line*) is inverse to the changes in incidence for the whole inpatient ACLR population (*solid line*) as well as for ACLRs that were the primary cause of hospitalization (*dashed line*). Inpatient hospitalization due primarily to ACLR accounted for 45.8 ± 11.6 % of the whole inpatient ACLR population, but decreased from 62.1 % in 2003 to 28.6 % in 2011. Inpatient hospitalizations involving, but not primarily due to ACLRs, consistently accounted for approximately 5,000 cases annually

ACLR treatments as well as rising costs of hospitalization, bed space, nursing, and more.

As hypothesized, the knee structures that were most commonly disrupted concomitantly with the ACL were the meniscus and MCL (which were both classified with multiple ICD-9 codes); 70 % of sports-related ACL injuries occur in non-contact scenarios during rapid deceleration or change of direction movements [4, 20]. Athletes with poor neuromuscular control have exhibited increased knee abduction during these athletic tasks [7, 8]. Knee abduction has been shown to increase strain on the ACL [26, 27] and has been prospectively associated with increased ACL injury risk [12]. These mechanics correlate well with the concomitant injuries recorded in the present study as the MCL is the primary ligamentous restraint to knee abduction rotation [5, 6, 25]. However, it is interesting to note that the rate of concomitant MCL injury for inpatient ACLRs reported in the present study was lower than MCL incidence reported for the overall population [17, 21, 25]. Similarly, meniscus injuries were less frequent in the present study than previously reported ACL injury cohorts [21]. The current database identified concomitant injuries through ICD-9 codes. These codes indicate procedures performed and therefore track repairs. In many cases, the MCL can go unrepaired after injury and may not generate an ICD-9 code in these instances. As such, it is possible that the incidence of concomitant MCL injuries presented in the NIS was lower than the actual rate of occurrence in the inpatient ACLR population.

In the present study, the incidence of inpatient ACLRs for all three cohorts consistently decreased between years from 2003 to 2011. This was mostly due to a decrease in the number of inpatient hospitalizations due primarily to ACLR, as the annual incidence of inpatient stays involving, but not primarily due to, ACLR was constantly between 4,500 and 5,000 cases. As inpatient ACLRs become less frequent, the cost disparity between inpatient and outpatient treatment has increased. That cost increase correlated with annual increases in number of procedures and length of hospitalization that were observed in the whole NIS cohort. These trends would seem indicate that the increasing inpatient expenses may be due to increased severity in injuries that require inpatient hospitalization. However, in the cohort admitted primarily for ACLR, the length of hospitalization only expressed a minor increase (0.4 days) over time, which implicates that rising costs in healthcare were also a driving force between the constantly increasing per-patient charges.

Between 2003 and 2011, the extrapolated national average cost per patient for an inpatient visit primarily due to ACL reconstruction increased by 88.0 %. Over this same time span, inflation would have accounted for a 22.0 % increase in expenses according to the Bureau of Labor Statistics (http://www.bls.gov). Therefore, the rise in cost per patient was greater than the rise in national inflation. As such, the additional expense per patient for inpatient ACLRs may be attributed to more complex repairs that may involve additional structures within the knee. This concept would seem to be supported as concomitant collateral ligament repairs increased by 7.0 % of cases and concomitant MCL sprains increased by 3.9 % of cases over the same time period (Table 4).

Table 4 Annual percentages of ACL classifications and concomitant injuries documented within the NIS inpatient ACLR population

ICD-9 CM	Description	2003 (%)	2004 (%)	2005 (%)	2006 (%)	2007 (%)	2008 (%)	2009 (%)	2010 (%)	2011 (%)
844.2	Sprain cruciate ligament of knee	61.4	60.6	65.2	66.6	61.7	65.9	70.5	68.6	69.4
81.45	Cruciate leg repair	88.6	86.9	79.7	75.6	73.8	71.9	69.5	59.1	55.1
717.83	Old disruption of anterior cruciate ligament	38.8	39.6	35.1	33.6	38.1	34.3	29.8	31.7	31.3
806	Closed fracture of C1–C4 level with unspecified spinal cord injury	36.5	37.6	32.5	31.1	28.8	26.6	27.7	21.2	21.9
401.9	Unspecified essential hypertension	8.3	7.9	12.1	14.6	14.4	17.7	19.0	20.5	19.4
836	Tear of medial cartilage or meniscus of knee	20.6	17.6	19.1	19.1	15.9	17.8	18.4	16.1	18.5
305.1	Nondependent tobacco use disorder	7.4	7.4	8.4	10.4	14.4	13.6	13.7	19.3	17.0
836.1	Tear lateral cartilage or meniscus of knee	16.2	16.7	16.9	16.8	15.5	17.7	19.0	15.8	16.1
8146	Collateral ligament repair	8.1	11.1	11.1	13.3	10.5	13.6	14.9	13.5	15.1
8147	Other repair of the knee	14.8	15.2	13.3	13.6	14.6	14.6	15.6	14.9	14.3
8026	Knee arthroscopy	29.0	17.7	15.5	18.0	16.1	17.7	20.1	13.7	12.3
844.1	Sprain of medial collateral ligament of knee	>1	8.1	8.5	10.8	>1	>1	9.6	11.7	12.0
793.6	Nonspecific (abnormal) findings on radiological and other examination of abdominal area, including retroperitoneum	>1	>1	8.2	8.4	>1	>1	10.7	12.4	>1
823	Closed fracture of upper end of tibia alone	>1	>1	>1	8.3	>1	>1	10.6	>1	>1
717.7	Chondromalacia of patella	6.7	7.2	10.0	8.8	>1	>1	>1	>1	>1

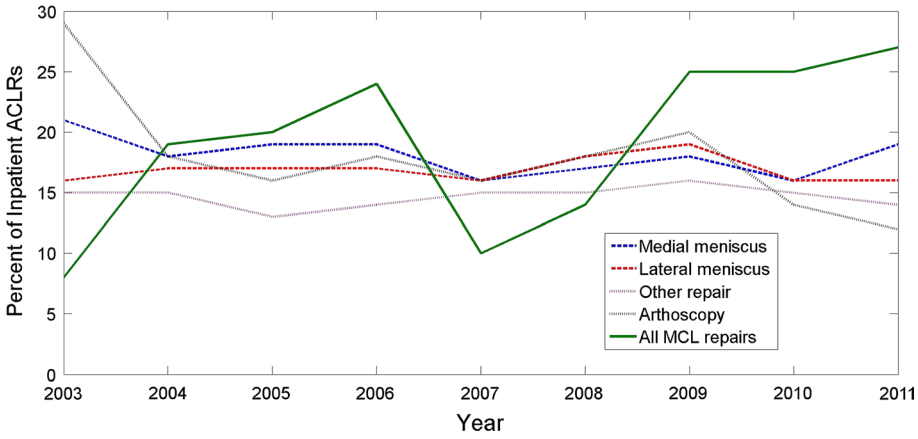

Fig. 2 Depiction of trends in the prevalence of additional knee procedures frequently documented with inpatient ACLRs. Prevalence is relative to inpatient ACLRs recorded in the NIS database. From 2003 to 2011, the percentage of collateral ligament injuries increased in prevalence, whereas meniscus injuries and other repairs remained constant, and knee arthroscopies decreased

The significant presence of concomitant closed fractures of C1–C4 level with unspecified spinal cord injury in the current sample likely indicates that many inpatient ACLRs result from trauma rather than sports injuries. In athletic populations, over 94 % of ACL injuries occur as a result of sports injuries, but in non-athletic populations, this drops to 75 % as injuries from traffic and daily living accidents are more common [21]. Therefore, it is likely that a significant number of injuries documented in the present study occurred in traumatic events such as car accidents where large forces are applied across multiple areas of a patient's body and resulted in the need for multiple surgical procedures. The presented data would seem to support this theory as the mean charge and length of stay per patient for the whole NIS cohort were $14,161 and 1.03 days greater than the subset of patients admitted primarily for ACLR. Also, the subset admitted primarily for ACLR had significantly lower variability in charge and length of stay, which indicated greater consistency in treatment than was present in the whole NIS cohort. Unfortunately, one of the limitations of the NIS data set is that injury cause is not documented and therefore could not be reported.

The ethnic distribution of ACLRs in the present study was representative of the national diversity reported by the United States Census Bureau for 2012 (Caucasian = 63.0 %, Hispanic = 16.9 %, African = 13.1 %, Asian = 5.1 %; www.census.org). The gender distribution reported by all three cohorts examined in the present study also compared favourably with previous data on knee injuries where males accounted for >60 % and females accounted for <40 % of the population [18, 21]. Therefore, inpatient ACLRs do not exhibit ethnicity bias and maintain the same gender bias as seen in the overall ACL injury population. Similarly, the age bias seen in previous ACL-injured populations was maintained in the present study as over 50 % of inpatient ACLRs were performed 18- to 44-year-old patients [18]. These statistics indicate that the cohort of inpatient ACLRs likely bears significant resemblance to the national ACL injury patient population.

A limitation of the NIS database is that it does not document the mechanism or cause of injury. Therefore, in the present study, it was not possible to definitively distinguish sports-induced injuries from those caused by alternative sources of trauma such as traffic accidents. Similarly, the NIS does not itemize expenditures. As such, it was not possible to partition out costs directly related to ACLR relative to those incurred from concomitant injuries. This inability to itemize expenses is likely what lead to the large standard deviations in annual treatment costs in the NIS database (Table 1). The authors acknowledge that a patient with concomitant spinal fractures, collateral ligament damage, and meniscus damage would most likely incur greater costs than an isolated ACLR. However, when isolated to inpatient stays where ACLR was the primary reason for hospitalization, the standard deviation for per patient was significantly reduced. Therefore, cases where ACLR was the primary cause of hospitalization were more likely to be representative of sports-related ACL injuries. Additionally, though the NIS database provides critical data regarding treatment, ICD-9 codes do not communicate specific details of treatment such as graft type used for ACLR, exact type of meniscal defect identified, or specific procedure used to repair cartilage damage. Accordingly, the authors were unable to further cross-examine the database in this manner.

Conclusion

In conclusion, although inpatient ACLRs continue to decrease in frequency, they still represent approximately 7.1 % of the ACLRs performed annually in the USA. Inpatient operations represent significant financial burden and typically well exceed the reported costs of an average outpatient ACLRs. The per-patient cost for inpatient ACLRs

is rising. This reflects inflation, but also improved surgical methods that allow for greater outpatient admittance in isolated ACLRs and necessitate inpatient hospitalization for only the most severe injuries. Demographics indicate that the inpatient cohort is likely representative of the overall ACLR population. However, the inpatient ACLR population presented exhibited different concomitant injury patterns than previously published ACLR cohorts.

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