Introduction:
Joint instability and glenoid loosening represents nearly half of all complications in total shoulder arthroplasty (TSA) [1, 2]. Eccentric loading of the glenoid appears to be responsible for these complications. It has been stated, that this subluxation tendency exists already preoperatively [3], demonstrating that a preoperative identification of humeral head de-centering is clinically important. In such cases an extensive release or reconstruction of the active stabilizers needs to be performed [3]. Although the direction of the joint reaction force is determined by the musculature, diagnostic work-up is currently restricted to morphological analyses.

We tested the hypothesis that (1) functional malcentering of the humeral head during arm elevation and normal neuromuscular control exist in patients with glenohumeral OA and (2) that this malcentering has a high correlation with the long-term loading of the glenoid.

Material and methods:
The shoulders of 35 healthy volunteers (23–39 y.) and of 20 patients (51-84 y.) with glenohumeral osteoarthritis (OA) were investigated. All patients complained of pain and loss of function in the affected shoulder; they revealed no history of trauma or surgery, and showed no systemic musculo-skeletal disease. Conventional radiography revealed severe glenohumeral arthritis in all patients. Morphologic analysis by highfield MRI demonstrated primary glenohumeral OA in all patients. Morphologic analysis of the rotator cuff was found (cuff-arthropathy). In all cases, findings were confirmed during subsequent surgery.

Open MRI and Digital Image processing
The shoulder joints were examined in an open MR system (0.2 T; Magnetom Open; Siemens; Germany) and a T1-weighted 3D GRE sequence (TR 16.1, TE 7.0 ms, FA 30°) was applied. The spatial resolution was 1.88 x 0.86 x 1.72 mm and the acquisition time 4`26 min. Transverse images were obtained perpendicular to the glenoid at 30° and 90° of abduction [neutral and external rotation]. After data-transfer onto a parallel computing system, 3D reconstruction of the bony structures were performed. A glenoid-based coordinate system was used to determine the 3D position of the humeral head and the amount and direction of glenohumeral translation.

Comparison of head position and mineralization pattern of the glenoid
In the transversal plane, all patients demonstrating a sufficient centering of the humeral head in all arm positions, showed a high-density maximum in the central aspects of the glenoid. Those shoulders with a fixed posterior decentering, yielded a mono-centric posterior mineralization pattern. In patients with a centered humeral head position at 30° of abduction and a posterior decentering during arm elevation a bicentric dorso-central density pattern was observed (Fig. 1). In the vertical plane patients with a fixed superior decentering of the humeral head (cuff-arthropathy) yielded similar mineralization pattern being shifted to superior (Fig. 1). A significant correlation (p<0.05) was found between the position of the mineralization maxima and the humeral head in both planes (Spearman coefficient of correlation: 0.966 and 0.956).

Conclusions:
We analyzed the hypothesis that in some patients a functional decentering of the humeral head exist and that the decentering of the humeral head influences the long-term stress distribution of the glenoid. While only 23% of the patients demonstrated a fixed posterior off-centering, more than 80% were off-centered (functional decentering) during arm motion. Furthermore, our results suggest that glenohumeral kinematics has a strong influence on the long-term stress distribution of the glenoid. This technique allows one to identify preoperatively patients with functional or fixed decentering and may lead to a reduction of the most frequent postoperative complications in shoulder arthroplasty.

References:

Affiliated Institutions for co-authors
** Department for Sports medicine; BG Clinics Frankfurt, Germany
*** Institute for medical informatics GSF Neuherberg, Germany