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Stress Sonography of the Ulnar Collateral Ligament of the Elbow in Professional Baseball Pitchers:

A 10-Year Study

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Abstract

Background—An injury to the ulnar collateral ligament (UCL) of the elbow is potentially career threatening for elite baseball pitchers. Stress ultrasound (US) of the elbow allows for evaluation of both the UCL and the ulnohumeral joint space at rest and with stress.

Hypothesis—Stress US can identify morphological and functional UCL changes and may predict the risk of a UCL injury in elite pitchers.

Study Design—Cross-sectional study; Level of evidence, 3.

Methods—A total of 368 asymptomatic professional baseball pitchers underwent preseason stress US of their dominant and non-dominant elbows over a 10-year period (2002-2012). Stress US examinations were performed in 30° of flexion at rest and with 150 N of valgus stress by a single musculoskeletal radiologist. Ligament thickness, ulnohumeral joint space width, and ligament abnormalities (hypoechoic foci and calcifications) were documented.

Results—There were 736 stress US studies. The mean UCL thickness in the dominant elbow (6.15 mm) was significantly greater than that in the nondominant elbow (4.82 mm) ($P < .0001$). The mean stressed ulnohumeral joint space width in the dominant elbow (4.56 mm) was significantly greater than that in the nondominant elbow (3.72 mm) ($P < .02$). In the dominant arm, hypoechoic foci and calcifications were both significantly more prevalent (28.0% vs 3.5%

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and 24.9% vs 1.6%, respectively; $P < .001$). In the 12 players who incurred a UCL injury, there were nonsignificant ($P > .05$) increases in baseline ligament thickness, ulnohumeral joint space gapping with stress, and incidence of hypoechoic foci and calcifications. More than 1 stress US examination was performed in 131 players, with a mean increase of 0.78 mm in joint space gapping with subsequent evaluations.

Conclusion—Stress US indicates that the UCL in the dominant elbow of elite pitchers is thicker, is more likely to have hypoechoic foci and/or calcifications, and has increased laxity with valgus stress over time.

Keywords

baseball; stress ultrasound of elbow; ulnar collateral ligament

Overhand athletes exert tremendous forces through the medial elbow joint during the act of throwing. The ulnar collateral ligament (UCL) of the elbow, more specifically its anterior band, is the primary soft tissue stabilizer to the valgus stress of throwing in these athletes.[7,29] Over time, the extreme repetitive stress of throwing, especially in the elite baseball pitcher, may lead to either an acute injury or chronic, progressive damage to the elbow and, more precisely, to this ligament. The current diagnosis of an injury to the UCL relies on history and physical examinations as well as radiographic imaging, which often assists in confirming the diagnosis of a UCL injury. Typically, imaging workup of the elbow includes plain radiography, stress radiography, and magnetic resonance imaging (MRI) with or without enhancement.[2,6,9,31,34] Plain radiography may define bony changes such as osteophytes, cystic changes, joint space narrowing, or loose bodies,[2,31,34] but it does not provide any direct information on soft tissue injuries. In addition, it is a static examination with the elbow in 1 position for each view obtained. Stress radiography has been proposed as a more precise, functional way of evaluating UCL laxity,[15,26,35] but it also does not provide a direct assessment of the ligament, may be cumbersome to use, and may be provider dependent.[32] Conventional MRI provides excellent visualization of acute ruptures of the UCL[4,19] but may be less accurate for partial-thickness injuries.[12,23,37] Magnetic resonance arthrography has been proposed as a more accurate technique for partial or chronic UCL injuries,[12,23,37] but it has several limitations, including expense, length of study time, and invasiveness.[12,23,32,37]

Quite often, elite-level pitchers are extremely reluctant to have contrast injected into their injured, dominant elbow. In addition, magnetic resonance arthrography is a static imaging technique; although it may clearly identify irregularities in the UCL, it does not provide any dynamic assessment of ligament laxity because the player's elbow is in 1 position throughout the procedure.

Stress ultrasound (US) is a unique imaging technique that directly visualizes the UCL and allows the assessment of ligament laxity as related to joint space gapping with stress[24,29,32,36] (Figure 1). The ability of this technique to visualize the UCL of the elbow with a cadaveric evaluation has been previously determined.[32] Additionally, the early results of this technique in Major League Baseball pitchers in the United States have identified it as a low-cost, quick, and noninvasive imaging modality for the UCL.[32] Moreover, it allows an evaluation of UCL laxity by applying stress, either manually or instrumented, to assess the amount of joint space gapping as compared with the contralateral elbow.[32,36]

An injury to the UCL of elite baseball pitchers may occur either acutely or with chronic repetitive stress.[6,9,11] In chronic, progressive injuries, there may be a point when structural changes in the UCL of the dominant elbow are not yet symptomatic but detectable by stress US. Preliminary data have identified such changes as hypoechoic foci, calcifications, and joint gapping in asymptomatic elite pitchers.[32] The purpose of this current study was to identify morphological changes on stress US in a large study population of pitchers and determine if these changes progress with continued exposure to pitching at an elite level. In addition, we aimed to compare the stress US changes noted in those elite pitchers who subsequently incurred a clinically symptomatic UCL injury with the stress US findings of the remaining asymptomatic pitchers. Most importantly, our goal was to determine if stress US may provide a predictive risk of a UCL injury in elite-level baseball pitchers as related to a particular level of morphological and dynamic abnormalities identified by this imaging technique.

MATERIALS AND METHODS

Study Population

A total of 736 stress US studies were performed on the elbows of 368 professional baseball pitchers during minor league spring training over a 10-year period (March 2002–March 2012). The mean age of the pitchers was 22.8 years (range, 17-34 years). All pitchers were members of the same professional baseball team and were evaluated with stress US during their spring training preparticipation examination. The participants had a mean professional baseball experience of 2.5 years (range, 0-14 years). There were 278 (76%) right-handed pitchers and 90 (24%) left-handed pitchers. All pitchers were asymptomatic at the time of their studies. The stress US studies were all obtained at the request of the head team physician as a baseline scan for comparison if any of the pitchers were to subsequently incur a UCL injury during the season. Institutional review board approval was obtained, and all participants provided written informed consent.

Imaging Technique

All participants were imaged by the same experienced musculoskeletal radiologist with a multifrequency 13-MHz linear-array transducer (SonoSite MicroMaxx or M-Turbo, SonoSite, Bothell, Washington, USA) and standard acoustic coupling gel. Participants were seated, and their right elbow was placed at 30° (as measured with a digital goniometer and the longitudinal axes of the forearm and upper arm) in a standardized instrumented device (Telos, Marburg, Germany). This elbow flexion angle was selected for 2 reasons: (1) the UCL has been demonstrated to be the primary restraint against valgus stress at 30° of elbow flexion and (2) appropriate stress using the standardized stress device can only be consistently applied at lower degrees of elbow flexion (the players' elbows could not be appropriately positioned in the stress device at flexion angles >60°). The thickness of the anterior band of the UCL at its midportion and the width of the ulnohumeral joint space at the level of the anterior band were measured both at rest and with 150 N of stress applied

(Figure 2). All images were evaluated for echotextural abnormalities, including hypoechoic foci and calcifications (Figure 3). The calcifications were defined as hyperechoic foci that demonstrated acoustic shadowing.[32] All electronic caliper measurements (thickness at rest and stress, joint space at rest and stress) and gray-scale echotextural findings were transcribed to a computer spreadsheet (Excel, Microsoft, Redmond, Washington, USA) for later analysis. These measurements were taken once by the sonologist on the US screen, utilizing electronic calipers with a precision of 0.1 mm. The same measurements were obtained for the left elbow in the same sequence. All the stress US studies were captured on cine loops on the US monitor, and still-frame images of the measurements were recorded on optical discs. During the stress US studies and the image interpretation, the radiologist was blinded to each pitcher's arm dominance.

Statistical Analysis

A retrospective cohort study was performed using prospectively collected data, assessing all players with more than 1 stress US scan during the study period with respect to all evaluated parameters. Players who subsequently incurred a UCL injury had their prior stress US findings compared with those of the remaining asymptomatic group of pitchers. Univariate statistical analysis with an independent-sample *t* test was used for all continuous variables. Continuous variables included (1) ligament thickness with and without stress in dominant and nondominant elbows, (2) ulnohumeral joint space with and without stress in dominant and nondominant elbows, (3) correlation of gray-scale abnormalities with years in professional baseball, and (4) ligament thickness and joint space data between the subsequently injured subgroup and the asymptomatic subgroup. Categorical variables including hypoechoic foci and calcifications in dominant and nondominant elbows were analyzed with the χ^2 statistic and Fisher exact test. Correlated analysis was performed comparing initial versus final stress US findings of the dominant elbows in all pitchers with more than 1 US examination. Finally, we conducted a Spearman rank correlation coefficient analysis to examine the relationship between ligament thickness and joint space width with stress. A post hoc power analysis was performed to determine whether potential predictors could be obtained with respect to injury. Results were considered statistically significant if the P value was <.05. An independent-sample *t* test was used, and STATA (v. 11.0) statistical software (StataCorp, College Station, Texas, USA) was used to perform all the analyses.

RESULTS

UCL Thickness

Data on thickness of the anterior band of the UCL for all pitchers are listed in Table 1. At rest, the mean thickness of the UCL was 6.15 mm in the dominant elbow and 4.82 mm in the nondominant elbow ($P < .001$).

Ulnohumeral Joint Space

Data on joint space width for all pitchers are listed in Table 2. The mean joint space width at rest was 3.32 mm in the dominant elbow and 2.94 mm in the nondominant elbow. The difference was not statistically significant. When stress was applied, however, the mean joint space width of the dominant elbow was significantly greater ($P < .003$) than that of the nondominant elbow, with values of 4.56 mm and 3.72 mm, respectively. The mean change in joint space width, defined as the width of the ulnohumeral joint space with stress minus that at rest, was 1.24 mm in the dominant elbow and 0.78 mm in the nondominant elbow ($P \leq .004$). Using Spearman rank correlation analysis, we noted a positive, although weak, correlation between ligament thickness and joint space width with stress ($r = 0.17$, $P = .001$).

Echotextural Abnormalities

The prevalence of hypoechoic foci and calcifications in the anterior band of the UCL of all pitchers is listed in Table 3. Hypoechoic foci were detected in 103 (28.0%) of the dominant elbows and 13 (3.5%) of the nondominant elbows of all 368 pitchers. Calcifications were noted in 92 (24.9%) of the dominant elbows and 6 (1.6%) of the nondominant elbows of all 368 pitchers. The prevalence of hypoechoic foci and calcifications was significantly greater ($P < .001$ for both) in the dominant elbow compared with the nondominant elbow.

Longitudinal Changes and UCL Injury

During the study period, 131 pitchers (36%) had more than 1 stress US scan (Table 4). Thirty-five of the 131 (26%) were noted to have a mean increase of 0.78 mm of joint space gapping (increase in ulnohumeral joint space) with stress on subsequent stress US studies. There were no pitchers who demonstrated less ulnohumeral joint space distance on subsequent examinations. There was no significant progression noted on subsequent stress US studies with respect to hypoechoic foci or calcifications. Twelve of the 368 pitchers (3.3%) incurred an injury to the UCL during the study period. These pitchers had a specific event resulting in symptoms, physical findings, and magnetic resonance arthrography findings documenting partial or complete damage of the anterior band of the UCL. The baseline stress US studies of these 12 pitchers, before their injury, were compared with those of the remaining asymptomatic 356 pitchers with respect to all data parameters. The comparison data for the injured and asymptomatic subgroups are listed in Table 5. We observed increased mean ligament thickness (6.84 vs 6.11 mm, respectively), mean joint space gapping with stress (4.55 vs 4.09 mm, respectively), and proportion of players with hypoechoic foci (42.0% vs 29.4%, respectively) and calcifications (25.0% vs 24.0%, respectively) in the 12 injured players compared with the 356 asymptomatic players. However, given the small number of UCL-injured players during the study period, we were unable to find any significant relationship between the presence of these changes and subsequent UCL tearing. Post hoc analysis revealed that with a sample size of 17 injured participants, the findings would have approached statistical significance. Of the 131 pitchers with more than 1 stress US scan during the study period, 9 subsequently incurred a UCL injury. There was no significant difference in the progression of joint space gapping, hypoechoic foci, or calcifications between those 9 players with an UCL injury and the other 122 players who remained asymptomatic.

DISCUSSION

This study supports the hypothesis that stress US can identify morphological changes of the UCL in elite pitchers as well as evaluate the ulnohumeral joint space width at rest and with stress. At the present time, stress US is unable to allow a determination of the relative risk of future UCL injuries in this population.

Overhand athletes exert tremendous forces through the medial elbow joint during the act of throwing. Injuries of the UCL were first recognized and described by Waris[39] in a series of 17 javelin throwers in 1946. More recently, UCL injuries have gained increasing attention in the medical and lay press with regard to their effect on elite baseball pitchers. Once, UCL injuries were thought to be a career-ending injury for these athletes, but a novel surgical technique developed by Jobe et al[22] allows for a successful return to competition. Despite improvements in training and conditioning, diagnostic methods, and surgical treatment, the incidence of injuries among pitchers has been slowly increasing in recent years.[11] Pitchers with UCL injuries, in particular, are often placed on the "disabled list," which requires them to rest from competition for a minimum of 15 days.[10] More importantly, if surgical treatment is required, it may take as long as 12 to 18 months for the player to return to the previous level of competition.[3,5,14,20]

Injuries to the anterior band of the UCL may occur either acutely or chronically.[6,9,11] In either situation, injuries are often diagnosed by history and physical examination and radiographic imaging. If the UCL injuries are near complete or complete, most require surgical reconstruction in the elite-level pitcher. Although imaging tests are often used to help corroborate the findings on history and physical examination, chronic injuries may have a more insidious onset and may be a diagnostic challenge. Asymptomatic elite-level throwers may have baseline progressive, adaptive changes in the UCL on imaging studies that may not correlate with the future risk of injuries.[21,24,25] Wright et al[41] used plain radiographs to examine a cohort of 56 asymptomatic professional baseball pitchers and found that degenerative changes developed over time, but these changes did not correlate to the time spent on the Major League Baseball disabled list or risk of future injuries. In addition, it is difficult for plain radio-graphs to accurately assess the structural integrity of the UCL or detect any associated soft tissue injuries. Conventional MRI provides excellent visualization of complete tears of the UCL, heterotopic calcification, flexor-pronator inflammation, and associated bony edema.[19,23,31,34,37] The addition of intra-articular contrast to conventional MRI has increased the detection of partial and subtle chronic injuries to the UCL; however, expense, length of time, invasiveness, and patient reluctance have made its routine use in elite-level pitchers less desirable.[12,23,32,37] Magnetic resonance imaging, with or without arthrography, also does not provide any functional or dynamic assessment of the ligament.

The UCL of the elbow, specifically its anterior band, is the primary soft tissue stabilizer to valgus stress with throwing.[7,30] An imaging modality that can accurately evaluate the UCL in a stressed position may provide more useful information than one that evaluates the UCL in a fixed, extended position as is the case with plain radiography and MRI. Rijke et al[35] have used a calibrated device to produce valgus stress during radiography to evaluate patients with UCL injuries. Lee et al[26] used radiography to compare the amount of ulnohumeral joint space gapping with and without stress in “normal” patients. They found a significant difference in the amount of gap-ping when 5 lb of valgus stress was applied at 0° and 30° of elbow flexion. There was no difference, however, in gap-ping whether they looked at the nondominant or dominant elbow. Ellenbecker et al[15] performed a similar study but looked specifically at uninjured professional baseball pitchers. They found a significantly greater difference in the amount of ulnohumeral joint space widening with stress when comparing the dominant and nondominant elbows. They concluded that increased medial elbow laxity exists in the dominant arms of uninjured pitchers. Despite providing a functional assessment of the ulnohumeral joint space, these reports utilizing plain radiography cannot simultaneously comment on the structural properties of the UCL or surrounding soft tissue structures, which are also functionally important factors.

Elbow US is a useful imaging modality to detect injuries of the bony and soft tissue structures of the elbow, including tendons, ligaments, muscles, bursae, and neurovascular structures. It is also safe, rapid, noninvasive, nonradiating, and inexpensive for therapeutic, guided injections and can be used in patients with claustrophobia or positioning difficulties.[27,28,38] Furthermore, it has been shown to be effective in detecting both partial- and full-thickness tears of the UCL, echotextural abnormalities (hypoechoic foci and calcifications), and ulnohumeral osteophytes.[13,24,29,32,39] The contralateral extremity is readily accessible for comparison, and most importantly, a stress device can be used to provide a measured dynamic and functional assessment of the UCL.[13,36,39] Wood et al[40] (1 patient) and DeSmet et al[13] (2 patients) reported cases of collegiate-level baseball pitchers who sustained UCL injuries diagnosed on stress US. In all cases, they were able to demonstrate medial valgus instability with appropriate stress, and images of the contralateral elbow were obtained for comparison. They were able to accurately detect a UCL injury in all cases that were later confirmed at the time of surgical reconstruction. Sasaki et al[36] performed stress US on 30 asymptomatic collegiate baseball players. They showed that the ulnohumeral joint space of the dominant elbow was significantly wider than that of the nondominant elbow and that increased laxity occurred with valgus stress. Their stress US methods were slightly different than those in the current study, as they placed the elbow in 90° of flexion, used gravity stress instead of instrumented stress, and did not comment on the actual qualitative characteristics of the UCL. In addition, only 12 of the players in their cohort were pitchers. In a previously published study,[32] stress US was performed on 26 asymptomatic professional pitchers. The results of this study showed that the anterior band of the UCL was thicker, was more likely to have echotextural abnormalities, and had increased laxity with valgus stress in the dominant elbow of these pitchers.[32]

The valgus stress applied to all elbows during this study was standardized by utilizing the Telos stress device. This allowed a consistent force to be applied, thereby eliminating a potential source of variation. Studies suggest that during the late cocking/acceleration phases of throwing, when the UCL is subjected to the highest valgus stress, the elbow is at 60° to 90° of flexion.[1,6,8,9] Theoretically, testing the elbow at 60° to 90° of flexion with the Telos device would most closely approximate the clinical setting. The proper use of this device, however, requires that the elbow be placed within a narrow, low range of elbow flexion so that the fixation pads contact the player's forearm and upper arm. This ensures that the exact amount of stress is applied to the medial elbow. This required positioning, however, did not allow the players' elbows to be placed at 60° to 90° of flexion. Thus, because of the variation in elbow flexion in the late cocking/acceleration phases of throwing, limitations in the proper use of the Telos device, and previous biomechanical studies that have identified the UCL as the primary restraint against valgus stress at 30° of elbow flexion, this elbow flexion angle was subsequently chosen for all testing.[30]

In the current study, we noted baseline anatomic changes of the UCL in the dominant elbows of elite-level baseball pitchers. We found that the mean thickness of the UCL was significantly greater in the dominant compared with the nondominant elbow. We also found that the gapping of the stressed ulnohumeral joint space was significantly greater in the dominant elbow. Echotextural abnormalities were more likely to be present in the dominant elbows of the pitchers as well. These changes in UCL thickness, joint space gapping with stress, and echo-textural abnormalities may be adaptive and secondary to repetitive throwing. The current study is unable to determine if their presence may or may not predispose pitchers to subsequent UCL injuries. Despite this, these findings serve as a baseline for medical caretakers of these players for comparison if subsequent UCL injuries do occur. In addition, stress US may also be beneficial for medical caretakers in scenarios where surgical treatment is being contemplated, such as for those pitchers found to have partial tearing on magnetic resonance arthrography, those with medial elbow pain who have undergone previous UCL reconstruction, and those who are having difficulty despite adequate nonoperative treatment. We hope that with further data collection and continued longitudinal surveil-lance, we may be able to determine whether these findings correlate with the risk of future UCL injuries.

The strengths of this study include the size of the study group and the length of the study period. It represents the largest and longest clinical study on the use of stress US for the evaluation of the UCL in professional baseball pitchers. In addition, the current study extended over a 10-year time period, and we were able to obtain ≥2 years of stress US studies for more than one third of our athletes. It provides both a quantitative assessment of the UCL with a standardized stress device and a qualitative assessment of UCL ultrastructural changes with throwing. Furthermore, all US data collected over the entire 10-year study period were obtained by the same experienced musculo-skeletal radiologist.

There were a few limitations in this study. There was no independent control group of nonoverhand athletes. However, we were able to use the nondominant elbow as a suitable control. Second, there were a relatively small number of throwers with injured UCLs during the study period that could be used as a subgroup comparison to noninjured throwers. Only 12 pitchers required UCL reconstruction during the 10-year study period. This low number of UCL reconstructions, although good for the baseball organization, did not allow any statistical significance to be achieved during this study period. An increased number of players requiring UCL reconstruction may have made these observed results statistically significant as shown in the post hoc power analysis. We will continue to collect data to amass larger numbers of UCL injuries in an effort to identify possible risk factors, such as increased ligament thickness, change in ulnohumeral joint space with stress, and presence of echotextural abnormalities. Third, only 131 (36%) of the pitchers remained with the team long enough to have more than 1 stress US examination during the study period. This, however, is unavoidable when studying professional baseball pitchers as the nature of the sport often dictates that players change teams frequently. Moreover, we did not have any pitching history data pertaining to skill level, position in the rotation, and pitch counts. Several reports have shown that these factors play a role in the incidence of elbow pain, elbow injury, and need for elbow surgery in youth and adolescent pitchers; it is possible that these unknown factors may have had an effect on our results.[16-18,33] Last, because our data were obtained from asymptomatic participants, it is difficult to say with certainty if these observed abnormalities on stress US correlate with clinical symptoms and instability. Despite this, our study has shown that stress US can be used for long-term surveillance of the elbows of elite-level pitchers.

CONCLUSION

We have shown that stress US can detect anatomic changes to the UCL in asymptomatic professional baseball pitchers. These abnormalities progress over an extended period of time and persist with continued exposure to pitching at an elite level. We were unable to determine if these abnormalities are directly associated with the risk of future UCL injuries because of the low number of UCL reconstructions performed over the 10-year study period. With continued longitudinal surveillance, we hope to precisely define the risk factors for future UCL injuries on stress US in this athletic population.

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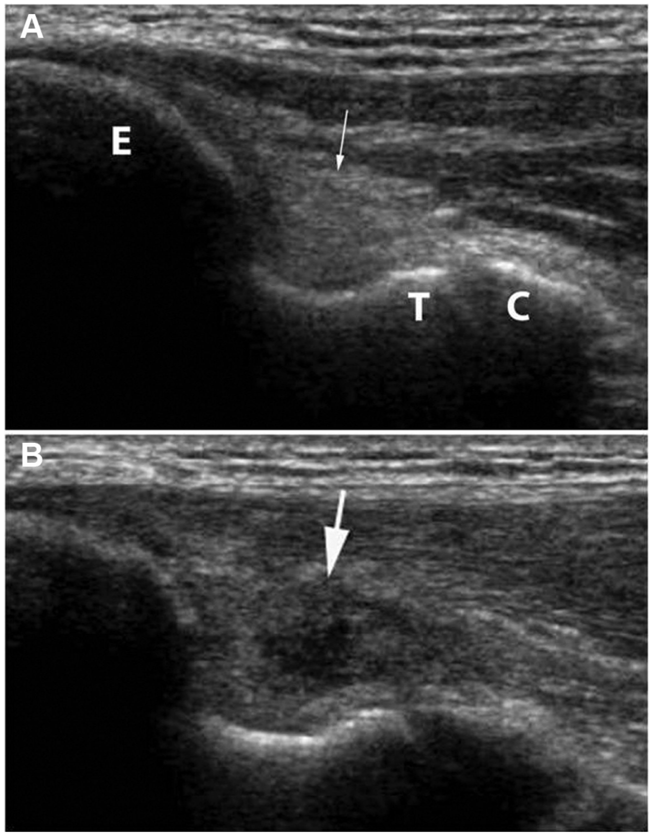

Figure 1.

Bilateral ultrasound images of the ulnar collateral ligament (UCL) in an asymptomatic professional baseball pitcher. (A) Image of the nonpitching arm shows a normal UCL (arrow). (B) Image of the pitching arm shows a slightly thicker UCL that contains a hypoechoic focus (arrow). C, coronoid process; E, medial epicondyle; T, trochlea.

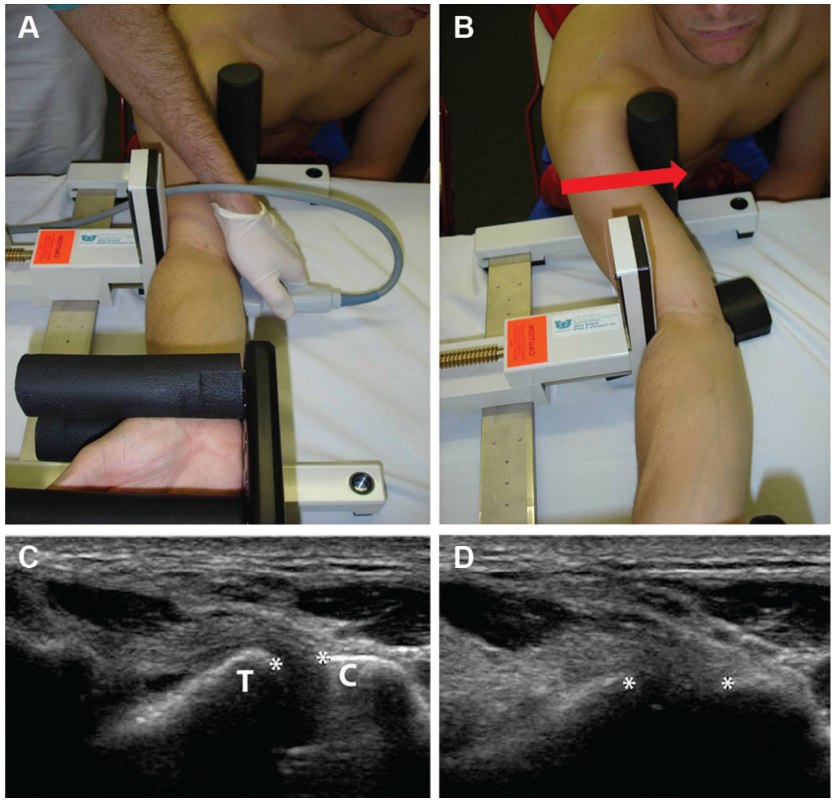

Figure 2.

Clinical and ultrasound images at rest and with valgus stress in the pitching arm of an asymptomatic professional baseball pitcher. (A) Stress ultrasound of the elbow in the Telos device. (B) Valgus stress being applied to the elbow by the Telos device. (C) At rest, the ulnohumeral joint (asterisks) measures 4.2 mm. (D) With valgus stress applied by the Telos device, the ulnohumeral joint (asterisks) widens to 7.9 mm. C, coronoid process; T, trochlea.

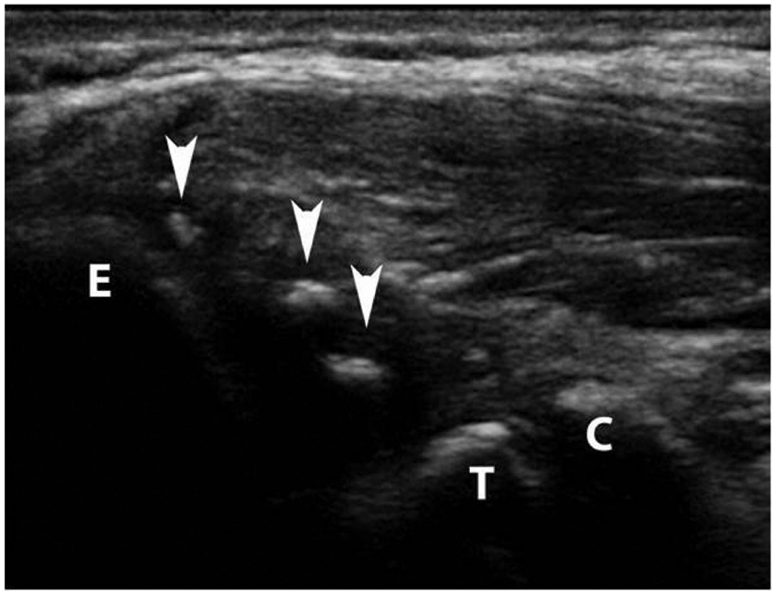

Figure 3.

Ultrasound images of the pitching arm of an asymptomatic professional baseball pitcher. Calcifications (arrowheads) are seen within a thickened, hypoechoic ligament. C, coronoid process; E, medial epicondyle; T, trochlea.

TABLE 1

Thickness at Rest of the Anterior Band of the UCL in the Dominant and Nondominant Elbows of All Pitchers (N = 736)[a]

	Dominant	Nondominant	*P* Value
Thickness at rest, mm	6.15 ± 1.57	4.82 ± 1.32	<.001

[a]Data are expressed as mean ± standard deviation. UCL, ulnar collateral ligament.

TABLE 2

Joint Space Widths and Differences in the Anterior Band of the UCL in the Dominant and Nondominant Elbows of All Pitchers (N = 736)[a]

Joint Space Width	Dominant	Nondominant	*P* Value
At rest, mm	3.32 ± 0.07	2.94 ± 0.12	.61
With stress, mm	4.56 ± 1.10	3.72 ± 0.92	<.003
Difference (with stress – at rest), mm	1.24 ± 1.04	0.78 ± 0.65	<.004

[a]Data are expressed as mean ± standard deviation. UCL, ulnar collateral ligament.

TABLE 3

Prevalence of Hypoechoic Foci and Calcifications in the Anterior Band of the UCL in the Dominant and Nondominant Elbows of All Pitchers (N = 736)[a]

	Dominant	Nondominant	*P* Value	χ^2 (df)
Hypoechoic foci	103 (28.0)	13 (3.5)	<.001	10.7 (2)
Calcifications	92 (24.9)	6 (1.6)	<.001	7.1 (1)

[a]Data are expressed as n (%). UCL, ulnar collateral ligament.

TABLE 4

Change Over Time Between Initial and Final Stress US Findings of Pitchers With at Least 2 Yearly US Examinations (n = 131)[a]

	Initial US	Final US	*P* Value	χ^2 (df)
Thickness at rest, mm	6.05 ± 1.44	6.12 ± 1.60	.62	
Joint space width, mm				
At rest	3.08 ± 0.74	2.96 ± 0.73	.11	
With stress	4.00 ± 1.12	4.37 ± 0.99	.001	
Change in joint space (with stress – at rest)	1.17 ± 0.96	1.03 ± 0.72	.06	
Hypoechoic foci, n (%)	65 (49.0)	70 (53.4)	.65	8.37 (1)
Calcifications, n (%)	40 (30.5)	35 (26.7)	.24	24.9 (1)

[a]Data are expressed as mean ± standard deviation unless otherwise indicated. US, ultrasound.

TABLE 5

Comparison of Baseline Stress US Findings of the Anterior Band of the UCL in the Dominant Elbows of Pitchers With Subsequent UCL Injuries and Asymptomatic Pitchers[a]

	Injured Pitchers (n = 12)	Asymptomatic Pitchers (n = 356)	*P* Value	χ^2 (df)
Thickness at rest, mm	6.84 ± 1.56	6.11 ± 1.57	.19	
Joint space width, mm				
At rest	3.44 ± 1.34	3.08 ± 1.77	.44	
With stress	4.55 ± 1.52	4.09 ± 1.25	.44	
Change in joint space (with stress – at rest)	1.06 ± 0.88	1.12 ± 0.95	.83	
Hypoechoic foci, n (%)	5 (42.0)	100 (29.4)	.17	1.90 (1)
Calcifications, n (%)	3 (25.0)	81 (24.0)	.68	0.17 (1)

[a]Data are expressed as mean ± standard deviation unless otherwise indicated. UCL, ulnar collateral ligament; US, ultrasound.