APPLICATION OF MEDICAL IMAGING IN ORTHOPEDIC BIOMECHANICS

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In the field of orthopedic biomechanics, geometry, alignment and movement of the anatomic structure, as well as the integrity and material properties of the tissues are the common parameters in making a diagnosis and planning treatment. Medical imaging has been a useful tool for possible mini- and non-invasive examination. Commonly used imaging techniques consist of x-ray radiography, fluoroscopy, computer tomography (CT), ultrasound (US), and magnetic resonance imaging (MRI). Traditionally, planar x-ray has been used extensively to identify the fracture and alignment of the bone structure. With the addition of contrast medium, the injury of soft tissue could be imaged. In the past several years, development and improvement of both the software and hardware for medical imaging have progressed tremendously. In this presentation we will review the applications of medical imaging to the measurements of bony alignment and joint motion, stress and strain analyses, and material properties of the musculoskeletal system.

For measuring skeletal motion and the migration of artificial implants, bi-planar stereo radiography has been developed and used for more than 30 years. A method was developed for registering three-dimensional models to single plane x-ray fluoroscopy images. CT and MRI are available for assessing the skeletal movement based on various techniques of registrations and animation. For the assessment of the internal stress and deformation of the musculoskeletal system, the 3D CT scan enables the finite element mesh generation of the internal structure. The imaging systems are able to directly measure the deformation and strain of the anatomic structures. Applications of the speckle tracking in US and texture or block matching in MRI images enable mapping of deformation and strain fields of the soft tissue. Material properties, such as the modulus and strength of bone, have been quantified by using quantitative CT. Furthermore, elastographies based on US and MRI enables the quantification of material properties of soft tissue. MR elastography uses the MRI method to map the physical response of a material to harmonic mechanical excitation. The resulting images allow calculation of regional mechanical properties. In summary, medical imaging provides useful tools for assessing biomechanical parameters of the musculoskeletal system. These technologies are essential for enhancing diagnoses in orthopedics, and monitoring the success of the tissue regeneration in the application of tissue engineering.