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A COMPREHENSIVE BIOMECHANICAL STUDY OF THE PATELLOFEMORAL JOINT: PART III: THE EFFECT OF LATERAL CONDYLE LENGTHENING

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INTRODUCTION

Anterior knee pain remains a leading cause of dissatisfaction following total knee arthroplasty (TKA), often in the absence of overt mechanical complications. Femoral component position in TKA is effected by multiple surgeon controlled factors such as alignment choice, joint line obliquity, tibiofemoral compartment balancing and the patellofemoral joint (PFJ). Variation from the native anatomy may lead to changes in the length of the lateral femoral condyle and change the behaviour of the PFJ. The purpose of this study was to determine the effect of changes in the length of the lateral condyle on PFJ kinematics and kinetics.

METHOD

Eight fresh-frozen cadaveric knees were implanted with a cruciate-retaining TKA. Each was tested in four states: Native, Neutral (resurfaced lateral condyle), Medium (+2.5 mm distalisation), and Maximum (+4.5 mm distalisation). PFJ kinematics were recorded during passive flexion and simulated stair descent using optical tracking. PFJ kinetics were measured using pressure sensors inserted behind the patella (Neutral, Medium, Maximum). 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

Passive Flexion

Kinetics. RForce increased from Neutral: 49.7 ± 34.8 N to Medium: 64.9 ± 47.1 N and Maximum: 73.1 ± 46.3 N, a +47% rise Neutral → Maximum (*p* < 0.05). C1 and C3 facet loads showed similar increases, while C2 changes were modest and non-significant.

Kinematics

Posterior patellar translation increased from Native: 1.3 ± 0.9 mm to Maximum: 2.7 ± 1.2 mm, a +108% increase (*p* < 0.01). Internal rotation rose from Native: 0.8 ± 0.5° to Maximum: 2.0 ± 0.8°, a +150% increase (*p* < 0.01). Other motions (medial shift, superior displacement, flexion, valgus) did not differ significantly.

Stairs Descent

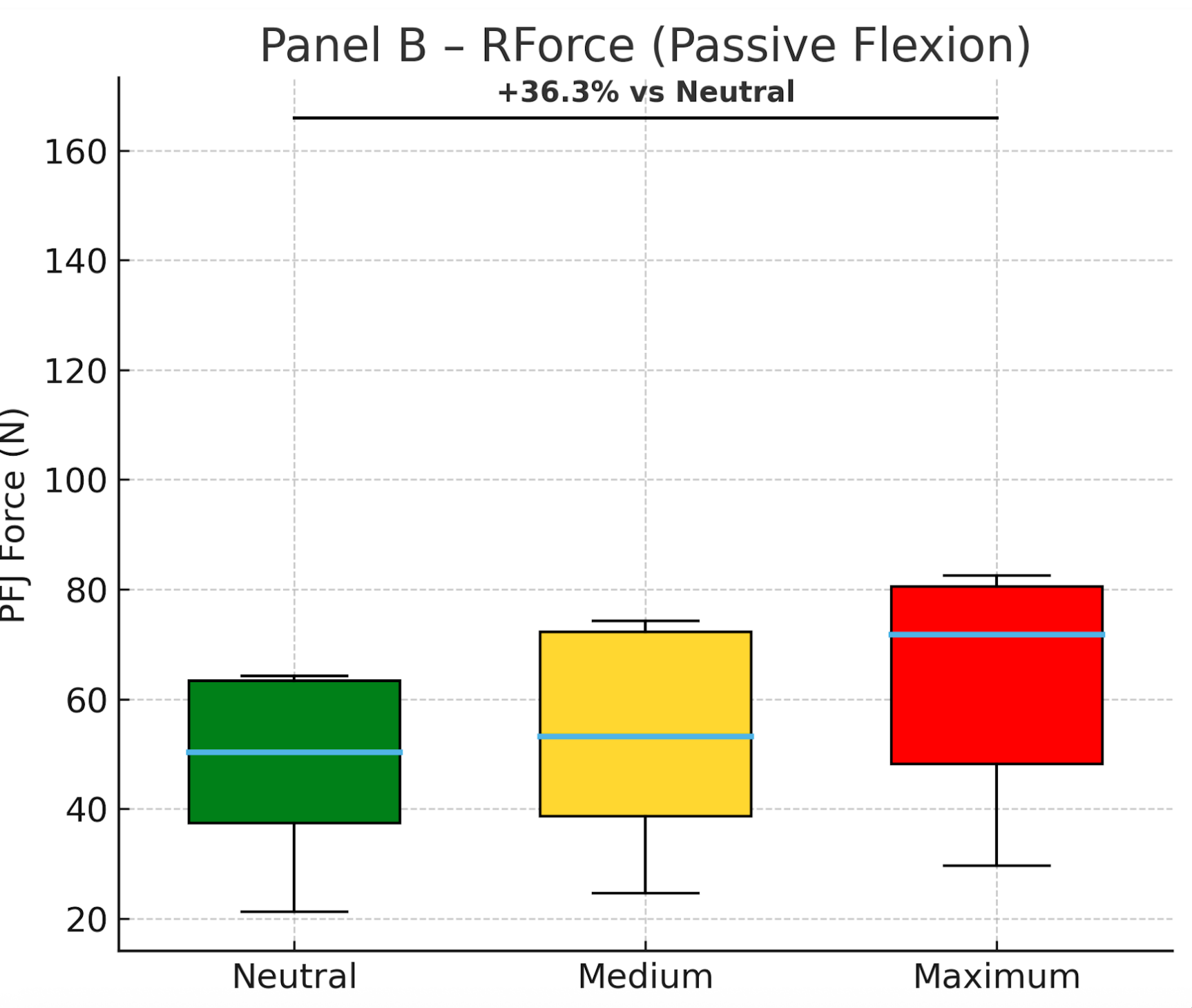
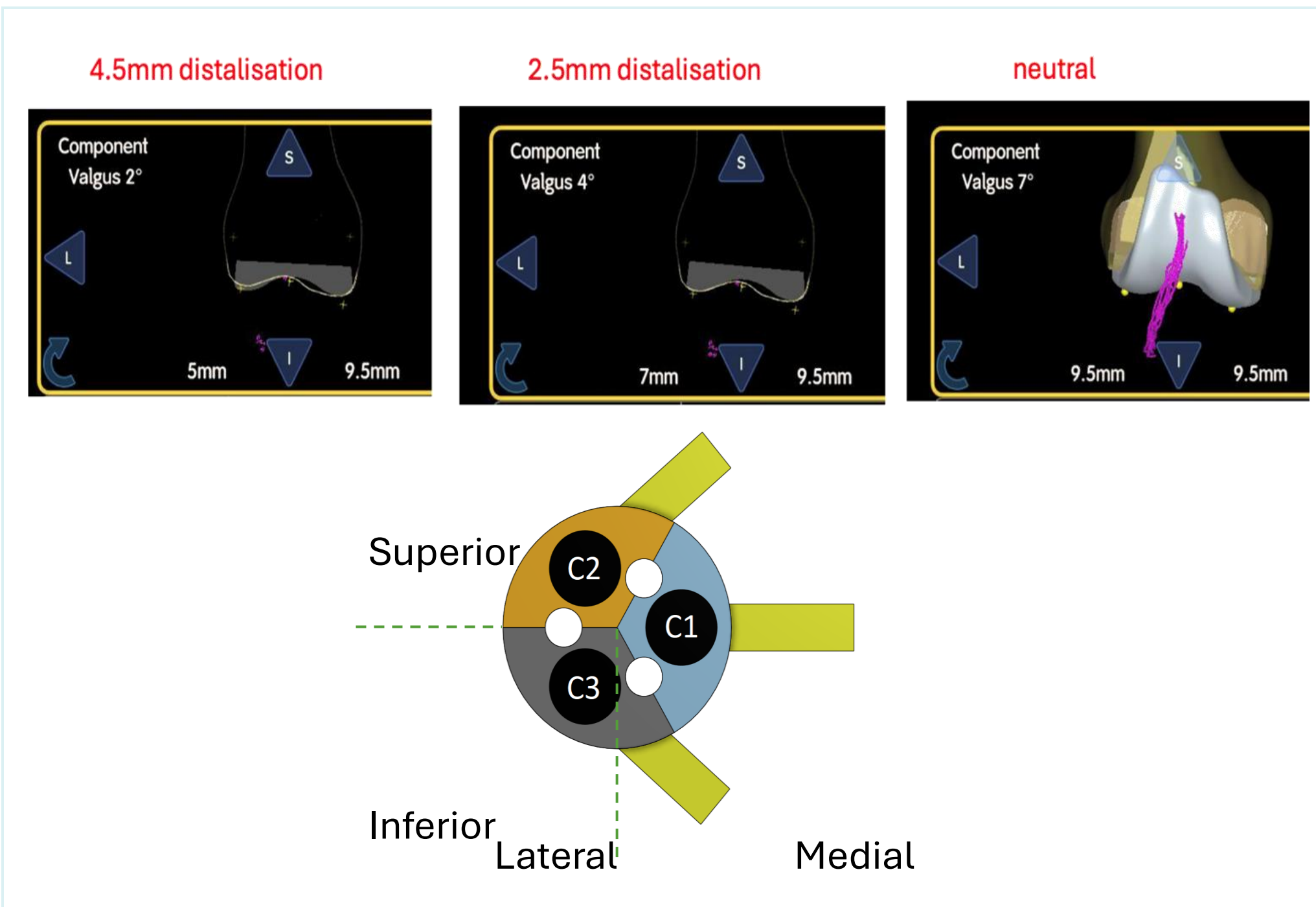
Kinetics. RForce increased from Neutral: 76.4 ± 39.7 N to Maximum: 112.3 ± 51.0 N, a +47.0% increase (*p* < 0.05). C1 rose from 1.94 ± 0.88 V to 2.69 ± 0.91 V (+38.7%, *p* < 0.05), and C3 from 2.01 ± 0.95 V to 2.79 ± 0.99 V (+38.8%, *p* < 0.05), while C2 changes were minor.

Kinematics

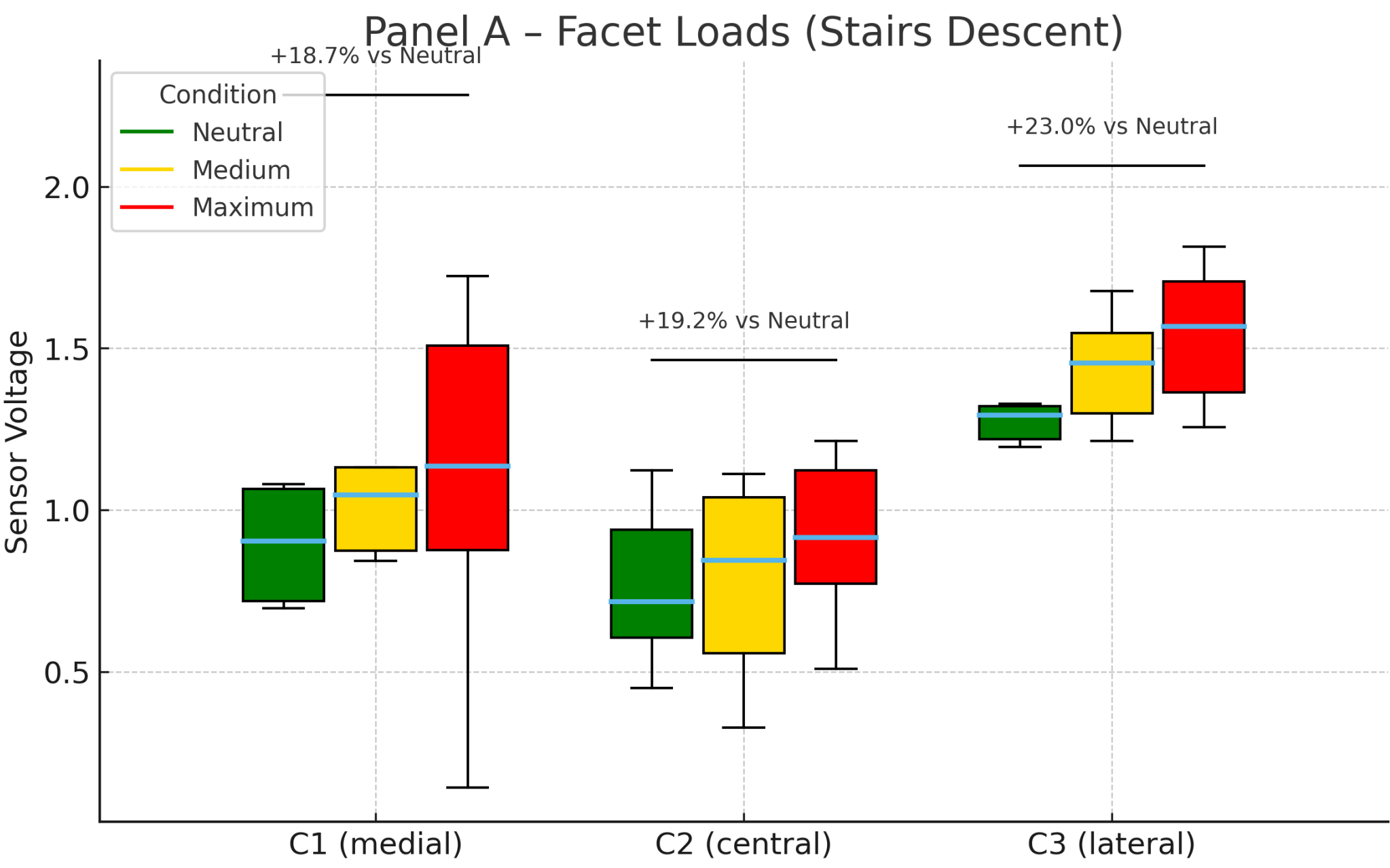
Posterior translation increased from Native: 1.2 ± 0.8 mm to Maximum: 3.1 ± 1.3 mm (+106%, *p* < 0.01). Internal rotation rose from Native: 0.7 ± 0.5° to Maximum: 2.2 ± 0.8° (+114%, *p* < 0.01). No significant changes occurred for medial–lateral shift, superior displacement, flexion, or valgus.

CONCLUSION

Lengthening the lateral condyle in TKA by 4.5mm increases PFJ reaction forces and alters tracking, particularly by driving internal rotation of the patella. Distalisation of 4,5mm led to PFJ reaction pressures at least 40% higher in deep flexion during passive knee flexion. These findings highlight the need to avoid excessive distalisation of the lateral condyle during femoral component preparation.



Patellofemoral joint contact pressure maps during passive flexion. Green = neutral resurfaced lateral condyle, yellow, medium lengthening (2.5mm) and red (4.5mm lengthening). Lengthening the lateral condyle resulted in a significant increase in PFJ kinetic forces – 36% increase during passive knee flexion relatively to a neutrally resurfaced femur.



Composite patellofemoral joint contact force during passive knee flexion under varying lateral condyle lengthening conditions. Minor differences were seen between the central and medial regions of the patella, however the lateral facet showed highest pressures and the largest changes in response to lengthening of the lateral condyle..