Musculoskeletal Research

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Form-Function relationship in the musculoskeletal system

The glenohumeral joint – a mismatching system? A morphological analysis of the cartilaginous and osseous curvature of the humeral head and the glenoid cavity

Radial mismatch, glenohumeral conformity ratios and differences between cartilaginous and osseous radii highly depend on the measured plane. The comparison of cartilaginous radii between humeral head and glenoid in different planes provides new information to understand the degree of conformity during abduction of the upper limb. To investigate the radii, CT-images of shoulder specimen were analysed using an image visualization software and statiscically analysed. Measurements of the radii in the glenoid revealed a significantly larger radius for bone than cartilage, whereas for the humeral head the opposite was the case. Highest ratios for cartilage in the transverse plane were found in the inferior and central areas of the joint surface, whereas the smallest ratios were found in the superior area (Fig.1). The radial mismatch varied between 0.1 mm and 13.6 mm, depending on the measured plane. The results suggest that in abduction, the cartilaginous guidance of the humeral head decreases which might permit the humeral head an anterior-posterior shifting as well as superior-inferior translation.

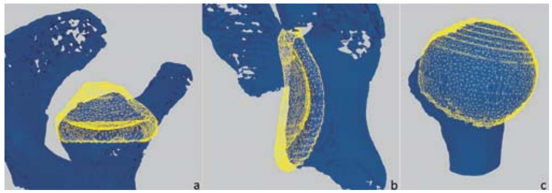

Fig. 1: Visualisation of the cartilaginous (yellow mesh) and osseous structure (blue) in (a) infero-superior view of the glenoid, (b) antero-posterior view of the glenoid and (c) frontal view of the humeral head.

Changes of Density Distribution of the Subchondral Bone Plate after Supramalleolar Osteotomy for Valgus Ankle Osteoarthritis

CT-osteoabsorptiometry (CT-OAM) has been used to visualize subchondral bone plate density distribution regarding to ist mineralization. The purpose of this study was to analyze changes in density distribution of the subchondral bone plate before and after supramalleolar realignment osteotomies due to adaptational processes. We retrospectively analysed pre- and postoperative CT images of patients with post-traumatic unilateral valgus ankle OA by means of CT-OAM. At a mean follow-up of 20 months we observed a significant pre- to postoperative decrease of the mean high-density area ratio in tibia (lateral and posterior area) (p_0.05) and the talus (lateral area) (p_0.05). Pairwise comparison between the pre- and postoperative mineralization at the articular surface showed a significant decrease of the high-density area ratio for the tibia and the talus. The tibial and talar subchondral bone plate density, regarding to its mineralization, decreased after supramalleolar medial closing wedge osteotomy in patients with valgus ankle OA correlating with an improvement of pain symptoms (VAS decreased from 6.2+/-0.9 pre- to 2.8+/- 0.9 postoperatively (p=0.027). The results of this study suggest that realignment surgery may lead to a better load distribution.

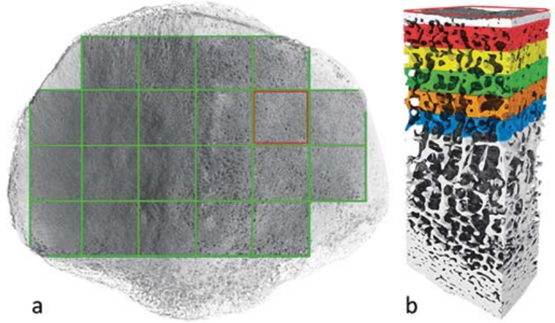

Fig. 2: Method of micro -CT; definition of measurement cube and regions of interest. (A)3D reconstruction, left patella in dorsal view, 21 areas for extraction of measurementcubes marked. (B) Measurement cube with 5 highlighted regions of interest (1st ROI:red; 2nd ROI: yellow; 3rd ROI: green; 4th ROI: orange; 5th ROI: blue) just below the subchondral bone plate.

Insight into the 3D-trabecular architecture of the human patella

The subchondral bone plate (SBP), a dynamic component of the osteochondral unit, shows functional adaptation to long-term loading by distribution of the mineral content in a manner best serving the mechanical demands. Since the received joint-load is transmitted into the trabecular system, the spongy bone should also exhibits topographical differences. To evaluate the regional variations in trabecular architecture, ten physiologic patellae were analysed for defined parameters of bony structure by means of micro-computed tomography (Fig.2). The obtained measurements are: Bone volume fraction (BV/TV); Bone surface density (BS/TV); Trabecular number (Tb.N); Trabecular separation (Tb.Sp); Trabecular thickness (Tb.Th); structure model index (SMI); and the Degree of anisotropy (DA). The evaluated architectural parameter varied within the trabecular system and showed regular distribution patterns (Fig.3). It proved to be distinctive with maxima of material and stability situated below areas of the highest long-term load intake. With increasing depth, the pattern of distribution was persistent but lessened in intensity. The parameters significantly correlated with the density distribution of the SBP. The trabecular network adapts to its mechanical needs and is therefore not homogenously built. Dependent upon the long-term load intake, the trabecular model optimizes the support with significant correlation to the density distribution of the SBP.

Selected Publications

Zumstein V, Kraljevic M, Hoechel S, Conzen A, Nowakowski AM, Müller-Gerbl M. (2014) The glenohumeral joint – a mismatching system? A morphological analysis of the cartilaginous and osseus curvature of the humeral head and the glenoid cavity. J Orthop Surg Res. 13;9:34

Nowakowski AM, Kamphausen M, Pagenstert G, Valderrabano V, Müller-Gerbl M. (2014) Influence of tibial slope on extension and exion gaps in total knee arthroplasty: increasing the tibial slope affects both gaps. Int Orthop. 38(10):2071–7

Lopez-Rios J, Duchesne A, Speziale D, Andrey G, Peterson KA, Germann P, Unal E, Liu J, Floriot S, Barbey S, Gallard Y, Müller-Gerbl M, Courtney AD, Klopp C, Rodriguez S, Ivanek R, Beisel C, Wicking C, Iber D, Robert B, McMahon AP, Duboule D, Zeller R. (2014) Attenuated sensing of SHH by Ptch1 underlies evolution of bovine limbs. Nature. 511(7507):46–51

Hoechel S, Schulz G, Müller-Gerbl M. (2015) Insight into the 3D-trabecular architecture of the human patella. Ann Anat 200:98–104

Hauser NH, Hoechel S, Toranelli M, Klaws J, Müller- Gerbl M. (2015) Functional and Structural Details about the Fabella: What the Important Stabilizer Looks Like in the Central European Population. Biomed Res Int. 2015:343728

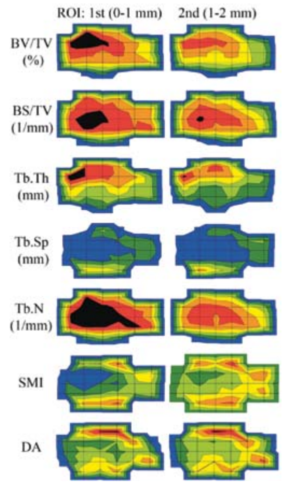

Fig. 3: 2D distribution charts of trabecular architectural parameters for the first two of analysed ROIs (1 and 2 mm below the SBP)