COMPARING CT AND MRI SEGMENTATION ACCURACY OF LONG BONES

Joyce Van den Broeck[12], Evie Vereecke[3], Roel Wirix-Speetjens[2], Jos Vander Sloten[1]
[1]Section Biomechanics, KULeuven, Leuven, Belgium; [2]Materialise NV, Leuven, Belgium; [3]Department of anatomy, KULeuven, Leuven, Belgium

Introduction

The use of 3D imaging methodologies in orthopaedics has allowed the introduction of new technologies, such as the design of patient-specific implants or surgical instrumentation. This has introduced the need for high accuracy, in addition to a correct diagnosis. Until recently, little was known about the accuracy of MRI imaging to reconstruct 3D models of the skeletal anatomy. This study was conducted to quantify the absolute errors between CT and MRI imaging compared to an optical scan for various regions of the bone.

Methods

Nine cadaver tibia bones were used to compare different medical imaging modalities to an optical scan. The MRI images were obtained with a 1.5T clinical MRI scanner (GE Signa HDxt), using a slice thickness of 2mm and a pixel size of 0.39mm x 0.39mm. CT scanning was performed using a clinical CT scanner (GE LightSpeed VCT) with a slice thickness of 0.625mm and a pixel size of 0.39mm x 0.39mm. Manual segmentation of the images was done using Mimics® (Materialise NV, Leuven, Belgium) by experienced users. The specimens were cleaned using a fat-removal procedure, removing both soft tissue and cartilage. For completeness, a second CT scan was taken after cleaning of the bones. These were then optically scanned using a white-light optical scanner (ATOS II by GOM mbH, Braunschweig, Germany) having a resolution of 1.2 million pixels per measuring volume, yielding an accuracy of 0.02mm. The optical scan of each bone reflects the actual dimensions of the bone and is considered as a ground truth measurement.

To compare the reconstructed 3D models to the optical scans, the models were registered in two steps: an initial registration by aligning the inertia axes and a global ICP-based registration [Besl, 1992]. The optical scan was compared to the 3D model of the bone by calculating the distance of the vertices of the optical scan to the reconstructed 3D objects. The models resulting from the different CT scans were also compared to assess the influence of the tissue removal protocol on the superficial bone layer.

Results

Comparison of the 3D reconstruction using CT images and the optical scans resulted in an average error of 0.53mm (±0.23mm). Similar results were found using MRI images: an average accuracy of 0.42mm (± 0.38mm) was listed. Both imaging methods provide segmentation accuracy with an RMS error below twice the pixel size. The impact of the cleaning process was also calculated. The mean error introduced here was equal to 0.18mm (± 0.14mm). Comparable results were found for the different regions of the bones.

Discussion

Previously, White published results of comparing MRI and CT imaging looking at the accurate positioning of landmarks on 3D printed models of the segmented images [White, 2008]. They reported an average accuracy of 0.61mm on CT reconstruction (± 0.41mm) and 2.15mm (± 2.44mm) using MRI. In comparison, Rathnayaka compared both CT and MRI-based 3D models to measurements of the real bone using a mechanical contact scanner [Rathnayaka, 2012]. They listed an accuracy of 0.15mm for CT and 0.23 for MRI using five ovine limbs.

The results from this study are close to the ones found by Rathnayaka, whereas we have used human specimens and a clinical scanning protocol. We have demonstrated the feasibility of 3D reconstruction of bones using MRI technology with accuracy comparable to CT imaging.

References

Besl and McKay, IEEE T Pattern Anal, 14: 239-256, 1992.

Rathnayaka *et al*, Med Eng Phys, 34: 357-363, 2012.

White *et al*, Int J Med Robotics Comput Assist Surg, 4: 224-231, 2008.