RAPID COLLISION DETECTION TECHNIQUE IN THE EVALUATION OF FEMOROACETABULAR IMPINGEMENT

INTRODUCTION:

In the native hip joint, Femoroacetabular Impingement (FAI) is also recognized as a cause of hip arthritis. Correction of the underlying structural abnormality permits the patient to regain a painless functional range of motion. A 2D approach to find an abnormality by checking alpha and beta angles [1] has been used. In cam type impingement where the femoral head is aspherical, recontouring of the femoral head neck junction restoring head sphericity has been shown to improve clinical function by means of both open and arthroscopic techniques. However, the less invasive techniques are more difficult in respect to accurately and reproducibly correcting the femoral head/neck deformity. More importantly, what represents a pathological head/neck deformity has not been fully delineated as well as the pathomechanisms of FAI which lead to joint deterioration.

Recent joint simulation studies using CT based HIP motion data have shown that patients with FAI have decreased flexion, internal rotation and abduction compared to normals [5]. While this information may be a useful tool in decision making as well as surgical planning for computer assisted surgery, this technique cannot account for cartilage strain which ultimately will lead to its deterioration.

The purpose of our study is to determine the feasibility of performing a rapid collision detection technique of the native hip joint using a patient based CT dataset in order to evaluate FAI. We present a rapid 3D system to rapidly detect impingements and compute and visualize approximate strain.

METHODS:

Computer tomography data of the hip joint as well as motion analysis data using a 3D Vicon analysis were collected from a patient suffering from FAI. For the motion analysis, seven VICON MX-13 cameras (VICON, Los Angeles, Calif.) at 200 Hz with retroreflective markers placed on anatomical landmarks were used. These data was then used for simulating the collision.

Like the common collision detection approaches, our solution [2] used two major algorithms: (i) Rapid Spherical Sampling (RSS) based on the fact that ball-and-socket joints, such as hip joint, are near-spherical objects (Figure 1). Our RSS samples the 3D mesh geometric information of the joint based on Spherical Coordinate System. The mesh is first mapped to 2D Spherical Coordinates with the distance data from the origin and then the distances of densely sampled points of the mesh surface are directly interpolated from ones of the triangle vertices through polygon rasterization. Then we use a large Lookup Table (LUT) [3] to maximally preserve the model’s geometry information using the distance field. (ii) Rapid Spherical Impingement Detection (RSID): the collision detection is instantly processed by testing how near the target point is compared to the distance field in LUT. It directly provides the approximate strain measurement on the surfaces of the ball-and-socket joint.

RESULTS:

Color scales are used to illustrate the distances between the ball and socket, to approximately represent the strain distribution without increasing any extra computation cost. Many collision detection algorithms such as RAPID [4] usually require extra functions to measure the distance information. In Figure 2, the 12K-triangle model is segmented from CT data (1.25mm thickness, resolution of 512*512).

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