Quantitative Evaluation of Elasticity in the Posteroinferior Shoulder Joint Capsules of Collegiate Baseball Players Using Shear-Wave Ultrasound Elastography

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Introduction: During the follow-through phase of pitching a baseball, the posterior rotator cuff and the posteroinferior capsule endures significant distraction forces (1). Repetitive microtrauma, due to overhead throwing and subsequent tissue healing, are thought to thicken the posterior aspect of the shoulder capsule (2). Some researches performing ultrasonography describe the posterior capsule as thicker on throwing shoulders than on non-throwing shoulders. Thomas et al. reported that a negative relationship existed between hypertrophied posterior capsules and the loss of glenohumeral internal rotation (2). However, the hardness of the thickened capsules was unknown. The purpose of this study was to investigate the thickness and elasticity of the posteroinferior capsule of the shoulder joint in collegiate baseball players using shear-wave ultrasound elastography (SWUE).

Methods: Forty-five male collegiate baseball players (mean age, 19.7 year) were examined during the off-season. There were thirteen pitchers and thirty-two field players. Thirty-six players were right-handed and nine were left-handed. The average career of the baseballers was 10.4 years (range, 6-14 years). One orthopaedic surgeon obtained all sonograms using Aixplorer® (SuperSonic Imagine, Aix-en-Provence, France), which can measure the tissue elasticity quantitatively without probe compression. The subjects were seated upright on a stool and placed their upper extremities on a table with their shoulder flexed to 90 degrees. The linear array transducer was placed on the posteroinferior aspect of their shoulder to visualize the humeral head, glenoid rim, labrum, and teres minor (Fig. 1). The thickness and elasticity of the posteroinferior capsule were measured at a location 5-mm laterally from the edge of the labrum (Fig. 2). Mean, minimum, and maximum tissue elasticity (Young’s modulus) in circular areas (Q-Box, set at a 1-mm diameter in this study) were automatically calculated. The mean value was recorded. Both thickness and elasticity were measured three times and the average figures were taken for analysis.

For statistical comparisons between the throwing and non-throwing shoulders, a paired t test was performed with significance set at P < 0.05. All data are reported as the mean±standard deviation. The statistical program R (R package; http://www.r-project.org/) was used for data analysis.

Figure 1. Patient positioning during ultrasound examination.
Figure 2. Ultrasound images of the posteroinferior aspect of the shoulder joint. Upper panel: Ultrasound elastography; Lower panel: B-mode.

Abbreviations: HC: humeral head; TM: teres minor; arrow head: glenoid rim; asterisk: labrum.
**Results:** The average thickness of the posteroinferior capsule was 1.40±0.20 mm on the throwing side and 1.04±0.13 mm on the non-throwing side. The average elasticity of the posteroinferior capsule was 39.4±7.4 kilopascals (kPa) on the throwing side and 31.6±5.4 kPa on the non-throwing side. Both the thickness and elasticity of the posteroinferior capsule were significantly greater (P < 0.01) on the throwing side than on the non-throwing side (Fig. 3).

**Discussion:** Shear-wave ultrasound elastography is a relatively new real-time diagnostic imaging technique. The principles of SWUE are as follows: the force of acoustic radiation generated from a transducer creates shear-waves, the velocity of propagated shear-waves is measured, and tissue elasticity (Young’s modulus) is calculated (3). This imaging method provides a quantitative assessment and is totally different from conventional ultrasound real-time tissue elastography, which requires manual cyclic compression forces and evaluates tissue strain. Besides thyroid and abdominal organs, the elasticity of muscle and tendon has been measured using SWUE in healthy populations (3). We measured the elasticity of the thickened shoulder capsule in throwing athletes. Our previous study determined that the posterior capsule was thicker and harder on the throwing shoulder than on the non-throwing shoulder (unpublished data, 2013). In our previous study, measurements of the posterior shoulder capsule were performed with subjects’ shoulders in the same neutral position (i.e., arm to their side with zero degrees abduction and adduction) used by other ultrasonographic researches (2). However, the posteroinferior capsule around the posteroinferior glenohumeral ligament, which is the more important region of interest for throwing injuries (1), was not be able to be visualized with subjects in that posture, as ultrasound beam could not reach the posteroinferior area vertically. Therefore, we asked subjects to flex their shoulders to 90 degrees and proceeded to scan the posteroinferior shoulder capsule in order to more clearly visualize the region of interest.

Burkhart et al. (1) reported that the posteroinferior capsule was 6-mm thick or more in the patients who underwent arthroscopic selective posteroinferior capsulotomy. Most of these patients were older, elite pitchers who had been throwing for many years. Burkhart and colleagues also noted that most college pitchers respond to stretching and rarely require selective posteroinferior capsulotomy. In our study, there were many asymptomatic players, because this investigation was performed as part of a medical check-up. Therefore, further research is needed to investigate the relationship between posterior capsule thickness/elasticity and posterior tightness. Such research may be able to distinguish pathologic conditions that require treatment from those with predominantly adaptive changes.

In conclusion, the posteroinferior capsule was thicker and harder on the throwing shoulder than on the non-throwing shoulder in collegiate baseball players with an average playing career of 10 years.

**Significance:** Thickening and hardening of the posteroinferior shoulder joint capsule could pose a potential risk for future throwing injuries.