

Epidemiology of Surgical Treatment of Adolescent Sports Injuries in the United States: Analysis of the MarketScan Commercial Claims and Encounters Database



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Purpose: To determine whether there is increasing surgical management of adolescent sports injuries and whether the average age of surgical patients is decreasing. **Methods:** The Truven Health MarketScan Database was searched from 2008 to 2014 for patients 10 to 19 years of age using the *International Classification of Disease, 9th Revision* codes and Current Procedure Terminology, 4th Edition, codes for operative treatment for the following conditions: anterior cruciate ligament (ACL) injuries, knee collateral ligament (KCL) injuries, meniscal injuries, Osgood–Schlatter syndrome, and elbow ulnar collateral ligament injuries. Patients identified were characterized by sex, age, year of injury, and type of residence (urban vs rural) based on metropolitan statistical areas. **Results:** A total of 516,892 patients sustained 1 of the identified injuries, and 133,541 (25.8%) patients underwent a related surgery. KCL and meniscal injuries demonstrated a consistent increase in the rate of surgical intervention ($P < .0001$). Average age of surgical intervention did not increase or decrease overall for any diagnosis. Female adolescents were more likely to undergo surgery for KCL injuries (adjusted odds ratio [aOR] 1.7, 95% confidence interval [CI] 1.58-1.79, $P < .0001$), Osgood–Schlatter syndrome (aOR 1.8, 95% CI 1.38-2.39, $P < .0001$), and ACL injuries (aOR 1.5, 95% CI 1.45-1.52, $P < .0001$), whereas male adolescents were more likely to undergo surgery for meniscal injuries (aOR 1.3, 95% CI 1.24-1.30, $P < .0001$) and ulnar collateral ligament injuries (aOR 1.1, 95% CI 1.06-1.23, $P < .0005$). Patients in rural areas were more likely to undergo surgical intervention for ACL and meniscal injuries ($P < .0001$) and KCL injuries ($P = .02$). **Conclusions:** We found that surgical treatment of 5 common sports injuries remains stable, with only KCL injuries and meniscal injuries showing an increase in surgical incidence. Average age of surgical intervention did not change significantly over the 7-year time span for any diagnosis. **Level of Evidence:** Level IV, Cross Sectional Study.

Concerns remain about increased incidence of injuries in youth athletes and sequelae of such injuries, including surgery.¹⁻⁸ Variability in study

populations as well as injuries has resulted in inconsistent findings.^{5,6,9-17} Bayt and Bell⁶ identified an overall increase in sport-related injuries presenting to an emergency department in patients age 5 to 18 years from 2001 to 2013, although they noted that injury trends varied by sport. Lykissas et al.,⁵ however, found that the incidence of sports-related injuries actually decreased from 2000 to 2010 among patients age 5 to 14 years within the same database. Werner et al.¹⁵ looked specifically at anterior cruciate ligament (ACL) injuries and reconstruction within the Pearl Diver database and found increases in the overall number of both diagnoses and surgeries in patients age 5 to 19 years from 2007 to 2011.

Several studies have looked at trends in surgical management of sports injuries in the pediatric and adolescent population.^{11,14,15,18,19} These studies have used state-specific or institution-specific series of

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Table 1. *International Classification of Diseases, Ninth Revision (ICD-9) Codes Queried for the Researched Conditions*

Condition	ICD-9 Codes
Anterior cruciate ligament injuries	717.83 – Old disruption of anterior cruciate ligament
	717.84 – Old disruptions of posterior cruciate ligament
	844.2 – Sprain of cruciate ligament of knee
Meniscal injuries	717.0 – Old bucket handle tear of medial meniscus
	717.1 – Derangement of anterior horn of medial meniscus
	717.2 – Derangement of posterior horn of medial meniscus
	717.3 – Other and unspecified derangement of medial meniscus
	717.40 – Derangement of lateral meniscus unspecified
	717.41 – Bucket handle tear of lateral meniscus
	717.42 – Derangement of anterior horn of lateral meniscus
	717.43 – Derangement of posterior horn of lateral meniscus
	717.49 – Other derangement of lateral meniscus
	717.5 – Derangement of meniscus not elsewhere classified
	836.0 – Tear of medial cartilage or meniscus of knee current
	836.1 – Tear of lateral cartilage or meniscus of knee current
	836.2 – Other tear of cartilage or meniscus of knee current
Knee collateral ligament injuries	717.81 – Old disruption of lateral collateral ligament
	717.82 – Old disruption of medial collateral ligament
	844.0 – Sprain of lateral collateral ligament of knee
	844.1 – Sprain of medial collateral ligament of knee
Osgood-Schlatter syndrome	732.4 – Juvenile osteochondrosis of lower extremity excluding foot
Ulnar collateral ligament (elbow)	841.1 – Ulnar collateral ligament sprain
	841.3 – Ulnohumeral (joint) sprain

patients that may not accurately depict trends in surgical management nationally secondary to smaller numbers of patients as well as a lack of geographic diversity within the patient population.

The purpose of our study was to use a large national database to characterize the incidence of surgical procedures for 5 adolescent sports orthopaedic injuries—ACL injuries, knee collateral ligament (KCL) injuries, meniscal injuries, Osgood–Schlatter syndrome, and ulnar collateral ligament (UCL) of the elbow injuries—based on age, sex, and year of injury. Our hypothesis was that surgical management for each diagnosis would demonstrate increasing incidence and that the average age of patients undergoing surgery

would be decreasing over the study period for each diagnosis.

Methods

A search of the Truven Health MarketScan Database was conducted to identify the incidence of surgical treatment for various pediatric orthopaedic conditions from 2008 through 2014. The MarketScan Commercial Claims and Encounters Database is a medical and drug insurance claims database that contains inpatient and outpatient records and services from non-public insurers across all 50 states. It consists of data from more than 100 insurance companies and large employers and contains data on an average of more than 50 million patients per year over the study period within the United States. The database was searched for patients who had *International Classification of Disease, 9th Revision (ICD-9)* codes for the following conditions: ACL injuries, KCL injuries, meniscal injuries, Osgood–Schlatter syndrome, and elbow UCL injury. Only patients aged 10 to 19 years were included, consistent with the World Health Organization definition of an adolescent individual. A full list of codes is found in [Table 1](#).

Patients were further characterized by the presence or absence of surgical treatment as designated by Current Procedural Terminology, 4th Edition codes for the aforementioned conditions. A full list of codes is found in [Table 2](#).

Patients identified were characterized by sex, age, year of injury, and type of residence (urban vs rural) based on metropolitan statistical areas. Surgical incidence was calculated by dividing the number of adolescents undergoing surgery for a related ICD-9 code by the total number of new patients with that ICD-9 code each year as well as over the study period. Any individual sustaining an injury was removed from further years of the study to eliminate duplicate entries. Although this may represent an additional injury, due to the nature of ICD-9 coding, this far more likely represents the previous injury sustained and follow up. Multivariable regression analysis was used to evaluate differences in surgical trends between individual patient groups delineated by age, sex, and type of residence. The Cochran–Armitage trend test was used to identify significant differences in surgical trends. A waiver was granted by the institutional review board after review of the study methodology.

Results

A total of 516,892 patients sustained one of the identified injuries, and a total of 133,541 (25.8%) patients underwent a related surgery during the study period. Surgery was performed for 64,358 (54.7%) of 117,753 patients (total identified codes 1,341,091) with an ACL injury, 3839 (3.7%) of 105,210 patients

Table 2. Current Procedural Terminology, 4th Edition (CPT-4) Codes for Surgical Procedures Associated With Queried Researched Conditions

Condition	CPT-4 Codes
Anterior cruciate ligament injuries	27407 – Repair, primary, torn ligament and/or capsule, knee; cruciate 27409 – Repair, primary, torn ligament and/or capsule, knee; collateral and cruciate ligaments 27427 – Ligamentous reconstruction (augmentation), knee; extra-articular 27428 – Ligamentous reconstruction (augmentation), knee; intra-articular (open) 27429 – Ligamentous reconstruction (augmentation), knee; intra- (open) and extra-articular 29888 – Arthroscopically aided anterior cruciate ligament repair/augmentation or reconstruction 29889 – Arthroscopically aided posterior cruciate ligament repair/augmentation or reconstruction
Knee collateral ligament injuries	27409 – Repair, primary, torn ligament and/or capsule, knee; collateral and cruciate ligaments 27427 – Ligamentous reconstruction (augmentation), knee; extra-articular 27428 – Ligamentous reconstruction (augmentation), knee; intra-articular (open) 27429 – Ligamentous reconstruction (augmentation), knee; intra- (open) and extra-articular
Meniscal injuries	27403 – Arthrotomy with meniscus repair, knee 29868 – Arthroscopy, knee, surgical; meniscal transplantation (includes arthrotomy for meniscal insertion), medial or lateral 29880 – Arthroscopy, knee, surgical; with meniscectomy (medial AND lateral, including any meniscal shaving) including debridement/shaving of articular cartilage (chondroplasty), same or separate compartment(s), when performed 29881 – Arthroscopy, knee, surgical; with meniscectomy (medial OR lateral, including any meniscal shaving) including debridement/shaving of articular cartilage (chondroplasty), same or separate compartment(s), when performed 29882 – Arthroscopy, knee, surgical; with meniscus repair (medial OR lateral) 29883 – Arthroscopy, knee, surgical; with meniscus repair (medial AND lateral) G0428 – Collagen Meniscus Implant procedure for filling meniscal defects (e.g., CMI, collagen scaffold, Menaflex)
Osgood–Schlatter syndrome	27360 – Excision procedures on the femur (thigh region) and knee joint
Ulnar collateral ligament of the elbow	24343 – Repair lateral collateral ligament, elbow, with local tissue 24344 – Reconstruction lateral collateral ligament, elbow, with tendon graft (includes harvesting of graft) 24345 – Repair medial collateral ligament, elbow, with local tissue 24346 – Reconstruction medial collateral ligament, elbow, with tendon graft (includes harvesting of graft) 29830 – Arthroscopy, elbow, diagnostic, with or without synovial biopsy (separate procedure) 29834 – Arthroscopy, elbow, surgical; with removal of loose body or foreign body 29835 – Arthroscopy, elbow, surgical; synovectomy, partial 29836 – Arthroscopy, elbow, surgical; synovectomy, complete 29837 – Arthroscopy, elbow, surgical; debridement, limited 29838 – Arthroscopy, elbow, surgical; debridement, extensive

(total identified codes 316,367) with a KCL injury, 60,034 (38.5%) of 155,845 patients (total identified codes 618,316) with a meniscal injury, 211 (0.2%) of 115,635 patients (total identified codes 212,468) with Osgood–Schlatter syndrome, and 5099 (22.7%) of 22,449 patients (total identified codes 86,447) with a UCL injury (Table 3).

For ACL injuries, the rate of surgical intervention was lowest in 2008 at 43.4% and increased to 57.2% in 2009 ($P < .001$). This change was statistically significant; however, this was not a sustained trend, as there was a statistically significant decrease from 2009 (57.2%) to 2010 (53.4%) ($P < .001$). Year-to-year increases were observed thereafter, with one increasing to statistical significance. The rate fluctuated between the low of 43.4% in 2008 and the high of 58.6% in 2014 (Fig 1).

Analysis of KCL surgery/injuries ratio demonstrated an increase in the rate of surgical intervention every year during the study period from 2.0% in 2008 to 5.3% in 2014 ($P < .001$), the exception being the final year, which did show an increase but was not statistically significant (Fig 1). The rate of surgical intervention for meniscal injuries increased from 33.2% in 2008 to 41.5% in 2014 ($P < .001$) with 2 years revealing a statistically significant raise in percent surgical intervention (Fig 1).

Surgery for UCL injuries ranged from 22.1% in the final year of the study to 24.6% in 2009. The year-to-year fluctuations were not statistically significant. Ultimately, there was no statistically significant increase in the ratio over the study period (Fig 1). The rate of surgery for Osgood–Schlatter remained low throughout the study, ranging from 0.12% to 0.21%. No statistically significant

Table 3. Raw Data Evaluated Throughout the MarketScan Database Based on Total Adolescents in Database, New Diagnoses, Number of Surgeries Performed, and Percentage of Surgery/New Diagnosis Over the Study Period

Year	Total Adolescents in Database	ACL			Collateral Ligaments (Knee)			Meniscal Injuries			Osgood–Schlatter			Ulnar Collateral Ligament (Elbow)		
		New Diagnoses	Surgery	%	New Diagnoses	Surgery	%	New Diagnoses	Surgery	%	New Diagnoses	Surgery	%	New Diagnoses	Surgery	%
2008	6,363,531	18,473	8015	43.39	13,845	272	1.96	23,154	7690	33.21	15,573	19	0.12	2463	563	22.86
2009	6,111,862	13,656	7815	57.23	12,457	306	2.46	19,361	7329	37.85	13,757	29	0.21	2364	582	24.62
2010	6,941,880	16,955	9053	53.39	14,903	437	2.93	22,302	8422	37.76	15,480	33	0.21	3005	690	22.96
2011	7,928,436	18,589	10,236	55.06	16,769	585	3.49	24,553	9485	38.63	18,120	38	0.21	3665	798	21.77
2012	7,966,329	18,538	10,779	58.15	17,503	716	4.09	24,961	10,103	40.48	19,193	28	0.15	3980	910	22.86
2013	6,489,956	15,290	8936	58.44	14,314	703	4.91	20,223	8171	40.40	16,235	31	0.19	3400	766	22.53
2014	6,868,983	16,252	9524	58.60	15,419	820	5.32	21,291	8834	41.49	17,277	33	0.19	3572	790	22.12
Total		117,753	64,358	54.66	105,210	3839	3.65	155,845	60,034	38.52	115,635	211	0.18	22,449	5099	22.71

ACL, anterior cruciate ligament.

changes were noted for Osgood–Schlatter surgical to diagnosis ratio (Fig 1).

The average age of surgical intervention over 7 years was 16.35 years for ACL injuries (range 16.28–16.42 years), 16.42 years for KCL injuries (range 16.26–16.59 years), 16.35 for meniscal injuries (range 16.30–16.39 years), 16.82 years for UCL injuries (range 16.66–16.97 years), and 15.9 years for Osgood–Schlatter syndrome (range 15.5–16.3 years) (Fig 2). No consistent decrease or increase in average age of surgical intervention during the study period was observed. Age greater than 15 years was associated with a greater likelihood for surgical intervention for all diagnoses ($P < .001$) (Table 4).

Female adolescents were more likely to undergo surgery for ACL injuries (adjusted odds ratio [aOR] 1.5, 95% confidence interval [CI] 1.45–1.52, $P < .0001$), KCL injury (aOR 1.7, 95% CI 1.58–1.79, $P < .0001$), and Osgood–Schlatter syndrome (aOR 1.8, 95% CI 1.38–2.39, $P < .0001$) whereas male adolescents were more likely to undergo surgery for meniscal injuries (aOR 1.3, 95% CI 1.24–1.30, $P < .0001$) and UCL injuries (aOR 1.1, 95% CI 1.06–1.23, $P = .0005$). Both male and female patients demonstrated a sustained increase in surgery for KCL injuries and meniscal injuries over the study period. All other evaluated diagnoses failed to demonstrate a trend specific to either sex (Fig 2).

Patients in rural areas were more likely to undergo surgical intervention for ACL (aOR 1.1, 95% CI 1.03–1.10, $P < .0001$) and meniscal injuries (aOR 1.1, 95% CI 1.08–1.14, $P < .0001$) and KCL injuries (aOR 1.1, 95% CI 1.02–1.20, $P = .02$) whereas other diagnoses showed no statistically significant difference (Table 4).

Discussion

Although our data found a consistent increase in the incidence of surgical intervention for patients sustaining a KCL injury or meniscal injury, contrary to our hypothesis, other diagnoses including ACL tears and UCL injury failed to show a sustained increase in the incidence of surgical intervention over the 7-year study period. In addition, average age of surgical intervention did not consistently increase or decrease for any of the studied diagnoses.

The aforementioned findings contradict the findings of other studies that have looked at trends in surgical intervention for sports injuries in youth and adolescent populations.^{10,11,14,15,18} Dodwell et al.¹¹ used the New York Statewide Planning and Research Cooperative System (SPARCS) database and identified an almost 3-fold increase in the incidence in ACL reconstruction among 25,315 patients from 3 to 20 years of age from 1990 to 2009. Werner et al.¹⁵ used the Pearl Diver database and also found that overall numbers of ACL injury diagnoses and reconstructions increased from

Average Age of Patients Undergoing Surgery By Diagnosis and Year

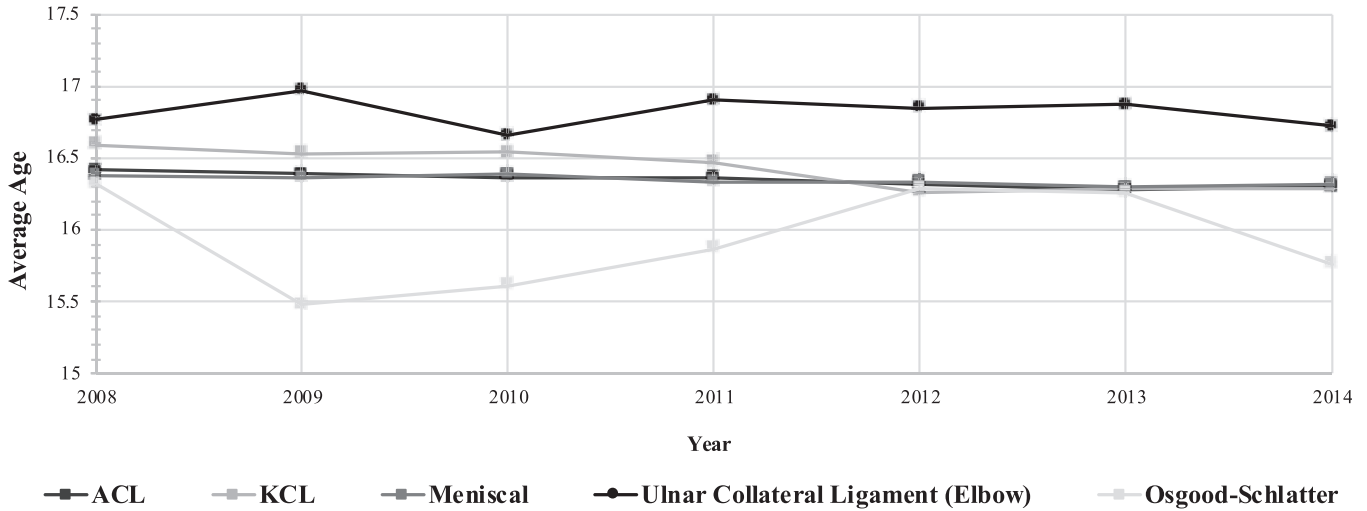


Fig 1. Rate of surgical intervention for injured patients by year. **P* value < .05. ***P* value < .001. Results of the analysis are that anterior cruciate ligament (ACL), knee collateral ligament (KCL), and meniscal surgeries had an increased incidence as shown. (UCL, ulnar collateral ligament.)

2007 to 2011, although incidence data were not available. Although our study showed a 30% increase in ACL reconstructions from 2008 to 2009 (43.4%-57.2%), this trend did not continue through the study period, as can be seen in Figure 1. The results of our data may indicate a change in the approach to adolescent ACL injuries over a more recent study period and also may be reflective of a the smaller time period in our study (1 decade vs 2 in the study of Dodwell et al.¹¹). On the contrary, this may be a more accurate representation of the national trend in ACL injury management, given the significantly higher number of patients from across the country seen in the current MarketScan database.

Hodgins et al.¹⁸ also looked at the SPARCS database from 2002 to 2011. They identified a 193% increase in the total number of UCL injuries and a 3-fold increase in the rate of UCL reconstructions, noting a significant increase specifically among patients 17 to 18 and 19 to 20 years of age. Petty et al.¹⁰ noted an increase in the proportion of 694 UCL reconstructions performed at their institution that were for high school athletes (8% vs 13%) from 1988 to 2003. Differences between our study findings and the previously mentioned studies may be attributed to a potential shift in the approach to UCL injuries or a more accurate reflection of the national trend in UCL management as our study evaluated a significantly greater number of patients from across the country seen in the current MarketScan database. Previous studies also looked at a shorter time frame, and the differences observed in these studies may represent a local short trend (year to year, as was

seen in our database for ACL reconstructions from 2008 to 2009) versus a true trend over time. Our study found that incidence of UCL surgery ranged from a low of 21.8% in 2011 to a high of 24.6% in 2009 with no consistent change over the study period.

Our sex-specific trends also showed varying agreement with previous findings. Hodgins et al.¹⁸ noted that male adolescents were 11.8 times more likely to undergo UCL reconstruction than female adolescents in their study, whereas our data demonstrated surgery was more likely in males with an odds ratio of 1.14 (*P* < .0005). In another study, Dodwell et al.¹¹ found that male adolescents were 15% more likely to undergo ACL reconstruction as opposed to female adolescents, similar to our data. The much larger number of patients and the geographic diversity of our database, as well as the more recent time period, may represent a more accurate and recent representation of the national trend to operate on these injuries.

The clinical response to our findings is intriguing. We believe these data and evaluation may help young patients understand that surgery is not the answer to every injury. The influence of professional athletics and social media may affect the patients desire to dictate their own care. We believe that treatment should be a joint decision between provider and patient, but that it should be driven by the odds for most favorable outcome. Although some injuries are best treated surgically, it is the job of the surgeon to help guide and direct the patient and their family towards the best individualized treatment. Our study helps affirm to patients, and the surgeon, of the national

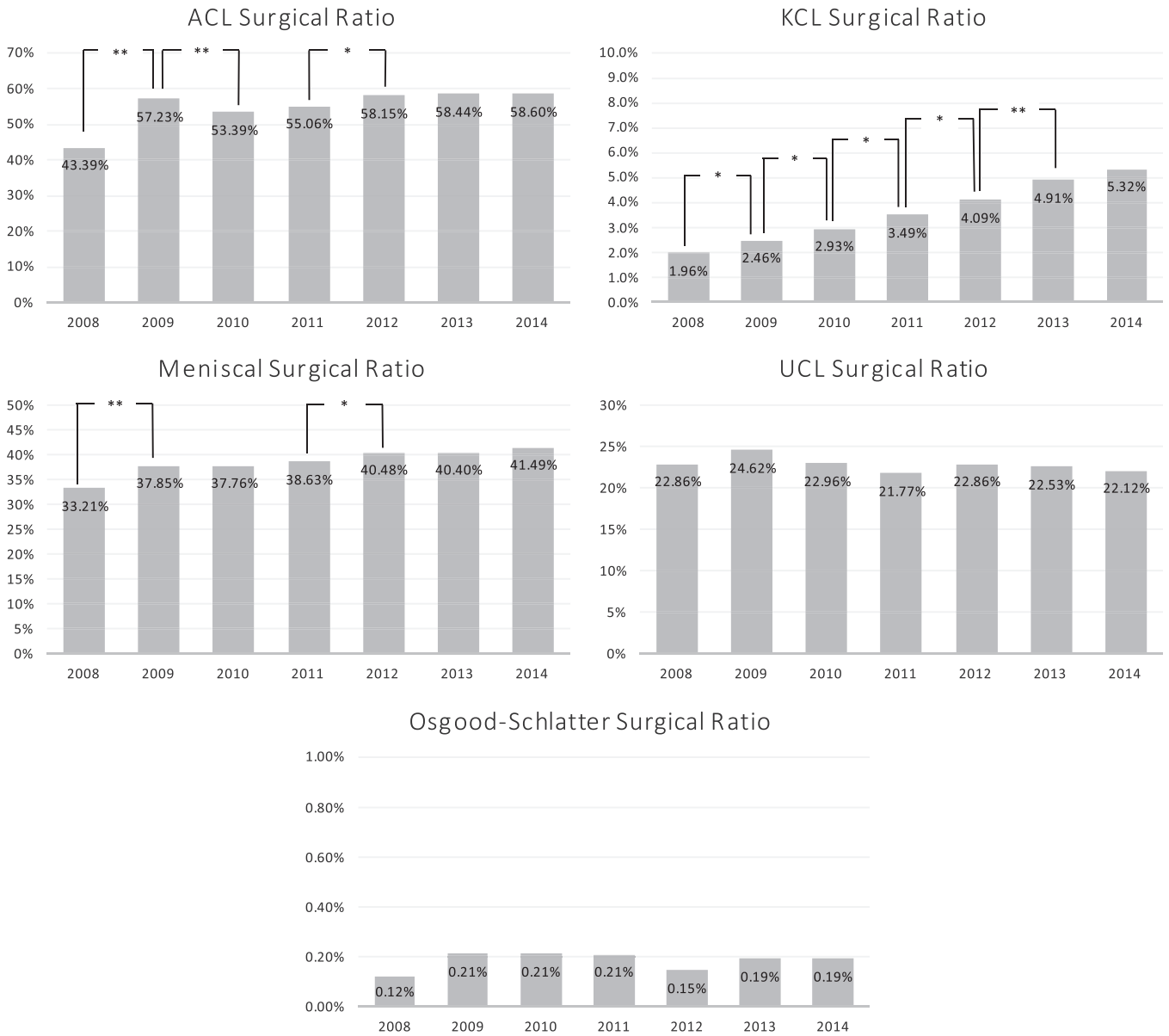


Fig 2. Average age of injured patients undergoing surgical intervention by year. Graphical representation of average age of surgical intervention represented by condition evaluated and year of evaluation. (ACL, anterior cruciate ligament; KCL, knee collateral ligament.)

trend in treating pediatric injuries surgically. The data presented herein can thus aid the patient-surgeon decisions tree towards a favorable outcome and relationship.

Limitations

A limitation to our study is that our data do not evaluate mechanism of injury and, thus, cannot delineate which injuries are due to sport versus other mechanisms such as trauma. Thus, we cannot be certain that these are all sports-related injuries. There is also inherent variability in who enters coding data and the accuracy of that data depending on provider and

institution. In addition, 7 years may not be a sufficiently long study period to capture significant changes seen in the incidence of surgical management of adolescent sports injuries. In addition, the MarketScan database does not include public insurers, which could introduce bias as well. Duplicate ICD-9 injury entries were removed in this study. Although this duplicate entry may represent an additional injury, due to the nature of ICD-9 coding, this far more likely represents the previous injury sustained and follow up and as such was removed. This is required as our database and ICD-9 coding in general is not granular enough to tease out follow-up from reinjury.

Table 4. Adjusted OR for Predisposing Factors Evaluated for Likelihood for Surgical Intervention by Diagnosis

Diagnosis/injury	Age, y	OR	P Value	Sex	OR	P Value	Location	OR	P Value
ACL	15-19	5.39	<.0001	Male	1.11	<.0001	Rural	1.16	<.0001
KCL	15-19	1.57	<.0001	Female	1.68	<.0001	Rural	1.11	.0197
Meniscal	15-19	1.79	<.0001	Male	1.27	<.0001	Rural	1.11	<.0001
UCL	15-19	1.36	<.0001	Male	1.14	<.0005	Rural	1.08	.0808
O-S	15-19	13.98	<.0001	Female	1.81	<.0001	Rural	1.23	.2472

NOTE. A factor listed in age, sex, and location column is factor that is more likely to have been treated operatively. A P value of <.0001 is considered statistically significant upon analysis for large data queries.

ACL, anterior cruciate ligament; KCL, knee collateral ligament; OR, odds ratio; O-S, Osgood–Schlatter; UCL, ulnar collateral ligament.

Conclusions

We found that surgical treatment of 5 common sports injuries remains stable with only KCL injuries and meniscal injuries showing an increase in surgical incidence. Average age of surgical intervention did not change significantly over the 7-year time span for any diagnosis.

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