The Mechanism of Injury’s Role in Jump Landing Mechanics After Anterior Cruciate Ligament Reconstruction

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Summary:
At the time of return to sport after anterior cruciate ligament reconstruction, jump landing mechanics, as indicated by Landing Error Scoring System score, does not seem to be impacted by the initial mechanism of injury.

Data:
Introduction: Many anterior cruciate ligament (ACL) injuries occur through a noncontact mechanism of injury where the patient is injured during deceleration, pivoting or jump landing. To regain stability in the knee and allow the athlete to return to sport the most common treatment is surgical reconstruction (ACL-R). However, there is a lengthy recovery process and a 15% secondary ACL injury rate. Poor jump landing mechanics are a common cause for noncontact ACL injury and are also a risk factor for secondary ACL injury. Therefore, addressing poor jump landing mechanics, especially in those who sustained a noncontact injury, is an important part of the rehabilitation process and decision to return to physical activity participation. Purpose: To determine if the initial ACL mechanism of injury is associated with the patients jump landing performance during a return to activity assessment. Methods: One-hundred and six patients (54M/52F, 21.4 ± 7.8yr, 171.8 ± 11.0cm, 74.4 ± 14.8kg, 9.1 ± 3.2mo post-ACL/R) participated in the observational study after a primary, isolated, and uncomplicated ACLR. Each patient self-reported their mechanism of injury as either contact or noncontact. The participant completed the Landing Error Scoring System (LESS) test which was recorded from a frontal and sagittal view then manually scored using Kinovea. A passing score for LESS was a score of four or below. A Chi-Square test was used to compare mechanism of injury and LESS pass/fail criteria. Independent samples t tests were used to compare LESS scores between groups. Tests were considered statistically significant if p = 0.05. Results: 45% (48/106) of participants failed the LESS test. Of those that failed, 69% (40/58) had sustained a noncontact injury and 31% (18/58) had a contact injury. There was no statistically significant difference in mechanism of injury between participants who passed the LESS test and those who failed (X² = 0.47, p = 0.49). There was no significant difference for total LESS score between the non-contact group (4.58 ± 2.07) versus the contact group (4.13 ± 2.08, p = 0.33). There was no significant difference for frontal LESS score between the non-contact group (2.80 ± 1.52) and the contact group (2.60 ± 1.55, p = 0.54), or for sagittal LESS score between the non-contact group (1.78 ± 1.41) and the contact group (1.53 ± 1.33, p = 0.41). Conclusion: Mechanism of initial ACL injury does not appear to impact LESS scores when the patient is being cleared to return to play. Therefore, patients with contact and noncontact injuries display similar landing mechanics following injury indicating that post-surgical landing mechanics may be unrelated to mechanism of ACL injury. There were patients that scored greater than a four for their overall LESS score, which has been associated with an increased risk for re-injury. The decision to allow a patient to return to play should occur after all risk factors, including jump landing mechanics, have been properly mitigated during rehabilitation.

Ceiling Effect of the Combined Norwegian and Danish Knee Ligament Registers Limits Anterior Cruciate Ligament Reconstruction Outcome Prediction

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Summary:
Machine learning analysis of nearly 63,000 patients in the Norwegian and Danish knee ligament registers enabled prediction of revision ACL reconstruction risk with moderate accuracy, however, accuracy was similar to a previously developed model based on 25,000 patients suggesting a ceiling effect of the current registers.

Data:
Background: Clinical tools based on machine learning analysis now exist for outcome prediction following primary anterior cruciate ligament reconstruction (ACL-R). Relying partly on data volume, a general principle is that more data may lead to improved model accuracy. The purpose of this study was to apply machine learning to a combined dataset comprised of the Norwegian (NKLR) and Danish (DKLR) knee ligament registers with the aim of producing an algorithm that can predict subsequent revision surgery with improved accuracy relative to a previously published model developed using only the NKLR. The hypothesis was that the additional patient data would result in an algorithm that is more accurate.

Methods: Machine learning analysis was performed on the combined DKLR and NKLR. The primary outcome was the probability of revision ACL reconstruction within 1, 2, and 5 years. Data were split randomly into training sets (75%) and test sets (25%). Four machine learning models intended for this type of data were tested: Cox Lasso, survival random forest, and gradient boosted regression (GBM), and super learner. Model performance was evaluated by calculating concordance and calibration using methods adapted for censored data. Concordance measures the proportion of pairs of observations in which predicted ranking of survival probabilities corresponds to actual ranking. Calibration is a measure of the accuracy of predicted probabilities that compares expected to actual outcomes. Results: After data cleaning, the combined registry population consisted of 62,955 patients. Revision surgery occurred in 5.1% of patients during an average follow-up time of 7.6 ± 4.5 years. The three non-parametric models — random survival forest, GBM, and super learner — had concordance in the moderate range (0.67, 95% CI 0.64-0.70) at all follow-up times. All three were also well calibrated, except for the random survival forest at 5 years (p<0.001). The Cox lasso performed more poorly. Multiply imputed data did not show notable differences from the complete case analysis. Conclusion: Machine learning analysis of the combined registers enabled the prediction of subsequent revision surgery risk after primary ACLR with moderate accuracy. The most important finding of this study, however, was that this analysis of nearly 63,000 patients yielded similar prediction accuracy as a previous study of approximately 25,000 patients. This suggests a so-called ceiling effect of the registries has been reached and that simply adding more patients to the database is unlikely to appreciably improve prediction accuracy. This information can be used to inform further evolution of the knee ligament registries regarding data collection. The present study suggests that for an improvement in our ability to predict outcome based on knee ligament registry data, an evolution in the variables collected would be required. This represents a significant challenge as the balance between optimal variable collection and surgeon compliance is a delicate one - data collection must be streamlined to avoid survey fatigue and the addition of variables to the registry must be carefully considered, weighing the added value against the additional onus on the surgeons which may affect compliance.

Level of Evidence: III

Category: Knee - ACL Post-Surgery

When ACL Reconstruction Does Not Help: Patient and Surgical Risk Factors Associated With Not Achieving A Minimal Important Change In KOOS Function in Sports and Recreation and Knee-Related Quality of Life Subscales After ACL Reconstruction

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Summary:
Background: Clinical tools based on machine learning analysis now exist for outcome prediction following primary anterior cruciate ligament reconstruction (ACL-R). Relying partly on data volume, a general principle is that more data may lead to improved model accuracy. The purpose of this study was to apply machine learning to a combined dataset comprised of the Norwegian (NKLR) and Danish (DKLR) knee ligament registers with the aim of producing an algorithm that can predict subsequent revision surgery with improved accuracy relative to a previously published model developed using only the NKLR. The hypothesis was that the additional patient data would result in an algorithm that is more accurate.

Methods: Machine learning analysis was performed on the combined DKLR and NKLR. The primary outcome was the probability of revision ACL reconstruction within 1, 2, and 5 years. Data were split randomly into training sets (75%) and test sets (25%). Four machine learning models intended for this type of data were tested: Cox Lasso, survival random forest, and gradient boosted regression (GBM), and super learner. Model performance was evaluated by calculating concordance and calibration using methods adapted for censored data. Concordance measures the proportion of pairs of observations in which predicted ranking of survival probabilities corresponds to actual ranking. Calibration is a measure of the accuracy of predicted probabilities that compares expected to actual outcomes. Results: After data cleaning, the combined registry population consisted of 62,955 patients. Revision surgery occurred in 5.1% of patients during an average follow-up time of 7.6 ± 4.5 years. The three non-parametric models — random survival forest, GBM, and super learner — had concordance in the moderate range (0.67, 95% CI 0.64-0.70) at all follow-up times. All three were also well calibrated, except for the random survival forest at 5 years (p<0.001). The Cox lasso performed more poorly. Multiply imputed data did not show notable differences from the complete case analysis. Conclusion: Machine learning analysis of the combined registers enabled the prediction of subsequent revision surgery risk after primary ACLR with moderate accuracy. The most important finding of this study, however, was that this analysis of nearly 63,000 patients yielded similar prediction accuracy as a previous study of approximately 25,000 patients. This suggests a so-called ceiling effect of the registries has been reached and that simply adding more patients to the database is unlikely to appreciably improve prediction accuracy. This information can be used to inform further evolution of the knee ligament registries regarding data collection. The present study suggests that for an improvement in our ability to predict outcome based on knee ligament registry data, an evolution in the variables collected would be required. This represents a significant challenge as the balance between optimal variable collection and surgeon compliance is a delicate one - data collection must be streamlined to avoid survey fatigue and the addition of variables to the registry must be carefully considered, weighing the added value against the additional onus on the surgeons which may affect compliance.

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