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# Higher re-rupture rate in quadriceps tendon ACL reconstruction surgeries performed in Denmark: let's return to the mean

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**Keywords** ACL reconstruction · Quadriceps tendon · Patellar tendon · Revision rate · Hamstring tendon

## Abbreviations

ACL Anterior cruciate ligament  
QT Quadriceps tendon  
HT Hamstring tendon  
PSM Propensity score matching

Dear Editor,

We read with deep interest the registry study from Lind et al., published recently in the *Knee Surgery, Sports Traumatology and Arthroscopy* journal [7]. In their analysis, the authors described a higher re-rupture rate after quadriceps tendon (QT) anterior cruciate ligament (ACL) reconstruction as compared to hamstring and patellar tendon grafts. As we are using the QT as primary reconstruction graft in high risk patients, we were surprised by the reported three-fold revision-rate difference between the three groups of patients.

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The three following comments might help readers to mitigate the conclusion by Lind et al.: First, a statistical bias should be discussed: the regression towards the mean. Jeremy Siegel [4] uses the term “return to (or toward) the mean” to describe an economic time series in which “returns can be very unstable in the short-term but more stable in the long-time-run. This phenomenon is a period in which the standard deviation of average annual returns declines faster than the inverse of the holding period, implying that the process is not a random walk, but that periods of lower returns are systematically followed by compensating periods of higher returns. To simplify this statistical concept, the following illustration might be helpful: there is a higher chance to obtain a result which is really different from 50% tails/ to 50% heads if 10 coins are flipped instead of 300. This may be similar to surgical outcomes if a small group is compared to a bigger one, for example 531 QT vs 14,213 HT ACL reconstructions.

Second, a selection bias may have occurred in this study. Three of the main predictors of ACL reconstruction failures were found in a higher and statistically significant proportion in the QT group: age, associated meniscus lesions, and rotational instability. QT patients were younger [1] and had a higher rate of associated meniscus injuries [3] as well as cartilage damage. Whereas the rate of high-grade pivot shift varies between 30 and 40% in a general population of ACL injured individuals nearly all of them (98%) presented with a positive preoperative pivot shift [5, 8] in the study by Lind et al. This presupposes that QT were mainly used in high risk individuals which may explain the higher rate of revision surgeries in this group. In addition, the learning curve of many surgeons participating in the Danish ACL reconstruction registry which was associated with a graft that has not been used on a routine basis previously may have affected the results negatively. This has been discussed by the authors, but a more thorough discussion of this finding as

well as its interaction with the previously mentioned selection bias would have been appreciated.

Third, as registries are influenced by scientific, demographic, geographic and economic factors, conclusions such as “quadriceps tendon autograft for anterior cruciate ligament reconstruction is associated with high revision rates” should be interpreted through the prism of intrinsic limitations that are well described by a recent essay of Franklin and Schneeweiss [2]. For example, to decrease the effect of uncontrolled bias in real world data, the use of propensity score could have been a good option, in the statistical analysis of big (observational) data, Propensity score matching (PSM) [9] is a statistical matching technique that attempts to estimate the effect of a treatment, policy, or other intervention by accounting for the covariates that predict receiving the treatment (for example young age, big pivot shift or complex meniscus lesion). PSM attempts to reduce the bias due to confounding variables that could be found in an estimate of the treatment effect obtained from simply comparing outcomes among units that received the treatment versus those that did not.

Finally, we wanted to congratulate Lind et al. for their publication. Analyzing registry data is fundamental to drive us to a better understanding of ACL reconstruction failures and to raise more clinically relevant questions. In this respect, we would like to raise the attention of the readers to a recently published randomized controlled trial by the same authors opposing two groups of patients (same age, same rate of meniscus injury and rotational instability rate) undergoing ACL reconstruction using QT and HT and resulting in equivalent clinical scores and re-operation rates [6].

**Author contributions** CJ and RS have made substantial contributions to acquisition of data, analysis and interpretation of data. EC, RP and JC have been involved in drafting the manuscript and revising it critically. MO has made substantial contributions to conception and design, acquisition of data, analysis and interpretation of data.

## Compliance with ethical standards

**Conflict of interest** Some of the authors disclosed potential conflict of interest.

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