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## ORIGINAL ARTICLE

# Stress ultrasound in baseball players with ulnar collateral ligament injuries: additional value for predicting rehabilitation outcome

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**Background:** The purpose of this study was to evaluate the additional value of stress ultrasound (US) for predicting rehabilitation outcome in baseball players with ulnar collateral ligament (UCL) injury.

**Methods:** Stress US and magnetic resonance imaging (MRI) in 41 baseball players with UCL injury who received rehabilitation treatment for more than 6 weeks were retrospectively compared between the rehabilitation group (n = 23) and surgery group (n = 18). The MRI grade of UCL injury was assessed as intact continuity, low-grade partial tear, high-grade partial tear, and complete tear. To estimate sonographic joint laxity, we assessed 3 sonographic criteria as present or absent: ligamentous waviness, joint gapping, and intra-articular ring-down artifact. In addition, the presence of concomitant tenderness was checked during stress US. The diagnostic validity of MRI with and without stress US was analyzed as a predictor for the rehabilitation outcome.

**Results:** The MRI grade was higher in the surgery group than in the rehabilitation group ( $P < .001$ ). Sonographic joint laxity showing the ring-down artifact and concomitant tenderness with stress were significantly more frequent in the surgery group ( $P = .024$  and  $P = .006$ , respectively). Sensitivity, specificity, and accuracy were 61.1%, 86.9%, and 75.6%, respectively, for MRI alone and 83.3%, 56.5%, and 68.2%, respectively, for the combination of MRI with joint laxity showing the ring-down artifact. For MRI in combination with joint laxity and concomitant tenderness, these values were 72.2%, 82.6%, and 78.0%, respectively.

**Conclusion:** The addition of stress US showing the ring-down artifact and concomitant tenderness was helpful for predicting the rehabilitation outcome of UCL injuries.

The Institutional Review Board of Konkuk University Hospital, Seoul, Republic of Korea, approved this study (No. KUH1140072). The requirement for informed consent was waived for this retrospective study.

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Ulnar collateral ligament (UCL) injury to the elbow is common in overhead throwing athletes.<sup>21</sup> Some of these are treated nonsurgically with good results<sup>27</sup>; however, if failure to return to the preinjury state occurs after conservative management in athletes, they will require surgical reconstruction. Good results have been reported in throwing athletes who underwent surgical reconstruction of the UCL.<sup>2,10,25,26</sup> If imaging studies could predict the response to nonsurgical treatment, athletes may be able to return more quickly with subsequent surgery on the UCL.

Classically, athletes with low-grade tears of the UCL can return to play after rehabilitation treatment. However, those with high-grade tears, which lead to considerable valgus laxity or persistent medial elbow pain, need to undergo an operation to return to sports.<sup>26</sup> Although magnetic resonance imaging (MRI) is excellent at assessing the structural integrity of the UCL or at detecting any associated soft-tissue injuries, MRI does not provide any functional or dynamic assessment of the ligament.<sup>2,3,13,16</sup> Contrary to the static imaging modalities, ultrasound (US) can give information not only about morphologic changes in the UCL but also about joint width changes in real time relating to valgus stress maneuvers.

Several studies have reported that stress US can demonstrate ulnohumeral joint laxity in symptomatic or asymptomatic elbows.<sup>8,9,11,24</sup> To our knowledge, there have been few studies to validate the usefulness of stress US added to MRI as a predictor of rehabilitation outcome of UCL injuries. We hypothesized that stress US in combination with MRI could help differentiate between the rehabilitation and surgery groups. The purpose of our study was to evaluate the value of additional stress US for predicting rehabilitation outcome.

## Materials and methods

### Patients

Our patient population comprised a group of competitive collegiate and professional baseball players with clinical evidence of UCL injury based on medial elbow pain and a positive response on the moving valgus stress test. By a computerized search of the hospital's clinical files between January 2011 and August 2013, 117 consecutive patients were identified. Among them, 61 underwent both elbow MRI and stress US within 3 months of initial symptoms. Stress US was a part of the clinical protocol during the workup except in cases of acute ligament rupture. We included patients who underwent MRI by use of identical field-strength systems and ex-

cluded patients who underwent US more than 1 month after MRI. Patients with a history of UCL surgery on the affected elbow were excluded from the study. MRI excluded other associated conditions in the origin of medial elbow pain such as medial epicondylitis and ulnar neuropathy. Thus, 41 patients were included in our study. The mean length of time between MRI and complementary US was 11.4 days. The time interval between initial symptoms and stress US ranged from 4 weeks to 3 months. A clinical chart review was performed to obtain demographic characteristics, dominant hand, main position, chief complaint, physical examination findings, initial clinical impression, prescribed treatment, duration of treatment, and outcome.

The patients presented to an orthopedic clinic in season with complaints of acute or chronic pain in the medial aspect of the elbow of the dominant arm. All physical examinations were performed by an orthopedic surgeon, and all the patients were male patients with a mean age of 19.9 years (range, 15-32 years). The patients initially received rehabilitation treatment at our institution or outside clinics for more than 6 weeks. Some had already started receiving rehabilitation treatment before visiting our institution. The patients were divided into 2 groups based on the presence of a reconstruction surgery history at the time of return. The first group included patients who had improvement of symptoms with only rehabilitation treatment (rehabilitation group). The second group included patients who were not responding to rehabilitation treatment and consequently underwent reconstruction surgery (surgery group). All the patients in the surgery group were evaluated for responses to valgus instability testing under general anesthesia, and the images were recorded using intraoperative C-arm fluoroscopy.

The rehabilitation program was as follows: The elbow was maintained in a hinged brace to permit a nonpainful arc of motion. The brace was set to allow 30° to 100° of range of motion (ROM) initially, and ROM was gradually increased by 5° to 10° per week. After 4 weeks, full ROM exercise was permitted with the arm in the brace. The brace was taken off at 4 to 6 weeks, at which time the athletes started rhythmic stabilization exercises. Isotonic strengthening exercises were initiated at 6 to 8 weeks, and the players were slowly progressed to plyometric exercises. At 3 months after injury, an interval throwing program was initiated, when the players regained full ROM, as well as adequate shoulder and elbow strength, and showed minimal discomfort during the valgus stress test. The players were allowed to return to play after the asymptomatic completion of the interval throwing program.

### MRI analysis

MRI was reviewed by consensus by 2 musculoskeletal radiologists who had 11 years and 7 years of experience. The site and degree of UCL injury were analyzed. The injury site was divided into the origin, midsubstance, and insertion site of the anterior band of the

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