Microstructural adaptations of the subchondral tibial bone are related to the mechanical axis deviation in end-stage varus osteoarthritic knees

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Purpose

- Recent studies suggest that OA involves the whole joint and highlight the crucial contribution of subchondral bone in OA development.
- Only limited data has been reported in this context.
- The relation between the morphometry of the cartilage and bone in the tibial plateau and the OA-induced changes in the joint's mechanical axis remains unexplored.

Aim

- The aim of this study was to analyze the subchondral bone microarchitecture and its specific relation to the knee alignment.
- We hypothesized that
  (1) the subchondral bone plate thickness and the trabecular bone volume fraction will increase closer to the weight-bearing axis of the knee.
  (2) that the trabecular orientation will be related to the distance of the mechanical axis.

Methods

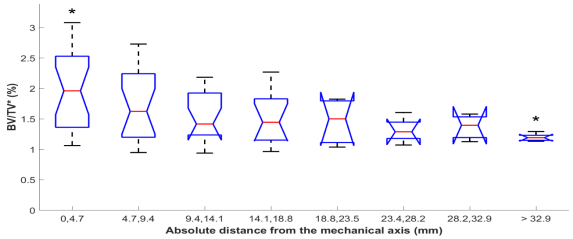
- Entire tibial plateau specimens were excised from eighteen patients with varus deformities during total knee arthroplasty.
- The tibial plateaus were micro-CT scanned (Skyscan 1172, Bruker, MA, USA) and reconstructed at 20.1 µm voxel size.
- For each medial condyle, 13 cylindrical VOIs were defined for further analysis of cartilage, subchondral bone plate (SBP), and subchondral trabecular bone (STB).
- Mechanical axis deviation, defined as the perpendicular distance from the center of the knee to the line through the centers of the femoral head and the ankle joint, was measured using radiographs.

Results

- Cartilage thickness was consistently getting smaller close to mechanical axis ($p<0.001$), whereas it was coinciding with regions of low SBP thickness and high STB bone volume fraction (BV/TV) underneath.
- The SBP with the average of 714.9 ± 205.8 µm was significantly higher for more medially positioned VOIs ($p<0.001$).

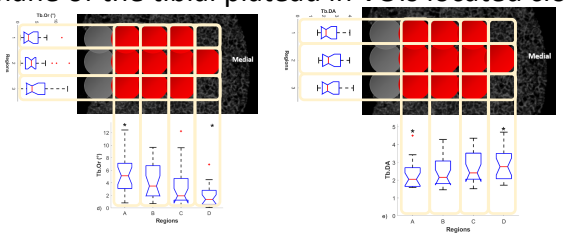
Results

- Close to the location of the mechanical axis BV/TV is significantly ($p< 0.05$) higher.



*To account for inter-individual differences, the BV/TV in medial condyle VOIs has been normalized with the BV/TV of the lateral condyle. Statistically significant differences ($p< 0.05$) were found between groups marked with *.*

- Trabeculae were also more superior-inferiorly oriented, i.e. perpendicular to transverse plane of the tibial plateau in VOIs located closer to the mechanical axis.



Starting from the knee center, 13 cylindrical VOIs were defined along the tibia's medio-lateral axis. For quantitative analysis, the VOIs were grouped with respect to their anatomical location from central to medial (groups A-D; Fig b) and from anterior to posterior (groups 1-3; Fig 4) in medial condyle Trabecular orientation (Tb.Or), and e) degree of anisotropy (DA) in subgroups A, B, C, and D as well as subgroups 1, 2, and 3.

Conclusions

- As cartilage and subchondral bone changes reveal responses to local mechanical loading patterns in the joint, our results suggest region-specific subchondral bone adaptations to be related to the degree of varus alignment.
- More specifically, subchondral sclerosis appeared to be most pronounced closer to the weight-bearing axis of the knee.
- Besides, the trabecular orientation changes related to the degree of varus alignment, whereby the trabeculae are directed towards the load bearing axis.