

# Results From the Swedish National Anterior Cruciate Ligament Register

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**Purpose:** The purpose of the study was to analyze the baseline variables and clinical outcomes for almost 24,000 patients entered into the Swedish National ACL Register between January 2005 and December 2012. **Methods:** The register consists of 2 parts: 1 section in which surgeons report baseline and surgical data and 1 section in which patients report the Knee Injury and Osteoarthritis Outcome Score (KOOS) and the EQ-5D score before and 1, 2, and 5 years after surgery. **Results:** By December 2012, 23,744 patients had been entered into the surgeons' part of the register. The female-male ratio in the register is 42:58. The mean age at primary anterior cruciate ligament (ACL) reconstruction was 26 years (SD, 11 years) and 28 years (SD, 9 years) for the female and male patients, respectively. The ACL injury occurred during soccer in 36% of the female patients and 49% of the male patients. In 2012, 95% of the primary ACL reconstructions were performed using hamstring tendon autografts. For patients who had a minimum of 5 years' follow-up, the revision rate was 3.3% and the contralateral reconstruction rate was 3.8%. On all follow-up occasions up to 5 years, patients who had undergone revision had a significantly ( $P < .001$ ) poorer outcome than those who had undergone primary unilateral ACL reconstructions in all KOOS and EQ-5D dimensions. On all follow-up occasions, smokers obtained significantly poorer scores than nonsmokers in terms of both the KOOS ( $P < .008$ ) and the EQ-5D ( $P < .024$ ). **Conclusions:** Soccer is the most common cause of injury in both female and male patients, and patients undergoing revisions fare less well than those undergoing primary unilateral ACL reconstructions, as well as bilateral reconstructions. Furthermore, smokers fare less well than nonsmokers. The cumulative risk of an ACL revision or contralateral ACL reconstruction during a 5-year period is approximately 7%. For patients aged younger than 19 years, the cumulative risk is significantly higher. **Level of Evidence:** Level II, retrospective prognostic study.

In Scandinavia there is a long tradition when it comes to disease-specific registers. The hip and knee replacement registers in particular have helped surgeons to abandon less successful products and methods at an early stage. Register studies are useful complements to randomized trials, especially when large

sample sizes are needed to show small yet important differences.

The Swedish National ACL Register ([www.aclregister.nu](http://www.aclregister.nu)) is a continuous, ongoing study that was initiated in January 2005 and comprises patients undergoing anterior cruciate ligament (ACL) reconstruction and ACL revision. The register contains both surgeon-reported data at baseline and patient-reported outcomes before the reconstruction and at the 1-, 2- and 5-year follow-up occasions. Information on smoking has been available since January 2009. The register covers more than 90% of all ACL procedures performed annually in Sweden and provides important information about the treatment and outcome after ACL injuries. Some results based on data from the register have previously been published.<sup>1,2</sup> Similar registers exist in other countries, such as the Danish<sup>3</sup> and Norwegian registers,<sup>4</sup> as well as the Multi-center Orthopaedic Outcomes Network (MOON) study.<sup>5</sup> In addition, databases such as the Kaiser Permanente Anterior Cruciate Ligament Reconstruction Registry<sup>6</sup> and the New York State database<sup>7</sup> exist but without patient-reported outcomes.

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The purpose of the study was to analyze the baseline variables and clinical outcomes for almost 24,000 patients entered into the Swedish National ACL Register between January 2005 and December 2012. Specifically, we hypothesized that young patients have an increased risk of undergoing revision reconstruction of the index knee and primary reconstruction of the contralateral knee. Furthermore, those patients who undergo revision reconstruction or bilateral reconstructions would have worse outcomes than patients who undergo unilateral primary reconstruction.

## Methods

The main functions of the Swedish ACL Register have previously been reported.<sup>2</sup> The register is a general database that uses a Web-based protocol. On the basis of the Swedish social security number, age and gender are registered automatically, and the most recent postal address is continuously updated. The protocol consists of 2 parts: 1 in which the surgeons report baseline and surgical data and 1 with patient-reported outcome measurements (PROMs).

In the surgeon-reported section, factors such as activity at injury, time from injury to reconstruction, graft selection, and fixation technique are registered. Previous surgery on the reconstructed knee and the contralateral knee and concomitant injuries are also registered. Revisions and reconstruction on the contralateral knee are registered as separate entries in the database and connected to the primary ACL reconstruction procedure.

In the PROM section, the patients report the Knee Injury and Osteoarthritis Outcome Score (KOOS)<sup>8,9</sup> and the EQ-5D score.<sup>10</sup> The KOOS is knee specific and covers 5 domains: symptoms, pain, activities of daily living (ADL), function in sports and recreation, and knee-related quality of life (QoL). Each subscale score ranges from 100, best, to 0, worst.

The EQ-5D is a non-disease-specific, patient-based evaluation of QoL consisting of 2 parts.<sup>10</sup> The first part consists of 5 domains (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression), which are converted to a summary index ranging from 1, full health, to -0.594, worst imaginable health state. The second part is a vertical visual analog scale (VAS) on which the patients rate their overall health state from 100, best imaginable health state, to 0, worst imaginable health state. The patient section is reported using the Web-based protocol, before the reconstruction, as well as 1, 2, and 5 years after surgery. The questionnaires together with instructions on how to log in to the Web system are sent to the patients, with at least 1 reminder for those who do not enter their Web-based outcome measures or return their questionnaires within a few months. The patient has the option to fill out paper forms or log in to the Web-based system. The

Web-based protocol includes several drop-down menus. If any answer is left out, the protocol warns that an answer is missing before registration is possible. This protocol ensures that there are no questions that are missed and not answered if the patient chooses to fill out the Web-based questionnaires. If the patient chooses not to fill out the questionnaires at all, despite multiple reminders, then he or she is lost to follow-up.

The database complies with the Swedish legislation relating to data security, which means that an unauthorized person can never obtain access to individual data.

## Data Analysis and Statistical Methods

Patient-related outcomes for those patients who had undergone revision reconstruction or reconstruction of the contralateral knee were followed up for each reconstruction only until the next reconstruction was performed. All subsequent registrations were considered to be related to the latest reconstruction.

Subgroup analyses were performed for primary, revision, and bilateral reconstructions; smokers and nonsmokers; gender; and type of graft. The times between injury and reconstruction and between primary and revision reconstruction are reported as median and interquartile range. Mean values are reported for all the KOOS subscales and EQ-5D values. A 1-way analysis of variance with Bonferroni post hoc test was used to compare the KOOS and EQ-5D values between subgroups, and the  $\chi^2$  test was used for dichotomous comparisons. Statistical significance was set at  $P < .05$ .

## Results

By December 2012, 23,744 patients had been entered into the surgeon-related part of the register; 22,059 unique patients had undergone primary ACL reconstruction, and 1,685 patients had undergone either multiple-ligament reconstructions or revision surgery. Thirty-seven patients had incomplete data, 530 reconstructions were performed on the contralateral knee (i.e., patients had undergone bilateral ACL reconstructions on different occasions), and 1,431 revision reconstructions had been performed. Of the patients with revision reconstructions, 558 underwent revision on a primary reconstruction previously recorded in the register (at a median of 633 days after primary reconstruction; interquartile range, 582 days), and 873 revision reconstructions were revisions performed on primary reconstructions performed before 2005 (the start of the register), were re-revisions, or had missing values.

Soccer was the most common cause of injury for both male and female patients. Patient demographic data, the time from injury to surgery, and the common causes of injury for male and female patients are given in Table 1. Patients with bilateral reconstructions were

2 years younger ( $P < .001$  compared with whole group; females, 3 years,  $P < .001$ ; males,  $P =$  not significant) than the unilateral group at the time of surgery and 2.5 years younger ( $P < .001$  compared with whole group; females, 3 years,  $P < .001$ ; males, 2 years,  $P = .002$ ) than the revision group. In the unilateral, bilateral, and revision patient groups, 61% of patients, 69% of patients, and 52% of patients, respectively, were injured in contact sports. The corresponding values for non-contact sports were 20%, 15%, and 13%, respectively. Information on smoking was available in 9,332 patients; 579 (6%) were smokers.

In 2012, 95% of the primary ACL reconstructions were performed using hamstring tendon autografts. The graft choice for primary ACL reconstructions over the years is shown in Fig 1. Double-bundle reconstruction was performed in a total of 598 patients. The most common fixation devices in 2005-2012 are listed in Table 2. The most commonly used fixation devices on the femoral side were transfixation implants in 2005 versus cortical fixation implants in 2012 ( $P < .001$ ).

At the time of surgery, patients who had undergone revisions had significantly fewer concomitant meniscal injuries (33% v 42%) but more concomitant chondral injuries (44% v 27%) and had more combined meniscal and chondral injuries (17% v 15%,  $P < .038$ ) than primary ACL reconstruction patients (Table 3).

The percentages of the maximum possible entries for the KOOS and EQ-5D data (i.e., response rate) preoperatively and at 1, 2, and 5 years varied between 38% and 72% and are shown in Table 4. The KOOS values and EQ-5D values for the primary, bilateral, and revision reconstructions preoperatively and at 1, 2, and 5 years are shown in Figs 2 and 3, respectively.

On all follow-up occasions, patients who had undergone revisions had a significantly poorer outcome than those who had undergone primary reconstructions in all KOOS dimensions (with differences between 5 and 19 points,  $P < .01$ ), EQ-5D index (with differences

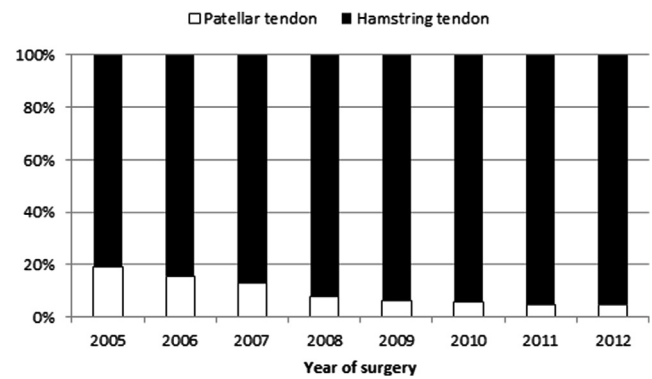


Fig 1. Graft choice over time for primary ACL reconstruction.

between 0.067 and 0.101,  $P < .001$ ), and EQ-5D VAS (with differences between 6 and 7,  $P < .001$ ). Patients with bilateral reconstructions obtained scores similar to those for patients with primary unilateral reconstructions for all KOOS and EQ-5D dimensions on all follow-up occasions, except for KOOS-QoL at the 2-year follow-up, on which patients undergoing bilateral reconstructions scored 7 points lower than the unilateral group ( $P = .008$ ). Patients undergoing bilateral reconstructions obtained higher scores than the revision group on all follow-up occasions on the KOOS subscales for pain, sports/recreation, and QoL (4 to 20 points higher,  $P < .01$ ) and had significantly higher scores at some follow-up points for the KOOS symptom and ADL subscales and the EQ-5D dimensions. Preoperatively, patients undergoing reconstruction for bilateral injuries scored 5 points higher on the sports/recreation subscale and 6 points higher on the QoL subscale than those who had unilateral injuries ( $P < .01$ ).

Small but significant differences were present on all follow-up occasions, for both the KOOS and EQ-5D scores, mostly favoring male patients, when we compared female and male patients undergoing primary unilateral ACL reconstructions. On all follow-up

Table 1. Demographic Data for Primary, Bilateral, and Revision Reconstructions

|                                                | Primary     |              |           | Bilateral |           |           | Revision  |           |        |
|------------------------------------------------|-------------|--------------|-----------|-----------|-----------|-----------|-----------|-----------|--------|
|                                                | Female      | Male         | Total     | Female    | Male      | Total     | Female    | Male      | Total  |
| No.                                            | 9,332 (42%) | 12,727 (58%) | 22,059    | 246 (46%) | 284 (54%) | 530       | 624 (44%) | 807 (56%) | 1,431  |
| Age at surgery [mean (SD)] (yr)                | 26 (11)     | 28 (9)       | 27 (10)   | 23 (9)    | 27 (8)    | 25 (8)    | 26 (9)    | 29 (8)    | 28 (9) |
| Time from injury to surgery [median (IQR)] (d) | 251 (347)   | 266 (382)    | 260 (367) | 153 (187) | 177 (233) | 162 (217) | NA        | NA        | NA     |
| Most common cause*                             |             |              |           |           |           |           |           |           |        |
| Soccer                                         | 36%         | 49%          | 43%       | 45%       | 53%       | 49%       | 34%       | 45%       | 40%    |
| Alpine skiing (including snowboard)            | 18%         | 10%          | 14%       | 10%       | 7%        | 9%        | 11%       | 6%        | 8%     |
| European handball                              | 9%          | 3%           | 6%        | 13%       | 4%        | 8%        | 6%        | 3%        | 4%     |
| Floorball                                      | 8%          | 10%          | 9%        | 9%        | 9%        | 9%        | 5%        | 5%        | 5%     |

IQR, interquartile range; NA, uncertain data in register.

\*Percentage of total injuries in each group.

**Table 2.** Fixation Devices, Year by Year, on Tibial and Femoral Sides for Primary ACL Reconstructions Using Hamstring Tendon Autografts

|                                                                                  | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Total |
|----------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|-------|
| Tibial side (%)                                                                  |      |      |      |      |      |      |      |      |       |
| Metal screw (DePuy Mitek, Andover, MA)                                           | 41.6 | 39.8 | 39.9 | 32.3 | 34.9 | 34.6 | 32.6 | 24.8 | 34.4  |
| Intrafix (DePuy Mitek)                                                           | 26.9 | 25.4 | 20.0 | 20.1 | 13.1 | 9.4  | 8.0  | 7.9  | 15.3  |
| Absorbable screw                                                                 | 0.0  | 0.3  | 4.3  | 13.5 | 14.8 | 19.6 | 24.3 | 32.4 | 15.2  |
| AO screw                                                                         | 7.6  | 7.1  | 9.5  | 12.4 | 16.8 | 16.9 | 15.9 | 17.1 | 13.5  |
| Metal screw + suture post fixation                                               | 10.8 | 13.8 | 10.8 | 9.8  | 13.0 | 13.6 | 14.1 | 13.7 | 12.6  |
| Rigidfix (DePuy Mitek)                                                           | 6.5  | 7.5  | 7.3  | 5.6  | 3.1  | 2.2  | 0.9  | 0.9  | 3.9   |
| RetroScrew (Arthrex, Naples, FL)                                                 | 1.8  | 3.0  | 4.7  | 3.3  | 2.1  | 2.6  | 1.7  | 0.6  | 2.4   |
| Other                                                                            | 4.6  | 2.8  | 3.0  | 2.6  | 1.9  | 0.7  | .8   | 0.9  | 2.0   |
| EndoButton/RetroButton/Tightrope (Smith and Nephew, Andover, MA/Arthrex/Arthrex) | 0.1  | 0.2  | 0.5  | 0.5  | 0.3  | 0.3  | 1.8  | 1.6  | 0.7   |
| Femoral side (%)                                                                 |      |      |      |      |      |      |      |      |       |
| EndoButton/RetroButton/Tightrope                                                 | 9.8  | 18.1 | 22.7 | 34.6 | 46.0 | 59.2 | 69.0 | 79.0 | 45.7  |
| Rigidfix/Transfix                                                                | 60.4 | 55.2 | 53.4 | 43.9 | 32.0 | 18.8 | 11.0 | 5.3  | 32.2  |
| Metal screw                                                                      | 28.7 | 26.2 | 23.1 | 20.4 | 19.9 | 19.6 | 16.9 | 13.5 | 20.4  |
| Other                                                                            | 1.0  | 0.4  | 0.8  | 1.1  | 2.1  | 2.4  | 3.0  | 2.2  | 1.8   |

occasions, female patients scored between 4 and 5 points worse than male patients only in terms of the sports/recreation dimension ( $P < .001$ ). For the bilateral and revision groups, small or no gender-related differences were found.

Except for the preoperative VAS score, significantly worse scores were found in smokers than in non-smokers on all follow-up occasions, in terms of both the KOOS (difference of between 4 and 16 points,  $P < .008$ ) and the EQ-5D scores ( $P < .024$ ) (Figs 4 and 5).

The KOOS and EQ-5D results after primary reconstructions using patellar tendon or hamstring tendon autografts are presented in Figs 6 and 7, respectively. Significant but small differences were found between the groups. However, on all follow-up occasions, the patients undergoing reconstruction with hamstring tendon autograft scored between 6 and 7 points better on the KOOS sports/recreation dimension.

When we compared double- versus single-bundle reconstructions using hamstring tendon autografts, the double-bundle reconstructions had slightly lower preoperative scores (2 to 4 points) in terms of the KOOS symptom, pain, and ADL subscales and a better score (7 points) in terms of the QoL subscale at the 5-year follow-up.

Of the patients who underwent primary ACL reconstruction in 2005-2007, 3.3% (33 of 985 [3.3%] in patellar tendon group and 197 of 5,961 [3.4%] in hamstring tendon group,  $P =$  not significant) underwent revision ACL reconstruction of the index knee

and 3.8% underwent ACL reconstruction of the contralateral knee during a minimum 5-year post-operative period until December 2012. For patients aged younger than 19 years at the primary ACL reconstruction, a 5.7% revision rate and 7.1% bilateral reconstruction rate were found ( $P < .001$  compared with whole cohort). In the whole study group, no gender-related differences in the revision or bilateral reconstruction rate were found. In 9 patients (0.1%) a second revision of the index knee was performed.

## Discussion

The principal findings in this study were that the revision and contralateral reconstruction rates have decreased compared with a previous report from the Swedish register.<sup>2</sup> Patients who had undergone revision or bilateral ACL reconstruction had a poorer outcome than patients who had undergone primary ACL reconstruction. Furthermore, smokers fared less well than nonsmokers. Gender- and graft-related differences were small, and a shift from the use of transfixation devices to cortical fixation devices on the femoral side has occurred. These results are a true representation of the Swedish population that has undergone ACL reconstruction, and most of the information should be generally applicable.

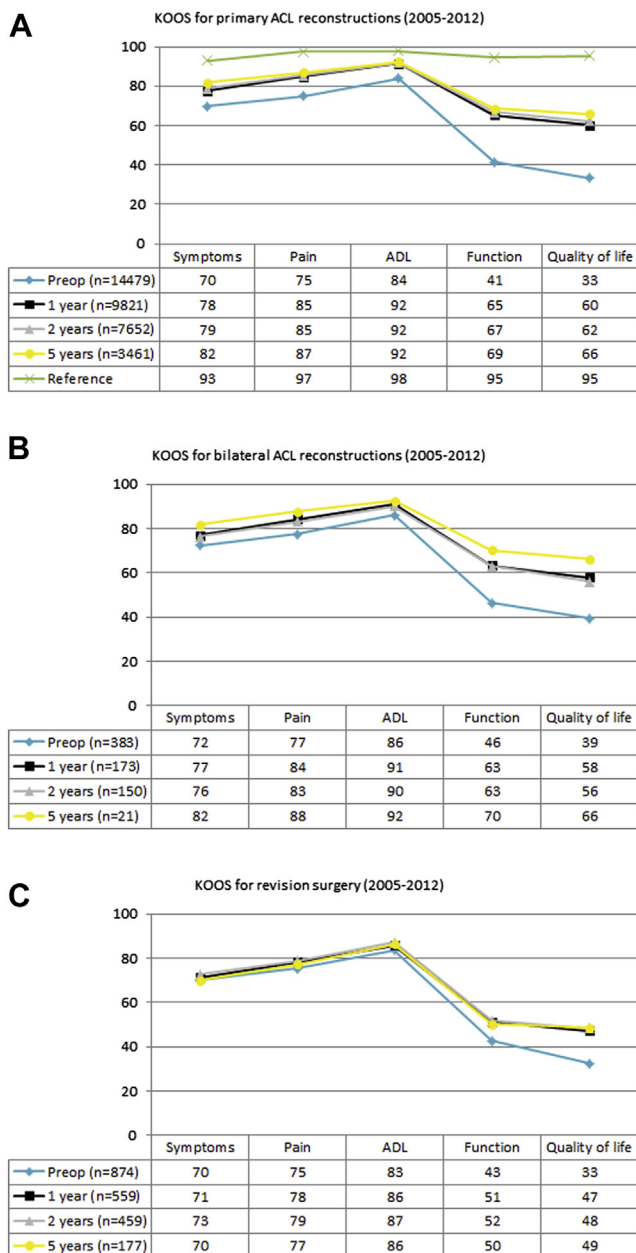
This study mostly confirms previously reported results from the Swedish ACL Register presented by Ahldén et al.<sup>2</sup> Two more years of demographic data and

**Table 3.** Associated Injuries in Primary and Revision Surgery Patients

|                              | Primary | Revision | P Value |
|------------------------------|---------|----------|---------|
| Meniscal injury              | 42%     | 33%      | <.001   |
| Chondral injury              | 27%     | 44%      | <.001   |
| Meniscal and chondral injury | 15%     | 17%      | .038    |

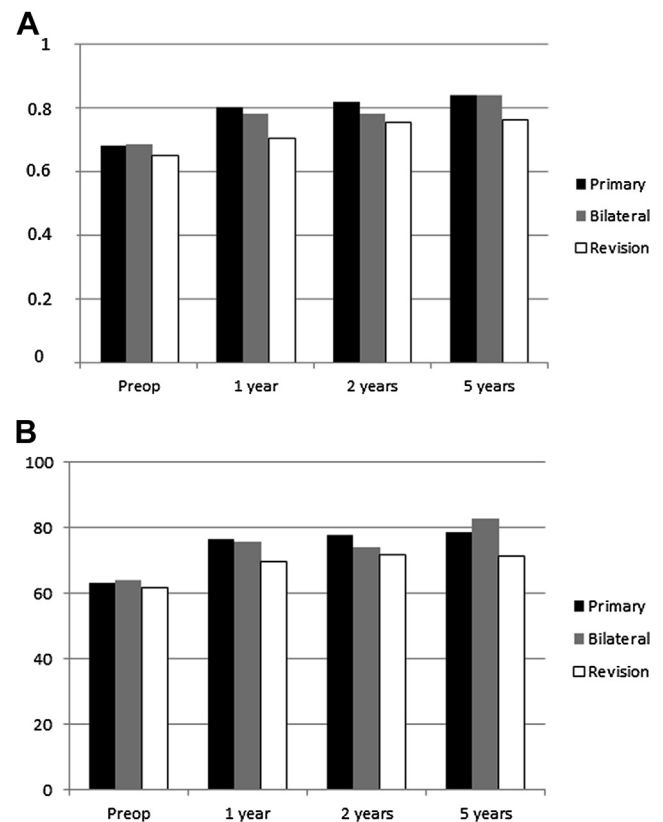
**Table 4.** Response Rate for KOOS and EQ-5D

|              | Primary |       | Bilateral |       | Revision |       |
|--------------|---------|-------|-----------|-------|----------|-------|
|              | KOOS    | EQ-5D | KOOS      | EQ-5D | KOOS     | EQ-5D |
| Preoperative | 66%     | 61%   | 72%       | 68%   | 61%      | 58%   |
| 1 yr         | 50%     | 49%   | 40%       | 38%   | 45%      | 43%   |
| 2 yr         | 48%     | 47%   | 47%       | 46%   | 45%      | 44%   |
| 5 yr         | 48%     | 46%   | 38%       | 38%   | 42%      | 42%   |



**Fig 2.** Mean KOOS values for primary (A), bilateral (B), and revision (C) reconstructions. Reference values are from 118 soccer players with healthy knees and no history of knee injury.<sup>11</sup> (Preop, Preoperative.)

outcomes, involving almost 6,000 additional patients and analyses of EQ-5D data and data from patients with bilateral injuries, have now been added. The most important finding is the trend toward lower revision and contralateral reconstruction rates. Unfortunately, because of different inclusion criteria and cutoff points, a direct comparison with the results of Ahldén et al. is not possible. Other studies from registers and databases report revision rates between 3% and 7.7%<sup>6,12-15</sup> and contralateral reconstruction rates of 4.6% to 6.4% for a 5-year follow-up period.<sup>12,13</sup> The reason for the

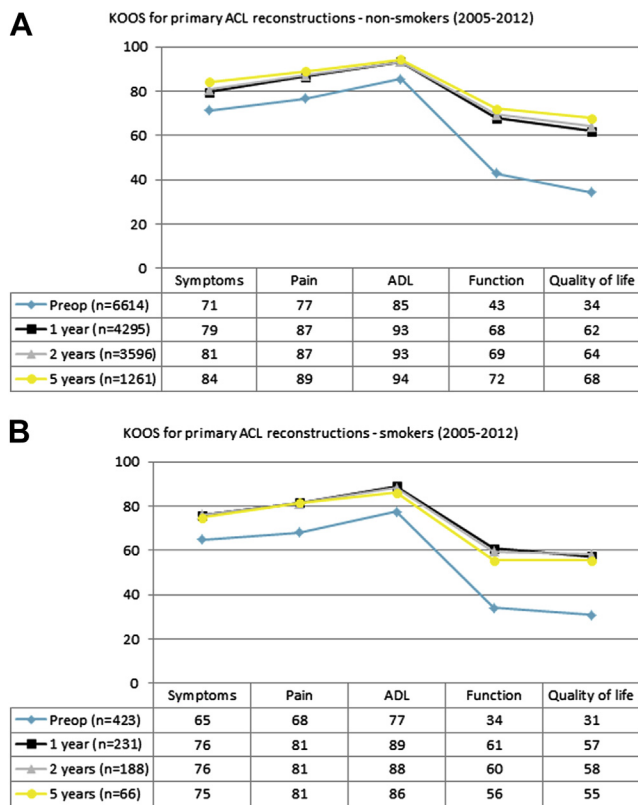


**Fig 3.** Mean values for EQ-5D index (A) and VAS (B) for primary, bilateral, and revision reconstructions. (Preop, Preoperative.)

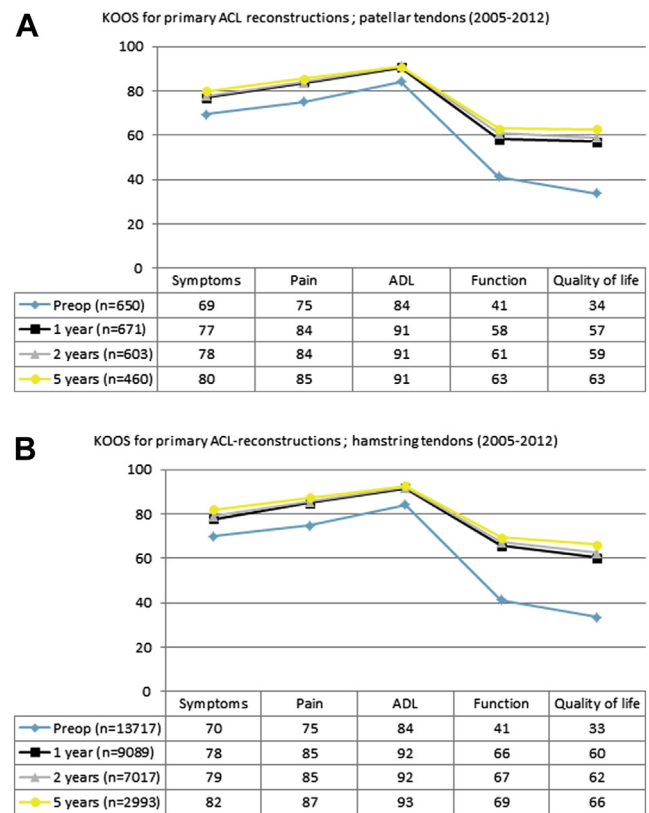
possible reduction in subsequent reconstructions in this population is unclear, and further analysis is needed.

The gender distribution for primary and revision reconstructions is similar to that in the last report from the Swedish ACL Register.<sup>2</sup> From the Danish register, Lind et al.<sup>14</sup> reported a higher male percentage for primary reconstructions (60%) and a similar gender distribution compared with our study in terms of revisions. Other databases have reported higher female percentages for primary reconstructions<sup>12</sup> and lower percentages of female patients with regard to primary and revision reconstructions.<sup>6,13</sup> Younger patients had a higher rate of revisions and bilateral reconstructions, thereby confirming the findings of previous studies.<sup>2,6,7,14</sup> Previous reports from the Swedish ACL Register have reported a higher rate of re-reconstruction for the specific group of female patients who sustained their injuries playing soccer.<sup>2</sup> Walden et al.<sup>16</sup> showed that ACL injuries can be prevented in adolescent female soccer players after introducing an injury prevention program. Further analyses of age and gender distribution with regard to re-reconstructions would be of interest.

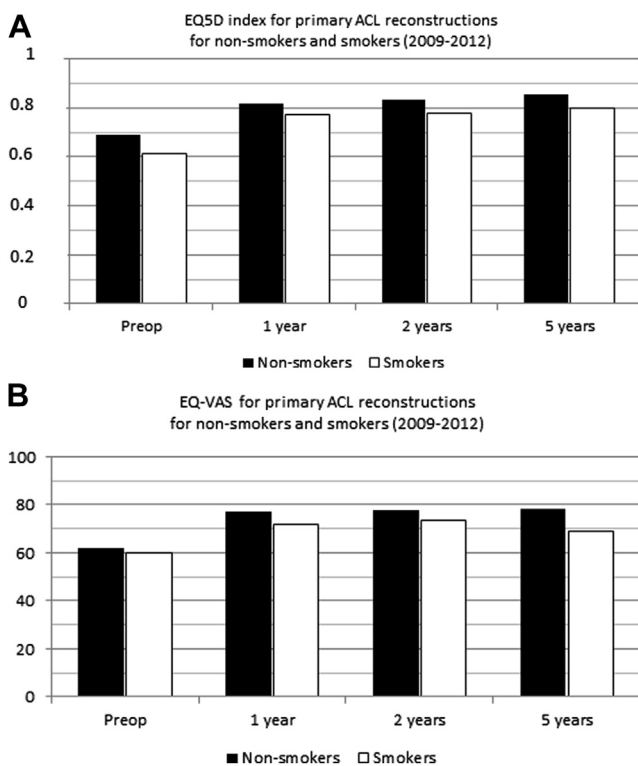
Treatment needs to be evaluated from a patient perspective with patient-reported outcomes, and treatment choices should be based on the best outcome from



**Fig 4.** Mean KOOS values for nonsmokers (A) and smokers (B). (Preop, Preoperative.)



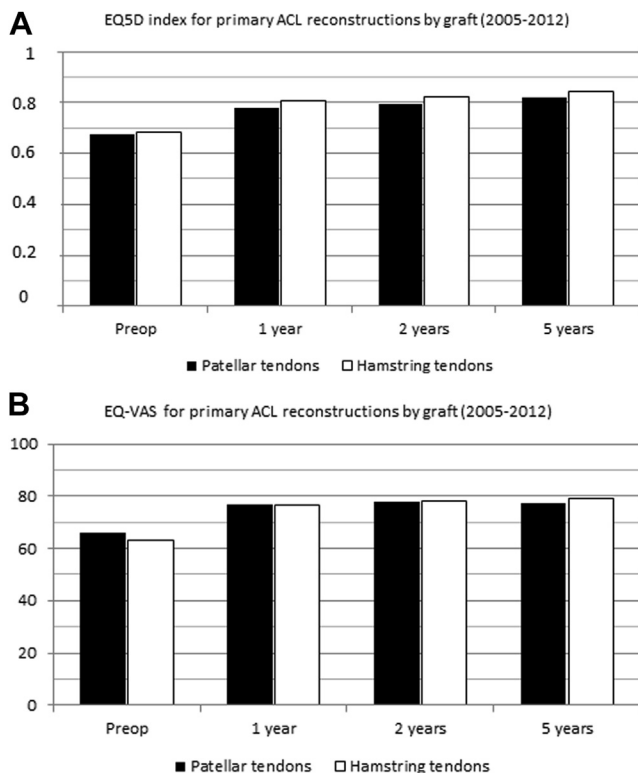
**Fig 6.** Mean KOOS values for patellar tendon (A) and hamstring tendon (B) autografts in patients undergoing primary ACL reconstructions. (Preop, Preoperative.)



**Fig 5.** Mean values for EQ-5D index (A) and VAS (B) for nonsmokers and smokers. (Preop, Preoperative.)

a general health care and patient perspective. The KOOS values are low on all follow-up occasions, especially on the subscales for sports/recreation and QoL. In fact, the 5-year results after primary ACL reconstruction in the register are slightly poorer compared with the non-reconstructed group in the randomized study by Frobell et al.<sup>17</sup> Together with the relatively high risk of graft ruptures and injuries to the contralateral knee, this finding indicates that the treatment after an ACL injury has the potential to be improved. It also indicates that the use of individualized rather than standardized treatment should increase in the future.

Like authors of previous reports,<sup>2,14</sup> we found that patients obtained lower scores in terms of the KOOS after revision surgery. Revision surgery also resulted in a poorer outcome compared with bilateral injuries. It is interesting that patients with bilateral injuries score better on the sports/recreation and QoL KOOS subscales before their contralateral reconstruction compared with the preoperative scores for the primary unilateral ACL reconstruction group. Two factors may influence these results: the patients' age and sports participation. Patients undergoing bilateral reconstructions were younger than the other 2 groups, and younger persons have been shown to obtain higher



**Fig 7.** Mean values for EQ-5D index (A) and VAS (B) for patients undergoing ACL reconstruction using patellar and hamstring tendon autografts. (Preop, Preoperative.)

scores on the KOOS.<sup>1</sup> In addition, patients who underwent bilateral reconstructions more frequently sustained their contralateral injury through contact sports compared with patients who underwent primary unilateral reconstruction or revision surgery, indicating that they might have returned to contact sports to a higher degree than the other 2 groups. Return to sports after primary ACL reconstruction is a risk factor for new injury. Fältström et al.<sup>18</sup> showed that patients who sustained a contralateral injury after primary ACL reconstruction had a higher activity level before the second injury compared with patients who did not sustain a contralateral injury. Unfortunately, the register does not provide data on return to sports. One interesting finding is that only 0.1% of the patients who underwent a primary reconstruction in 2005-2007 underwent a second revision on the same knee. Whether this is because the revisions did not retear to the same extent as primary reconstruction or because the patients did not want to undergo a second revision is an important question.

In accordance with previous studies of musculoskeletal disorders,<sup>2,19</sup> smokers obtained lower scores on all PROM evaluation occasions both before reconstruction and on all subsequent follow-up occasions. Smoking has several harmful effects on general health and on the musculoskeletal system,<sup>20</sup> and smoking cessation reduces

postoperative complications.<sup>21</sup> Data from the register provide an opportunity for further analysis of the effect of smoking on the outcome of ACL reconstruction.

In Sweden a common treatment algorithm for ACL-injured patients is to have patients undergo a supervised rehabilitation period before deciding whether a reconstruction is necessary. This is reflected by the time from injury to primary ACL reconstruction, which was a median of more than 8 months. This is in line with, but somewhat shorter than, findings in previous reports from the same register.<sup>1,2</sup>

As previously reported, the graft choice in Sweden is predominantly hamstring tendon autograft. The small differences favoring hamstring tendon autograft should therefore be interpreted with caution. The comparisons and analyses in terms of double-bundle reconstructions are based on relatively few patients and might therefore be of less value. However, in a randomized study, Ahlén et al.<sup>22</sup> recently reported no significant differences in clinical and functional outcome when comparing single- and double-bundle ACL reconstructions. The introduction of the anatomic ACL reconstruction concept and drilling the femoral tunnel through the medial portal is most likely why there has been a shift from transfixation devices to cortical fixation devices on the femoral side.<sup>23,24</sup>

The ongoing continuous analysis of data from the national Swedish ACL Register is helping to improve and develop treatment algorithms through feedback to hospitals and surgeons with the aim of finding predictive factors for good outcomes.<sup>25</sup> For example, predictive factors related to the lower rate of revisions and contralateral reconstructions should be the focus of future analyses.

## Limitations

National registers provide important data on outcomes and predictors; however, there are some limitations. The register only provides data on new reconstructions, and there is only limited knowledge of the actual number of graft failures and injuries to contralateral knees. Another limitation is the relatively low response rate for the PROMs, ranging from 38% to 72% on different follow-up occasions. However, a study from the Danish register showed high validity despite the low KOOS response rate.<sup>26</sup> In addition, no information exists about rehabilitation protocols. In Sweden it is common for the patient to participate in a rehabilitation program for at least 6 months before returning to sports, but we have no information about compliance, which is of course a limitation.

## Conclusions

Soccer is the most common cause of injury in both female and male patients, and patients undergoing revisions fare less well than those undergoing primary

unilateral ACL reconstructions, as well as bilateral reconstructions. Furthermore, smokers fare less well than nonsmokers. The cumulative risk of an ACL revision or contralateral ACL reconstruction during a 5-year period is approximately 7%. For patients aged younger than 19 years, the cumulative risk is significantly higher.

### Acknowledgment

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