Soft tissue motion measurement on shank and thigh with MRI

M. Sangeux [a], F. Marin [a], F. Charleux [c], L. Dürselen [b], M.C. Ho Ba Tho [a]

[a] Laboratoire de biomécanique et génie biomédical, CNRS 6600, UTC, Compiègne, France
[b] Institute of Orthopaedic Research and Biomechanics, University Hospital of Ulm, Germany
[c] Polyclinique St Côme, Centre d'Imagerie Médical Avancé, Compiègne, France

Corresponding author : frederic.marin@utc.fr

***Abstract*—Most in vivo knee kinematic analyses are based on external markers attached to the shank and the thigh. However, the positioning of the markers and skin artifacts can affect the kinematic parameters of the bones true movement. The aim of the present study was to develop and to use a protocol and a modeling method that allows the computation of the relative motion between the bones and the markers. MRI acquisitions were performed on the right knee of eleven volunteers without knee injury. The subjects were equipped with external MRI-compatible markers and a foot drive device allowing the subjects to perform an active loaded knee extension. The bones and external markers were modeled from MRI images, a registration algorithm was applied to the bones and finally the relative motion of the thigh and shank markers with respect to their underlying bones was computed semi-automatically. As a result it has been found that the marker movement differs from the bone movement at their maxima 22 mm in translation and 15° in rotation.**

Soft tissue artifact; MRI; 3D movement

I. INTRODUCTION

In vivo joint kinematic analysis is a major tool to investigate functional activities of the knee [1]. Different systems - video, magnetic or optoelectronic - are used to capture the tibiofemoral kinematics in vivo and non-invasively. The most popular method use external markers fixed to the thigh and the shank, either with an external attachment system or directly glued to the skin. However, the question of the reliability of the kinematic parameters e.g. Euler angles [5] or helical axes [17] arose concerning these external markers [7]. Moreover the soft tissues motion between the bones and the markers is not very well known and new results in this field could alter the conclusions for motion analysis studies [2, 3, 8, 10].

During two decades the scope for Magnetic Resonance Imaging (MRI) has been constantly expanding parting from anatomical imaging to biomechanical kinematic analyses [12,14]. The MRI technology gives 3D images and presents the advantage of not being invasive for the bony structure and the soft tissues (muscles, ligament,…) surrounding it.

It has been the objective of this study to assess the 3D relative movement of a external marker sets dedicated to knee motion analysis with dynamic MRI.

II. MATERIAL & METHODS

The measurements were performed on the right knee of eleven healthy volunteers (mean age 33 years old, range 23-54, 6 males and 5 females). All the volunteers underwent a clinical knee exam performed by an orthopedic surgeon at the Polyclinique St Côme in Compiègne, and signed in an informed consent.

Inside the 1.5T Signa MRI scanner (GE Medical Systems, Milwaukee, WI, USA), the subjects were in supine position. Their ankles were fixed to a custom-made foot drive device (figure 1) manufactured with MR compatible materials.

Figure 1: Foot drive device

The foot drive device was designed in order to allow a reproducible active knee movement. The subjects were equipped with an external marker set for external kinematic analyses. The femur marker set was mounted on a very light carbon composite structure and fixed to the thigh with a large neoprene band. The tibia marker set was attached to the shank, and was mounted on a PVC base attached with two Velcro bands. The thigh marker set (TMS) and shank marker set (SMS) were composed of a PVC structure equipped at each corner with four cylindrical (15mm long, 5mm in diameter) Adalat (Bayer, AG, Germany) capsules. Adalat capsules were chosen as MRI markers because of their low cost and highly visible MRI signal.