Abstract: This work presents a fully unsupervised segmentation method for the segmentation of 3D DESS MRI images of the human knee. Five MRI knees manually segmented by human experts are used as reference atlases to automatically segment subsequent MRI images. The five segmentations are averaged to create the knee segmentation. The methodology was tested on the pilot Osteoarthritis Initiative (OAI) image set of MRI DESS sequences. The data includes longitudinal images from healthy normals and subjects with osteoarthritis (OA) scanned twice at baseline and at the 24 month follow-up. The segmentation methodology was able to produce precise cartilage segmentations of the knees that were used to extract volume, thickness, and subchondral bone plate curvature information of the knee. The quantitative thickness showed precisions ranging from 0.025mm to 0.051mm. The longitudinal reproducibility of the cartilage thickness measurement methodology showed intra-class correlations coefficients (ICC) ranging from 0.39 to 0.79.

Results

Figure 2 shows a sample of the output segmentation created by the multi-atlas segmentation algorithm. The cartilage tissue of the segmented results are 3D reconstructed and quantitated for volume, thickness, and surface curvature. Table 1 shows the performance of the method on the OAI pilot data set. Coefficients of variation of 1.3% were achieved for the average cartilage thickness. The reproducibility to observe changes in cartilage topography are shown in table 2. Good ICC were observed in the estimation of changes for the femoral cartilage volume and thickness (ICC=0.75). Changes in curvature were not as significant and as changes in cartilage volume.

Conclusion

This work shows that it is possible to get precise quantitative data automatically from OAI data sets. The measured degree of precision enabled detection of reproducible changes in a two year period using only 12 subjects from the pilot OAI data. The main limitation of the system is that it may introduce some atlas bias to the measurement. The system mitigated this defect by the introduction of five different atlases, but those atlases are still based on normal knee anatomy. Therefore this system may not be applicable to advanced OA subjects that have large focal cartilage lesions. As next steps, we will evaluate the performance of the system in large OAI data sets and corroborate the observed changes by other OAI investigators.

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