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CT IMAGE SEGMENTATION AND REGISTRATION TO MONITOR DISEASES AROUND THE KNEE JOINT

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Purpose: Early diagnosis of OA (osteoarthritis) and monitoring treatment response are very important for OA patients. The follow-up examinations are frequently used by CT scan or MR imaging. The comparison of each medical image from different follow-up examinations is very important for OA treatment. For this comparison, accurate registration of 3D medical images between different CT examinations of same patient should be important to overcome unexpected misregistrations originated from many causes, different patient posture, different field of view, and different resolution of images on each CT scanning. In this study we attempt to show our new fast and effective registration algorithm for medical images.
Methods: A dataset of knee CT images are used to validate a hybrid segmentation and registration method. The CT data is nearly isotropic and the physical size of voxel is 0.36 x 0.36 x 0.5 mm. The fully automatic segmentation based on Active Contour is employed to extract bone regions of knee joint image. Then a two-steps 3D rigid body registration method is performed after segmentation. First, two CT volumes are initially aligned based on their principal axes. Then, the alignment is refined by optimizing the similarity score of the image's voxel. A normalized cross-correlation (NCC) is used as similarity metric and downhill simplex method is employed to attain the optimal score. The registration is separately accomplished for segmented femur and tibia bone region. For each segmented bone volume, new 20 datasets were created by applying random rigid transformation along x-, y-, z-axes varying between ±10 degree for rotation and ±10 pixel for translation.

Table 1. Mean±SD transformation error measurement

	Rotation (°)			Translation (mm)		
	α	β	γ	t_x	t_y	t_z
Femur	0.31±0.44	0.27±0.40	0.28±0.36	0.24±0.15	0.32±0.22	0.18±0.19
Tibia	0.18±0.27	0.06±0.05	0.18±0.13	0.22±0.13	0.32±0.19	0.34±0.34

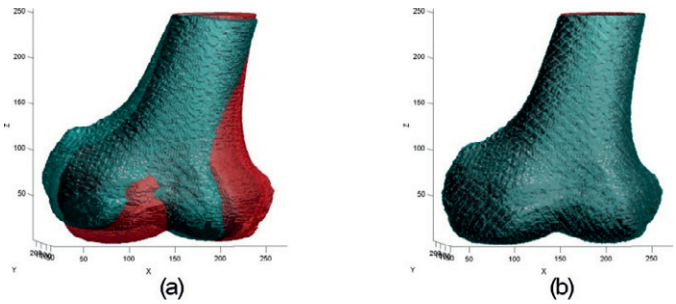

Fig. 1. Femur bone: the superimposed 3D visualization of reference and float volume. (a) before registration, (b) after registration.

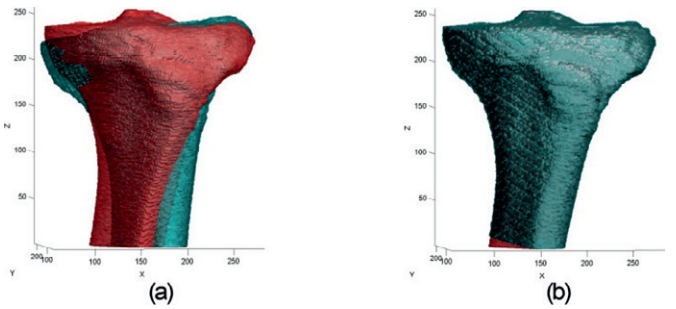

Fig. 2. Tibia bone: the superimposed 3D visualization of reference and float volume. (a) before registration, (b) after registration.

Results: The registration accuracy was 0.21 (±0.26 SD) degrees for rotation and 0.27 (±0.2 SD) mm for translation. The accuracy was evaluated by mean and standard deviation (SD) of transformation errors and rotation errors. Table 1 shows the mean (±SD) of transformation errors and rotation errors of femur and tibia registration. Figure 1 and Figure 2 show 3D visualization before and after registration of femur and tibia bone. Red volume denotes the reference volume and green volume represents float volume. The figures demonstrate that the float volumes were aligned to the same coordinate of reference volumes accurately.
Conclusions: The preliminary study of synthetic datasets showed that the segmentation and registration method can be readily applicable for monitoring the knee joint disease.

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EARLY SUBCHONDRAL BONE MORPHOMETRIC CHANGES IN OSTEOARTHRITIS: A MICRO-CT STUDY IN THE MURINE JOINT INSTABILITY MODEL

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Purpose: Subchondral bone is involved in osteoarthritis (OA) both at early and late stages. Subchondral bone modifications have been described in mice models of osteoarthritis at early and late stages. However, time-dependent effects of changes in subchondral and trabecular bone are poorly known. The objective of this study is to analyse the changes of trabecular bone structure along with subchondral plate in OA using the model of joint instability in mice.
Methods: To analyse the effects of instability, partial meniscectomy (MNX) of the medial meniscus was performed on right knees of 10 week-old CD1 mice. A sham operation was performed on controlateral knees. At 4 and 6 weeks, samples were fixed and prepared for ex vivo micro-CT acquisition (pixel size 9 µm, Skyscan® 1172, Kontich, Belgium). Then, knees were decalcified and prepared for cryosections. For each medial compartment, the OARSI OA score (sum of the scores at tibiae and femurs) was the mean of 3 saggital slide levels stained by Safranin-O. Morphometric analyzes by micro-CT were performed in the medial tibial plateau to study the trabecular network. Subchondral plate thickness was also measured on reconstructed images. Wilcoxon's tests were performed.
Results: Animals were sacrificed at week 4 and 6. The OA score confirmed a time-dependent effect of MNX in cartilage degradation (4.00 and 6.22 at 4 and 6 weeks respectively). At week 4, micro-CT showed a marked decrease in bone volume in MNX knees compared to sham (BV/TV: 47.6% ± 5.0 vs 62.0% ± 4.7, respectively) which was still observed at week 6 although milder (51.2% ± 2.9 vs 58.0% ± 1.5, $p = 0.028$). These results were accompanied by a higher trabecular separation markedly more severe at week 4 indicating that bone loss was related to a higher bone resorption. No significant effect on the thickness of subchondral plate was observed at week 4 but a mild increase appeared at week 6 (0.184 mm vs 0.171 mm, $p = 0.043$).
Conclusions: These preliminary results show that micro-CT evaluation of tibial epiphysis trabecular network and subchondral bone plate thickness is a reliable technique in the murine joint instability OA model. This confirms that an initial decrease in bone volume occurs at the early stages of the disease. Further experiments with greater number of animals are required to describe subchondral bone morphometric changes in a time-dependent fashion.

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CARTILAGE SIGNAL INTENSITY ON MRI: ASSOCIATION WITH BODY MASS INDEX, CARTILAGE DEFECTS AND TYPE II COLLAGEN BREAKDOWN

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Purpose: MRI has enabled the observation of many abnormal features of OA. However, the ability of MRI to detect early osteoarthritic changes is limited. Our aim was to develop a semi-automatic computer program to assess cartilage signal intensity on T1-weighted MRI images, and then examine whether signal intensity is associated with 1) body mass index (BMI), 2) cartilage defects, and 3) type II collagen breakdown in young to middle-aged adults.
Methods: A total of 50 subjects (mean age 41, range 29–57; 64% female) were randomly selected from the community. MRI scans of right knees were performed (sagittal T1-weighted fat saturation 3D gradient recall