

Presented at the OARSI Annual Congress 2014

Bone marrow lesions are spatially associated with denuded cartilage in osteoarthritic knees: data from the Osteoarthritis Initiative

**Michael A. Bowes¹, Stewart WD McLure², Christopher BH Wolstenholme¹, Graham R. Vincent¹,
Sophie Williams², Philip G. Conaghan²**

¹ imorphics Ltd, Manchester, UK, ² Leeds Institute of Rheumatic and Musculoskeletal Medicine, University of Leeds, Leeds, UK

Purpose: Factors which affect the formation of bone marrow lesions (BML) in knee osteoarthritis (OA) are poorly understood. This study employed statistical shape modelling to study the spatial distribution of BMLs in all knee bones of an OA cohort, and compare this with the spatial distribution of denuded cartilage in the same knee joints.

Methods: A convenience cohort of 77 subjects with medial OA was identified from the NIH-OAI dataset. Subjects had K-L scores of 2 or 3; medial JSN > lateral JSN, medial osteophytes and $\geq 1^\circ$ of varus mal-alignment. Baseline and 12 month images were segmented. BML were manually segmented in the TSE images, articular cartilage using the DESS images. Segmenters were blinded to time point but not to subject, using EndPoint software (Imorphics, UK). Bone surfaces were identified in both types of image by automated segmentation using active appearance models; this provides a reference bone surface in each image allowing for direct comparison of the BML and cartilage results. Cartilage thickness was measured on each cartilage plate using normal projection from the bone surface; thickness of less than 0.5mm (the average size of 1 voxel edge) was considered as denuded. A semi-quantitative method for analysing the comparative position of the BML and denuded cartilage was developed. BML volumes were projected onto the bone surface, and the resultant area was displayed alongside the denuded cartilage from the same imaging visit. For each anatomical region if a BML was present it was scored as either overlapping the denuded area or not. 3-dimensional images of the characteristic BML spatial distributions were prepared by creating 3D surfaces of all BMLs, along with the bone surface in which they were found. These surfaces were linearly warped to the mean bone reference image, and a population image created which containing the number of BML 'hits' found at each voxel in the image. Typical BML distribution was calculated by identifying all voxels in the reference image which had a value equal to or greater than half of the maximum number of recorded BMLs in any one voxel in the image.

Results: 38 of the subjects were women, mean age (SD) was 61.4 (9.9), and mean BMI was 30.9 (4.7). The majority of BML lesions were confined to 4 regions; 40 subjects had BML in the medial femorotibial region (MFT), 29 in the lateral patellofemoral region (LPF), 40 in the medial tibia (MT), and 25 in the lateral patella (LP). 72 subjects had BMLs present in more than one compartment. Mean volume of BML in each of these regions was MFT: 972 mm³, LPF: 954, LP: 745, MT: 1282. Overlap scoring for these 4 regions were as follows. MFT: 65%, MPF region: 87%, LPF: 69%, MT: 93%). Denuded cartilage showed a clear pattern in the femur and tibia, with denudation concentrated in regions rather than across the articulating surface. Denudation in the patella was more evenly distributed. 3D visualisation

of the BML spatial distribution showed good agreement between the characteristic position of the BML volumes, and the areas of denuded cartilage (Figure 1).

Conclusions: The study of BMLs is typically conducted using semi-quantitative methods, which do not provide good spatial information of either cartilage or BML lesions. The strong association between BML and denuded cartilage in this study is striking, and suggests that BMLs are at least in part caused by mechanical loading, which will be higher at regions lacking the protection of hyaline cartilage.

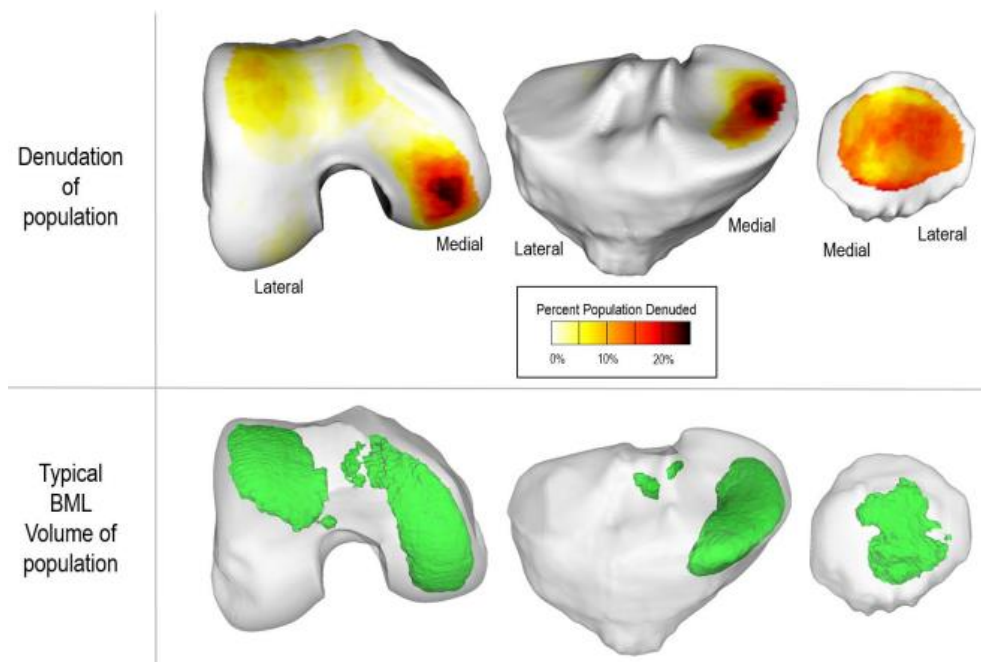


Figure 1 – Spatial comparison of summary population for denuded cartilage (top row) and typical BML volume (bottom row). Denudation figures show the percentage of the population who have denuded cartilage at each point on the bone surface (scale in legend). BML volumes calculated as described in text.