A Novel Biomechanical Method to Assess The Risk For Slipped Capital Femoral Epiphysis in Children

John M Martell; Robert Ellis; Alfred Atanda; Christopher Sullivan; Robert Bielski; Jimmi Mangla

Section of Orthopaedic Surgery and Rehabilitation, The University of Chicago, Chicago, IL

Introduction

- There is no consensus on the surgical indication for prophylactic pinning of the asymptomatic contra-lateral hip in patients presenting with unilateral slipped capital femoral epiphysis (SCFE).
- Young skeletal age, posterior slip angle and high femoral offset have been advocated as indicators for contra-lateral prophylactic pinning in SCFE patients.
- We developed custom software that calculates the shear stress in the capital femoral epiphysis using a computer assisted method based on anatomic landmarks on an AP pelvis radiograph and the patient's body weight.
- We hypothesize that the risk of slipped capital femoral epiphysis will be greater in those patients having high shear stress in the epiphyseal cartilage.

Objectives

- To determine which clinical, biomechanical and radiological factors which are significantly correlated with slipping.
- To develop a predictive model for the risk of slipped epiphysis in the contra-lateral hip of patients undergoing unilateral SCFE pinning.

Patients and Methods

- After IRB approval, we retrospectively selected 54 patients with SCFE who were admitted in the past to the University of Chicago Medical Center for surgical pinning. Twenty three of these patients were known to have developed contra-lateral SCFE requiring surgical pinning as well.
- Thirty-one of these patients have not required contra-lateral pinning to date. We analyzed the AP pelvis and frog leg images of all patients with SCFE using our computer assisted custom software that determined the shear stress in the capital femoral epiphysis.
- The software first calculates the joint reaction force factor based on the patient's anatomy and body weight. The software (Figure 1) uses a lever arm analysis followed by free body diagram solution for the joint reaction force of the hip. The capital femoral epiphysis is then traced by the user (Figure 2) and broken into 10 equal line segments (Figure 3).
- For each segment the perpendicular and parallel components of the joint reaction force vector are calculated and the parallel components totaled to determine the overall shear stress in the epiphysis (Figure 3).
- Modified Oxford Scores (Figure 4) and Posterior Slip Angles (Figure 5) for every patient were measured as described in literature.
- Correlation analysis was performed and a binary logistic regression model was developed using the predictive variables significantly correlated with slipping.
- A Round Robin leave one out binary logistic regression was then performed such that each case was judged by a model that it did not contribute to, and each case contributed to a model that judged all other cases. The accuracy, sensitivity, specificity, negative predictive value (NPV) and positive predictive value (PPV) of this model were calculated. The 95% confidence limits were used to determine whether the binary logistic regression model was significantly related to the development of SCFE.
- Receiver Operating Characteristic (ROC) analysis was performed to determine the az value for the predictive model.

Results

- Correlation analysis showed that significant correlations between body weight (P = 0.041), AP shear stress of the epiphysis (P = 0.049), body weight lever arm (P = 0.006), posterior slip angle (P = 0.003) and modified Oxford score (P = 0.001) with subsequent development of SCFE in the uninvolved hip.
- The binary logistic regression model developed all factors mentioned above was significantly related to the development of SCFE (P = 0.000). The model was 92.2% accurate with 100% Sensitivity, 85.7% Specificity, 100% NPV and 85.2% PPV. ROC analysis showed an az value of 0.9776 (Figure 6).

Conclusion

We have developed a binary logistic regression model that successfully predicts SCFE in the contra-lateral hip of patients who are at risk of developing a slip. This tool will improve the basis for surgical decision making regarding the need for prophylactic pinning of hips in children at risk for SCFE.

References