

FUNCTIONAL IMAGING OF THE NORMAL AND ARTHRITIC KNEE

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INTRODUCTION

Osteoarthritis (OA) is the most common condition to affect the joints of humans and a frequent cause of pain and disability. The appropriate selection of treatment plans for OA is dependent on the development of better methods for the assessment of the disease process. Degenerative changes to articular cartilage can be described in biological, mechanical and morphological terms.

From a morphological viewpoint there has been substantial progress in our ability to study cartilage using MRI. From a mechanical viewpoint recent studies have demonstrated a relationship between the dynamic loads at the knee during gait and progression of knee OA (Prodromos 1985). The combination of imaging methods with functional kinematic information obtained during walking could greatly enhance our ability to study OA. The primary purpose of this work is to integrate cartilage imaging techniques with newly developed methods to study the functional kinematics of the knee joint.

MATERIALS AND METHODS

Kinematic measurements were obtained using a point cluster technique (Andriacchi et al. 1998) with interval deformation correction (Alexander et al. 1998) described elsewhere. These techniques seek to minimize the error associated with skin deformation relative to the bone. The marker set is shown in Figure 1. The medial markers are in place only during a reference data acquisition, with the subject standing still.

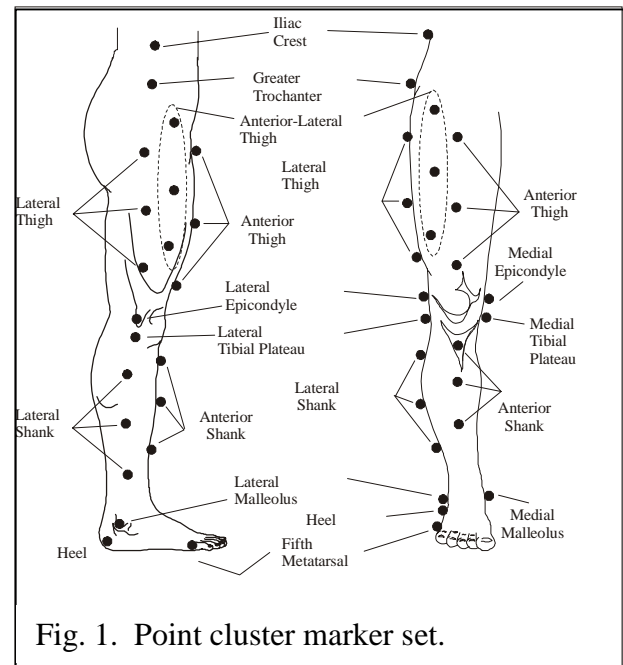


Fig. 1. Point cluster marker set.

These markers are magnetically opaque; that is, they are designed to be observable by both the opto-electronic system and the MRI. Some of these markers, and their corresponding coordinate systems, are shown in Figure 2. By corresponding these external and internal markers, it is possible to animate high resolution 3D internal images, such as 3D cartilage thickness maps, with subject specific motion data.

A computational method for the calculation of the 3D cartilage thickness maps is based on a 3D Euclidian distance transformation (EDT) (Stammerberger 1999). For a given set of feature points in a binary volume, the EDT computes the distance to the closest feature point for each non-feature point of the volume. By using the points on the cartilage-bone interface (inner cartilage surface, ICS) as feature points, the EDT measures the distance to the closest voxel on the ICS for all other points,

including the ones on the outer cartilage surface, resulting in a truly three-dimensional distance value determined normal to the ICS.

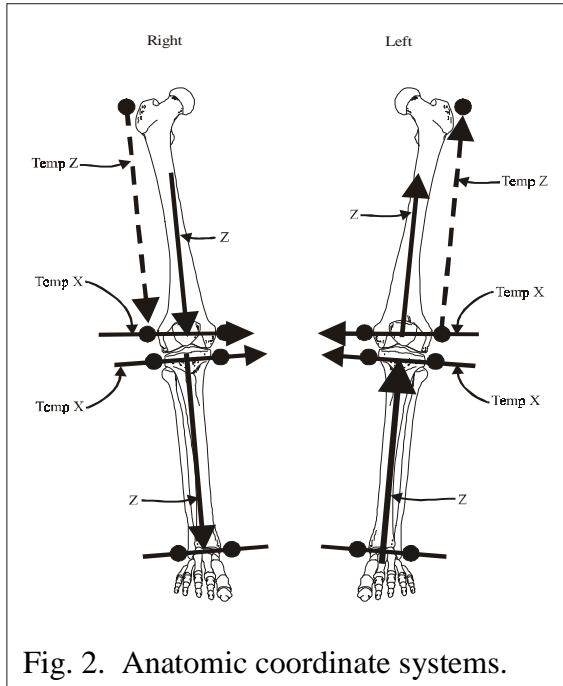


Fig. 2. Anatomic coordinate systems.

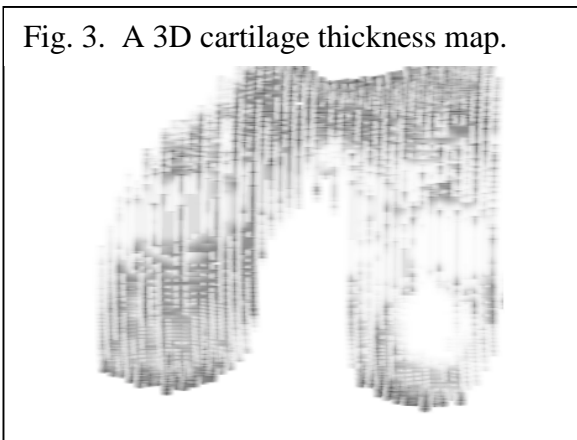
RESULTS

Figure 3 shows a three dimensional cartilage thickness map clearly showing a large defect on the medial femoral cartilage. Figure 4 show another result, three time steps of an animation of a healthy cartilage from an anterior and lateral point of view.

DISCUSSION

This methodology describes a technique

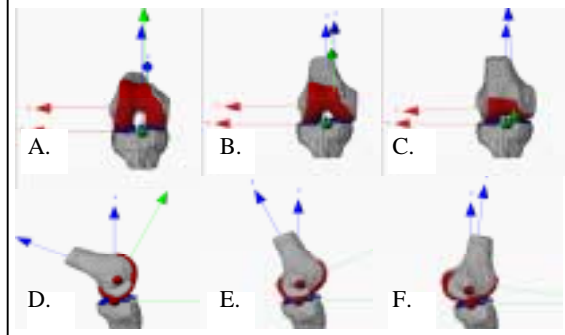
Fig. 3. A 3D cartilage thickness map.



that combines medical images (MRI) of articular cartilage with dynamic measurement of human movement. Thus, for the first time

the relative *in vivo* movement of cartilage in the weight bearing portion of the knee can be examined. Local defects can be identified and studied relative to the areas loaded during such activities as walking. This should allow us to be able to generate visualizations which detail the motion of the knee joint over lesion areas in the cartilage.

Fig 4. Healthy knee, leg extension, anterior(A-C) and lateral(D-F) views.



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