# Keynote Lecture

**Video analysis of ACL injuries in sports**
**- 3D reconstruction of human motion from regular TV image sequences**

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The mechanism for non-contact Anterior Cruciate Ligament injury is a matter of controversy and several theories have been proposed. A precise description of the injury mechanism is critical for the development of effective preventive measures for ACL injuries. A number of different methodological approaches have been used to study injury mechanisms in sports. These include interviews of injured athletes, analysis of video recordings of actual injuries, clinical studies, in vivo studies, cadaver studies, mathematical modeling and simulation of injury situations, or measurements/estimation from “close to injury” situations. Of these approaches, video analysis is essential as it is the only way to systematically collect kinematic information from real injury situations.

Traditionally, simple visual inspection has been used to analyze videos of injury situations. This approach can be valuable for understanding the circumstances of the injury, e.g. the match situation and player-opponent behavior, but a detailed biomechanical assessment is not possible. For this reason, we have developed a Model-Based Image-Matching technique to reconstruct the kinematics of the injured person in three dimensions, from one or more camera views. In this method, 3D models of the surroundings as well as a customized skeleton model are manually matched to the background video footage. An obvious advantage with this technique is the ability to produce estimate temporal joint angle histories, velocities and accelerations, which are necessary for detailed biomechanical analyses of the injury mechanism.

In a validation study, this method proved to be much more accurate with an rms difference to traditional marker-based motion analysis of less than 12° for hip and knee flexion/extension. Although an analysis can be done with single cameras, the accuracy will improve significantly with two or more cameras available.

After a 10-year effort to collect and analyze videos of 10 ACL injury situations that were filmed with at least two cameras, we found surprisingly consistent knee kinematics in the impact phase of the injury situation. All the 10 players showed immediate valgus motion within 40 ms after initial contact. Moreover, the tibia rotated internally during the first 40 ms. These results, in combination with other important findings in the literature, led us to propose a new hypothesis for the mechanism of ACL injuries.

This method may also be used for other purposes. So far, it has been used for analyzing other injury situations in sports; ankle sprains, head injuries and ACL injuries in alpine skiing.

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