Femoral derotation osteotomy medially shifts patellofemoral loading in individuals with patellofemoral instability

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Summary

We simulated femoral derotation osteotomies in a cohort of individuals with patellofemoral instability to investigate patellofemoral loading. Musculoskeletal simulations were performed using a pre- and post-surgery model. Surgery medialized patellofemoral force in most patients, whereas gait pattern had an impact on the effectiveness of femoral derotation osteotomy.

Introduction

Increased femoral anteversion (FA) is associated with patellofemoral (PF) instability [1], increased lateral loading of the patella [1,2] and can be treated with femoral derotation osteotomy (FDO) in excessive cases. However, the effects of FDO on PF stability and loading while walking are not fully understood and cannot be measured in vivo. Therefore, this study used personalised in silico musculoskeletal modelling to investigate the effect of FDO on medio-lateral PF joint loading in individuals with PF instability.

Methods

We analysed retrospective 3D gait analysis and MRI data from 16 participants (15 females; age 15.8±1.9 years; weight 60.2±9.6kg; height 1.68±0.08m) with recurrent PF instability and FA ≥30° (mean FA 36.1±4.9°) using musculoskeletal simulations. We prepared two OpenSim models [3] per participant, based on 3D gait analysis and MRI data: (i) a model with personalised FA and tibial torsion and (ii) a post-surgery model with FA adjusted to 12° to simulate the FDO. Tibial torsion and FA were personalised using the Torsion tool [4]. We assessed joint angles, joint moments, muscle moments, muscle forces and PF joint contact forces. We compared peak PF joint loading before and after FDO using a paired t-test and correlated the change in rectus femoris force with the change in peak medial lateral PF force before and after FDO (alpha = 0.05). Furthermore, we checked for unsuccessful cases, defined by no medialization of the patellofemoral joint contact force post-surgery.

Results and Discussion

The FDO significantly increased peak medial PF joint contact force (mean change: 0.03 body weight, $p < 0.001$), although two participants showed no change (Figure 1). These two individuals walked with reduced knee flexion angle and moment during the stance phase. The change in peak medio-lateral PF forces due to the FDO strongly correlated with the initial femoral version angle in the individuals with successful FDO ($r=0.86$, $p<0.001$). A strong negative correlation ($r=-0.86$, $p<0.001$) was found between rectus femoris force and the shift to a more medial PF force post-surgery in the successful cases.

Considering the mean body weight of the participants and the mean change in peak medio-lateral PF joint force, the resulting additional medialising force would be 17 N. Compared to the mean tensile strength of the medial PF ligament (approximately 208 N [5]), the mean effect of the FDO represents less than 10% of this force value. In the successful cases, the medialization of PF force ranged from 9 N to 46 N. Therefore, in patients with excessive femoral version, FDO may enhance treatment outcomes for PF instability, when used in conjunction with other treatments, such as medial PF ligament reconstruction.

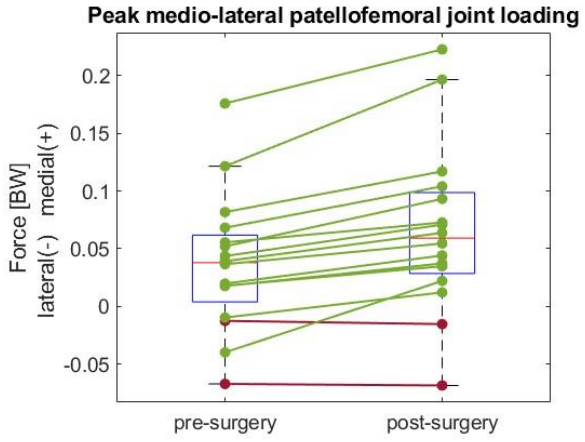

Figure 1: Peak medio-lateral patellofemoral joint force. Each dot represents the peak medio-lateral patellofemoral joint force of one individuum pre- and post-surgery. Green lines represent the successful cases and red ones the unsuccessful. BW = body weight

Conclusions

Our findings support the consideration of FDO as an additional treatment in individuals with PF instability and excessive FA but emphasize the importance of incorporating functional assessments such as gait analysis into treatment planning, as the effectiveness of FDO may vary between individuals with different gait patterns.

References

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