PATHOMECHANICS IN ATRAUMATIC SHOULDER INSTABILITY –
CORRELATION BETWEEN SCAPULAR KINEMATICS AND HUMERAL HEAD POSITION

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Introduction:
Malpositioning of the scapula is assumed to be a relevant factor of atraumatic shoulder instability, which must be considered for therapy. However, only few quantitative data exists on scapular kinematics in these patients [1]. Therefore it is unknown whether a correlation between scapular kinematics and glenohumeral instability really exist and whether all or only some patients demonstrate scapular malpositioning. The identification of scapular malpositioning as potential pathogenetic factor is clinically relevant, because an inferior capsular shift will likely fail to be effective in such patients, since the positioning of the scapula is not affected by this procedure.

The objective of this study was to analyze 3D scapular kinematics and glenohumeral (de-)centering in patients with atraumatic shoulder instability and to investigate the correlation between both factors.

Material and methods:
The shoulders of 28 healthy volunteers (24 – 39 y.) and both shoulders of fourteen patients (8- 53 y.) with atraumatic shoulder instability were investigated. All patients complained of instability symptoms or of pain during specific activities, and they reported a large number of (sub-) luxations (= 8) during daily activities. All patients were able to reduce their shoulders without aid of a physician. Highfield MRI revealed an increased capsular volume in these patients, but no Bankart lesions.

The shoulder joints were examined with an open MR system (0.2 Tesla; Magnetom Open; Siemens; Germany) and a T1-weighted 3D gradient recalled echo sequence (TR 16.1, TE 7.0 ms, FA 30°). 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 cavity at different arm positions (30° and 90° of abduction [neutral and external rotation], maximal abduction)- with and without muscle activity.

Digital Image processing
After image acquisition and data-transfer onto a parallel computing system, segmentation and 3D reconstruction of the humerus, clavicle and scapula were performed. A glenoid-based coordinate system was used to determine the amount and direction of glenohumeral translation in all three dimensions [2]. To determine 3D scapular kinematics the principal axis of the humerus and scapula were calculated. The arm abduction angle ([H] angle formed by the longitudinal axis of the humerus and the spine axis), and the scapulo-thoracic angle ([G] angle formed by the plane of the glenoid and the spine axis) were then calculated (Fig. 1). Finally, the scapulo-humeral-rhythm (SHR) was analyzed according to the method described by Poppen and Walker [3].

In the transversal plane, the angle [IRO] between the scapular and frontal plane was calculated (Fig. 1).

Results:
Scapular kinematics
In atraumatic unstable shoulders, the scapula position was significantly different in both planes (30° of abduction: scapulo-humeral rhythm: unstable 3.5±2.6:1 versus healthy 2.4±1.3:1 (p<0.05); internal rotation: unstable 59±29° versus healthy 49±23° (p<0.05), Tab. 1).

In nine patients the scapulo-humeral rhythm was obviously larger at the affected side, but three shoulders demonstrated an almost physiologic rhythm, and two a smaller ratio. In the horizontal plane, five patients showed an almost physiologic or only slightly (< 10°) larger internal rotation of the scapula. Only in two of these patients the scapular kinematics was unchanged in both planes.

<table>
<thead>
<tr>
<th>30° abd.</th>
<th>90° abd.</th>
<th>90° abd. + ERO</th>
<th>Max. add.</th>
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<tr>
<td>SHR</td>
<td>IRO</td>
<td>SHR</td>
<td>IRO</td>
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<tr>
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<td>2.4</td>
<td>49.0</td>
<td>2.9</td>
</tr>
<tr>
<td>Affected</td>
<td>3.5*</td>
<td>58.6*</td>
<td>2.3</td>
</tr>
<tr>
<td>Unaffected</td>
<td>2.6</td>
<td>57.0*</td>
<td>2.3</td>
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Tab. 1: Mean scapulo-humeral rhythm (SHR) [ratio] and internal rotation of the scapula [IRO] during different arm positions. * p < 0.05

Humeral head position
During passive shoulder motion, the humeral head position relative to the glenoid cavity was significantly different in both shoulders of patients with atraumatic instability (p < 0.05) compared to the healthy control group. The difference was even higher for the affected side.

During isometric muscle activity, the healthy shoulders demonstrated significant centering of the humeral head. The affected shoulders of the patient group, on the other hand, showed a significantly decentred humeral head position to inferior and posterior.

Correlation between scapular kinematics and humeral head position
In all groups (affected, unaffected and healthy) a significant (p < 0.05) correlation was found between scapular kinematics and the humeral head position during muscular relaxation (r = 0.46 – 0.87; Tab. 2). In shoulders with a larger SHR (caused by a decreased upwards rotation of the glenoid cavity) centering of humeral head towards superior was observed. The five patients with almost physiologic or smaller SHR showed an inferior humeral head position. In the transversal plane in patients with larger internal rotation (> 10° compared to the healthy shoulders), a posterior position of the humeral head was recorded. The five patients with almost physiologic internal rotation, on the other hand, demonstrated an anterior or centered humeral head position. However under the influence of muscle activity, no significant correlation was measured between SHR and head position (r = 0.25 – 0.49; Tab. 2).

<table>
<thead>
<tr>
<th>30° abd.</th>
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<th>90° abd. + ERO</th>
<th>Max. add.</th>
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<td>Vert. plane</td>
<td>Hori. plane</td>
<td>Vert. plane</td>
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<tr>
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<td>Affected</td>
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<tr>
<td>Unaffected</td>
<td>0.87</td>
<td>0.62</td>
<td>0.54</td>
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Tab. 2: Coefficient of correlation [r] between scapular positioning and humeral head position for the vertical and horizontal plane

Conclusions:
We found in 12 of 14 patients significant alterations of scapular kinematics in the horizontal and vertical plane and simultaneously a decentralized of the humeral head. The correlation between both factors suggests that scapular positioning is relevant for humeral head (de)centering. Patients with scapular malpositioning should therefore be identified preoperatively, because an inferior capsular shift will likely fail to be effective in these patients. Furthermore, these data support that in physiotherapeutic therapy the stabilizing muscles of the glenohumeral joint – especially the rotator cuff- but also the scapulo-thoracic muscles should be included in workup. Muscle strengthening should thereby take into account the direction of instability.

References: