IA-6

In vivo Quantification of Arthritis Severity in a Murine Model by µCT Imaging

B. Hoffmann, C.M. Svensson, I. Irmler, T. Kamradt, M.T. Figge, H.P. Saluz

01/09/2014

Leibniz Institute for Natural Product Research and Infection Biology - Hans Knöll Institute

In vivo Quantification of Arthritis Severity in a Murine Model by µCT Imaging

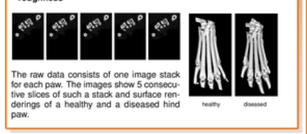
Bianca Hoffmann[1,2,3], Carl-Magnus Svensson[2], Ingo Irmler[1], Thomas Kamradt[1], Marc Thilo Figge[2,3], Hans Peter Saluz[1,3]

[1]Cell and Molecular Biology, Leibniz Institute for Natural Product Research and Infection Biology - Hans Knöll Institute
[2]Applied Systems Biology, Leibniz Institute for Natural Product Research and Infection Biology - Hans Knöll Institute
[3]Friedrich Schiller University Jena
[4]Immunology, University Hospital Jena

1. Introduction

As shown previously, inflammation in Glucose-6-phosphate isomerase induced arthritis in mice can be examined by visual scoring or positron emission tomography [1, 2]. We want to have a deeper look inside erosive processes leading to bone damage via µCT imaging using the following methods:

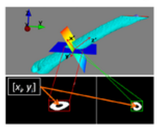
- **Texture based segmentation** and quantification of **cortical bone thickness**
- **Surface reconstruction** and quantification of **cortical bone surface roughness**



The raw data consists of one image stack for each paw. The images show 5 consecutive slices of such a stack and surface renderings of a healthy and a diseased hind paw.

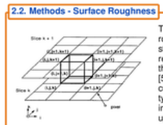
2.1. Methods - Cortical Thickness

The original CT images are convolved with a set of filters shown left [3]. Pixels are clustered using k-means algorithm based on their filter responses into foreground and background pixels.

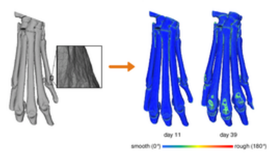


The slices in the original CT dataset are parallel to the x-y plane. We are looking for slices that are orthogonal to the bone in the coordinate system x'-y'-z'. The orthogonal slices are used to determine the thickness of the cortical bone.

2.2. Methods - Surface Roughness

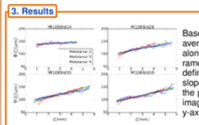


The calculation of local surface roughness follows [4]. In a first step a high resolution surface reconstruction is performed with the marching cubes algorithm [5]. The objects surface cuts cube edges with different pixel types at its ends and the crossing point is interpolated to make up the isosurface.

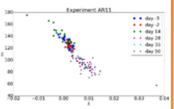


The resulting model consists of triangular facets with each facet having a normal vector. For the calculation of local roughness for each facet the average angle between its normal vector and all normal vectors of facets in a given vicinity is computed. A high value denotes a rougher region while a low value denotes a smoother region with minimum and maximum being 0° and 180°, respectively.

3. Results



Based on profiles of the average cortical thickness along the bones, two parameters k and m can be defined with k being the slope of a line fitted to the profile and m being the imaginary crossing with the y-axis at $\xi = 0$ mm.



A scatterplot of calculated k and m parameters shows clear differences between measurements of the acute and the chronic stage of the disease.

The change of surface roughness is expressed as effect size and p-value for each timepoint and shows clear differences around day 14 after immunization.

Outlook

- Validation of bone thickness and roughness measures by longitudinal studies with control animals
- Combination of the measures and construction of an algorithm for evaluation of disease diagnosis and progression
- Adaptation of the algorithm for rheumatoid arthritis for clinical use

References

[1] Irmler *et al.*, *Arthritis Res Ther.*, 12(6):R203, 2010.
[2] Irmler *et al.*, *Arthritis Res Ther.*, 16(4):R155, 2014.
[3] Malik *et al.*, *IJVC*, 43(1):7–27, 2001.
[4] Silva *et al.*, *Mol Imaging*, 5(4):475–484, 2006.
[5] Lorensen *et al.*, *Computer Graphics*, 21(4):163–169, 1987.

Bundesministerium für Bildung und Forschung
grant number 0316040A

Contact: bianca.hoffmann@hki-jena.de; carl-magnus.svensson@hki-jena.de