In vivo quantification of arthritis-induced alterations of murine bones based on PET/CT image data

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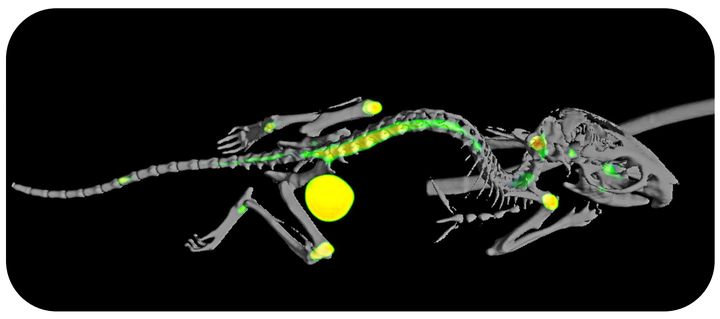
Background

Rheumatoid Arthritis (RA)
- one of the most common autoimmune diseases
- leads to joint swelling, bone erosion, loss of joint function

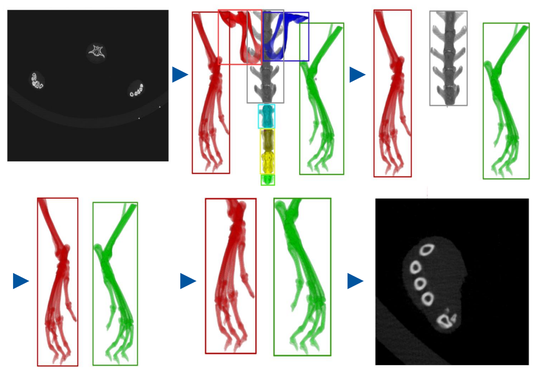
Experimental Arthritis
- used to study RA and arthritic processes
- induced by glucose-6-phosphate isomerase (G6PI) [1]

Longitudinal, *in vivo* Imaging (PET/CT)
- combined positron emission tomography/computed tomography

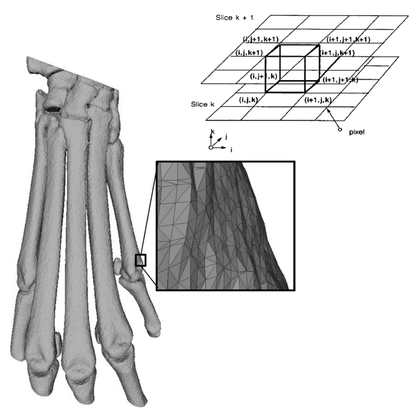


Methods

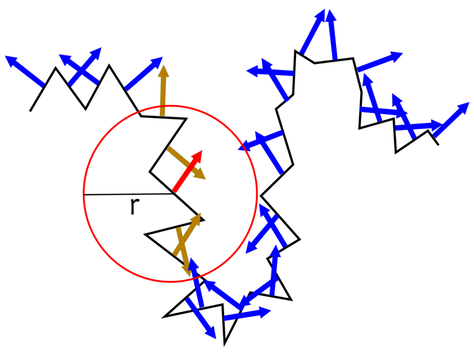
1. Prepare volumes of interest (VOIs)
   - extract parts of image stack that contain the hind paws



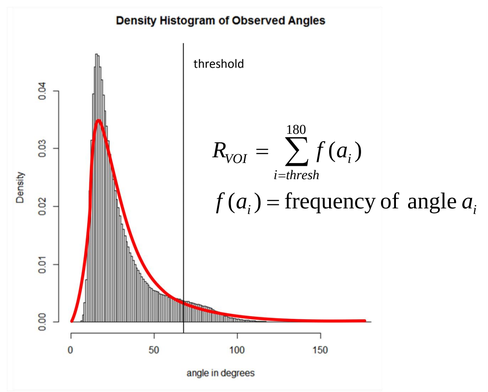
2. Reconstruct surface
   - marching cubes algorithm [2]
   - triangulated surface mesh

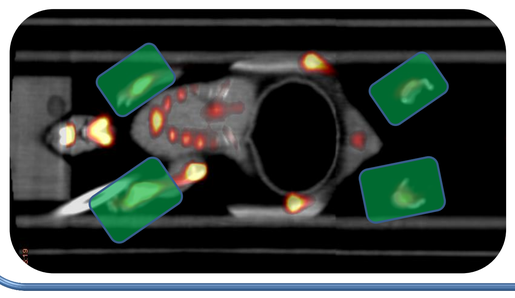


3. Calculate local roughness [3]
   - for each facet normal
   - average angle between facet normals



4. Calculate global roughness [3]
   - composite histogram
   - sum of frequencies of angles above threshold

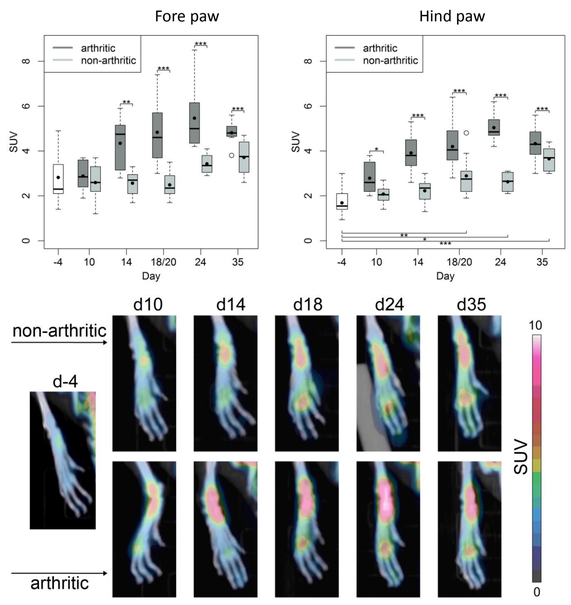


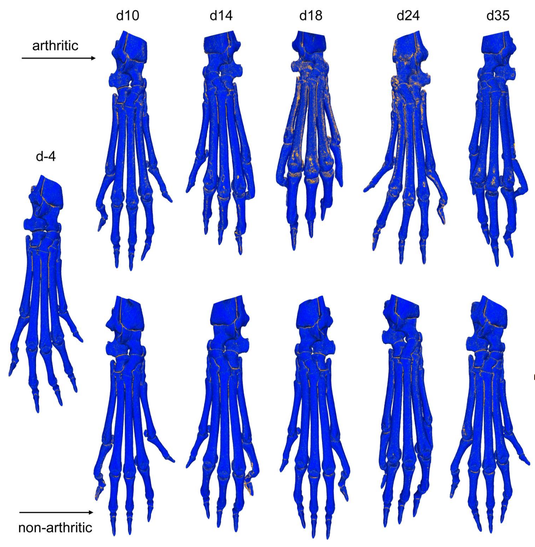


PET image analysis
- manually place regions of interest around paws
- calculate standard uptake value (SUV)

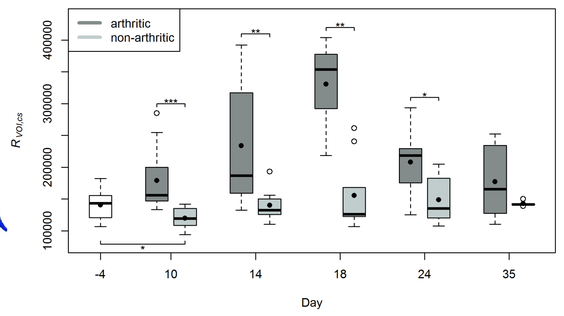
Results

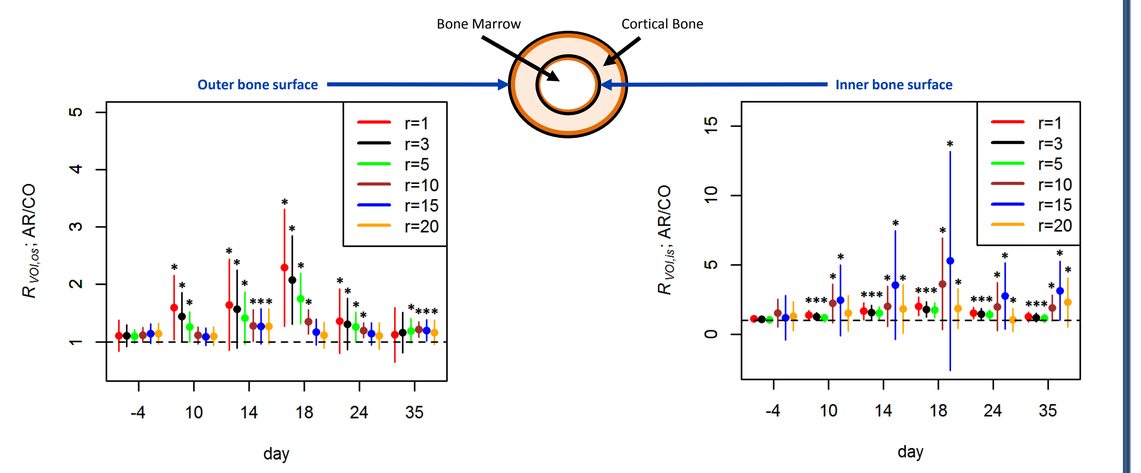
PET imaging results
- increased uptake of [^{18}F]-fluoride in arthritic animals
- distribution of the tracer is visualized by PET/CT image fusion
- accumulates predominantly in metatarsophalangeal and tarso-crural joint regions





CT imaging results
- arthritic animals show increased bone roughness in hind paws
- roughness is significantly increased already at day 10





- variation of roughness radius *r* reveals differences between periosteal and endosteal cortical bone surface

Conclusion

- combined PET/CT imaging allows for longitudinal, *in vivo* studies
- ^{18}F-fluoride is well suited to quantify pathological bone metabolism [4,5]
- automated CT image analysis allows for fast and objective quantification of bone destruction [4,5,6]
- roughness evaluation very sensitive for early bone erosion
- revealed different dynamics of bone erosion at periosteal and endosteal sites of cortical bone

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References:

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