BIOMECHANICS PRIORITIES CONFERENCE
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Priority Statement Title: Integrating structural and functional joint imaging

Priority Statement Code: CJ2H

Domain: Joints

Priority Statement

Background and Relevance

Over the past decade, imaging modalities for joint structure and function have improved dramatically. High-resolution static 3D imaging from MRI and CT, along with new MRI sequences that provide enhanced contrast for specific tissues, can provide detailed information on the structure, properties and geometry of most joint tissues (e.g. cartilage, ligaments, menisci, bone). Advanced techniques for dynamic imaging of joint function, including cluster-based video-motion analysis, dynamic and cine-phase contrast MRI and x-ray based systems (dual fluoroscopy, stereo cineradiography) can provide accurate joint kinematics during a variety of functional activities and are becoming widely available. The integration of these two modalities (detailed tissue structure with high-accuracy dynamic imaging/kinematics) presents unique opportunities for understanding structure/function relationships, as well as assessing the mechanical response of specific joint tissues after joint injury or disease. These rich multi-modal datasets are also essential for developing subject-specific applications for both research and potentially clinical applications (e.g. for improved diagnosis of movement disorders and treatment decision support).

The primary barrier to greater use of these techniques is the absence of available tools for extracting structural information from 3D imaging and registering this information to multi-modality dynamic imaging/kinematic data. Commercially available software is either poorly suited for these applications or unavailable. Thus, each laboratory attempting to integrate multiple imaging modalities has had to develop its own approaches, leading to inefficient and often poorly validated applications and no cross-laboratory compatibility. These approaches are largely manual, typically requiring 40 man-hours or more per subject. This labor-intensive approach rules out clinical applications and makes even research applications prohibitively expensive.

Objectives

1. Provide more powerful and widely available analysis tools to the clinical and research biomechanics communities for integrating kinematic data with structural imaging.

2. Facilitate practical application of integrated imaging approaches to support patient-specific clinical decision making based on function-based diagnosis and treatment recommendations.

The work would bridge the traditionally independent domains of 3D structural imaging (CT, MRI), motion analysis and computational engineering.

Recommended Actions

- Develop tools for segmentation of joint tissues from 3D imaging with minimal user intervention.
- Develop approaches for efficient, robust co-registration of kinematics/dynamic imaging data with tissue structural data to enable subject-specific analyses of joint structure/function relationships.
- Where possible, adapt tools/techniques to enable quantitative analysis using the range of equipment currently available, from purpose-designed research facilities to clinically available imaging systems.
- Validate the performance of these tools under realistic testing conditions.
- Develop a model for distribution and application support (could be open-source and/or commercial).