Subject-specific Computational Modeling of Normal, Dysplastic and Retroverted Hips

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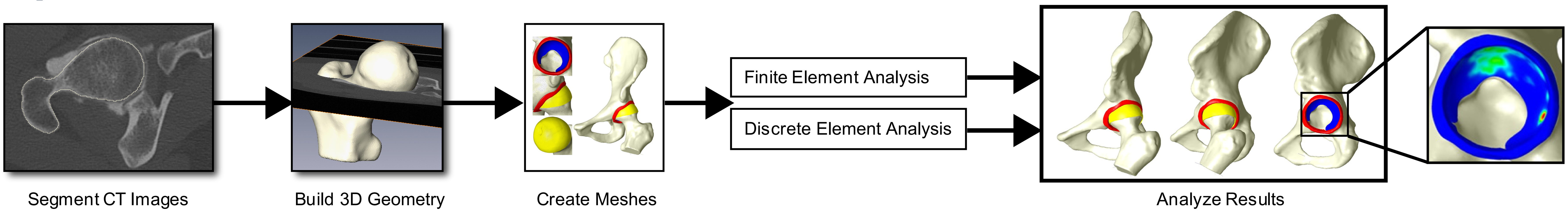
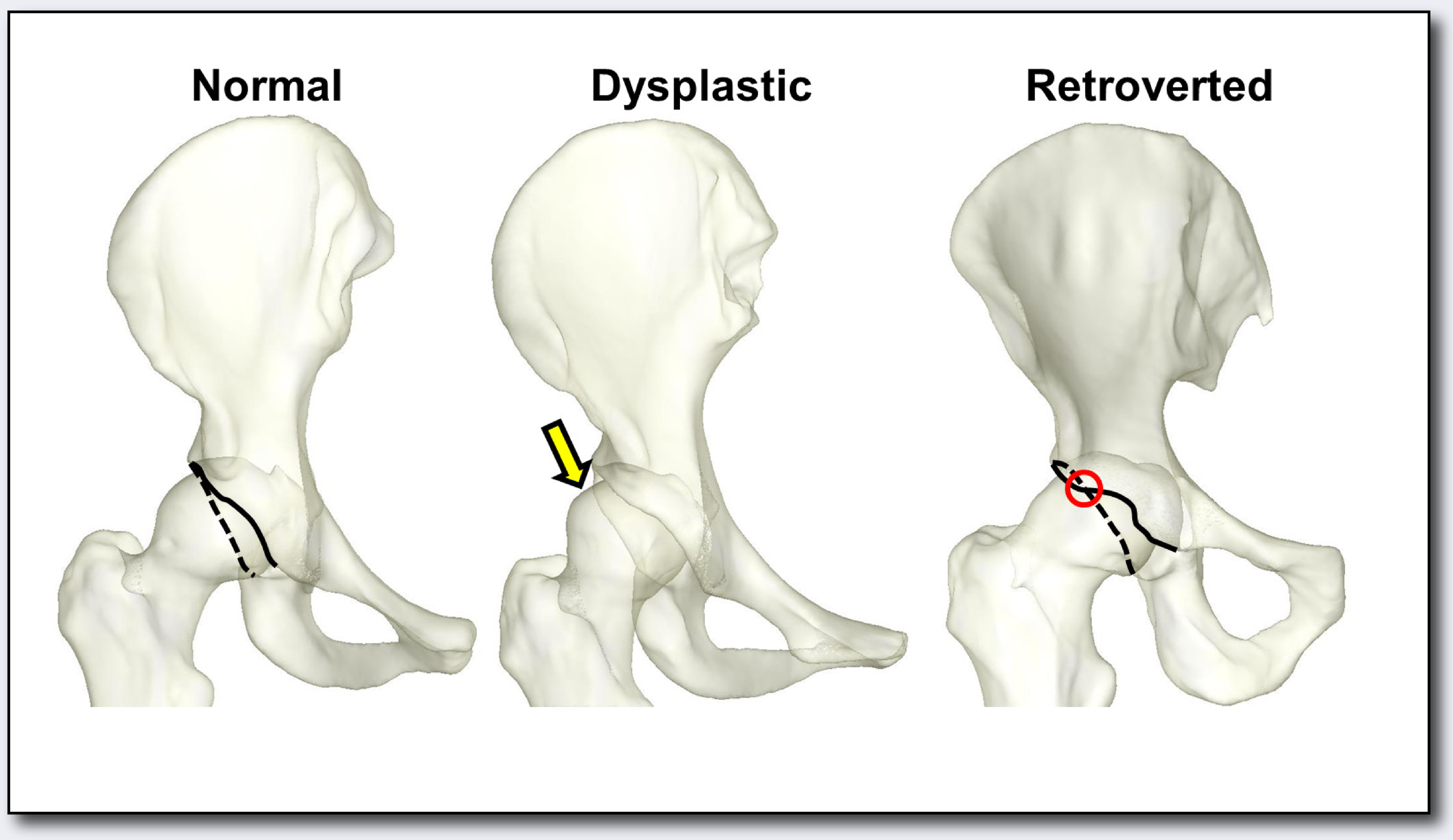
Pipeline

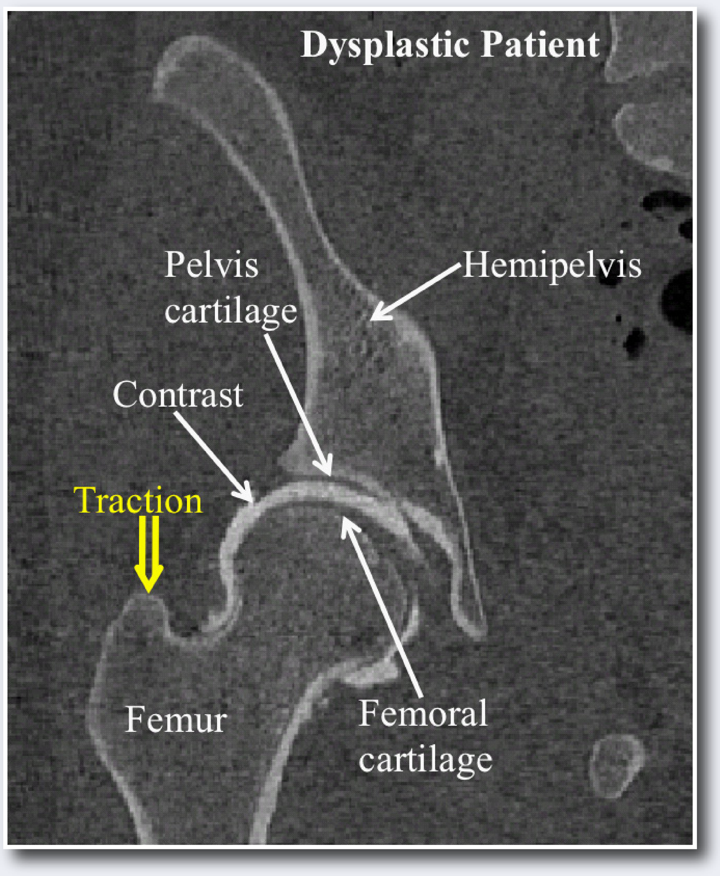


Hip Pathology

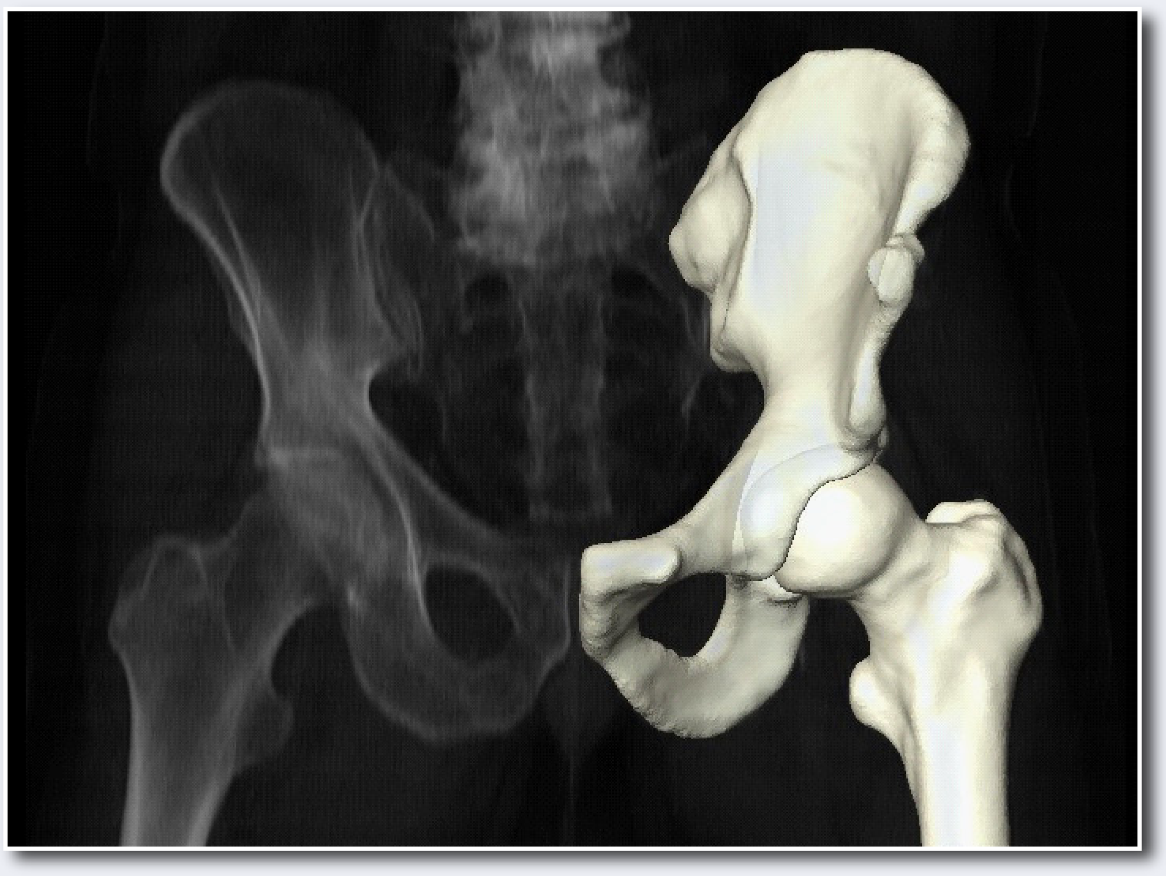
Bony pathologies such as acetabular dysplasia and acetabular retroversion may be the leading cause of premature osteoarthritis (OA) of the hip. Hip OA is a degenerative joint disease affecting ~9% of the US population. While it is thought that mechanical factors are the link between bony pathology at OA, clinical studies cannot directly measure cartilage mechanics.



In acetabular dysplasia, the acetabulum (socket) is shallow, causing undercoverage of the femur (arrow). Acetabular retorversion is a mal-orientation of the socket, which results in the cross-over sign between the anterior (solid black line) and posterior (dashed line) acetabulum (red circle).



CT arthrogram captures three-dimensional hip geometry. Image data are segmented using a combination of automatic and manual methods.



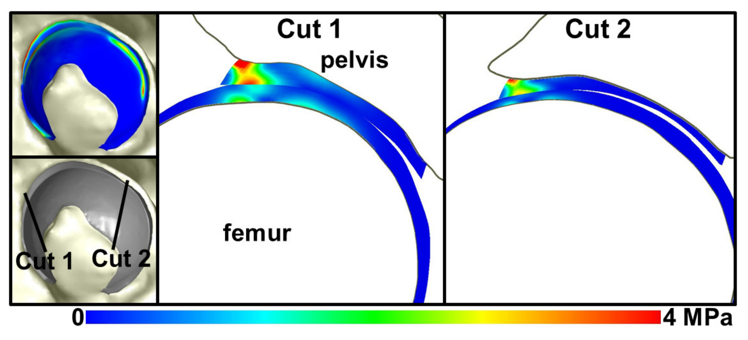
Subject-specific 3D reconstruction of bony geometry, overlaid on volumetric CT data. Incorporating subject-specific geometry into models produces more accurate predictions of cartilage contact stresses [Anderson et al., 2008 *J Biomech Eng*].

Patient-specific Hip Joint Computational Models

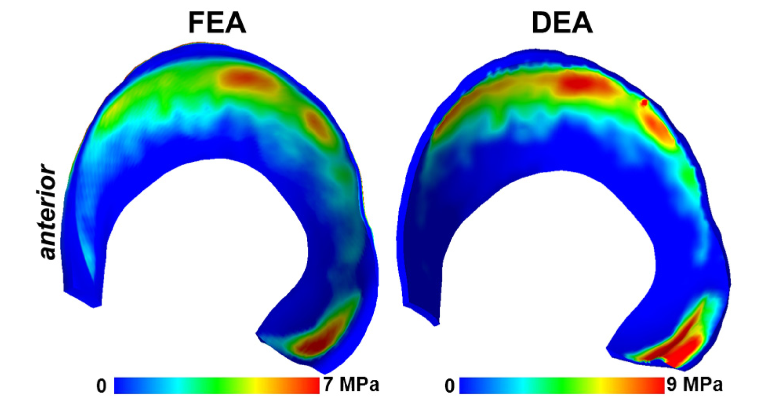
Patient-specific finite element analysis (FEA) and discrete element analysis (DEA) is used to determine cartilage mechanics during simulated activities of daily living. FEA provides results on the articular surface as well as through the depth of the cartilage, which can provide insight into the initiation and progression of OA. DEA provides contact mechanics in a fraction of the time required for FEA. This makes DEA an efficient method which can be used in pre-operative planning to optimize surgical procedures on a patient-specific basis.

Subjects with traditional dysplasia tend to have more lateral contact while subjects with retroverted acetabuli tend to more medial and superior contact when compared to normal subjects.

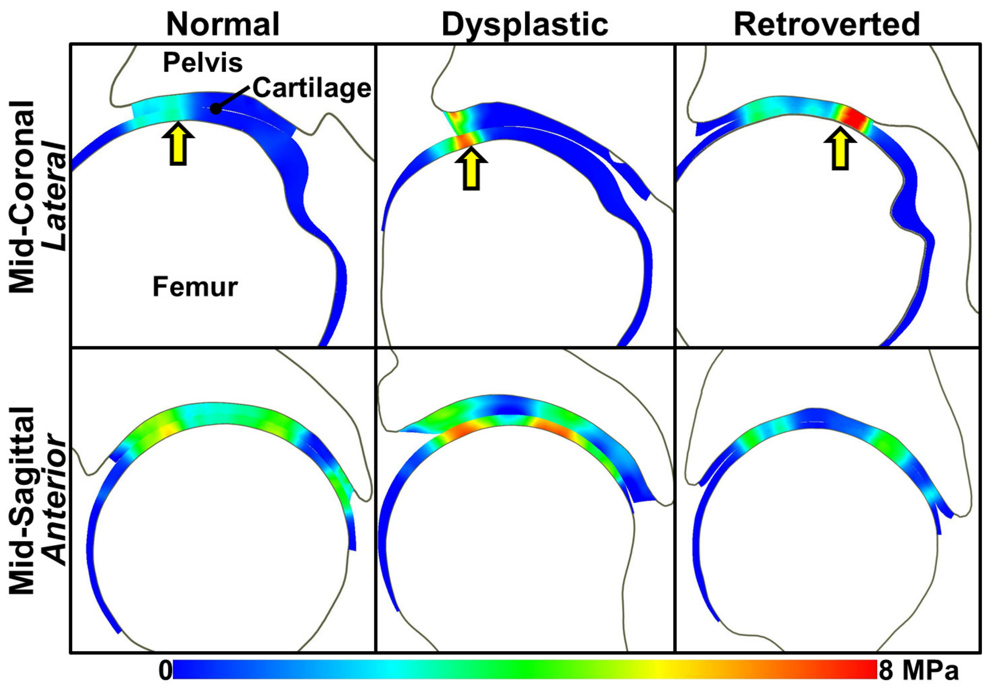
Peak contact pressure was larger in retroverted subjects in the superior-medial region and smaller in the posterior-lateral region in heel-strike of walking (WH). Peak contact pressure was smaller in normal subjects in the posterior-medial region in chair rise (CR).



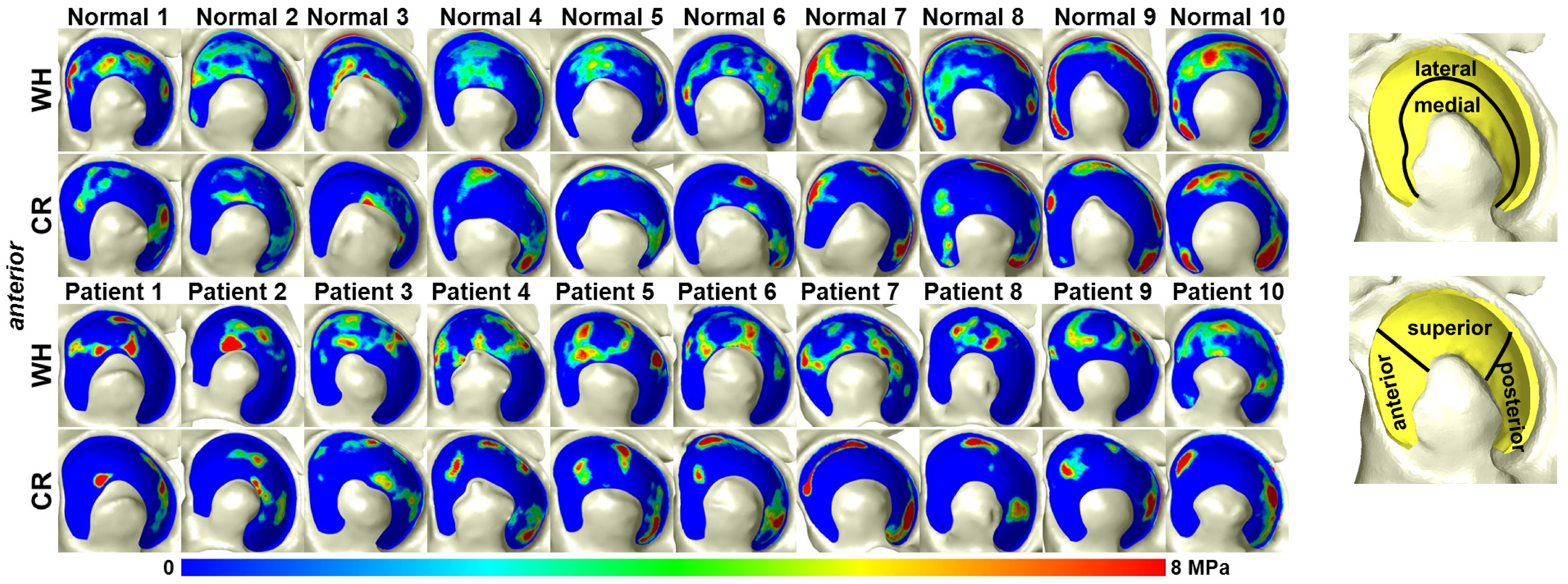
Maximum shear stress through the cartilage thickness can provide insight into the initiation of OA.



DEA predicts contact stress in agreement with FEA, but takes <1% of the time for analysis.



The location of contact is different between normal, dysplastic and retroverted subjects.



Cartilage contact mechanics vary by anatomical region between normal subjects and retroverted subjects.