

3D HR-MRI at 3T for dedicated visualization of in-vivo locoregional deformation pattern of the knee cartilage for cartilage contact areas in different work-related flexion postures

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Purpose: To analyse locoregional deformation patterns as a potential indicator for cartilage contact areas in the knee joint after loading.

Materials and Methods: The right knees of 10 healthy volunteers were examined before and after loading as well as after 90 min rest at 3T using a sagittal 3D-T1-w FLASH-WE sequence (14.2ms/7.2ms/15°/ 0.3²x1.5mm³). Chosen loading positions (kneeling, squatting, heel sitting) represent frequent exerted positions in craftsmen professions (1-2), while 50x knee bends served as reference to literature (3-4). Based on 3D-reconstructions of segmentations of the femoral, patellar and tibial cartilage, 2σ-thickness-difference-maps were generated for visualization of significant deformations. The individual maps were fused for analysis of common deformation patterns across the group. Voxelbased and global precision error (PE) and differences in volume (Vol), mean thickness (mTh) and cartilage-bone-interface-area (CBIA) were calculated between the examination steps (Wilcoxon test) as quality control.

Results: Significant deformations were found vertically in the medial facet and in the horizontal caudolateral area of the patellar cartilage, at the dorsal femoral condyles, medial>lateral and at the anterior inner and central areas of the tibial cartilage, lateral>medial. Squatting showed specific pronounced deformations at the medial peripheral patellar facet, the dorsomedial femoral condyle and semicircumferential at both medioanterior tibial plates, while after knee bends the deformation areas were overall shallower, but broader for all cartilage plates. Voxelbased PE depended on cartilage thickness (Th) with values between 0.12–0.35mm. For Th≥1mm PE was <0.31mm (under voxel size), for Th≥2mm <0.22mm. Global PE was 1.9-4.0% for Vol, 1.8-3.6% for mTh and 1.3-2.8% for CBIA. Significant global changes were 1.0-4.9% for Vol and mTh.

Conclusion: The data provide direct quantitative visualization of locoregional deformation patterns in-vivo after standardized loading positions in the knee cartilage. They are anatomically and functionally plausible and might indicate areas at risk for load-associated degeneration and consecutive osteoarthritis (5-7). Similarities in the deformation patterns might be a consequence of knee flexion over 90° in all exercises. However, specific patterns were found for squatting and knee bends possibly due to a higher flexion grade in the former and the dynamic movement character in the latter. The data may further support the understanding of individual knee kinematics and contribute to improvement and validation of biomechanical models for the knee.

Figure:

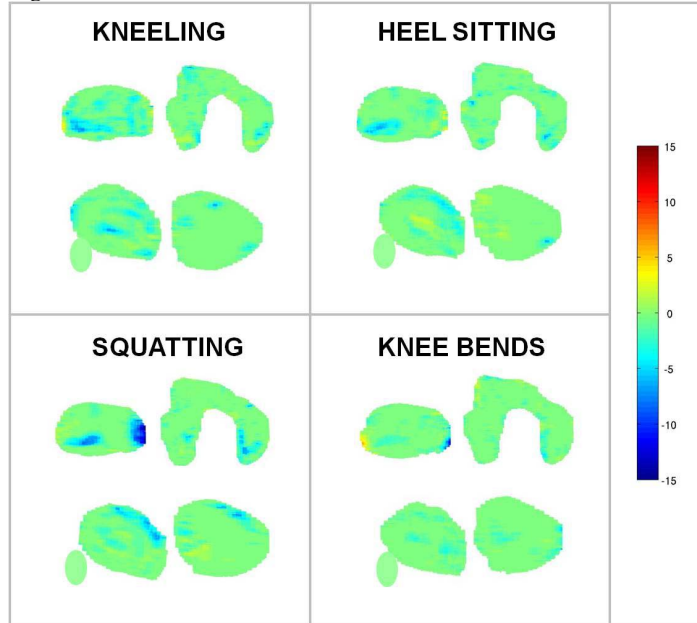


Figure:
The figure shows the fused 2σ-thickness-difference-maps for each of the four examined loading postures for each cartilage plate. Color-coded bar in %-change.

Literature:

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