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Meta-Analysis

Secondary Injury Rates in Patients Following Anterior Cruciate Ligament Reconstruction: Systematic Review and Meta-Analysis

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Abstract

Introduction: One of the knee's most often injured ligaments is the anterior cruciate ligament (ACL). ACL reconstruction (ACLR) is currently the gold standard of care for elite athletes, with the aim of regaining function and returning to preinjury levels of activity. Although ACLR usually produces good outcomes, second ACL reinjuries are often found, especially in athletes. The aim of the study is to describe the rate of secondary injury in patients following ACLR.

Methods: A comprehensive search for pertinent scientific papers was carried out for this study utilizing a mix of keywords like "reinjury," "secondary injury", "ACLR", and "rate" across several medical databases, including PubMed, Cochrane, and Wiley Online. There were 200 studies found throughout the search from 2019 to 2024. After conducting separate screenings of the abstracts and reference lists and reaching a consensus on any differences, the reviewers included 11 papers.

Results: The electronic search yielded 189 records across multiple databases, with 11 additional records from a registry. After removing duplicates and screening for eligibility, 11 studies were included in the qualitative synthesis, while other studies were excluded for language, differing criteria, or insufficient parameters. This meta-analysis involved 2,620 patients who were athletes from the USA and Europe, aged 15–26, who experienced a first-time ACL injury and underwent ACL reconstruction (ACLR). The stratified analysis revealed a secondary ACL injury rate of 19% (95% CI: 13%-25%). This study showed low heterogeneity (I = 95%, P<0.10). The study found that the secondary ACL injury rate after ACL reconstruction (ACLR) ranged from 13% to 25%, with variation across studies due to differences in patient demographics and reporting methods. Age was a critical factor, with younger patients, especially men under 18, showing higher rates of graft rupture. Contralateral injuries are believed to be influenced by factors like knee alignment and residual deficits, and females may be particularly vulnerable due to rehabilitation-related compensatory mechanisms.

Conclusion: To our knowledge, this is the first study (within the last 5 years) to review the current available literature focusing on secondary injury rates after ACLR. Findings suggest that secondary reinjury rates after ACLR are comparable to previously reported rates. The study highlights that modification in activity, enhanced rehabilitation and return-to-play (RTP) guidelines, and neuromuscular training may help athletes safely return to sports and lower the risk of reinjury.

Keywords: Secondary Injury, Reinjury Rate, ACL Reconstruction, Return to Play, ACL Injury

Introduction

One of the knee's most often injured ligaments is the anterior cruciate ligament (ACL). The ACL is essential for giving the knee stability in both translation and rotation.[1] According to current estimates, between 100,000 and 200,000 ACL injuries occur each year in the US. ACL injuries cost the healthcare system more than US$625 million a year, making them a burden as well.[2] Professional athletes are more likely than the general population to get a knee injury; the total incidence of ACL damage in professional athletes ranges between 0.15 and3.7%. Younger athletes who play high-risk sports like basketball, football, skiing, and soccer that require cutting and pivoting have the highest rate of ACL injuries. Young age (particularly in teens) and female sex are common risk factors for ACL injury.[3]

If treatment is not received, people who suffer from ACL will continue to feel instability, and research indicates a higher chance of meniscal and chondral injuries as well as early knee osteoarthritis development.

It has been shown that nonoperative treatment of ACL injuries in skeletally immature athletes leads to meniscal injuries, cartilage loss, early osteoarthritis, and ongoing instability. Consequently, surgical management of ACL injuries in this patient group has been recommended, particularly for young athletes.[4] ACL reconstruction (ACLR) is currently the gold standard of care for elite athletes, with the aim of regaining function and returning to preinjury levels of activity.[5] It is generally acknowledged that young, active adults (18–35 years old) should have their ACLs reconstructed (ACLR) in order to decrease knee laxity, instability episodes, and the risk of further injuries, such as meniscal tears.[6]

Although ACLR usually produces good outcomes, second ACL reinjuries are often found, especially in athletes. According to a systematic review by Ardern et al., 63% of all athletes were able to resume their pre-injury level of participation in sports; only 44% of competitive athletes were able to do so.[7] According to a meta-analysis on failure/revision rates, athletes' overall second ACL reinjury rate was calculated to be 15%.[2] A significant number of athletes suffer from both their first and second ACL injuries, particularly in contact and pivoting sports. Therefore, lowering the risk of both primary and subsequent ACL injuries is a common and significant objective in sports medicine. Young age, returning to cutting and pivoting sports, and returning to sport (RTS) before nine months following ACLR are risk factors for sustaining a second ACL injury.[8]

The spectrum of reinjury following an ACL injury is poorly understood, particularly in the absence of comprehensive follow-ups after nonsurgical treatment. Clinicians should consider this while deciding whether to perform an ACLR or not to treat an ACL damage. The aim of this study was to describe the rate of secondary injury in patients following ACLR. Knowing how often the rate of second injury occurs after ACLR, doctors are expected to be able to consider the most appropriate options according to the needs of ACL patients.

Materials and Methods

Search Strategy

The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guideline statement was followed when doing the research. From 2014 to 2024, a thorough search was conducted to find studies that might be included in this analysis. PubMed, Cochrane, and Wiley Online are the databases that are used. Researcher using a combination of keywords such as "reinjury," "secondary injury, " "ACLR," and "rate". The reference lists and abstracts were checked separately by reviewers. Conflicts amongst reviewers about whether to include or not include a study will be settled by consensus and, if necessary, discussion with an outside reviewer. This research will include studies that employ full text, are in English, and provide the data about secondary injury rate. This meta-analysis is a meta-analysis of proportions that combines rates from several studies.

Inclusion Criteria

The criteria for including studies were as follows: (1) Studies that provide secondary injury rates in patients following ACLR; (2) English-language studies; (3) Studies published within 2019-2024, which this timeframe was utilized to provide the most recent data; Excluded from consideration were studies reporting on ACLR combined with other ligamentous procedures or studies that did not present outcomes data (Table 1).

Table 1. PICO Criteria for Inclusion Study

	Inclusion	Exclusion
Patient	Patient with ACL injury	Patient with history of knee infection, prior surgery on the affected knee, or use tobacco, corticosteroids, or chemotherapy
Intervention	Patients treated with ACLR	Patients treated with conservative measures and surgery of other technique other than ACLR
Outcome	Rate of reinjury (secondary injury) at months follow-up	Outcomes not clearly mentioned Outcome with other parameter than our inclusion criteria
Design	Randomized controlled trials (RCT), cohort, case control, case series, cross sectional	Systematic review or meta-analysis

Quality Evaluation

Every manuscript was subjected to an impartial review by reviewers. Any disparities found were settled by thorough debate and consensus. The seven

Cochrane criteria for assessing risk of bias in the "Risk of bias" assessment tool—which include selection, performance, detection, attrition, reporting, and other bias—will be used by the same independent reviewers to evaluate the quality of the included studies (Figures 1 & 2).

Data Synthesis

For every study that was found and included, data extraction was gathered using specified tables under the headings of fundamental characteristics and results. Review Manager was used to carry out quantitative analysis once the data were available. Forest plots were used to display the results. In each study, the mean difference for continuous outcome and odds ratio for dichotomous outcome with a 95% confidence interval (CI) were calculated. When the heterogeneity (I2) was less than 10%, a fixed-effects model was employed; when the heterogeneity was greater than 10%, a random-effects model was utilized.

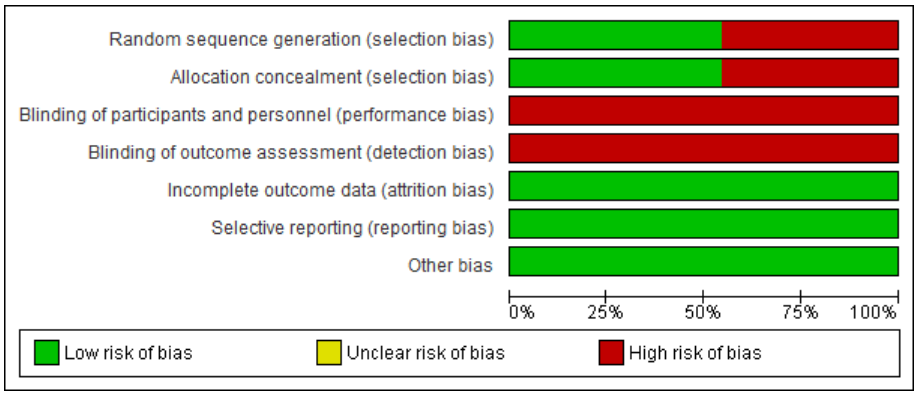

Figure 1. Risk of Bias Graph.

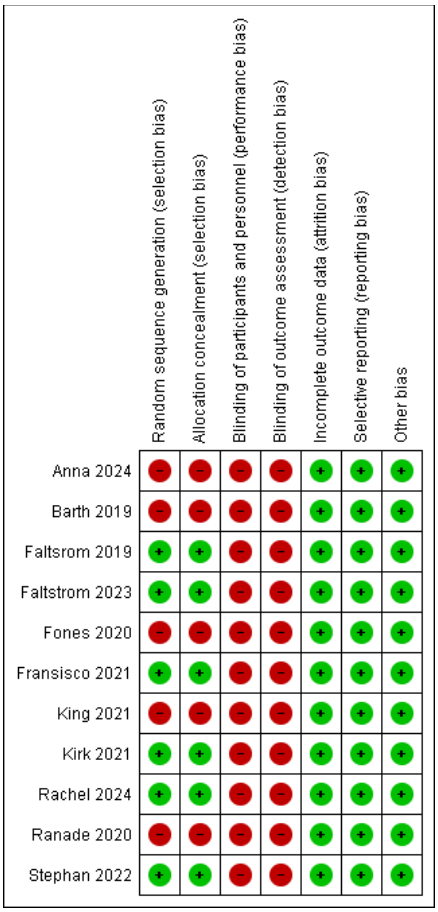

Figure 2. Risk of Bias Summary.

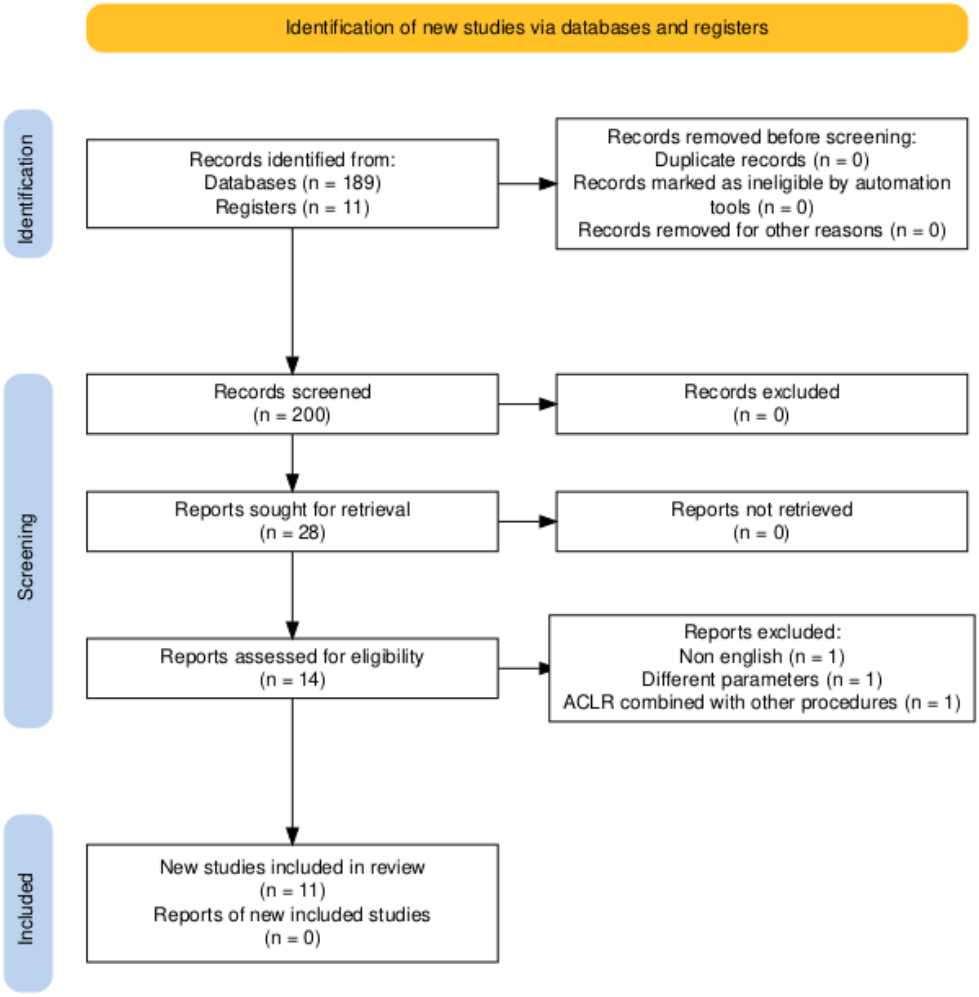

Figure 3. PRISMA Flowchart for the Included Study.

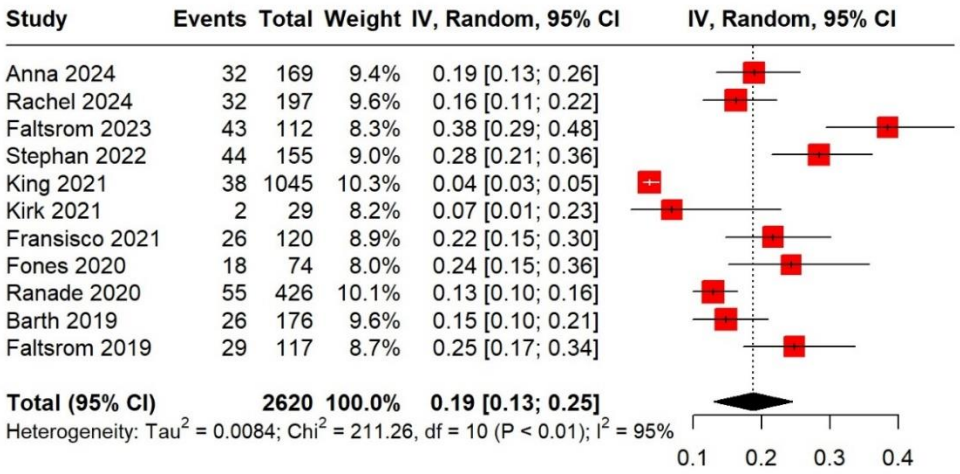

Figure 4. Forest Plot Showing Pooled Overall Secondary ACL Injury Rate after ACLR.

Results

Literature Search, Study Selection, and Study Characteristics

189 records were found using the electronic search across several databases and 11 records from the register. Following the steps of removing duplicates, screening, and excluding research, the final 11 studies were incorporated into the qualitative synthesis. The

remaining papers were eliminated because they weren't in English, had different criteria, or didn't have enough parameters. There were 2620 patients in all in this meta-analysis who had first-time ACL injuries and underwent ACLR. The age range of the patient was 15–26 years old (Table 2).

Table 1. Main Characteristics of the Included Studies (2019-2024)

No	Author (Year)	Country of Origin	Study Design	Mean Age	Population	Events	Graft Used
1	Anna (2024)[9]	Sweden	Prospective cohort	23	169 patient athletes who underwent ACLR	32 patient suffering from secondary ACL injury	NR
2	Rachel (2024)[10]	USA	Retrospective cohort	19.6	197 patient athletes who underwent ACLR	32 patient suffering from secondary ACL injury	Bone-patellar tendon-bone, hamstring tendon autograft, quadriceps tendon autograft
3	Faltsrom (2023)[8]	Sweden	Prospective cohort	18.8	112 patient athletes who underwent ACLR	43 patient suffering from secondary ACL injury	Hamstring tendon, Bone-patellar-tendon-bone, quadriceps
4	Stephan (2022)[11]	USA	Prospective cohort	21.2	155 patient athletes who underwent ACLR	44 patient suffering from secondary ACL injury	Patellar tendon, hamstrings, quadriceps tendon
5	King (2021)[12]	Ireland	Case control	NR	1045 players with first-time ACL injury and ACLR	38 patient suffering from secondary ACL injury	Bone–patellar tendon–bone, hamstring (gracilis/semitendinosus) graft
6	Kirk (2021)[13]	America	Case series	NR	29 players with first-time ACL injury and ACLR	2 patient suffering from secondary ACL injury	NR
7	Fransisco (2021)[14]	Sweden	Prospective cohort	25	120 players with first-time ACL injury and ACLR	26 patient suffering from secondary ACL injury	Patellar tendon autograft, hamstring tendon autograft, iliotibial tendon autograft, quadriceps tendon autograft and different allografts
8	Fones (2020)[15]	USA	Case control	15.8	74 athletes who underwent ACLR	18 patient suffering from secondary ACL injury	Hamstring autograft, Bone-patellar-tendon-bone
9	Ranade (2020)[16]	USA	Retrospective cohort	12.3	426 athletes who underwent ACLR	55 patient suffering from secondary ACL injury	Hamstring graft with cortical button fixation of the femoralgraft
10	Barth (2019)[17]	US	Case series	26.1	176 athletes who underwent ACLR	26 patient suffering from secondary ACL injury	NR
11	Faltsrom (2019)[18]	Sweden	Cross sectional	18.4	117 patient athletes who underwent ACLR	29 patient suffering from secondary ACL injury	Hamstring tendon, Bone-patellar-tendon-bone

Rate of Injury

A stratified analysis of the secondary ACL injury rate was 19%, 95% CI (13%, 25%), I^2 = 95%. A heterogeneity (P<0.10) was discovered in the rate of secondary ACL injury. These studies showed low heterogeneity (I^2 = 95%; P<0.10). Subgroup analysis for the effect of sex and type of graft on reinjury risk was not possible, as individual studies did not report the necessary stratified data.

Discussion

Our study discovered that the total secondary ACL injury rate in patients after ACLR ranged from 13% to 25%. Warner et al. conducted a systematic evaluation of long-term outcomes following ACLR and discovered that the ipsilateral ACL graft rupture rate was 5.8% and the contralateral ACL damage rate was 11.8%.[19] According to a recent systematic review and meta-analysis by Wiggins et al. the total rate of secondary

ACL injury following ACLR in all athletes who had returned to sports was 15%, with a 7% ipsilateral graft failure rate and an 8% contralateral ACL injury rate.[2] Barber-Westin and Noyes' systematic review indicated that age <20 years is a critical predictor for the probability of secondary ACL reinjury after ACLR, noting that 18% reinjured either the ACL graft and/or contralateral ACL.[20]

In 2016, Webster and Feller conducted cohort research (level of evidence 3) to determine the rates of graft rupture and contralateral ACL injury in young athletes. The study compared the risk of subsequent ACL rupture based on gender and age (under 18 vs. 18-19 years old during surgery). A total of 354 people under 20 years old who had their initial primary hamstring autograft ACLR were examined. After a median 5-year follow-up, the number of further ACL lesions (graft rupture or contralateral injury to the natural ACL) was determined. The overall follow-up rate was 89% (316/354). 57 people (18%) experienced graft ruptures within an average of 1.8 years after surgery. 47% occurred in the first year after surgery, and 74% within the first two years. Younger men (<18 years) had the highest rate of graft rupture at 28.3%, significantly higher than women of the same age (12.9%) and men over 18 years (13.8%). In 56 individuals (17.7%), contralateral ACL injuries occurred within an average of 3.7 years from surgery. There were no significant age or gender variations in contralateral ACL rupture rates. After the first surgery, 110 patients (35% of the total) experienced at least one subsequent ACL rupture. Younger patients have a higher likelihood of experiencing further ACL rupture. Graft ruptures were more common in those who underwent surgery before the age of 18. Graft rupture was more common in men than in women, with younger men (<18 years) being at highest risk of rupture.[21]

Unfortunately, reinjury does not just affect the operated limb. The exact causes of contralateral ACL tears are unknown; however, they are most likely multifactorial. Risk factors for bilateral ACL tears have been identified as notch width, gender, knee alignment, and/or genetic predisposition.[22] However, the increased incidence of contralateral injury could be attributed to the persistence of the same risk factors that predispose patients to initial injury, such as graft type, residual functional deficits at the time of RTP, or altered motor patterns that protect the reconstructed knee while increasing stress on the contralateral limb.[23] According to Paterno et al.,[24,25] females are more likely to sustain contralateral injuries. Although not expressly addressed in this analysis, females may be more at risk for deficiencies in the uninvolved limb at the time of injury or as a result of compensatory mechanisms developed during rehabilitation. Additional procedures should be implemented during this group's rehabilitation to address deficits in the uninvolved limb following ACLR. More long-term research investigations are required to determine reasons prospectively.

In 2019, Loscialeet colleagues investigated whether judgments based on RTS criteria were linked to a lower risk of a second ACL lesion (either graft failure or contralateral ACL lesion). Losciale et al. conducted a comprehensive review and meta-analysis (level 2a evidence) to assess the danger dissimilarity (approved versus failed RTS criteria), injury prevalence, and diagnostic accuracy of each RTS guideline. In total, 42.7% of people met the RTS parameters, with 14.4% experiencing a second ACL lesion (graft rupture or contralateral ACL lesion). Passing RTS standards reduced the risk of a second ACL lesion by 3%, although this was not statistically significant. The Grading of Recommendations Assessment, Development, and Evaluation scale has "very low quality" evidence due to inaccurate and heterogeneous estimates of the cumulative risk difference. The study found no statistically significant link between RTS guidelines approval and the risk of developing a second ACL injury.[26]

This study has some limitations; there was a lack of standardization when reporting secondary ACL damage (graft failure and contralateral ACL tear), and our meta-analysis did not account for the diversity in reporting when investigating ACL graft failure. Some studies reported a secondary ACL injury defined by reoperation, whereas others obtained this information through scheduled clinical follow-up, registry data, publicly available sources reporting injury news for professional athletes, and postoperative patient questionnaires, which may understate the reinjury rate. Registry studies use revision cases to evaluate failure, thereby underestimating the reinjury incidence. Furthermore, because of the limited number of studies that recorded the differentiation, our analysis was unable to assess the risk of ipsilateral versus contralateral eventual ACL damage in athletes.

Conclusion

To our knowledge, this is the first study to review the current available literature (within the last 5 years) focusing on secondary injury rates after ACLR. The results of this study show that the secondary reinjury rates after ACLR are not much different from the range of previously reported rates in general. These data indicate that activity modification, improved rehabilitation and RTP guidelines, and the use of integrative neuromuscular training may help individuals more safely reintegrate into sport and reduce second injury.

Conflict of Interest

The authors declare no conflicts of interest.

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