MRI Sequence Influences Geometrical Information of Osseous Tissues

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ABSTRACT INTRODUCTION:

Although CT-scan data gives accurate geometrical information of bones, MRI data is commonly used instead due to its non-ionizing nature. The geometrical information has a number of applications, including image registration and computer simulations of the human joints, presurgical planning, prosthesis design, linking geometry with function and pain and kinematics. Hence, it is important to for the geometrical information extracted from the MRI data to be accurate. However, this information is influenced by the choice of the MRI sequence. Therefore, the aim of this study is to investigate the effect of different MRI sequences on the accuracy of geometrical information of bones.

METHODS:

Two fresh frozen cadaveric legs were CT-scanned, using a GE Medical Systems CT-scanner, at 120 kV and 100.00 mAs with a 512 x 512 pixel resolution. The field of view was 307 mm and the pixel size was 0.6 mm. The MRI data of the first specimen was obtained, using a 3.0 Tesla GE Medical Systems, signa excitation, with a 512 x 512 pixel resolution and no fat suppression. The field of view was 140 mm, the pixel size was 0.273 mm and the slice increment was 0.5 mm. The MRI for the second specimen was obtained, using a 3.0 Tesla GE Medical Systems, signa HDx excitation, with a 512 x 512 pixel resolution and fat suppression. A Xeta sequence, a field of view of 150 mm, pixel size of 0.293 mm and slice increment of 0.29 mm were used.

The CT and MRI data were used to create accurate three dimensional (3D) models of the distal femurs and proximal tibia of the two cadaveric limbs, using thresholding and region growing techniques. The 3D model, created from MRI data, for each cadaveric specimen was registered to the respective 3D model created from CT-scan data, using both point registration and global registration techniques, employing the least root mean square method (Figure 1). Commercially available Mimics V13.1 software (Materialise, Belgium) was used for this purpose.

Physical measurements of different parts of the cadaveric bone were compared to the corresponding dimensions obtained from CT scan data. The results were within 99% accuracy. The discrepancies in dimensions of the 3D models of the femur and tibia created from CT and MRI data were calculated at 5 mm intervals, as shown by the red lines in Figure 1, using the Medcad module of Mimics V13.1. This method was chosen as opposed to the root mean square of each bone because the magnitude of discrepancy varied with the distance from proximal to distal. This process was carried out for the 3D models of each cadaveric specimen, using the same CT-scannig technique and but different MRI sequences.

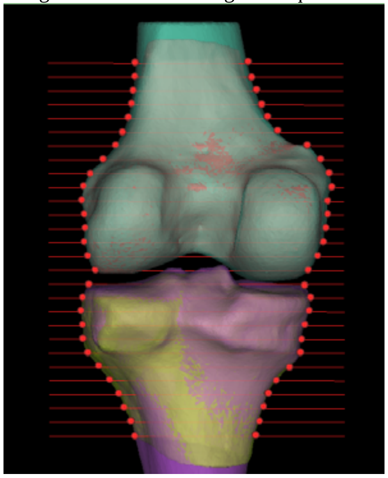

Fig. 1: Registered 3D geometries created from CT and MRI data were used to calculate the discrepencies in dimensions at 5 mm intervals both superior and inferior to the joint line.

RESULTS SECTION:

The discrepancy percentage between the CT and MRI geometries for each cadaver, using the Xeta and 'Citi' sequences are illustrated in Figure 2.

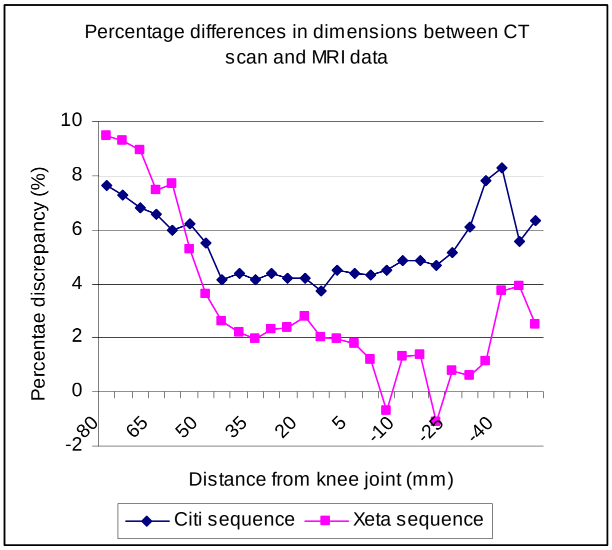

Fig. 2: Percentage difference in dimensions between CT and MRI data, comparing Xeta and 'Citi' sequences. 0 mm corresponds to the joint line. '+' values refer to frmur and '-' refers to tibia

The inaccuracy incurred from the Xeta sequence was 1.17% at joint line, within 2 % from -15 mm to 35 mm and within 4% from -50 mm to 50 mm. The inaccuracy increased to 9.45% at 80 mm proximally. The inaccuracy incurred from the 'Citi' sequence was 4.31 % at joint line, within 4.5% from 0 mm to 45 mm and increased to 7.62% at 80 mm proximally.

DISCUSSION:

Both sets of MRI data gave the least discrepancy at the centre of the field of view, which corresponded to the joint line. The accuracy of the Xeta sequence was four times better than that of model created from the 'Citi' sequence. The accuracy of the model created from the 'Xeta' reduced considerably outside the field of view, at +50 mm and above.

The results show that is is important to chose the right MRI sequence, depending on on the application. The Xeta sequence with a field of view of 150 mm will give accurate geometrical information, within an accuracy of 2% for applications, such as high tibial osteotomy and joint replacements where the implants are 40 mm or shorter. The 'Citi' sequence resulted in innaccuracies of 4.31 % at the joint line. This magnitude of error will make the registration of CT and MRI data for applications such as finite element modeling very difficult. Studies on kinematics, using inappropriate sequences, would lead to questionable results. Some custom-made implants that are designed based on patients' MRI data can lead to less favourable results if the wrong MRI sequence is chosen. Hence, it is important to chose the right MRI sequence for the different applications.

REFERENCES:

References are optional.