Outcome measures after medial ulnar collateral ligament reconstructions in a military population

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Background: Medial ulnar collateral ligament (MUCL) reconstruction outcomes are well described in competitive throwers but not in nonthrowers. This investigation elucidated epidemiologic variables, functional outcomes, and prognostic factors after MUCL reconstruction in young active patients.

Methods: United States military service members undergoing MUCL reconstruction were isolated using the Management Analysis and Reporting Tool (M2) database from 2009 to 2016. Demographics, injury characteristics, and surgical variables were extracted. Multivariate analysis was performed, discerning variables predictive of postoperative functional outcomes, complications, and reoperation.

Results: Sixty-six patients met inclusion criteria, and 47% participated in throwing sports. Of these, 36.4% reported a throwing mechanism of injury (MOI), 60.6% reported an acute trauma MOI, 59% reported preoperative ulnar nerve symptoms, and 39.4% experienced symptoms postoperatively. At final follow-up, average Disabilities of the Arm, Shoulder and Hand (DASH) and Mayo Elbow Performance Score (MEPS) scores were 10.8 ± 16.2 and 87.6 ± 17.1, respectively. A total of 86.4% reported no disability (DASH < 30), and 83.3% experienced good or excellent outcomes (MEPS >74). Age < 30 years, dominant arm injury, competitive throwing history, and throwing MOI correlated with improved DASH and MEPS scores, push-up count, postoperative pain and instability, and rates of ulnar nerve symptoms ($P < .05$). Psychiatric diagnosis and preoperative stiffness and instability were associated with lower outcome scores ($P < .05$). Ulnar nerve interventions did not correlate with presence or absence of postoperative ulnar nerve symptoms.

Conclusions: MUCL reconstruction demonstrates a high good-to-excellent outcome rate and low complication and revision rates in young active individuals with intense upper extremity demands. Nonthrowing MOIs and psychiatric pathology are associated with postoperative complications and poorer outcomes.

Level of evidence: Level IV; Case Series; Treatment Study
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Medial ulnar collateral ligament (MUCL) injuries are classically associated with throwing sports,[16] particularly baseball pitchers,[8] and are thought to develop as chronic injuries secondary to repetitive valgus stress to the elbow.[8,9] Although rehabilitation is generally recommended initially, surgical management may be appropriate for high-performance athletes who wish to continue at their current level of play.[8] MUCL reconstruction is furthermore favored over repair given the

superior functional outcomes and higher likelihood of returning patients to their preinjury levels of sporting activity (80%-90%).[3,5,8,9,11,13,15] A variety of surgical techniques have been described for ligamentous reconstruction, although none has demonstrated a clear biomechanical or clinical advantage over the others.[8]

Due to the relative prevalence of MUCL injuries among competitive throwers compared with the general population, literature has predominantly evaluated outcomes among these individuals. As a result, evidence is sparse surrounding functional and recreational outcomes for young active individuals not involved in throwing sports. Active duty military represent a population of individuals subject to intense daily upper extremity demands and therefore serve as a suitable proxy for the young athletic nonthrowing patient. The purpose of this investigation was to elucidate the (1) surrounding epidemiologic variables, (2) functional and occupational outcomes, and (3) factors prognostic of superior outcomes after MUCL reconstruction in a young active population with intense upper extremity demands.

Materials and methods

All triservice (Army, Navy, and Air Force) United States (US) military patients undergoing isolated MUCL reconstructions (Current Procedural Terminology [American Medical Association, Chicago, IL, USA] code 24346) between December 2009 and April 2016 were isolated via the Military Health System Management Analysis and Reporting Tool (M2). Patients were included who underwent isolated MUCL reconstruction and had at least 2 years of follow-up. Exclusion criteria were applied to patients with insufficient follow-up or documentation or who did not consent to a final telephone interview.

The electronic medical record was retrospectively reviewed for demographic and occupational data (age, sex, history of throwing sports), injury characteristics (laterality, mechanism of injury [MOI], hand dominance), and surgical variables (technique, graft type, concomitant ulnar nerve decompression, time from injury to surgery). An acute trauma MOI was defined as a single, nonthrowing, traumatic event. Preoperative and postoperative examination findings were extracted from the record, including preoperative pain, instability, pain at MUCL insertion, findings with valgus stress testing, preoperative and postoperative range of motion, and postoperative flexion and extension strength.

Patients with throwing sports as their MOI typically had the preoperative chief complaint of instability and pain, specifically while throwing. For nonthrowing patients, typical preoperative chief complaints included any or all of pain, instability with heavy activity, difficulty with particular work-related tasks, or ulnar nerve paresthesias. Aggravating activities in our cohort were more varied than in typical patients with MUCL injuries (ie, pain or instability with combatives, grappling, carrying a heavy load). These activities generally had the common trait of causing valgus stress across the elbow. Most patients underwent extended trials of nonoperative management. Exceptions to this were generally acute trauma patients (ie, fractures/dislocations requiring elbow surgery more urgently).

Preoperative and postoperative instability were reviewed from the patient's records for the last postoperative clinical note describing their elbow examination. In addition to the patient's elbow examination findings, high-level activities that the patient had been able to resume after surgery (ie, pitching, push-ups) were also used as a surrogate for stability. Clinical notes generally used similar verbiage (ie, "stable," or "slight laxity") for the Mayo Elbow Performance Score (MEPS) to infer elbow stability.

Clinical and functional outcomes were obtained at the final follow-up via telephone interview, including (1) overall satisfaction with the surgical outcome, (2) whether the patient remained active within the military or was separated due to disability attributable to the elbow, and (3) postoperative combat deployment. Patient's pain level before surgery and current average level of pain were evaluated by visual analog scale (VAS, range 0-10), with 0 corresponding to no pain, and 10 corresponding to the worst pain imaginable. VAS scores ≤3.4 correspond to mild interference with functioning, 3.5 to 6.4 moderate interference, and ≥6.5 severe interference for musculoskeletal pain.[1] The MEPS and the Disabilities of the Arm, Shoulder and Hand (DASH) score were obtained for all patients at the final follow-up.

The MEPS was calculated using data from the telephone interview as well as the last range of motion and degree of instability as described in the last occupational therapy or orthopedic surgery encounter from the electronic medical record. For the MEPS, a score >90 points was considered an excellent outcome, 75 to 89 a good outcome, 60 to 74 fair, and <60 was considered a poor outcome.[4] For the DASH, a score is generated between 0 and 100, with 0 corresponding with no disability and 100 to complete disability. A score of <30 is considered to correspond to little to no disability of the limb, and >69 is considered significantly limiting.[4]

Lastly, perioperative complications, reoperation, and revision operations were collected for each patient and cross-referenced with the electronic medical record. Major complications were defined as those requiring a return to the operating room for revision or an additional procedure. Minor complications included all other complications. We defined a failure of reconstruction as continued subjective instability at the time of the telephone interview. All interviews were performed by the same primary investigator (JBF) to minimize variability.

Statistical analysis

Continuous variables are reported as means and standard deviations. Frequencies are reported for categoric variables. To evaluate the effect of the various independent variables on the continuous outcomes of interest, the 2-sample t test (for categoric independent variables), linear regression analysis (for continuous independent variables), and the χ^2 statistic (for categoric data) were performed. With significant t-test results, the mean and standard deviation for the continuous outcome variable are reported by the categories of the independent variable. Logistic analysis was performed for the binary outcome variables. Multivariate analysis was also performed to eliminate confounders. Corresponding odds ratios (ORs) and 95% confidence intervals are reported for significant logistic results. A P value of <.05 was considered statistically significant. Calculations were performed using SAS 9.4 software (SAS Institute Inc., Cary, NC, USA).

Results

The initial M2 query identified 139 patients, of which 66 were isolated based on the predefined inclusion/exclusion criteria
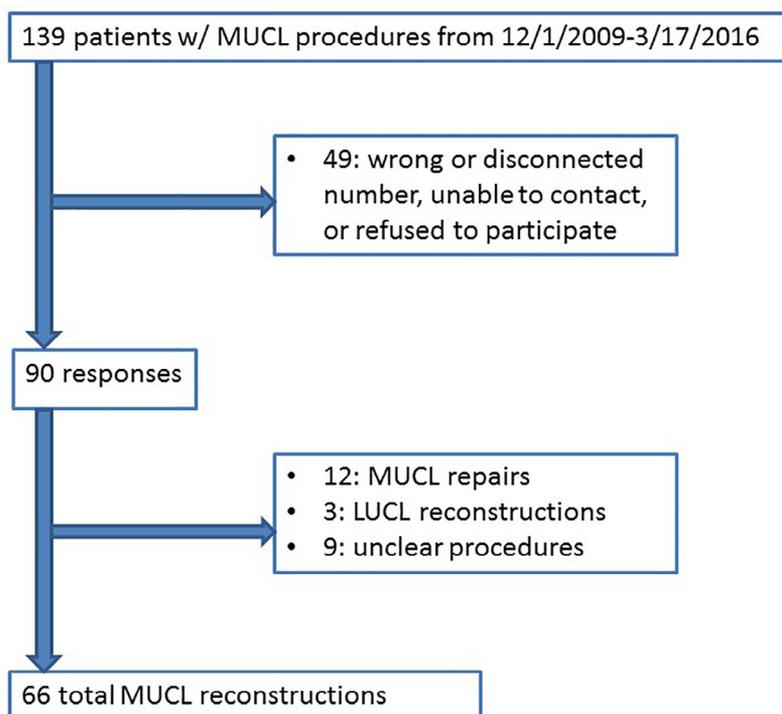
Figure 1 Identification of study cohort and inclusion and exclusion criteria. *MUCL*, medial ulnar collateral ligament; *LUCL*, lateral ulnar collateral ligament.

(Fig. 1). The final cohort was an average age of 30.2 ± 10.3 years, 89.4% were men, 47% reported a history of throwing, and 90.3% of these had a history of primarily baseball pitching. There were also 2 lacrosse players, and 1 football quarterback. The patients with a history of throwing or with a throwing MOI were on average found to be younger ($P = .0118$). Reported MOIs including throwing (36.4%) and nonthrowing sports injuries (24.2%), falls (25.8%), combat or motor vehicle accident (7.5%), and other (6%). The nonthrowing injuries among those patients with a history of throwing included 5 sports trauma injuries, 1 motocross accident, and 1 fall onto an outstretched hand. Acute trauma, defined as a single, traumatic event, was responsible for 60.6% of the cohort's injuries. Most patients (59.1%) reported preoperative ulnar nerve symptoms, defined as any or all of altered grip strength, numbness, paresthesias, or pain in an ulnar nerve distribution.

Patients underwent MUCL reconstruction an average of 16 ± 22.7 months after the index injury (Table I). Of those cases (90.9%) that documented the surgeon's choice of graft, autograft was used in 78.3%. This was most commonly palmaris longus (70%), followed by gracilis (3.3%). An allograft was used in the remaining 21.7%. The source was not specified in 46.2% of the allograft cases; the most common specified source of allograft was gracilis (57.1%). Six cases did not document choice of graft. As part of the reconstruction procedure, 31.8% of patients underwent concomitant ulnar nerve decompression (Table II).

At the time of final follow-up, patients experienced a mean DASH score of 10.8 ± 16.17, with 86.4% reporting no significant disability (scores of <30).[4] Similarly, the average MEPS was 87.6 ± 17.1, with 83.3% of patients reporting a good or excellent outcome (scores >74).[4] Of the 28 patients with a history of baseball pitching, 92% reported return to baseball, with 89.3% reporting a return to pitching. Return to sport occurred in 10.9 ± 5.3 months. Two of these patients reported returning to pitching at a lower level of competition. The majority (63%) of military patients (n = 57) were active duty at 2 years postoperatively; 14% were currently active duty but had had their operation <2 years before the telephone follow-up. Another 12.1% of patients reported retiring from military service for reasons other than their elbow, and 13.6% were no longer active duty due to their elbow injury (Table II).

Postoperative complications or reconstruction failure, or both, occurred in 21 patients (31.8%). At the time of their telephone interview, 13 patients (19.7%) reported subjective feelings of instability, which constituted a failure of reconstruction. Of those patients with postoperative instability/failure, the MOI in 92.3 was other than throwing sports.

The reoperation rate after the initial MUCL reconstruction was 9.1%, most commonly for persistent ulnar nerve symptoms (Supplementary Table S1). Two patients had failure of reconstruction (characterized by persistent instability and pain) requiring revision, and 1 required removal of intraarticular hardware from the initial procedure (Table II). Ten

Table I Cohort demographics, preoperative examination, and injury variables

Variables	Patient data (n = 66)
Demographics	
Age, yr	30.2 ± 10.2
<30	63.6
<35	68.2
<40	81.8
Male sex	89.4
Military	86.4
Cadet	28.8
Jr	10.6
Army/Marine	48.5
Psychiatric diagnosis	28.8
Thrower	47
Preoperative injury characteristics	
Laterality (right)	62.1
Dominant	62.1
Throwing MOI	36.4
Acute trauma	60.6
Concomitant injury (any)	45.5
Prior procedure	7.6
>1	4.6
>2	1.5
Chronicity, mo	16 ± 22.7
<6 mo	59.1
<1 yr	33.3
Preoperative	
Pain	93.9
Instability (subjective)	68.2
Instability (objective)	84.9
Ulnar nerve symptoms	59.1
Weakness	12.1
Stiffness (arc <100°)	10.6

MOI, mechanism of injury; *Jr*, junior officer.
Continuous data are presented as the mean ± standard deviation and categoric data as the percentage of patients.

Table II Surgical variables, postoperative outcomes, and complications

Variables	Patient data (n = 66)
Surgical variables	
Ulnar nerve procedure	31.8
Decompression	7.6
Transposition	24.2
Reconstruction	100
Autograft (n = 60)	78.3
Midsubstance tear	6.1
Outcomes	
DASH	10.8 ± 16.2
<30 (no disability)	86.4
>69 (major)	0
MEPS	87.6 ± 17.1
>74 (good-excellent)	83.3
<60 (poor)	6.1
Pain	1.2 ± 2.1
>3	12.1
<5	92.4
Active at 2 yrs	54.6
Active now	60.6
Total flexion-extension arc, °	134 ± 18.9
<100°	4.5
Complications	31.8
>1	0
>2	0
Post-op instability	19.7
Ulnar nerve symptoms	39.4
New post-op ulnar nerve symptoms	12.1
Reoperation	9.1
>1	3
>2	3
Revision	3

DASH, Disabilities of the Arm, Shoulder and Hand; *MEPS*, Mayo Elbow Performance Score.
Continuous data are presented as the mean ± standard deviation and categoric data as the percentage of patients.

patients (15.2%) reported 1 or more minor complications. At time of the final follow-up, 39.4% of patients reported ulnar nerve symptoms; however, 69.2% of these patients reported ulnar nerve symptoms preoperatively. Only 8 patients (12.1%) developed new postoperative ulnar nerve symptoms. Superficial infections in 2 patients were treated to resolution with oral antibiotic therapy, and 2 experienced functionally limiting postoperative stiffness secondary to heterotopic ossification or capsule contracture, or both, necessitating return to the operating room.

Univariate and subsequent multivariate analysis demonstrated that younger age (<30 years), injury of the dominant extremity, history of competitive throwing, and throwing MOI were associated with multiple improved outcome measures (Supplementary Table S1). The overall complication rate was lower in patients with a history of competitive pitching (*P* = .0147) or throwing MOI (*P* = .0053). Military cadet status was associated with better DASH scores (*P* = .0489) and push-

up count (*P* = .0018) compared with the overall cohort. Psychiatric diagnosis and preoperative stiffness were predictive of poorer scores in several outcome measures (Supplementary Table S1). Performance of an ulnar nerve procedure did not correlate with presence or absence of postoperative ulnar nerve symptoms (Supplementary Table S1).

Of our cohort of 66 patients, 39 (59.1%) reported ulnar nerve symptoms preoperatively. In the total cohort, no specific ulnar nerve procedure was performed in 45 patients, 5 underwent release, and 16 underwent transposition. Of those patients who had ulnar nerve symptoms preoperatively and who had no specific ulnar nerve procedure performed during their MUCL reconstruction (n = 25), 60% of patients reported postoperative improvement in ulnar nerve symptoms, whereas 50% improved after release (n = 4), and 40% improved after transposition (n = 10). Twenty-seven patients

Table III Outcomes after ulnar nerve procedures

Ulnar nerve symptoms and outcomes of interventions	Throwers (n = 31) % (No.)	Nonthrowers (n = 35) % (No.)	Total (N = 66) % (No.)
Presence of preoperative ulnar nerve symptoms (No.)	67.7 (21)	51.4 (18)	59.1 (39)
Outcomes after no ulnar nerve procedure (No.)	71% (n = 22)	65.7 (n = 23)	68.2 (n = 45)
No new symptoms	36.4 (8)	30.4 (7)	33.3 (15)
New symptoms	22.7 (5)	0 (0)	11.1 (5)
Improvement of preoperative symptoms	22.7 (5)	43.5 (10)	33.3 (15)
No improvement in preoperative symptoms	18.2 (4)	23.1 (6)	22.2 (10)
Outcomes after ulnar nerve releases (No.)	9.7 (n = 3)	5.7 (n = 2)	7.6 (n = 5)
No new symptoms	0 (0)	50 (1)	20 (1)
New symptoms	0 (0)	0 (0)	0 (0)
Improvement of preoperative symptoms	66.7 (2)	0 (0)	40 (2)
No improvement in preoperative symptoms	33.3 (1)	50 (1)	40 (2)
Outcomes after ulnar nerve transpositions (No.)	19.4 (n = 6)	28.5 (n = 10)	24.2 (n = 16)
No new symptoms	33.3 (2)	10 (1)	18.8 (3)
New symptoms	0 (0)	30 (3)	18.8 (3)
Improvement of preoperative symptoms	16.7 (1)	30 (3)	25 (4)
No improvement in preoperative symptoms	50 (3)	30 (3)	37.5 (6)

The first row demonstrates overall preoperative prevalence of ulnar nerve symptoms. Patients underwent 1 of 3 treatment pathways regarding the ulnar nerve: (1) no procedure, (2) ulnar nerve release, or (3) ulnar nerve transposition. Ulnar nerve procedures are sometimes performed in patients without ulnar nerve symptoms; we therefore divided patients into 1 of 4 categories, after undergoing one of the above 3 treatment pathways: (1) no new symptoms, (2) new symptoms, (3) improvement in symptoms, (4) no improvement in symptoms.

reported no ulnar nerve symptoms preoperatively; of those who did not undergo a ulnar nerve procedure (n = 20), 25% reported new ulnar nerve symptoms postoperatively, 0% developed symptoms after release (n = 1), and 50% developed symptoms after transposition (n = 6; Table III).

Operative reports detailing reconstruction techniques were unavailable for 44 of the 66 patients. However, specific reconstruction techniques and implants are not included in this study because intraoperative records were often incomplete.

Discussion

In this investigation we found that that young, active predominantly nonthrowers undergoing MUCL reconstruction experienced generally excellent postsurgical functional outcomes (86.4% with DASH scores of <30, 83.3% with MEPS scores >74) and demonstrated a high rate of return to preoperative levels of activity, with a comparably low incidence of complications (33%) and reoperation (9.1%). We identified 3 key prognostic variables that will be of value for counseling patients on return to function: (1) time to reconstruction was not associated with ultimate functional outcomes; (2) younger age, involvement in throwing sports, and dominant-sided injuries were associated with improved functional outcomes; and (3) preoperative stiffness, instability, and history of psychiatric disease portended inferior functional results after reconstruction.

Given that preoperative stiffness and subjective instability were predictive of inferior functional outcomes whereas time to surgery was not, there is clearly no impetus for early MUCL reconstruction in the nonthrower. On the contrary, early directed physical therapy could only serve to improve functional outcomes by optimizing range of motion and maximizing elbow stability. These findings are consistent with current treatment guidelines, which recommend a trial of nonoperative treatment of up to 3 to 6 months before consideration for reconstruction.[2,8,9] Further studies of early rehabilitation compared with acute reconstruction may be warranted, especially in the young throwing athlete in whom these injuries are more common.

Patients aged younger than 30 years, with injury to the dominant extremity, and involved in throwing or pitching sports attained superior functional outcomes than did their counterparts. Throwing MOI and history of competitive throwing were also associated with a decreased complication rate; however, no difference was found in rates of reoperation.

Similar to our findings regarding age, Lansdown and Feeley[7] found a statistically significant decline in fastball velocity among older patients who had undergone MUCL reconstructions. In a case series of 88 pitchers, they found that mean pitch velocity dropped from 91.3 to 90.6 mph (146.9 to 145.8 kmh; $P = .003$), with the most significant decline in patients aged >35 (91.7 to 88.8 mph [147.5 to 142.9 kmh], $P = .0048$) The authors concede that the difference may not be significant enough to affect performance, but it was noted that these pitchers used fastball pitches less frequently, possibly secondary to decreased effectiveness of this pitch.

One possible explanation for our findings is that the younger, high-level athletes had perhaps better physiologic

function and also a stronger mental drive to return to competitive levels of function or to regain full function of an injured dominant limb. It is important to note that 29 of our 31 patients with throwing history sustained an injury to their dominant extremity and that those patients with history of throwing or throwing MOI were on average younger than their counterparts. Our study suggests that we can expect better outcomes from this patient population.

Although our sample sizes are insufficient for full statistical analysis, there is a slight trend in favor of performing no ulnar nerve procedure. Of patients with ulnar nerve paresthesias, 60% improved without ulnar nerve intervention, whereas 43% of asymptomatic patients who underwent an ulnar nerve procedure developed new ulnar nerve symptoms postoperatively.

A history of psychiatric diagnosis was also prognostic of poor postoperative functional and occupational outcomes. This is in agreement with previous studies[14,17] that have demonstrated behavioral health diagnoses are predictive of poor postoperative physical function and overall inability to return to preoperative levels of activity. In the longitudinal observational study by Schoenfeld et al,[14] 4087 active duty personnel were monitored for 4 years and assessed for development of musculoskeletal problems, behavioral health diagnoses, and inability to remain in service. Behavioral health diagnoses were significant predictors for referral to the Medical Evaluation Board for a musculoskeletal problem. In addition, in the prospective longitudinal observational study by Warren et al,[17] 259 patients who were admitted to a Level I trauma center were evaluated for development of post-traumatic stress disorder 6 months after injury. In this population, pain scores of ≥5, below-average physical function, below-average mental function, or inability to return to work after 6 months were predictive of having post-traumatic stress symptoms. Whether a psychiatric diagnosis is necessarily causative or merely associated with poor outcome remains unclear. However, this will regardless aid in preoperative counseling patients with active psychiatric pathology as well as assessment of patient motivation to return to function.

In light of the significant findings of this study, we acknowledge a number of limitations. Given the reliance on patient interviews, which frequently occurred several years after the index injury and reconstruction, recall bias or reporting errors may be present. The 2010 study by Razmjou et al[12] explored the potential inaccuracy of pain recall, demonstrating that patients who have undergone rotator cuff repair are likely to remember higher pain scores than what they actually reported preoperatively. However, the effect of recall bias or reporting errors may be minimized by the significant emotional effect of these injuries. Furthermore, interviewer bias was minimized by establishing a single interviewer and performing all interviews within a short timeframe.

Because operative reports detailing reconstruction techniques were not available for most of the patients during our record review, potential variability in surgical approach limits our ability to apply our findings to the total reconstruction population. However, this may have little effect on outcomes, because no one technique has been proven superior to others.

Finally, the retrospective nature predisposes this investigation to selection bias. The low incidence of these injuries makes prospective evaluations difficult, and selection bias may be mitigated by a strong, validated methodology, as in this case.[6,10]

Despite the limitations, this study provides new demographic, outcome, and prognostic information on a previously understudied patient population, which will aid physicians in counseling patients with MUCL injury.

Conclusion

In our physically active cohort, MUCL reconstruction demonstrated a reliably high rate of good and excellent outcomes and a low rate of revision surgery in a young active population with intense upper extremity demands. However, patients with a nonthrowing MOI demonstrated significantly lower functional outcomes. Findings from prior MUCL studies on throwers should not be extrapolated to these patients without caution. Preoperative physical therapy is recommended in these patients to optimize preoperative range of motion and stability. The prognosis remains more guarded in patients with psychiatric history, and these patients should be counseled on their risk for lower functional outcomes.

Disclaimer

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Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jse.2018.07.025

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