ORIGINAL ARTICLE

Incidence Rate of Anterior Cruciate Ligament Reconstructions

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Abstract

Context: Anterior cruciate ligament (ACL) reconstructions are among the most common sports medicine procedures performed in the US each year. Differences have been reported in the incidence rates (IRs) of ACL tears among male and female national elite athletes. However, there is little information in the published literature that assesses IRs for ACL reconstructions done in the Health Maintenance Organization (HMO) setting specifically. Different populations may show variation in ACL reconstruction IRs.

Objective: This study reports on the IR of ACL reconstructions in a predefined population and compares the differences in age and sex over time.

Design: A retrospective analysis of 4485 ACL reconstructions performed within Kaiser Permanente Southern California between 2001 and 2005 was completed by a query of an administrative database. Trends in IRs per 100,000 members were calculated and compared across age, sex, and the five-year study period.

Main Outcome Measures: Linear regression was used to test trends in IR. Sex distribution was compared using the χ^2 test. Analysis of variance was used to compare the mean age from year to year in males and females. The independent sample t-test was used to compare mean age between males and females for each independent year.

Results: The IR of ACL reconstructions in females rose significantly ($p = 0.010$) from 14.4 in 2001 (95% confidence interval [CI], 12.6–16.3) to 19.3 in 2005 (95% CI, 17.2–21.5). Within specific age groups, IR increased significantly for females age 14 to 17 ($p = 0.013$), 18 to 21 ($p = 0.017$), and 45 to 49 years ($p = 0.014$). The most dramatic change was seen in the female age category of 14 to 17 years, which increased at a rate of 8.14 cases/100,000 members per year.

Conclusion: Identifying the sex and age groups with most rapidly increasing rates of ACL reconstructions is important in implementing ACL injury-prevention programs.

Introduction

Differences have been reported in the incidence rates (IRs) of anterior cruciate ligament (ACL) tears among male and female national elite athletes.[1] However, IRs have not been assessed for Kaiser Permanente (KP) patients. In fact, there is little information in the published literature that assesses IRs for ACL reconstructions done in the Health Maintenance Organization (HMO) setting specifically. HMO populations are larger and more diverse than elite athlete populations. The elite athlete population also lacks the ethnic and socioeconomic diversity of the KP membership population. Different populations may show variation in ACL reconstruction IRs. Therefore, it is necessary to evaluate the IRs of ACL reconstructions in our HMO population.

ACL reconstructions are among the most common sports medicine procedures performed in the United States, numbering about 100,000 each year.[2] Currently there is no evidence that ACL reconstructions prevent the development of arthritis.[3] Therefore it is not enough to just diagnose and treat ACL tears. The focus of many orthopedic surgeons and of ACL-related research is on the prevention of ACL tears and the development of prevention programs.[4] KP, where our social mission includes improving the overall health of the population we

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Table 1. Demographics for patients undergoing anterior cruciate ligament reconstruction

Parameter	2001	2002	2003	2004	2005	Total	P value
Sex (n, %)							.282
Males	559 (70.6)	571 (68.0)	643 (69.1)	689 (69.0)	606 (65.6)	3068 (68.4)	
Females	229 (28.9)	264 (31.4)	285 (30.6)	303 (30.4)	311 (33.7)	1392 (31.0)	
Other	1 (0.1)	0	0	1 (0.1)	2 (0.2)	4 (0.1)	
Missing	3 (0.4)	5 (0.6)	4 (0.4)	4 (0.4)	5 (0.5)	21 (0.5)	
Total	792	840	932	997	924	4485	
Age (mean, SD)							
Males	29.1 (9.51)	30.5 (10.1)	29.7 (9.7)	30.0 (10.1)	29.8 (10.4)	29.8 (10.0)	.226
Range	12–79	14–85	14–64	13–71	13–76	12–85	
Females	26.3 (10.8)	27.6 (12.3)	27.6 (11.6)	26.2 (11.1)	26.3 (11.8)	26.81 (11.6)	.335
Range	14–66	13–62	13–68	13–57	13–58	13–68	
P value	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	

SD = standard deviation

serve, is particularly interested in identifying specific populations at risk for injury. Prevention programs may then be implemented for the highest-risk group. Particularly with respect to complicated and costly procedures such as ACL reconstructions, where much may be gained but much is risked, it is important to identify the IRs of various populations over time.

Our study objectives were to determine the IR of ACL reconstructions in the KP Southern California (KPSC) population and compare the differences in age and sex over time.

Materials and Methods

We conducted a retrospective review of the number of ACL reconstructions performed in KPSC between 2001 and 2005. The KPSC institutional review board approved this project. IRs per 100,000 members were calculated and compared across years, sex, and age categories.

The number of ACL reconstruction procedures between 2001 and 2005 was obtained using the KP Anesthesia and Surgery Information System, a surgery-scheduling and case-tracking database. ICD-9-CM codes (*International Classification of Diseases, Ninth Revision, Clinical Modification*) were used to query the administrative data. Patients who underwent ACL reconstruction were identified by procedure code 81.45. Sex, age, and admitting diagnosis were noted.

We calculated ACL reconstruction IRs by dividing the number of procedures performed each year from 2001 through 2005 by the total number of KP members reported at the end of that calendar year. IRs are reported here per 100,000 members. Sex-specific and age category-specific IRs were also calculated. Linear regression was used to test trends in IRs where IRs were the dependent variable and surgery year was the independent variable.

Sex distribution over the years was compared using the χ^2 test. Analysis of variance was used to compare the mean age from year to year in males and females. Finally, the independent sample *t*-test was used to compare mean age between males and females for each independent year.

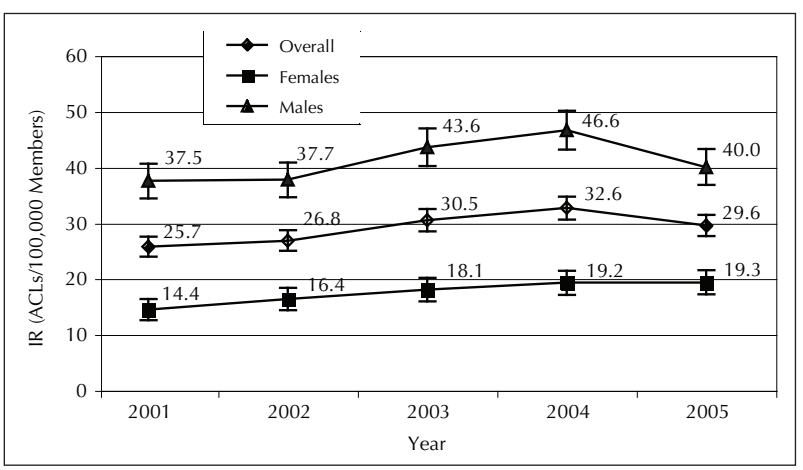

Figure 1. Incidence rate and 95% confidence interval for anterior cruciate ligament reconstructions per 100,000 members.

ACL = anterior cruciate ligament; IR = incidence rate.

Results

Between 2001 and 2005, 4485 ACL reconstructions were performed. Table 1 shows demographics for the KP ACL reconstruction

population between 2001 and 2005. The number of males is higher than the number of females consistently throughout the years (overall, 68.4% vs 31.0%), but the overall sex distribution did not change over time (p = 0.282). The overall male mean age was 29.8 years (±10.0 years; range, 12–85 years) and did not change from 2001 to 2005 (p = 0.226). The overall female mean age was 26.8 years (±11.6 years; range, 13–68 years), and it also did not change over the years studied (p = 0.335). Males were consistently older than females in every year studied; see Table 1 for p values.

Detailed IRs for ACL reconstruction can be seen in Figure 1. The trend in IR was tested using linear

Table 2. Overall incidence rate for females/100,000 members/year

	2001			2002			2003			2004			2005		
Age category (years)	Members	ACLs	IR	Members	ACLs	IR	Members	ACLs	IR	Members	ACLs	IR	Members	ACLs	IR
0–13	308,457	0	0.0	304,412	3	1.0	289,657	1	0.3	284,271	1	0.4	285,179	3	1.1
14–17	96,696	60	62.1	99,860	74	74.1	100,165	72	71.9	103,204	93	90.1	106,553	101	94.8
18–21	83,759	50	59.7	83,102	48	57.8	79,159	51	64.4	78,842	55	69.8	81,368	59	72.5
22–25	78,394	22	28.1	79,534	19	23.9	74,731	26	34.8	73,992	30	40.5	76,464	27	35.3
26–29	82,512	15	18.2	82,996	18	21.7	78,652	26	33.1	76,906	16	20.8	78,287	17	21.7
30–34	113,864	25	22.0	115,304	28	24.3	109,245	34	31.1	106,397	27	25.4	106,193	21	19.8
35–39	119,420	24	20.1	119,009	15	12.6	113,405	22	19.4	111,813	32	28.6	114,721	28	24.4
40–44	126,757	20	15.8	128,649	30	23.3	125,111	25	20.0	122,621	27	22.0	123,239	22	17.9
45–49	126,158	8	6.3	129,916	10	7.7	128,088	14	10.9	127,486	13	10.2	129,877	18	13.9
50–54	115,837	1	0.9	119,245	11	9.2	118,330	7	5.9	119,185	3	2.5	122,510	8	6.5
55–59	92,442	2	2.2	99,061	7	7.1	102,190	5	4.9	105,538	6	5.7	110,790	7	6.3
60–64	71,814	1	1.4	76,466	1	1.3	78,915	0	0.0	80,292	0	0.0	82,470	0	0.0
65–69	57,354	1	1.7	58,944	0	0.0	59,802	2	3.3	60,488	0	0.0	62,138	0	0.0
70+	112,680	0	0.0	117,860	0	0.0	120,816	0	0.0	123,352	0	0.0	128,183	0	0.0
Total	1,586,144	229	14.4	1,614,358	264	16.4	1,578,266	285	18.1	1,574,387	303	19.2	1,607,972	311	19.3

ACL = anterior cruciate ligament; IR = incidence rate.

Table 3. Overall incidence rate for males/100,000 members/year

	2001			2002			2003			2004			2005		
Age category (years)	Members	ACLs	IR	Members	ACLs	IR	Members	ACLs	IR	Members	ACLs	IR	Members	ACLs	IR
0–13	319,599	2	0.6	316,555	2	0.6	302,284	0	0.0	296,414	2	0.7	297,563	1	0.3
14–17	99,854	43	43.1	103,310	53	51.3	103,061	66	64.0	106,650	59	55.3	111,038	65	58.5
18–21	79,456	97	122.1	78,957	73	92.5	75,270	80	106.3	75,718	103	136.0	79,229	97	122.4
22–25	65,289	84	128.7	67,330	77	114.4	63,247	102	161.3	64,203	98	152.6	67,230	71	105.6
26–29	70,792	70	98.9	70,949	76	107.1	66,946	95	141.9	65,629	91	138.7	68,393	86	125.7
30–34	106,707	121	113.4	106,809	94	88.0	100,217	103	102.8	97,209	125	128.6	96,848	103	106.4
35–39	115,039	62	53.9	114,768	86	74.9	108,706	80	73.6	107,528	83	77.2	109,745	68	62.0
40–44	119,456	37	31.0	121,946	64	52.5	118,874	65	54.7	117,094	66	56.4	118,471	57	48.1
45–49	114,889	24	20.9	118,834	32	26.9	117,443	37	31.5	117,678	30	25.5	121,206	42	34.7
50–54	104,612	14	13.4	106,798	9	8.4	106,107	11	10.4	107,801	25	23.2	111,565	8	7.2
55–59	83,976	4	4.8	90,148	2	2.2	92,008	3	3.3	95,025	5	5.3	100,091	5	5.0
60–64	65,846	0	0.0	69,205	0	0.0	70,861	1	1.4	71,861	1	1.4	73,942	1	1.4
65–69	53,078	0	0.0	53,867	1	1.9	54,362	0	0.0	54,770	0	0.0	56,541	0	0.0
70+	91,230	1	1.1	94,968	2	2.1	96,996	0	0.0	99,486	1	1.0	103,248	2	1.9
Total	1,489,823	559	37.5	1,514,444	571	37.7	1,476,382	643	43.6	1,477,066	689	46.6	1,515,110	606	40.0

ACL = anterior cruciate ligament; IR = incidence rate.

regression, where the IR was the dependent variable and the calendar year was the independent variable. The IR of ACL reconstruction in females increased significantly ($p = 0.010$) from 2001 to 2005, going from 14.4 in 2001 (95% confidence interval [CI], 12.6–16.3) to 19.3 in 2005 (95% CI, 17.2–21.5) at a rate of 1.26 cases/100,000 members per year (95% CI, 0.57–1.96). We also calculated IR by sex and by age categories (Tables 2 and 3) and found that in females age 14 to 17 ($p = 0.013$), 18 to 21 ($p = 0.017$), and 45 to 49 years ($p = 0.014$), IR increased significantly, with the IR for the age category of 14 to 17 years increasing fastest, at the rate of 8.14 cases/100,000 members per year. Overall IR and IR for males did not change significantly from year to year.

Even after adjustment for higher participation rates, girls had a significantly higher rate of ACL reconstructions.

Discussion

In our study, the IR of ACL reconstructions was clearly increasing in the female population. The largest increase was in female high school students between ages 14 and 17 years, followed by the 18-to-21-year-old and 45-to-49-year-old female age groups. The overall IR of ACL reconstructions was 29.6/100,000 members by the end of the study period. In a population similar to ours, an overall IR of 60 knee ligament injuries per 100,000 persons was seen in a knee injury clinic. About 50% of these ligament injuries were ACL tears, for 30 ACL tears/100,000 persons. Seventy-two percent of the patients were male and 28% were female. Sixty-five percent of the injuries were sustained during sports.[5] The sex distribution in that study was very similar to that in ours. In another study,[6] the sex distribution was also comparable, at 68% male and 32% female. Of the knee injuries, 45% were ACL tears. For both men and women, the highest number of knee injuries was seen in the 20-to-29-year-old age group.

IRs for ACL reconstructions in adolescent soccer and basketball athletes were analyzed according to sex.[7] Girls had a higher adjusted IR of ACL reconstruction in both sports than did boys. The number of ACL surgeries in soccer players increased significantly during the five years studied for both boys and girls; however, the rate of increase was faster among the girls. The frequency of ACL reconstructions among the basketball players also increased for both sexes, although the rate of increase was similar for both sexes. Participation on soccer teams increased by 30% for girls and 10% for boys during the study period. Even after adjustment for participation rates, girls had a significantly higher rate of ACL reconstructions. In another study, the IRs of ACL reconstructions was 1.39/1000 aviators per year among females and 0.50/1000 aviators per year among males. Females, when compared with males, had a significantly increased risk of ACL reconstructions, with the highest risk occurring in the 18-to-29-year-old group.[8] Among competitive alpine ski racers, females were 3.1 times more likely to have sustained an ACL tear than were their male counterparts.[9] In an athletic population of patients undergoing ACL reconstruction, females athletes outnumbered male athletes in high school basketball (9:1) and soccer (1.7:1), whereas there were more male than female participants in amateur basketball (5:1), soccer (2.7:1), and skiing (1.6:1).[10]

One of the potential limitations of our study was that the administrative database was not developed for the sole purpose of research and may be subject to coding errors. Another limitation is the IR calculated was of ACL reconstructions, not ACL tears, and might have been influenced by surgeons' changing perceptions of surgical indications over time. This may be reflected in the 45-to-49-year-old female group. Our younger female populations' increasing IR with ACL reconstructions could reflect the increasing participation of these groups in sports, as indicated in earlier studies by other researchers.[7–10] However, the database did not contain information about whether the population was athletic or about the mechanism of injury.

Conclusion

Our study identified certain female age groups with increasing rates of ACL reconstructions. Future directions may include initiating preventive programs aimed at these high-risk groups, additional study to identify risk factors, and improved methods of data collection. ❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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Gathering Up Crumbs

Be careful with the crumbs. Do not overlook them.
Be careful with the crumbs; the little changes to love,
the tiny gestures, the morsels that feed, the minims.
Take care of the crumbs; a look, a laugh, a smile,
a teardrop, an open hand.
Take care of the crumbs. They are food also.
Do not let them fall. Gather them. Cherish them.

—Becoming Bread: Embracing the Spiritual in the Everyday *by Gunilla Brodde Norris, writer, meditation leader, psychotherapist, and children's book author*