Knee Mechanics After Joint Replacement Using Computed Tomography

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Anterior knee pain affects 10-25% of total knee arthroplasty patients. Patellar maltracking is often cited as a likely cause of pain, but current two-dimensional, non-weightbearing methods have failed to evaluate the precise mechanics of the patella after arthroplasty. We propose a computed tomography (CT) imaging technique that offers the potential for accurate, three-dimensional calculations of post-arthroplasty knee mechanics.

Our protocol involves taking CT scans of the patient's post-arthroplasty knee, at multiple flexion angles under partial weightbearing, segmenting the bones and components, and registering the images to each other. We use a semi-automatic segmentation process to identify key distinctive features of each component. With precise 3D CAD models of the knee components, we can register these geometries to the segmented features, thus producing an accurate segmentation. Use of this approach is limited by the artifacts created by the metallic components as well as the risk of radiation to patients; however, CAD model registration techniques can overcome the issue of artifacts, and the use of low-dose protocols will reduce the overall radiation risk. Patellofemoral and tibiofemoral joint mechanics as well as contact areas will be calculated for each flexion angle, and a spline fit to the resulting points will estimate the mechanics over the range of flexion.

An accurate, validated CT protocol for measuring knee mechanics can potentially provide a method for precisely assessing post-arthroplasty patellar tracking and provide a means for answering clinical questions such as comparing patients with and without pain or with different implant geometries.