

Patellofemoral Instability Risk Factors Through Machine Learning Analysis

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INTRODUCTION:

Acute lateral patellofemoral instability remains a common injury in pediatric patients. While risk factors have been well-established in adults, but a paucity of data currently exists in the pediatric patients. This study aims to develop a reproducible method for quantitatively assessing patellofemoral morphology in pediatric patients using magnetic resonance imaging (MRI) and to investigate whether these parameters increase the risk of patellofemoral instability through machine learning analysis.

METHODS:

A retrospective review from 2005 to 2022 of all pediatric patients diagnosed with acute lateral patellofemoral dislocation group (58 patients) who had MRI imaging were included for analysis. An age-based control group was also identified (57 patients). The patellofemoral morphological parameters (Fig.1a-f), patella height, and tibia morphological parameters are measured. Differences between groups were analyzed with respect to the MRI parameters. In addition, to assess the potential diagnostic utility of the parameters, a machine learning approach was employed.

RESULTS SECTION:

Among the patellofemoral morphological parameters, there were significant differences between the two groups in 5 parameters, excluding trochlear facet asymmetry, Wiberg index, and trochlear groove medialization. In the patellar height morphological parameters, all methods except the BP method exhibited significant differences between the two groups. Among the tibia morphological parameters, only the TT-TG distance exhibited significant differences between the two groups. All measured parameters showed no differences between genders. The most significant difference was observed in anatomic patellar instability risk factors, particularly the KS method, which was present in 82.7% of the lateral patellofemoral dislocation group but only 17.5% in the control group. The highest AUC was 0.87 for the KS method, followed by 0.84 for the Wiberg index and 0.82 for patellar tilt. Utilizing genetic algorithms and logistic regression, our model excelled with 7 key independent variables: Trochlear depth, lateral trochlear inclination, IS, TT-TG distance, KS, Wiberg index, and facet angle.

DISCUSSION:

The average values of all recognized anatomic patellar instability risk factors showed a notable difference between pediatric patients with lateral patellofemoral dislocation and the control group. KS index was the main patellofemoral risk factor, and lateral wiberg index, they had the strongest association with lateral patellofemoral dislocation. In addition, we evaluated the performance of the optimized logistic regression model, achieving an AUC of 0.92. Such performance is considered excellent and clinically relevant, indicating the model's effectiveness for the intended application. Anatomical irregularities can make pediatric patients more susceptible to an increased risk of patellofemoral dislocation. Comprehensive preoperative analysis is imperative to mitigate the risk of recurrent dislocations within the pediatric patients.

SIGNIFICANCE/CLINICAL RELEVANCE:

This study addresses the lack of data on acute lateral patellofemoral instability in pediatric patients. Through MRI-based analysis and machine learning, it identifies key risk factors, including the KS index and lateral Wiberg index, associated with lateral patellofemoral dislocation. The optimized logistic regression model demonstrates high predictive accuracy (AUC of 0.92), offering a valuable tool for clinicians. Understanding these risk factors enables tailored preoperative strategies to reduce the risk of recurrent dislocations in pediatric patients, contributing to improved clinical decision-making and patient outcomes.

Fig1. patellofemoral morphological parameters

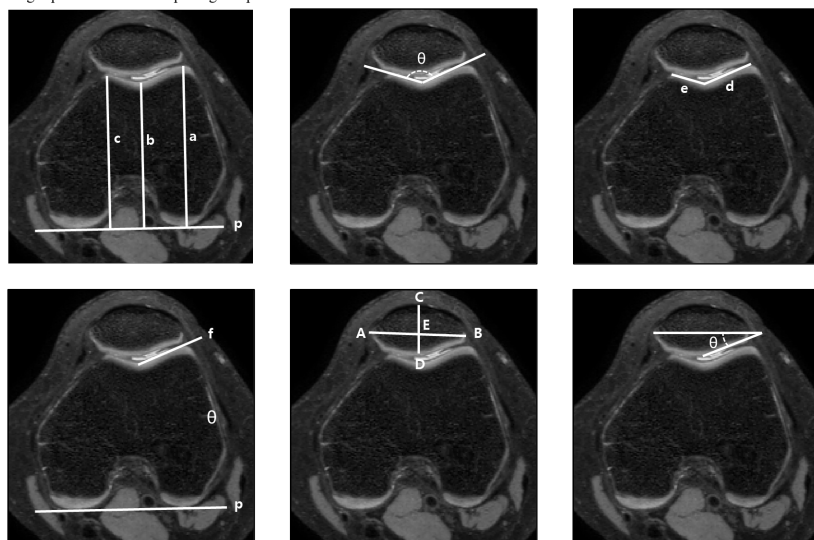


Fig2. Genetic algorithm

