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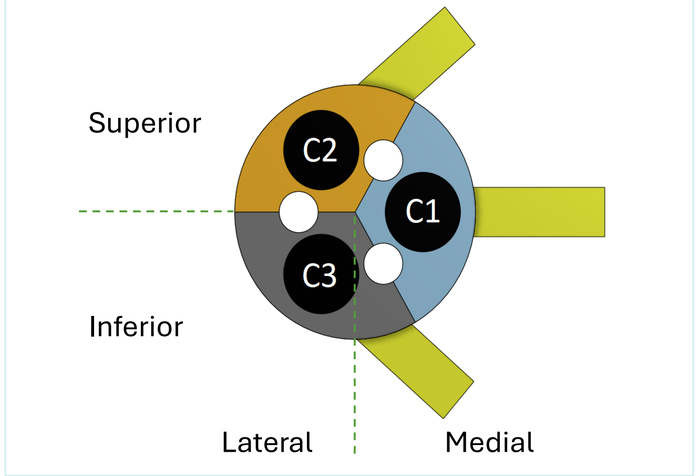
A COMPREHENSIVE BIOMECHANICAL STUDY OF THE PATELLOFEMORAL JOINT: PART II: THE EFFECT OF THE PATELLA THICKNESS

Jobe Shatrov[1,2], A. Mounir Boudali[1], Koki Abe, David Parker[2,3], Elizabeth Clarke[1,4]William L. Walter[1,3,4]
[1] Sydney Musculoskeletal Health, Kolling Institute, Faculty of Medicine and Health, University of Sydney, Sydney, NSW
[2] Landmark Orthopaedics, St. Leonards, NSW
[3] Department of Orthopaedics and Traumatic Surgery, Royal North Shore Hospital, St. Leonards, NSW
[4] Murray Maxwell Biomechanics Laboratory, Kolling Institute, Northern Sydney Local Health District, St. Leonards, NSW

INTRODUCTION

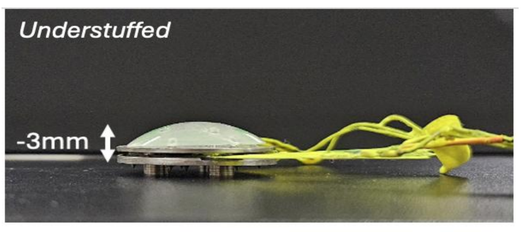
Anterior knee pain remains a leading cause of dissatisfaction following total knee arthroplasty (TKA), often in the absence of overt mechanical complications.

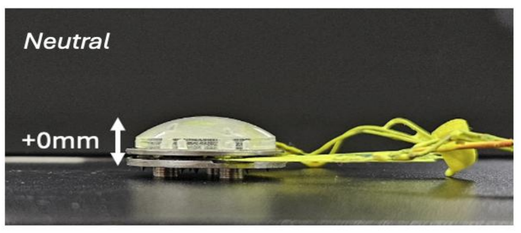
The biomechanical consequences of altered patellar thickness during TKA are not well characterized. This study aimed to evaluate the effects of changes in reconstructed patellar thickness on patellofemoral joint (PFJ) kinematics and kinetics using a cadaveric model.

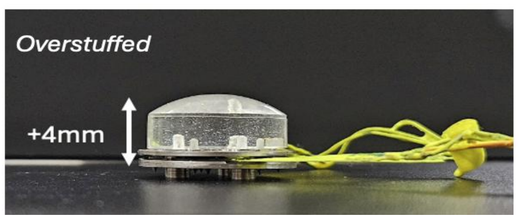


METHOD

Eleven knees from six unembalmed whole-lower-extremity cadaveric specimens were tested using a robotic simulation platform and optical motion capture system. Patellar thickness was systematically altered in three conditions: understuffed (-3 mm), neutral (native thickness), and overstuffed (+4 mm). PFJ kinematics and contact forces were assessed during passive knee flexion and simulated stair descent. Total contact force and regional pressures at the medial facet (C1), central ridge (C2), and lateral facet (C3) were recorded using a custom multi-sensor patellar array.





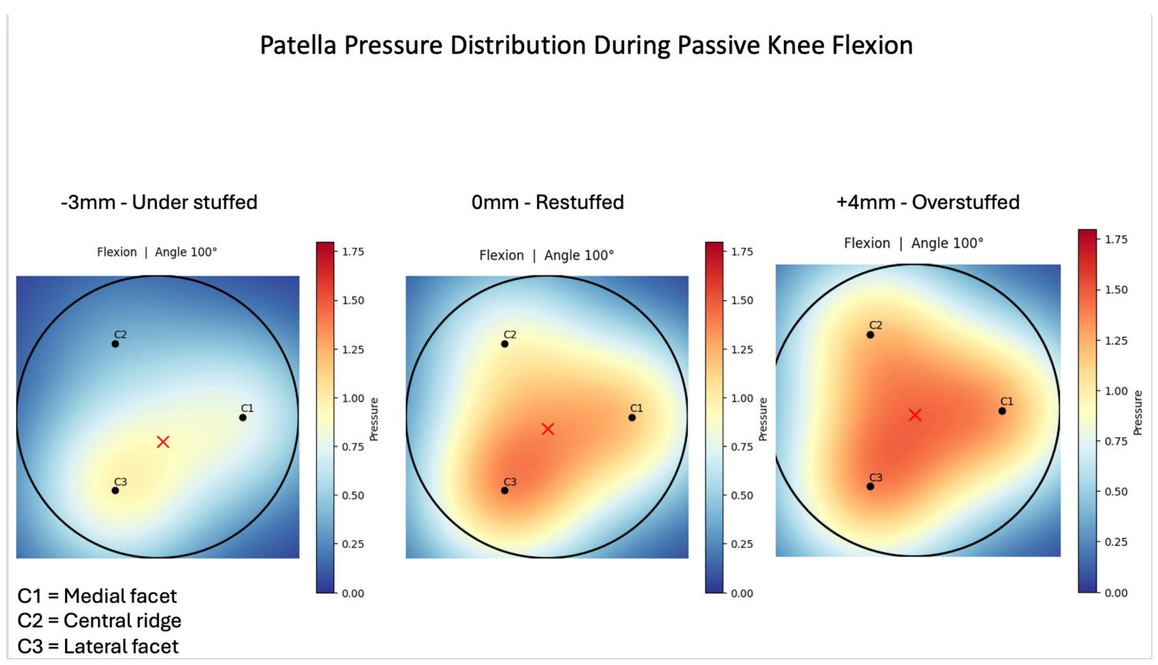


RESULTS

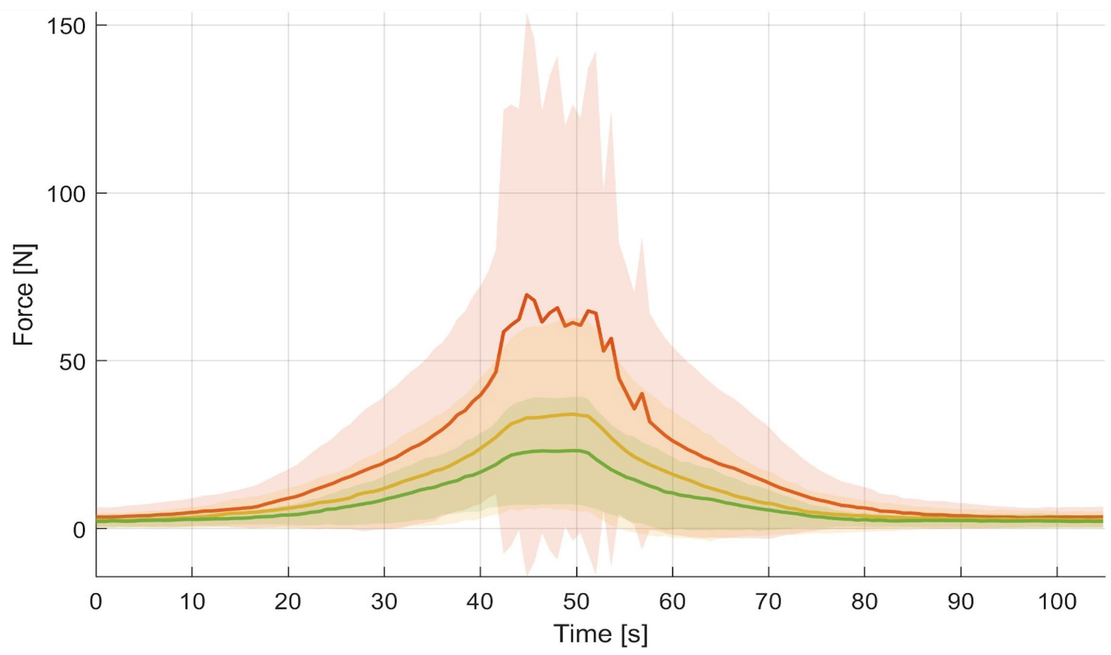
Overstuffing significantly altered PFJ kinematics, including increased posterior translation ($p < 0.0001$), reduced flexion angle ($p = 0.0010$), and altered valgus alignment ($p = 0.0199$).

Patellar overstuffing also increased total PFJ composite force during passive flexion (mean: overstuffed = 59.93 ± SD N; neutral = 33.93 ± SD N; understuffed = 23.49 ± SD N; $p < 0.0001$) and stair descent (overstuffed = 50.51 N; neutral = 27.49 N; understuffed = 17.91 N; $p < 0.0001$).

Regional analysis (voltages) revealed a lateral shift in contact pressures, with the lateral facet showing the most pronounced force increase ($p = 0.0004$). Understuffing produced the lowest joint pressures with minimal effect on kinematics.



Patellofemoral joint contact pressure maps during passive flexion. Colour maps depict contact distribution across three patellar regions: C1 = medial facet, C2 = central ridge, C3 = lateral facet. Blue represents low contact force (0), while red denotes higher joint reaction forces. Forces were not evenly distributed across the patella. With increasing thickness, there was a clear predilection for higher loading on the lateral facet, consistent with a lateralisation of contact.



Composite patellofemoral joint contact force during passive knee flexion under varying patellar thickness conditions. Force–time curves (mean ± 95% confidence interval) are shown for understuffed (green, –3 mm), neutral (yellow), and overstuffed (+4 mm, red) patellae. Minimal differences between groups were observed during the first 30–40° of flexion. Beyond this range, overstuffing produced a marked increase in joint reaction forces, with peak composite force substantially higher than neutral and understuffed conditions.

CONCLUSION

Even small increases in reconstructed patellar thickness significantly alter PFJ kinematics and contact mechanics, particularly increasing lateral facet loading. These findings highlight the biomechanical sensitivity of the PFJ to thickness variation and support the need for thinner, modular, or patient-specific patellar components to enable finer intraoperative control. Restoring native patellar geometry may help mitigate anterior knee pain and dissatisfaction following TKA.

For more information on this poster contact:
jobeshatrov1@gmail.co