Systematic Review

Elbow Ulnar Collateral Ligament Repair With Suture Augmentation Results in Good Clinical Results, a Return-to-Play Rate Between 67% and 93%, and a Postoperative Complication Rate Up to 11.9%: A Systematic Review

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Purpose: To review the Kerlan-Jobe Orthopaedic Clinic (KJOC) scores, return-to-play rates, and complications after ulnar collateral ligament (UCL) repair with suture augmentation. **Methods:** A literature search of the PubMed and Scopus databases was conducted on February 17, 2023, using the terms "ulnar collateral ligament," "repair," "internal brace," and "suture augmentation." The search strategy was based on the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) protocol and included 4 articles published from 2019 to 2022. The inclusion criteria included studies reporting outcomes, return-to-play rates, and/or complications after UCL repair with suture augmentation. The exclusion criteria consisted of non—English language studies, case reports, cadaveric studies, animal studies, letters to the editor, studies with overlapping cohorts, and review articles. The risk of bias was evaluated using the Methodological Index for Non-Randomized Studies (MINORS) criteria. **Results:** The final analysis included 4 studies with 510 patients (457 male and 53 female patients), ranging in age between 17.8 and 27.5 years, treated with repair and suture augmentation for UCL tears. In this review, we found a mean postoperative KJOC score ranging from 87.9 to 92.6. The overall rate of return to play at the preinjury level or at a higher level than the preinjury level ranged from 67% to 93%; the mean time to return to play ranged from 6.7 to 17.6 months. The postoperative complication rate in this review ranged from 0% to 11.9%. Among the complications, the most common were ulnar nerve paresthesia (range, 0%-8.2%) and postoperative medial elbow pain (range, 0%-3.1%). Overall, the reoperation rate ranged from 0% to 3.4%. No reruptures were reported. **Conclusions:** UCL repair with the use of suture augmentation results in postoperative KJOC scores ranging from 87.9 to 92.6, a return-to-play rate between 67% and 93%, and a postoperative complication rate up to 11.9%. **Level of Evidence:** Level IV, systematic review of Level IV studies.

There has been an increased incidence of elbow ulnar collateral ligament (UCL) injuries, particularly in overhead throwing athletes.[1-8] This is due, in part, to the rising throwing velocity and frequency of games being played.[1,6] Since the introduction of elbow ulnar collateral ligament reconstruction (UCLR), or Tommy John surgery, in 1986, most of these athletes (97%) have been able to return to their preinjury level of play or a higher level.[2,4-6,8] However, this return takes time, with the current literature estimating 11 months for young athletes and 15 to 18 months for professional athletes to resume full activity.[1,4]

Motivated by the demand for a quicker return to sport, recent innovations have emerged, leading to the

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development of UCL repair with suture augmentation.[1-8] Suture augmentation to address UCL injury involves augmentation of the primary UCL repair with the addition of a nonabsorbable high-strength suture tape. Although UCLR remains the gold standard, repair with suture augmentation has its advantages. Its use has been proposed in UCL injury cases with a ligament tear at the proximal or distal insertion, a common injury pattern among young athletes.[2,3,6] In these cases, relative tissue integrity and maintained joint congruity favor ligament repair and make suture augmentation a viable option.[2,6] The direct repair allows for the restoration of normal anatomy, eliminating the need for a graft, thereby obviating donor-site morbidity or allograft-related complications and a prolonged recovery time.[3,6,7]

The purpose of this study was to review the Kerlan-Jobe Orthopaedic Clinic (KJOC) scores, return-to-play rates, and complications after UCL repair with suture augmentation. We hypothesized that UCL repair with suture augmentation would result in good clinical outcomes, a quick return to play, and few complications.

Methods

Search Strategy and Eligibility Criteria

A literature search was conducted according to the 2020 Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.[9] A comprehensive database search was performed using the PubMed and Scopus databases on February 17, 2023, for clinical studies reporting outcomes, return-to-play rates, and/or complications of UCL repair with suture augmentation with a minimum 6-month follow-up. The search criteria included the following keywords: "ulnar collateral ligament" AND ("repair" OR "internal brace" OR "suture augmentation"). The initial search yielded 744 articles; 280 duplicates were removed. Non−English language studies, case reports, cadaveric studies, animal studies, letters to the editor, studies with overlapping cohorts, and review articles were excluded. Two independent investigators (G.J., H.J.) screened the titles, abstracts, and full text. A third author (A.B.) was then asked to resolve any disagreements by collegial discussion.

Data Extraction and Outcome Measures

Data were extracted from the relevant studies and entered into a Microsoft Excel spreadsheet (version 16.63; Microsoft, Redmond, WA) for additional analysis. Collected data included the first author's name, publication year, level of evidence (as reported by Wright et al.[10]), patient demographic characteristics, postoperative KJOC score, return-to-play rate, reoperations, and postoperative complications. The selected articles were not blinded regarding author, affiliation, or source. The KJOC score is a functional assessment tool used to evaluate the outcomes of shoulder and elbow surgery in overhead athletes.[11] The questionnaire has been described as valid and more accurate than previously used questionnaires for assessment of the overhead athlete.[12] This questionnaire consists of 10 items to evaluate the patient's function, performance, and pain, with a score ranging from 0 to 100.

Risk-of-Bias Assessment

To ensure that the risk of bias was minimized, 2 investigators (G.J., H.J.) independently performed a methodologic quality assessment using the Methodological Index for Non-Randomized Studies (MINORS) criteria.[13] If disagreements occurred, they were resolved by a third investigator (A.B.). The MINORS scale is a numerical scale composed of 8 questions to evaluate noncomparative, nonrandomized studies. Each question is scored as follows: 0, not reported; 1, reported but inadequate; and 2, reported and adequate. An ideal score for a noncomparative study is 16.

Statistical Analysis

Increased heterogeneity of the included studies precluded data pooling. Patient KJOC scores were reported as means with standard deviations and ranges when provided in the included studies. Statistical illustration through forest plots or box-and-whisker plots was not performed because of the lack of studies reporting standard deviations and ranges, thus precluding the ability to calculate confidence intervals.

Results

Title and abstract screening included 464 articles, of which 457 were excluded. A total of 7 full-text articles were evaluated for eligibility (Fig 1). After full-text screening, 4 studies with 510 patients (457 male and 53 female patients) met our search criteria.[3,4,14,15] Patient age in the included studies ranged between 17.8 and 27.5 years. Follow-up time ranged between 6 and 56.7 months (Table 1).

KJOC Score

The KJOC score was reported in 3 studies.[3,14,15] The mean postoperative KJOC score ranged from 87.9 to 92.6 (Table 2).

Return to Play

Of the 4 studies, 3 reported return-to-play metrics[3,14,15] (Table 2). The overall rate of return to play at the preinjury level or at a higher level than the preinjury level ranged from 67% to 92.5%; the mean time to return to play ranged from 6.7 to 17.6 months.

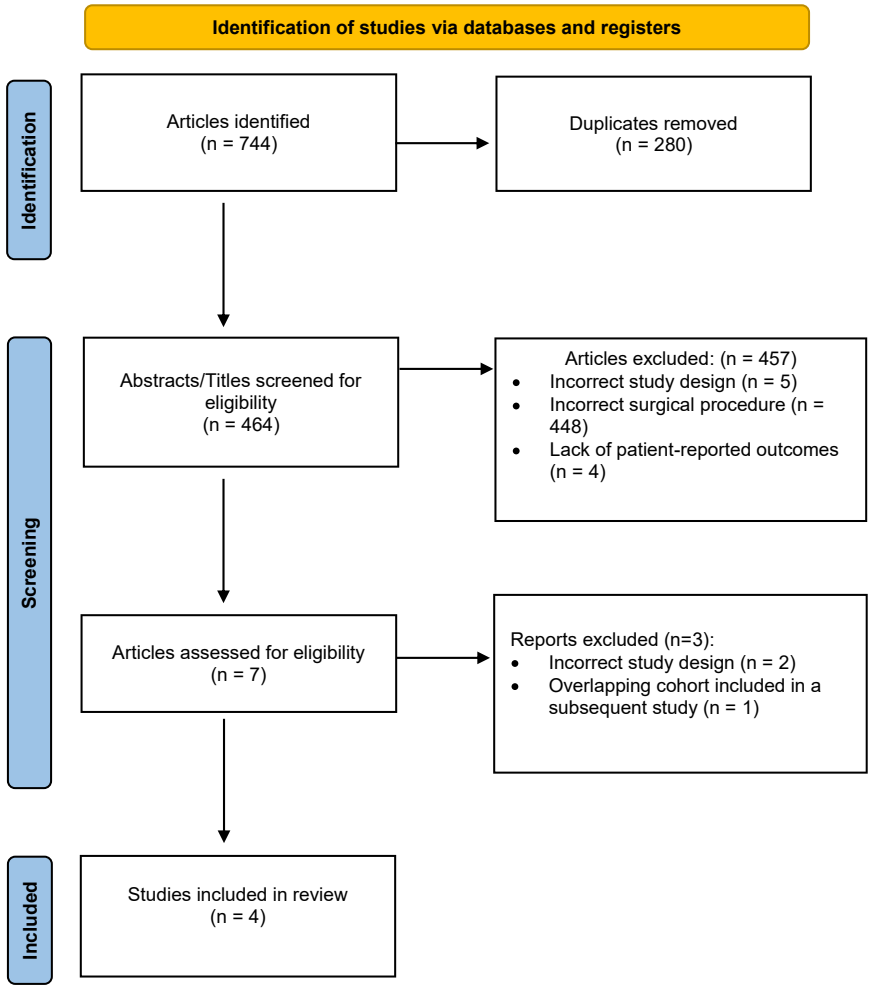

Fig 1. Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) diagram for included studies.

Postoperative Complications

All 4 studies in this analysis reported on postoperative complications (Table 3). The overall complication rate ranged from 0% to 11.9%. Among the complications, the most prevalent were ulnar nerve paresthesia, with an overall incidence ranging from 0% to 8.2%, and postoperative medial elbow pain, with an overall incidence ranging from 0% to 3.1%. Overall, the reoperation rate ranged from 0% to 3.4%, with 17 patients requiring a return to the operating room; the primary reasons were ulnar nerve–related problems (13 of 17, 76%) and heterotopic ossifications (3 of 17, 18%). No reruptures were reported after UCL repair with suture augmentation.

Discussion

This systematic review suggests that UCL repair with suture augmentation for UCL injury results in good clinical outcome scores with a quick and adequate return to play. Among younger athletes, UCL injuries remain a common occurrence. With increasing pressure to shorten return-to-play times, direct repair with suture augmentation has proved a viable option.[3,6,7,14] Multiple biomechanical studies have found the use of suture augmentation in UCL repair to yield improved results when compared with standard UCLR.[2,5,16,17] One such study performed by Urch et al.[5] found that the use of suture augmentation adequately restored valgus laxity and rotation to the intact state at all degrees of flexion whereas UCLR resulted in increased laxity at full extension and 30° of flexion, as well as overconstraint at 90° and 120°. However, the authors did report that reconstruction yielded superior load-to-failure values when compared with suture augmentation (23.9 Nm vs 17.6 Nm, $P = .039$). In a more recent study of 10 cadaveric arms, although contact mechanics were largely similar, Roth et al. reported that UCL repair augmented with a suture brace restored joint torque more closely to its original intact state when compared with UCLR.[16]

In addition, the use of suture augmentation was found to have increased resistance to gap formation at time zero under exhausting conditions compared with modified Jobe UCLR, showing a potentially faster

Table 1. Patient Demographic and Study Characteristics

Authors (Year)	LoE	Patients, n	Dominant Arm, n	Sex: M/F, n	Mean Age, yr	Mean Follow-up, mo	Sport	Level	Surgical Technique	MINORS Score
Steffes et al.[15] (2022)	IV	6	NR	6/0	27.5 ± 3.1 (22-31)	56.7 ± 37.8 (24-129)	Professional baseball	Professional (N = 6)	Exposure and longitudinal split of graft; debridement; nonabsorbable SutureTape suture (Arthrex, Naples, FL) stitched in running fashion from nondiseased end of graft toward avulsed end; graft fixed with 3.5-mm SwiveLock anchor (Arthrex) or 2.6-mm cortical button (Arthrex) based on epicondyle bone stock	14
O'Connell et al.[3] (2021)	IV	40	Left: 10 Right: 30	35/5	17.8 (14-28)	23.8 (12-44)	Baseball, n = 35; tumbling, n = 4; volleyball, n = 1	High school, n = 22; college, n = 17; coach, n = 1	Identification of MUCL; longitudinal split of ligament and capsule at location of tear; insertion of first 3.5-mm SwiveLock anchor from InternalBrace implant system (Arthrex); repair of ligament with No. 0 FiberWire (Arthrex); insertion of second 3.5-mm SwiveLock anchor and ligament repair; PRP blood clot (Harvest Technologies, Plymouth, MA) placed on top of construct (not in all cases); insertion of additional single-loaded 1.8-mm Q-Fix anchor (Smith & Nephew, Andover, MA) in case of proximal and distal injuries	12

(continued)

Table 1. Continued

Authors (Year)	LoE	Patients, n	Dominant Arm, n	Sex: M/F, n	Mean Age, yr	Mean Follow-up, mo	Sport	Level	Surgical Technique	MINORS Score
Rothermich et al.[4] (2021)	IV	353	NR	309/44	19.1 ± 4.9 (12-68)	6	Baseball, n = 272; football, n = 22; cheerleading/ tumbling/ gymnastics, n = 18; softball, n = 14; falling accident, n = 6; javelin, n = 6; wrestling, n = 4; weightlifting, n = 3; volleyball, n = 2; basketball, n = 1; horseback riding, n = 1; unknown, n = 4	NR	Native ligament repaired to its origin; internal brace incorporated into native ligament using 3 simple stitches; collagen-coated FiberTape (Arthrex) secured using two 3.5-mm PEEK (polyether ether ketone) SwiveLock anchors, inserted at UCL footprints in medial epicondyle and sublime tubercle, respectively	13
Dugas et al.[14] (2019)	IV	111	NR	107/4	18.3 ± 42.7 (13-26)	— (12-24)	Baseball, n = 102; football, n = 4; softball, n = 4; javelin, n = 1	High school, n = 74; college, n = 31; recreational, n = 4; middle school, n = 1; professional, n = 1	UCL split in line with its fibers; repair performed using InternalBrace and 3.5-mm SwiveLock anchors; first anchor placed in location of tear and loaded with collagen-dipped FiberTape and No. 0 FiberWire; free needle used to pass No. 0 FiberWire in mattress fashion into UCL; torn tissue tied down to UCL footprint on medial epicondyle or sublime tubercle; remainder of native ligament closed using No. 0 Ti-Cron suture (Medtronic, Minneapolis, MN); second anchor placed at opposing attachment site with collagen-dipped FiberTape loosely tensioned	11

NOTE. Data are presented as mean ± standard deviation (range) unless otherwise indicated.

F, female; LoE, level of evidence; M, male; MINORS, Methodological Index for Non-Randomized Studies; MUCL, medial ulnar collateral ligament; NR, not reported; PRP, platelet-rich plasma; UCL, ulnar collateral ligament.

Table 2. Postoperative Outcomes and RTP Data

Authors (Year)	KJOC Score	RTP Rate, n (%)	RTP Time, mo
Steffes et al.[15] (2022)	87.9 ± 14.6 (60.3-100)	4 (67)	17.6 ± 6 (12-24)
O'Connell et al.[3] (2021)	92.6 (64-100)	37 (92.5)	6.9 (2-12)
Rothermich et al.[4] (2021)	—	—	—
Dugas et al.[14] (2019)	88.2	102 (92)	6.7

NOTE. Data are presented as mean ± standard deviation (range) unless otherwise indicated.
KJOC, Kerlan-Jobe Orthopaedic Clinic; RTP, return to play.

return to play.[2,18,19] A study performed by Bachmaier et al.[20] found that UCL repair with suture augmentation restored valgus stability comparable to the intact state, in addition to showing improved torsional resistance and gap formation, when compared with reconstruction with a modified docking technique. In another study, however, Bodendorfer et al.[21] found no significant difference in load to failure, gap formation, or valgus opening angle between 9 matched pairs of cadaveric elbows after either repair with suture augmentation or reconstruction with a docking technique. Prior literature thus supports the idea that UCL repair with suture augmentation can have comparable biomechanical outcomes to reconstruction with a docking technique—and may even have superior biomechanical outcomes.[20,21] Additionally, the use of suture augmentation has been shown to protect the UCL as it heals and allows the strength of the native ligament to be restored, a key feature in recovery.[5] Nevertheless, it should be noted that even augmented repairs rely on the integrity of the remaining UCL tissue, which is frequently compromised in patients who have sustained chronic injuries after repeated microtrauma—with eventual permanent ligament damage. Under such conditions, often present in high-level athletes, insufficient tissue viability warrants ligament reconstruction with a graft.

Our review found that the use of suture augmentation results in a postoperative KJOC score ranged from 87.9 to 92.6 at a mean follow-up of 9.3 months. In a systematic review of 512 patients who underwent UCLR, Glogovac et al.[22] reported that the KJOC score ranged from 76 to 89.3 at a mean duration of follow-up ranging from 31 to 58 months.

For athletes, returning to play remains an important factor during their injury course. In this review, the rate of return to play at the preinjury level or at a higher level than the preinjury level ranged from 67% to 92.5% and the mean time to return to play ranged from 6.7 to 17.6 months. It is important to note that (1) the 2 professional pitchers (27%), reported in the study of Steffes et al.,[15] who did not return to play were actively seeking professional pitching opportunities at final follow-up and (2) the longer time and lower rate of return to play can be attributed to their cohort, made up of older patients in a professional setting (i.e., pitchers). In the aforementioned systematic review of UCLR patients, the mean rate of return to play at the same level or a higher level was found to be 84% at a mean time ranging from 11 to 13.4 months.[22] A systematic review reporting on the return to play of 350 athletes following a rehabilitation plan tailored to UCL repair with suture augmentation showed that athletes were allowed to return around 5 months.[22] On the basis of these results, UCL repair with suture augmentation may allow for quick rehabilitation and a short return-to-play time. The return-to-play time was found to be significantly shorter than the currently reported time for UCLR.[22]

Similarly to UCLR, UCL repair with suture augmentation entails a risk of complications. The complication rate found in this review ranged from 0% to 11.9%, comparable to the lower end of the spectrum of 5.3% to 20% reported when using reconstruction techniques.[23-27] Of note, the majority of the complications

Table 3. Postoperative Complications and Reoperations

Authors (Year)	Complications	Reoperations
O'Connell et al.[3] (2021)	Ulnar nerve paresthesia (n = 1)	None
Dugas et al.[14] (2019)	Postoperative cubital tunnel syndrome (n = 2); postoperative ulnar nerve instability (n = 1); postoperative medial elbow pain (n = 1); heterotopic ossification (n = 1)	Ulnar nerve transposition due to cubital tunnel syndrome (n = 2); exploration owing to medial elbow pain (n = 1); excision of heterotopic bone ossification (n = 1); revision ulnar nerve transposition for nerve instability (n = 1)
Rothermich et al.[4] (2021)	Ulnar nerve paresthesia (n = 29); postoperative medial elbow pain (n = 11); postoperative superficial wound complication (n = 2)	Ulnar nerve exploration/debridement (n = 6); primary ulnar nerve transposition (n = 4); heterotopic ossification (n = 2)
Steffes et al.[15] (2022)	None	None

in patients undergoing augmented UCL repair were found in the study performed by Rothermich et al.[4] Their analysis reported a complication rate of 15.3% (54 of 353 patients). In our analysis, we found the most common complications to be minor, including ulnar nerve paresthesia, medial elbow pain, and postoperative superficial wound complications. Major complications that required reoperations occurred in 17 of 510 patients. Among these patients, the most prevalent reason for a return to the operating room was ulnar nerve transposition.

Limitations

A few limitations have been identified in this review. First, our review was limited in the number of studies that met the inclusion and exclusion criteria, comprising only 4 studies with a total of 510 patients. In this light, it is worth noting that 2 of the 4 studies[4,14] make up the majority of patients in this systematic review. Second, all 4 studies included were case series, resulting in an overall low level of evidence, without adequate prospective collection and analysis of data. Additionally, the mean follow-up time for the included studies was relatively short, at 9.3 months. Finally, the overall number of patients lost to follow-up is unknown: Dugas et al.[14] reported that 17 patients were lost to follow-up, O'Connell et al.[3] reported that 0 patients were lost to follow-up, Rothermich et al.[4] did not provide loss—to—follow-up data, and Steffes et al.[15] reported that no patients were lost to follow-up.

Conclusions

UCL repair with the use of suture augmentation results in postoperative KJOC scores ranging from 87.9 to 92.6, a return-to-play rate between 67% and 93%, and a postoperative complication rate up to 11.9%.

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