Effect of Arthroscopic Stabilization on In-Vivo Glenohumeral Joint Motion and Clinical Outcomes in Patients with Anterior Instability

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Introduction: Shoulder dislocations occur often, and the resultant glenohumeral joint (GHJ) instability is one of the most common pathologic conditions of the shoulder [1]. Current surgical procedures for GHJ instability often result in favorable short-term clinical outcomes, but these patients appear to be at higher risk for developing GHJ osteoarthritis (OA) [2]. The development of OA is believed to be associated with altered joint mechanics, but the effects of shoulder instability and its associated surgical treatment on GHJ mechanics (particularly under in-vivo conditions) are not well understood. The objective of this study was to determine the extent to which arthroscopic stabilization for anterior instability affects in-vivo GHJ motion and clinical outcomes. We hypothesized that instability patients would have altered GHJ motion before surgery, with the humerus located more anteriorly on the glenoid prior to surgery. Secondarily, we hypothesized that range of motion (ROM), strength and patient-assessed subjective outcomes would improve following surgery.

Methods: Following IRB approval and informed consent, 11 control subjects (age: 27±4) and 10 instability patients (age: 21±5) enrolled in this study. Control subjects had no history of shoulder injury, surgery, or symptoms. Instability patients were diagnosed with anterior GHJ instability following a dislocation event and positive apprehension test. In-vivo GHJ motion was measured from biplane x-ray images that were acquired during an apprehension test, i.e., passive external rotation to maximum allowable rotation with the shoulder positioned in 90º of coronal-plane abduction. In addition, CT scans of the humerus and scapula were acquired at the time of testing. After reconstructing the CT scans into subject-specific bone models, the 3D positions of the humerus and scapula were tracked from the biplane x-ray images using an accurate (±0.4 mm, ±0.5°) CT model-based technique [3]. GHJ contact patterns were estimated by combining joint motion measured from the biplane x-ray images with the subject-specific bone models [4]. For each frame of data, the GHJ contact center was estimated by calculating the minimum distance between the humerus and glenoid. Using these data, we calculated the average joint contact center (i.e., the average center of contact of the humerus on the glenoid over the entire apprehension test), the range of the joint contact center in both the anterior/posterior (A/P) and superior/inferior (S/I) directions, and the contact center path length throughout the trial. To account for differences in subject size, these joint contact data were normalized relative to subject-specific glenoid height and width. In addition to measures of joint motion, active external rotation (ER) and internal rotation (IR) ROM were assessed with a goniometer with the arm in 90º of abduction. Isometric ER and IR strength were assessed using an isokinetic dynamometer. Strength and ROM were normalized relative to the contralateral shoulder in both control subjects and instability patients. Clinical outcome was assessed in the instability patients with the Western Ontario Shoulder Instability (WOSI) index. These data were acquired prior to surgery and at 6 months post-surgery for the instability.
patients, and at one time point for the control subjects. Differences in all outcome measures were assessed with t-tests. Significance was set at $p \leq 0.05$.

**Results:** Prior to surgery, the instability patients' humerus was positioned significantly more anteriorly on the glenoid than in the control subjects ($p=0.01$, Fig. 1). The joint contact center (averaged across all patients) was shifted slightly posterior on the glenoid after surgery, but this change was not found to be statistically significant compared to the pre-surgical condition ($p=0.13$, Fig. 1). Additionally, no significant difference in the average joint contact center was detected between the instability patients' post-surgery condition and the control subjects ($p=0.21$, Fig. 1). No significant differences were detected between control and pre-surgery, control and post-surgery, or pre- and post-surgery conditions in terms of the S/I contact center ($p>0.2$), A/P contact center range ($p>0.3$), S/I contact center range ($p>0.7$), or contact center path length ($p>0.4$). Prior to surgery the instability patients also demonstrated lower ER ROM ($p=0.01$) and ER strength ($p=0.05$) than the control subjects, and these differences in ER ROM ($p=0.01$) and strength ($p=0.02$) persisted after surgery. No significant differences in ER ROM and strength were detected between pre- and post-surgical time points ($p>0.6$). The instability patients’ IR strength prior to surgery was significantly lower than the control subjects ($p=0.001$), but increased significantly after surgery ($p=0.002$) and was not different from control subjects ($p=0.99$). No significant differences were detected in IR ROM ($p>0.6$). WOSI scores increased significantly between pre-surgical (48.3±13.1) and post-surgical (85.0±16.7) time points ($p<0.001$).

**Discussion:** These data indicate that GHJ motion is altered in instability patients prior to surgery and that arthroscopic stabilization does not fully restore normal GHJ motion. Although the humerus is positioned more posteriorly on the glenoid after surgery, this change from the pre-surgical condition was not found to be statistically significant. The standard deviation of the post-surgical joint contact center was found to be quite large ($\pm 12\%$ of the glenoid width), indicating that the effects of arthroscopic stabilization on GHJ motion may be highly variable. This is further supported by the finding that 7 of the 10 instability patients’ A/P contact center moved posteriorly on the glenoid following surgery, but 3 of 10 patients’ A/P contact center moved anteriorly on the glenoid. Although arthroscopic stabilization was not found to have a significant effect on GHJ motion, ER ROM, or ER strength, instability patients reported a significant increase in subjectively-assessed quality of life scores 6 months following surgery. Future efforts will further evaluate these data for possible associations between these patient-assessed outcomes, GHJ motion, ROM, and strength. The extent to which altered GHJ motion may be associated with OA progression in this patient population is still not known, but on-going research efforts are focused on characterizing the relationship between GHJ motion and MRI-based measures of early OA progression.

**Significance:** Research suggests that patients who are treated surgically for glenohumeral joint instability may be at increased risk for developing osteoarthritis due to altered joint mechanics, but the extent to which instability alters in vivo joint mechanics is not well understood. These data suggest that the effect of arthroscopic stabilization on GHJ motion is quite varied, with not all patients achieving normal GHJ motion after surgery.
Fig. 1. The instability patients’ humerus was positioned approximately 9% more anteriorly on the glenoid pre-operatively compared to control subjects (p=0.02). The position of the humerus post-operatively was not significantly different compared to either the instability patients’ pre-operative time point (p=0.13) or control subjects (p=0.21).
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