KNEE KINEMATICS OF TOTAL KNEE REPLACEMENT PATIENTS: PRE AND POSTOPERATIVE ANALYSIS USING COMPUTER GENERATED IMAGES

Christopher J. Barr[1], Alexander.C. Nicol[1], Mark Blyth[2], Martin Sambrook[3]
[1]Bioengineering Unit, University of Strathclyde, [2]Orthopeadic Dept, Glasgow Royal Infirmary, [3]Radiography Dept, Glasgow Royal Infirmary. email: Christopher.Barr.100@strath.ac.uk, web: www.strath.ac.uk/bioeng

INTRODUCTION

Gait analysis has previously been conducted on osteoarthritc patients [1]. Techniques have been developed to study the contact areas of the knee in vivo, but these are in non-weight bearing conditions, and on healthy subjects [2]. The current project aims to show a comparison of knee kinematics in pre- and post– operative knee replacement surgery, using computer animation to represent a patient specific model of the knee joint interactions under every day conditions.

METHODS

Nine patients were recruited from the waiting lists for total knee replacement (TKR) from the orthopeadic department in Glasgow Royal Infirmary hospital. All were selected on the criteria that they suffered from osteoarthritis of the knee joint, and had no secondary conditions that affected their gait.

Each subject underwent preoperative gait analysis using a Vicon 612 Motion Analysis System (©Oxford Metrics). A cluster set of 4 markers was attached to the thigh, shank and pelvis segments. All boney landmarks were then identified, and virtual points were made at each landmark. Each subject was then asked to perform the following every day activities: level walking, ascending and descending stairs, and chair rising and sitting. This was repeated one year postoperatively.

Preoperative magnetic resonance (MR) images were taken for each subject. Postoperatively, Computerized Tomography (CT) scans were taken, as the implant could not be imaged using MR. The scans were rendered into 3D images, which were then combined with gait analysis data and animated in Virtual Reality Modeling Language (VRML).
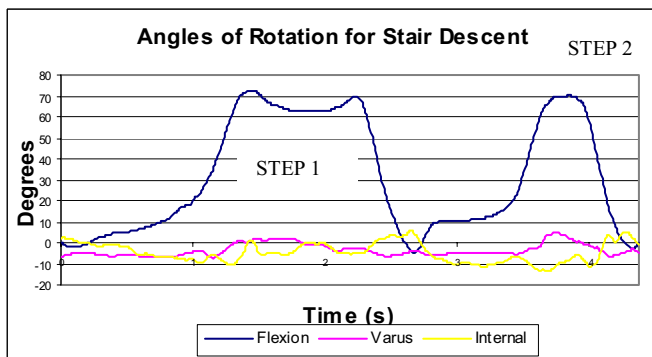

Figure 1: Typical flexion angles stair descent

RESULTS AND DISCUSSION

Figure 1 details angles of rotation during stair descent in the preoperative patient. All subjects reported this to be the most difficult task. The difference in pattern of flexion angle in the two steps demonstrates the difficulties experienced by the

subject when descending the stairs. The lack of smooth motion in internal and vulgus rotation illustrates the lack of muscle control during motion.

A 3D surface image of the knee joint was created using MIMICS software from Materialise (figure 2). Preoperatively, 44 axial slices of 3 mm thickness were taken from MRI. Postoperatively 144 slices of 1mm thickness were taken from CT. For each image, each slice was surfaced by outlining the contour of the bone. The dimensions of the scan were input into the software and the slices were then stacked to create a 3 dimensional model.
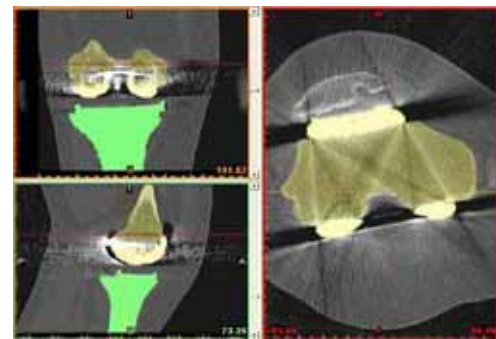

Figure 2: 3D rendering of the knee joint

The 3D model of the knee joint was exported as a VRML file and an animation of the pre- and postoperative knee joint was produced (figure 3). This shows the knee joint at 70° flexion during stair descent, with a slight varus and external rotation, as shown in figure 1. This method allows for the visualization of 3D motion between the tibia and femur during everyday activities. The comparison of pre and postoperative animations will provide data that can be incorporated in preoperative planning of TKR for a wide spectrum of patient groups.
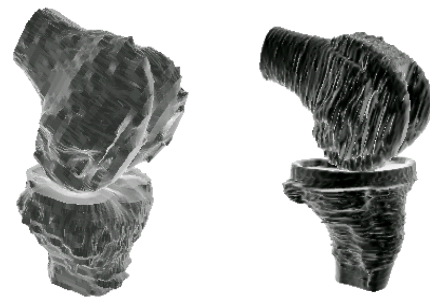

Figure 3: Screenshot of VRML animation (a) preoperation and (b) postoperation

REFRENCES

1. Kaufman KR, et al *J Biomech* **34**, 907-915, 2001.
2. von Eisenhart-Rothe R, et al *J Biomech* **37,** 927-934, 2004.