3D knee kinematics variability pre-operation versus post-operation in adolescence with Anterior Cruciate Ligament injury using functional principle component analysis

Leila Ayoubian, A. Fuentes, J. A. De Guise, G. Grimard, N. Mezghani

Abstract

Background: Anterior cruciate ligament (ACL) injuries in adolescents have increased in the past decade. The goal of ACL reconstructive surgery is to restore knee stability, however apart from subjective manual testing, there is no objective method to assess the impact of the treatment on knee stability. In clinical biomechanics, decreased variability in three dimensional (3D) kinematic angles can be associated with increased stability of the joint in performing a movement. Typically, the study of variability of 3D knee kinematics proceeds by reducing what are intrinsically functional responses to a single discrete measurement (e.g. peak flexion angle). As a result, many potentially informative data is ignored.
Aim: Prospective gait variability analysis pre- and 6 months post- ACL reconstructive surgery in adolescence patients using Principle Component Analysis (FPCA).
Method: FPCA is a multivariate statistical data analysis technique that focuses on treating an entire dataset as functions. Twenty eight ACL adolescent patients pre- and post-operation walked on a treadmill and the 3D knee kinematics were collected (flexion/extension, abduction/adduction and internal/external rotation angles). Functional Principle Component (FPCs) scores of the angle data were extracted to compare variability in gait. Repeated measures of ANOVA and box plots on FPC scores provided evidence of significant difference with decreased variability post-operation for both within-group and within-patients studies.
Conclusion:
Variability in the 3D knee kinematics have been significantly reduced six months post- versus pre-operation. The proposed functional objective assessment method suggests that ACL reconstructive surgery increases joint stability during walking in adolescents.

Keywords

Functional principle components analysis, Anterior cruciate ligament, ACL reconstructive surgery, 3D knee kinematics, gait variability, knee stability