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Am J Sports Med 2014 42: 675 originally published online January 29, 2014

DOI: 10.1177/0363546513518412

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20 Years of Pediatric Anterior Cruciate Ligament Reconstruction in New York State

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Background: There have been no population-based studies to evaluate the rate of pediatric anterior cruciate ligament (ACL) reconstruction.

Purpose: The primary aim of the current study was to determine the yearly rate of ACL reconstruction over the past 20 years in New York State. Secondary aims were to determine the age distribution for ACL reconstruction and determine whether patient demographic and socioeconomic factors were associated with ACL reconstruction.

Study Design: Descriptive epidemiology study.

Methods: The Statewide Planning and Research Cooperative System (SPARCS) database contains a census of all hospital admissions and ambulatory surgery in New York State. This database was used to identify pediatric ACL reconstructions between 1990 and 2009; ICD-9-CM (*International Classification of Diseases, 9 Revision, Clinical Modification*) and CPT-4 (*Current Procedural Terminology, 4th Revision*) codes were used to identify reconstructions. Patient sex, age, race, family income, education, and insurance status were assessed.

Results: The rate of ACL reconstruction per 100,000 population aged 3 to 20 years has been increasing steadily over the past 20 years, from 17.6 (95% confidence interval [CI], 16.4-18.9) in 1990 to 50.9 (95% CI, 48.8-53.0) in 2009. The peak age for ACL reconstruction in 2009 was 17 years, at a rate of 176.7 (95% CI, 160.9-192.5). In 2009, the youngest age at which ACL reconstruction was performed was 9 years. The rate of ACL reconstruction in male patients was about 15% higher than in females, and ACL reconstruction was 6-fold more common in patients with private health insurance compared with those enrolled in Medicaid.

Conclusion: This study is the first to quantify the increasing rate of ACL reconstructions in the skeletally immature. Only ACL reconstructions were assessed, and it is possible that some ACL tears in children are not diagnosed or are treated nonoperatively. The rate of ACL tears in New York State is likely higher than the rate of reconstructions reported in this study.

Significance: This study quantifies the increasing rate of ACL reconstruction in the skeletally immature and suggests that there may be some disparities in care based on insurance status.

Keywords: pediatric ACL reconstruction; disparity; pediatric ACL tear; insurance

Historically, anterior cruciate ligament (ACL) tears are an uncommon injury in the skeletally immature population. The low occurrence of this injury has been attributed to the greater strength of the ligament over open physes or developing bone.⁹ When diagnosed, ACL tears had often been managed nonoperatively; however in 1989, Angel and Hall² noted that ACL injury was less benign than previously recognized, and the literature since then has shown poor outcomes with nonoperative management.²⁵ These

injuries can be missed, and a retrospective review of patients diagnosed with knee strain found that 13% of patients had increased anterior laxity several years after initial injury.³⁵

The incidence of ACL reconstruction in children has not previously been reported on a population basis. The rate of ACL injury, as opposed to reconstruction, has been assessed in previous studies within a series of patients with knee injuries or traumatic effusions and hemarthroses. In patients with traumatic effusions, 29% were found to be a result of ACL tears.²¹ In another study in which 70 children underwent arthroscopy after traumatic hemarthrosis, 47% of preadolescents and 65% of adolescents had ACL tears.³⁴ Analysis of insurance claims in young soccer players found that ACL tears comprised 31% of all knee injury claims.³³

Current literature suggests that the rate of pediatric ACL tears is increasing.^{3,7,9} This trend is commonly attributed to an increased participation in competitive youth

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The authors declared that they have no conflicts of interest in the authorship and publication of this contribution.

TABLE 1
Patient Demographics^a

| | Age 3-20 y (n = 25,315) | All Ages (N = 100,020) |
|------------------|----------------------------|---------------------------|
| Age group, y | | |
| 3-10 | 53 (0.2) | 53 (0.1) |
| 11-14 | 1987 (7.9) | 1987 (2.0) |
| 15-18 | 16,867 (66.6) | 16,867 (16.9) |
| 19-20 | 6408 (25.3) | 6408 (6.4) |
| 21+ | — | 74,705 (74.7) |
| Sex | | |
| Male | 13,806 (54.5) | 63,437 (63.4) |
| Female | 11,502 (45.4) | 36,557 (36.6) |
| Unknown | 7 (0.0) | 26 (0.0) |
| Race/ethnicity | | |
| White | 14,222 (56.2) | 52,862 (52.9) |
| Black | 1431 (5.7) | 5413 (5.4) |
| Hispanic | 1078 (4.3) | 5098 (5.1) |
| Other | 2125 (8.4) | 9452 (9.5) |
| Unknown | 6459 (25.5) | 27,195 (27.2) |
| Insurance status | | |
| Not covered | 712 (2.8) | 2895 (2.9) |
| Private | 21,886 (86.5) | 76,328 (76.3) |
| Medicare | 42 (0.2) | 1109 (1.1) |
| Medicaid | 1494 (5.9) | 4898 (4.9) |
| Other | 1181 (4.7) | 14,790 (14.8) |

^aData are expressed as n (%).

sports. In Australia, an increased incidence of ACL injuries and reconstructions was seen in both the amateur and professional athletes compared with the general population.²⁷ Not only has participation grown, but children often begin at a younger age and compete at a higher level. This trend has also led to an increased diagnosis of sport-specific overuse injuries in children and adolescents.

Anterior cruciate ligament tears in the pediatric population are likely increasing, but the true incidence of this injury remains unknown because of the limitations of current epidemiologic data.^{13,15} Analyzing ACL reconstruction rates provides an indirect measure of ACL tears. The purpose of the current study was to assess the rate of ACL reconstruction in children and young adults in the state of New York over the past 20 years.

METHODS

The Statewide Planning and Research Cooperative System (SPARCS) database was surveyed for all pediatric ACL reconstructions from 1990 to 2009. This database contains a census of all hospital admissions and ambulatory surgery cases performed in New York State, with the exception of those cases done in a Veterans Affairs facility and other federal hospitals. The ACL reconstructions were identified through the use of ICD-9-CM (*International Classification of Diseases, 9th Revision, Clinical Modification*) and CPT-4 (*Current Procedural Terminology, 4th Revision*) codes. Isolated ACL reconstruction was coded as ICD-9-CM 81.45 for inpatients or CPT-4 27407 (open) or 29888 (arthroscopic)

for outpatients. Combined ACL and collateral ligament reconstruction was coded as ICD-9-CM 81.43 for inpatients or CPT-4 27409, 27427, 27428, or 27429 for outpatients. Pediatric patients were defined as patients younger than 21 years of age, consistent with the National Institute of Health's definition of a child. Children younger than 3 years were excluded. Patients were further subdivided into age categories: 3 to 10 years, 11 to 14 years, 15 to 18 years, and 19 to 20 years.

Age, sex, race/ethnicity, residential zip code, and health insurance status were identified for each patient. Race/ethnicity was defined as *white*, *black*, *Hispanic*, *other*, or *unknown*. Insurance status (expected payer) was defined as *private*, *Medicare*, *Medicaid*, *other*, or *not covered*. Patients with New York State Child Health Plus (CHP)-managed Medicaid plans were categorized under *Medicaid*. Medicaid coverage differs by state. In New York State, Medicaid covers infants younger than 1 year at an income of 200% of the federal poverty level, and children aged 1 to 18 years are covered at 133% of the federal poverty level. Child Health Plus is similar to Medicaid; children 18 or younger are eligible for Child Health Plus in New York State if they do not have private insurance and if the family income is such that they do not qualify for Medicaid. Patients with CHP do not pay a premium if income is 160% or less than the federal poverty level; CHP premiums for higher earning families are on a sliding scale depending on income and family size. Education level and median family income were estimated based on patient residential zip code using US Census Bureau data from the 2000 census. Annual population estimates from 1990 to 2009 were obtained from US Census Bureau intercensal estimates to calculate rates per 100,000 population of pediatric ACL reconstruction.

RESULTS

Characteristics of the study population are detailed in Table 1. In the surveyed time period, the rate of ACL reconstruction per 100,000 population aged 3 to 20 years inclusive rose steadily in New York State from 17.6 (95% confidence interval [CI], 16.4-18.9) in 1990 to 50.9 (95% CI, 48.8-53.0) in 2009 (Figure 1). Of all the age groups analyzed, patients aged 15 to 18 years had the highest rate of ACL reconstruction and also the greatest increase in the number of ACL reconstructions from 1990 to 2009 (Figure 2). In 2009, the peak age for ACL reconstruction was 17 years, at a rate per 100,000 population of 176.7 (95% CI, 160.9-192.5) (Figure 3). The rate of ACL reconstructions per 100,000 population in each age group was as follows: ≤10 years, 0.2 (95% CI, 0.0-0.4); 11 to 14 years, 22.9 (95% CI, 19.9-25.9); 15 to 18 years, 142.5 (95% CI, 135.4-149.7); and 19 to 20 years, 89.1 (95% CI, 81.5-96.8).

Analysis by sex showed that the rate of ACL reconstruction in males was 15% higher than in females (in 2009: males, 54.3 [95% CI, 51.4-57.3]; females: 47.2 [95% CI, 44.3-50.1]) (Figure 4). When stratified by insurance, ACL reconstruction was 6-fold more common in patients with private insurance compared with Medicaid (in 2009:

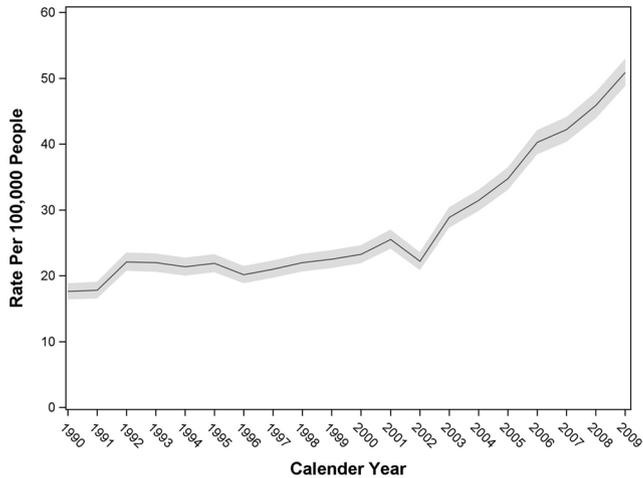


Figure 1. Rate of anterior cruciate ligament reconstructions in the pediatric population (aged 3-20 years) in New York State, 1990 to 2009. Shaded areas indicate 95% confidence intervals for rates.

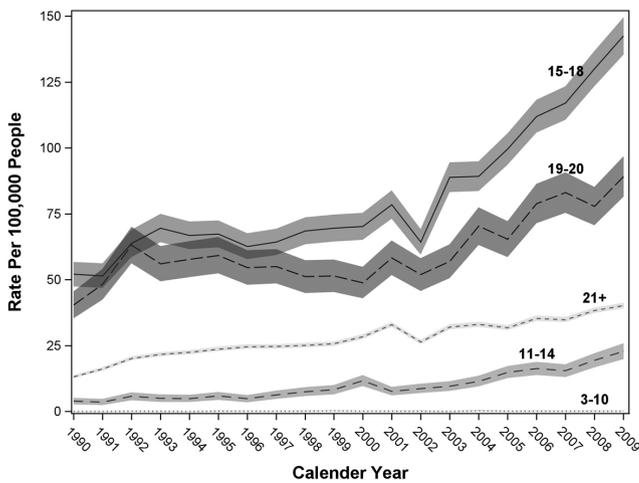


Figure 2. Rate of anterior cruciate ligament reconstructions per 100,000 people stratified by age group. Shaded areas indicate 95% confidence intervals for rates.

private insurance, 47.3 [95% CI, 44.7-49.9]; Medicaid, 7.7 [95% CI, 6.4-9.0]) (Figure 5).

DISCUSSION

Numerous publications over the past decade have commented on the increasing incidence of ACL tears without direct citation. In our study, we were able to obtain detailed longitudinal long-term data on ACL reconstructions in a statewide population because of mandatory reporting. Although we have shown only that ACL reconstruction rates have increased, we propose that this is an indirect measure of an increased rate of ACL injury. Other

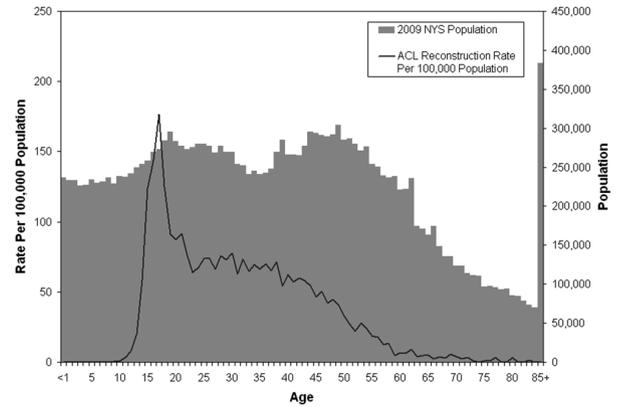


Figure 3. Rate of anterior cruciate ligament reconstructions in 2009 compared with 2009 New York State (NYS) population.

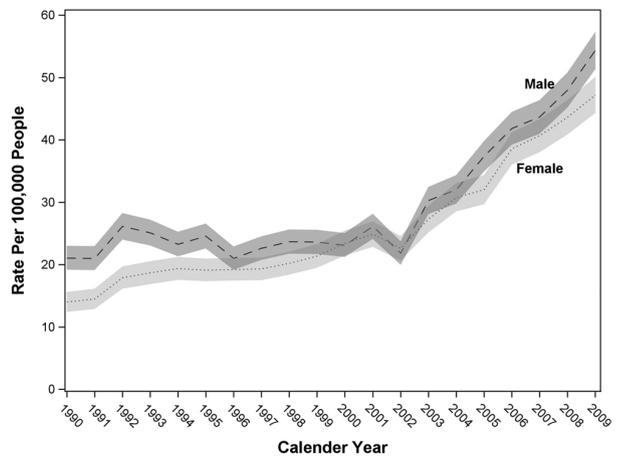


Figure 4. Rate of anterior cruciate ligament reconstructions per 100,000 people stratified by sex. Shaded areas indicate 95% confidence intervals for rates.

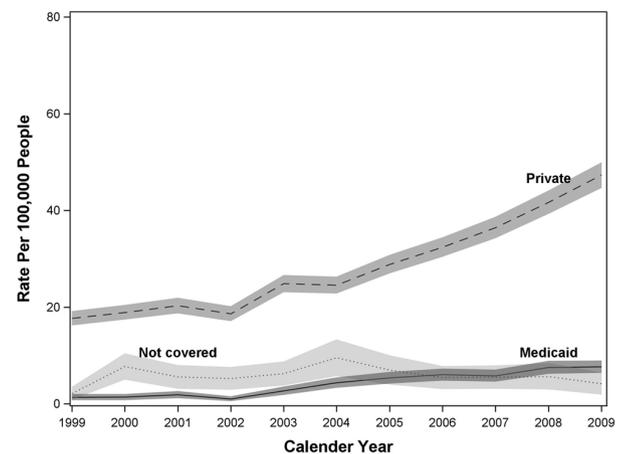


Figure 5. Rate of anterior cruciate ligament reconstructions per 100,000 people in patients younger than 18 years stratified by insurance status. Shaded areas indicate 95% confidence intervals for rates.

studies have shown a population increase in ACL reconstruction rates, although have not specifically examined the rate in younger patients. Lyman et al²² showed that ACL reconstructions increased in New York State by 21.5% and up to 67.8% nationwide over a 9-year period. As early as 1996, Bollen and Scott⁷ reported on the quiet epidemic of ACL tears. In the current study we demonstrate that the rate of ACL reconstructions is steadily increasing at a much higher rate than expected in the pediatric population, by definition an epidemic. Although it is possible that improved methods of diagnosis are responsible for greater rates of reconstruction, or that reconstruction rates have increased due to improved methods of treatment in the skeletally immature, it is also possible that ACL tears are truly increasing in children and adolescents.

In the active duty military population, 58% of patients with ACL tears underwent reconstruction, and the rate of reoperation was significantly lower in this subset of the population.¹⁰ Nonoperative management of ACL tears in skeletally immature patients has demonstrated poor outcomes.^{1,3,24,25} Increased incidence of meniscal injury and articular cartilage damage occur in nonoperatively managed ACL tears.^{10,14,26} These injuries occur almost exclusively in the young athlete. Those managed nonoperatively and followed after return to sport often complain of instability, pain, swelling, and irritability. Aichroth et al¹ followed nonoperatively managed patients with ACL tears for 10 years and because of poor outcomes recommended operative management.

Operative techniques vary in graft choice, tunnel options, and physeal involvement and are dependent on the amount of remaining growth of the patient.¹⁶ Ligamentous repair is generally accepted as a poor surgical option. A recent systematic review confirms that surgical stabilization is the best option; however, it did not support an optimal technique for reconstruction.³⁷

Several studies have reported on the outcomes of pediatric ACL reconstruction. Good clinical outcomes have been demonstrated with transphyseal reconstruction; all these patients returned to their preinjury level of sport.^{3,8,20} Intra-articular ACL reconstruction in a small series eliminated instability, with 19 of 20 patients returning to sport.¹¹ A series of 47 knees treated with transphyseal reconstruction had satisfactory outcomes in 77%, with a rerupture occurring in 3 out of 47.¹

A meta-analysis of operatively managed ACL tears in skeletally immature patients showed that 84.2% achieved excellent or good knee function and average Lysholm scores of 96.3.¹² Complications included re-rupture and growth disturbances, however these were low. Another meta-analysis looking at return to play after ACL reconstruction found that 82% returned to sports participation; however, in this series only 63% did so at preinjury level.⁴

Sports equipment sales estimate that nearly 70% of children in the US are playing team sports. There appears to be a trend in younger age at initiation of sports participation as well as more frequent competition and a higher level of training. This trend has been shown to have repercussions for cardiac and musculoskeletal health, maturation, and development, as well as for psychosocial development.¹⁸

In the current study, children with Medicaid/Medicare received ACL reconstruction at a much lower rate. We utilized Medicaid coverage as a marker for low socioeconomic status including low income, level of education, and inclusive of minorities. Patients with private insurance coverage were 6 times more likely to undergo ACL reconstruction compared with patients covered by Medicaid. It is possible that this represents a disparity in access to care or specifically subspecialty care. Baraga et al⁵ showed that patients with private insurance had ACL injuries diagnosed earlier and had fewer medical visits before diagnosis than patients with Medicaid or no insurance. However, it is also possible that part of this difference could be explained by children of lower socioeconomic status participating in fewer activities that put them at risk for ACL tears and therefore reconstruction. It is also possible that there are racial differences in risk for ACL injury and that this could explain decreased ACL reconstruction rates in children of lower socioeconomic status. It is important to note racial stratification of patients on Medicaid, of which the largest race/ethnicity is white. In the United States, more adolescents are overweight and sports participation is lower in racial/ethnic minorities and youth of low socioeconomic status.¹⁸ It is also important to note that the rates seen here are in the entire population of New York State and are not stratified based on activity level. The population studied here includes both active and inactive children, thus the rate of ACL reconstruction in active children would be higher than reported here.

Although greater sports participation in patients of higher socioeconomic status⁶ may partially explain the 6-fold higher ACL reconstruction rate in children with private insurance, past studies have documented that patients with ACL tears may face disparities in access to care based on insurance status. In a study of orthopaedic surgery practices in the US, a fictitious privately insured patient reporting an ACL tear was offered an appointment within 2 weeks with 90% of practices called.³² A patient of the same age and diagnosis but with Medicaid insurance was offered an appointment within 2 weeks at only 14% of offices. Disparities in management based on insurance status has previously been demonstrated for other surgeries. Nuno et al³⁰ found that in patients with idiopathic scoliosis, white patients, and patients with private health insurance were more likely to undergo surgical treatment even when controlling for comorbidities.

Another influence on the rate of ACL reconstruction may be access to imaging modalities that lead to diagnosis, such as magnetic resonance imaging (MRI). Racial/ethnic differences have been demonstrated that limit access to medical technology. Kim et al¹⁹ showed that Hispanic patients were less likely than whites to utilize high-technology hospitals with resources such as MRI. Given that diagnoses without advanced imaging have been shown to lead to missed diagnoses of ACL tears,³⁵ lack of access to this imaging modality could lead to disparities in diagnosis.

The findings in New York State are concerning as they demonstrate that lower paying insurance programs are an independent risk factor for a lower rate of ACL reconstruction. Expected surgeon's reimbursement for arthroscopic

ACL reconstruction in children covered by Medicaid is \$475, while those covered by private insurance have an expected reimbursement in the range of \$6300 to \$11,200, depending on the hospital site within New York City, and may vary further, throughout New York State (personal communication with authors' billing company). Given current health care reform, attention must be paid to the implications of large disparities in physician reimbursement and how this may affect disparity in care as exemplified by ACL reconstructions.

Interestingly, in this study the rate of ACL reconstructions in male patients was 14% higher in 2009 compared with that in females. Parkkari et al³¹ demonstrated an increased hazards ratio for ACL tears in young female athletes compared with males. Literature has shown that female athletes tear their ACLs at a much higher rate in sports such as basketball, handball, and soccer. These are sports that involve quick changes in direction, cutting, jumping, and stopping, during which the female anatomy and physiology may predispose them to ACL tears.³⁶ Although female athletes may sustain more ACL injuries than their male counterparts per unit of time spent playing "high-risk" sports, males in general spend more time at high-intensity activities, which may explain the higher overall incidence in males.

Lastly, this study provides further evidence that ACL injuries in children are an important public health issue that requires attention. Exercise programs have been developed that have been demonstrated to dramatically decrease the risk of ACL injury.^{23,28,29} We believe prevention programs should be implemented at schools, starting with prepubescent children. Further, junior sports teams at all levels should do the same.

In conclusion, pediatric ACL reconstruction rates are steadily increasing in New York State. This is very likely associated with an increased rate of ACL ruptures in the skeletally immature. Implementing prevention programs early in childhood may help to mitigate this increasing problem. Further, there is an association between lower socioeconomic status and lower rates of ACL reconstruction. This may represent a disparity in access to care based on insurance status. The results of this study have important implications for health policy, both in relation to development of education and training programs to avoid ACL injury and in relation to policies that will ensure improved access to care for children based on sex, race, and socioeconomic status. This study is the first to quantify the increasing rate of ACL reconstructions in the skeletally immature. This study assessed only ACL reconstructions, and it is possible that some ACL tears in children are not diagnosed or are treated nonoperatively. The rate of ACL tears in New York State is likely higher than the rate of reconstructions reported here.

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