Knee osteoarthritis (OA)
- Most prevalent cause of disability among adults and elders
- This disease degrades the articular cartilage tissue
  - The pain impairs the joint function
  - In severe cases an artificial joint is necessary

Research in knee OA
- There is little understanding about the pathophysiology of OA
- Currently emphasizes on non-invasive imaging methods
- The morphology of knee OA is well documented
- There is a necessity to also study the biochemical changes

MRI T2 imaging: Sensitive to biochemical of tissue

Characterization of imaging sequences
- Multiple images at different position along the knee acquired
- Segmentation of bone and cartilage tissues
  - Define the cartilage region
  - Option of characterizing mean of image sequence values
- Build 3D model from segmentation vertices and faces (mesh)
- Use 3D mesh to obtain spatial distribution of image sequence
  - Example: Variation of cartilage thickness
- The spatial variation is a better indicator for OA
- Spatial distribution of MRI T2 values has yet to be studied

New approach to study the biochemical spatial variation of cartilage using MRI T2 needed!

Evaluation of registration method
- Sagittal 3D SPGR sequences of 9 healthy subjects (5 male; 24±3 years; 1.7±0.1 m; 68±11 kg)
- Subjects were scanned twice
- 3D model from segmenting bone and cartilage
- Source mesh registered to target mesh

Comparison of source and target
- Distance error of femur and tibia
- Rigid and Non-rigid transformation
- Distance error of registration method
- Aggregation of error at the edges
- Improves with non-rigid transformation
- Decrease of error in tibia more visible

Identification of voxels in target sequence
- Original (target) cartilage region is known
- Source mesh is registered to target mesh
- Overlapping of source and target regions
  - Calculate sensitivity and specificity

Rigid Transformation
- Sensitivity: 87.75% Specifity: 98.47%
- Sensitivity: 90.82% Specificity: 98.67%
- Sensitivity: 93.06% Specificity: 98.12%

Evaluation of method on MRI T2

Data
- Source sequence T1 weighted MRI
- Target sequence MRI T2

Characterization of T2 sequence
- Value assigned for each vertex
- Selection of voxel in 6 mm radius
- Corresponding to cartilage
- Sum up voxel values in 3D space
- Average by number of voxels
- Obtained density map of T2
- Spatial variation of T2 sequence!

Verification of correct T2 values
- Current papers calculated average T2
- Single image with acceptable contrast
- Estimation of cartilage region
- Mean value for T2 relaxation time
- Comparison with values obtained
  - Same range as literature values
  - Additionally the spatial variation of T2 relaxation times obtained

Fibres: T2 values

Different parameters like cartilage thickness and collagen fibrils probably correlate and adapt to each other in a healthy knee. OA could be initiated when this balance is disturbed and a negative cycle starts degrading the cartilage.

Conclusion
- A method was developed to assess the T2 cartilage region
- The accuracy of the method was evaluated
- A practical application on MRI T2 sequence was shown
- Useful tool for localization of the T2 cartilage region
- Future potential for discovering correlation between spatial variation of different parameters like thickness and T2
- Better understanding of the processes involved in knee OA

Design a method for cartilage localization

Image sequence with bone and cartilage segmented
- MRI T2 sequence with only bone segmented
- Register 3D mesh of source bone and cartilage to target bone of MRI T2
- Obtain location of cartilage region

Registration method

Rigid transformation
- Variation of Iterative Closest Point (ICP) algorithm
- Rotation and translation of whole source 3D mesh
- First general alignment, no deformation

Non-rigid transformation
- Deformation of 3D mesh
- Individual point alignment
  - a) Projection of source bone vertices (red) onto the target bone surface (turquoise)
  - b) Vector field from old to new vertices position
  - c) Applying vector field to source cartilage vertices

Source Cartilage Vertices
Target Bone Vertices
Source Bone Vertices

The non-rigid transformation of the source mesh onto the target.

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