Shape Matters: Tibial Baseplate Shape and Component Stability in Cementless Total Knee Arthroplasty

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INTRODUCTION:

Initial stability of cementless total knee arthroplasty tibial components is necessary for bony ingrowth. The tray design features including peripheral pegs, keel and plate shape as well as surgical and patient factors that contribute to initial stability remain poorly understood. In this study, we investigated tibial component design factors that may affect implant stability using a biomechanical model.

METHODS:

Physiological loading (level walking and stair descent) was robotically applied to cementless tibia trays implanted in foam tibia models. The models replicate cortical and cancellous bone material properties and the shape of the tibia. Three commercially available cementless tibia trays with keels and peripheral pegs from two different manufacturers were tested including symmetric, asymmetric, and anatomically shaped tray profile. Maximum 3D micromotion was measured between the bone foam model and tibial tray at 10 locations using an optical measurement system.

RESULTS:

The symmetric tibia tray had the greatest micromotion during level walking (229 ± 23 µm), followed by the asymmetric (205 ± 56 µm) and anatomic designs (84 ± 22 µm) (Figure 1). During stair descent the symmetric, asymmetric, and anatomic designs saw maximum motion of 165 ± 17 µm, 151 ± 60 µm, and 92 ± 17 µm, respectively. The anatomic tibia shape saw less 3D micromotion than the symmetric and asymmetric designs during walking ($p<0.05$) and less motion than the symmetric design during stair descent ($p<0.05$).

DISCUSSION AND CONCLUSION:

While the anatomic tibia tray saw equivalent micromotion across both activities, it experienced less micromotion than the other two designs. Interestingly, the symmetric and asymmetric trays saw greater micromotion during level walking compared to stair descent, despite the peak loads in stair descent being higher than walking. This study suggests tibial tray coverage afforded by an anatomic baseplate design improves tibial component stability during both level walking and stair descent activities.

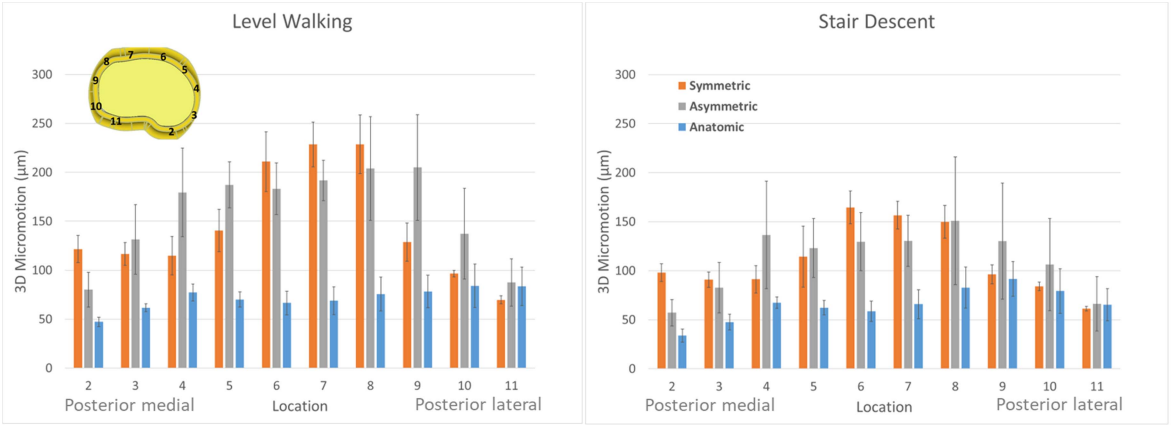

Figure 1: Left: Maximum 3D micromotion of the tibia plate relative to the foam during level walking at different locations of the tibia plate. Right: Maximum 3D micromotion of the tibia plate relative to the foam during stair descent at different locations of the tibia plate.