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Review Article

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Review of Current Surgical and Nonsurgical Treatment Options for Ulnar Collateral Ligament Injuries in High Level Baseball Pitchers

Rachel Kazmirski, PAS2[1*] and John Grosel, MD[1]

[1]Marietta College Physician Assistant Program, Marietta, Ohio

[*]**Corresponding author:** Rachel Kazmirski, PAS2, Email: rlk005@marietta.edu

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Abstract

The purpose of this review was to examine the risk factors associated with ulnar collateral ligament (UCL) injuries in high level baseball pitchers and to provide a comprehensive analysis of both nonsurgical and surgical treatment options. Particular emphasis is placed on recent advancements in surgical management of UCL injuries. As medical knowledge and surgical technology continue to evolve, novel techniques have emerged with the potential to optimize returnto play timelines for competitive athletes while reducing intraoperative and postoperative morbidity. This review compares established reconstructive procedures—including the Jobe, modified Jobe, and docking techniques—with the more recently developed UCL repair with internal brace augmentation. The goal is to evaluate the advantages and limitations of each approach and to provide an indepth review of both nonsurgical and surgical treatment options in the context of individual player characteristics, specific UCL injury patterns, and surgeon expertise.

Introduction

Approximately 25% of active Major League Baseball (MLB) pitchers have undergone surgical repair for an ulnar collateral ligament (UCL) injury of the elbow[1].

Across all divisions of National Collegiate Athletic Association (NCAA) baseball, an average of 0.86 players per team annually undergo UCL reconstruction, commonly referred to as Tommy John surgery[2]. This highlights the frequency of UCL injuries among highlevel throwing athletes, many of whom face limited prevention strategies and lengthy recovery periods. For partial tears or injuries in nonthrowing athletes, conservative treatments such as nonsteroidal antiinflammatory drugs (NSAIDs), plateletrich plasma (PRP) injections, and physical therapy may be sufficient[3]. However, for complete UCL tears, especially in highlevel throwing athletes, ulnar collateral reconstruction has remained the gold standard treatment[4]. This procedure typically involves reconstructing the UCL using an autograft, most often harvested from the palmaris longus or gracilis tendon[5]. In 2015, a notable advancement in surgical treatment emerged: UCL repair with internal brace augmentation[6]. This technique involves repairing the ligament with sutures and reinforcing it with an internal brace composed of ultra high molecular weight polyethylene fibers and collagen6. The internal brace provides additional durability and support during the healing process6. Further investigation into this innovative approach is warranted to determine its effectiveness in reducing recurrence rates, accelerating returntoplay timelines, and evaluating the longterm biocompatibility of the implanted material.

Risk Factors

UCL injuries in baseball players most commonly arise from repetitive microtrauma related to the overhead throwing motion, with acute traumatic events accounting for a smaller proportion of cases[7]. Complete UCL tears typically present acutely, often described by athletes as a sudden "pop" accompanied by immediate, severe medial elbow pain and an inability to continue throwing, reflecting fullthickness ligament disruption and loss of valgus stability. By contrast, partial UCL tears most commonly result from chronic overuse, as persistent valgus stress progressively weakens the ligament, leading to microtearing and degeneration while overall ligament continuity is preserved[7]. These partial injuries generally present with an insidious onset of medial elbow pain, gradual declines in pitch velocity and accuracy, and symptoms that worsen over time. Among the established risk factors for chronic UCL injury, overuse remains the most significant[7]. Pitchers who throw more than 100 innings annually are 3.5 times more likely to sustain a UCL injury, and those who pitch for more than 8 months per year demonstrate a fivefold increased risk of ultimately requiring surgical intervention[7].

Second, biomechanics play a significant role in the risk of UCL injury. The UCL is composed of the anterior oblique ligament (AOL), transverse ligament, and posterior oblique ligament, which work together to stabilize the elbow during functional movements. Of these, the AOL is the strongest and the only bundle that provides meaningful stabilization and resistance against valgus forces as the elbow moves through a flexion range of 30° to 120°8. As a result, the AOL bears the majority of the stress with each pitch, gradually leading to fiber deterioration. Research shows that the AOL typically requires forces of at least 260 Newtons before tearing occurs; however, during the throwing motion of a collegiate baseball pitcher, valgus forces on the AOL can exceed 300 Newtons8. In addition, pitch velocity, pitch type, and elbow torque are key contributors to UCL injury risk. Elbow torque refers to the rotational force that produces valgus stress across the medial elbow during throwing9. When this torque repeatedly approaches the physiological limits of the elbow, the UCL is subjected to nearmaximal tensile loading, predisposing the ligament to cumulative degeneration and microtearing9. Multiple studies have examined these biomechanical relationships. Hodakowski et al. reported that 4seam fastballs generate the highest pitch velocities and peak elbow torque, suggesting that a greater reliance on fastballs increases mechanical stress on the elbow and elevates the risk of UCL injury[9]. Sakurai et al. attached measurement devices to the throwing arms of healthy Division I pitchers without prior elbow pathology to assess pitch velocity and elbow varus torque10. Clinically significant differences in pitch velocity and elbow torque were observed across pitch types within the same pitcher and across different pitchers. Notably, a positive relationship was observed between elbow varus torque and ball velocity, indicating that pitchers who generate higher velocities are exposed to greater repetitive medial elbow stress and, consequently, increased UCL injury risk[10].

Keller et al. examined 83 MLB pitchers to assess pitch type distribution and velocity for individuals who underwent UCL reconstruction11. The evaluation of pitch selection revealed that pitchers requiring reconstruction threw a significantly higher proportion of fastballs compared with controls who did not undergo UCL reconstruction (46.7% vs. 39.4%, p 5 0.035)[11]. Importantly, the proportion of fastballs thrown was directly associated with injury risk, with each 1% increase corresponding to a 2% increase in the likelihood of UCL injury[11]. According to this study, exceeding a threshold of 48% fastballs served as a significant predictor of UCL reconstruction (p 5 0.006)[11].

Although pitch velocity and pitch type are widely recognized as the primary risk factors for UCL injury, other factors, including environmental conditions, may also contribute. Pescatore et al. conducted a crosssectional study of 320 NCAA Division I baseball pitchers who underwent UCL reconstruction between July 1, 2015, and June 20, 2022, using the 33rd parallel in North America to categorize warm vs. cold climates[12]. The average annual temperature for warm states was 62.7°F, compared with 49.3° F for cold states. Among the pitchers studied, those in warmweather states averaged 0.0156 UCL reconstructions per season, whereas pitchers in coldweather states averaged 0.0091 reconstructions per season (p 5 0.00011)[12]. The relationship between climate and UCL injury, however, may involve multiple mechanisms. Elevated ambient temperatures can influence musculoskeletal physiology by enhancing muscle contraction speed and force, which may increase ligament flexibility and range of motion (ROM), enabling pitchers to generate greater torque and higher throwing velocities[12]. In addition, warmer climates allow athletes to spend more time outdoors, leading to longer in season practice periods and shorter off seasons, which can contribute to overuse injuries.

Genetic components, such as height, weight, and upper extremity length, are all risk factors for UCL pathology. Slowik et al. analyzed elbow varus torque in 627 collegiate and professional pitchers using individualized measures of height, weight, pitching biomechanics, kinematics, and kinetics during the throwing motion[13]. Their findings demonstrated a strong positive correlation between elbow varus torque and both body weight and the product of weight and height. Moderate positive correlations were observed between elbow varus torque and body mass index (BMI), while weaker positive correlations were noted with forearm length, overall height, ball velocity, and upper arm length[13]. Collectively, these data suggest that increases in body mass, BMI, limb length, stature, and pitch velocity are associated with proportionally greater valgus stress transmitted to the UCL. This relationship is clinically significant, as the UCL contributes approximately 33% of the total varus torque required to stabilize the elbow during pitching[13]. Consequently, the elevated torque generated by taller and heavier pitchers may result in increased UCL loading and a heightened risk of injury, particularly given that larger body size does not confer a proportional increase in UCL tensile strength[13].

This concern is underscored by longitudinal trends in professional baseball; in 1974, the average MLB pitcher measured approximately 6 ft 1 in and 190 pounds, whereas contemporary pitchers average roughly 6 ft 2 in and 225 pounds[13]. This idea is also supported by Chalmers et al., who followed 1,327 pitchers in the MLB during an 8year period and discovered a significant difference in weight between pitchers with UCL reconstruction compared with pitchers with no UCL injury[14]. This raises the question of whether the prevalence of UCL reconstruction surgery is rising due to increased height and weight in MLB pitchers. Forsythe et al. examined 1,028 MLB pitchers from 1950 to 2010 to assess changes in BMI and pitching statistics over time[15]. Their analysis revealed that the average BMI increased from 24.7 in the 1950 to 1959 cohort to 27.38 in the 2000 to 2010 cohort[15]. Interestingly, player height did not change significantly across these decades, suggesting that increases in body weight were primarily responsible for the rise in BMI.

Since the 1950s, strength training and muscle hypertrophy have become integral components of athletic conditioning at both the collegiate and professional levels. Although these practices contribute to increased body weight and BMI, it remains unclear whether muscle maintenance and functional strength training confer a protective effect against UCL injuries. Lopez et al. investigated this concept by enrolling 14 healthy NCAA Division I collegiate baseball players in an 8week forearm strengthening program targeting the throwing arm16. The study assessed medial elbow gapping and grip strength, both established risk factors for UCL injury, at baseline and following the intervention16. Medial elbow gapping refers to excessive separation of the medial ulnohumeral joint under valgus loading, reflecting UCL laxity or microstructural compromise that limits the ligament’s ability to resist valgus stress. Grip strength serves as a surrogate marker of forearm flexorpronator muscle function, which provides dynamic stabilization and helps offload valgus stress from the UCL during throwing. Reductions in grip strength suggest muscular fatigue or weakness, resulting in increased valgus loading and greater strain on the UCL. There was a clinically significant increase in peak grip strength (pre: 5.67, post: 5.85, p 5 0.03) and average grip strength (pre: 5.39, post: 5.48, p 5 0.05) in the throwing arm[16]. This can be important in UCL injury prevention as 80% of a pitcher’s grip strength comes from forearm muscles that stabilize the UCL. However, there was no significant change in medial elbow gapping in the throwing arm.

The introduction of pitchclock regulations in the 2023 MLB season has prompted concern regarding their potential impact on pitcher fatigue and elbow injury risk[17]. Under the current rules, pitchers are allotted 15 seconds to initiate their delivery with the bases empty and 18 seconds with runners on base after receiving the ball from the catcher[17]. Mastroianni et al. conducted a retrospective evaluation of seasontoseason UCL reconstruction rates comparing 4 full prepitch clock seasons (20182019 and

20212022; 2020 excluded due to limited statistics from COVID19 pandemic) with the 2023 and 2024 seasons following implementation[17]. The authors reported no significant change in the overall number of UCL reconstructions per season after im plementation of the pitch clock[17]. However, the 2023 and 2024 seasons had significantly higher percentages of starting pitchers who undergo UCL reconstruction than relief pitchers (56.4% vs. 28.9%, p 5 0.01)[17]. This finding may reflect differences in workload characteristics, as starting pitchers typically accumulate higher pitch volumes within shorter interpitch intervals, whereas relief pitchers more frequently enter with runners on base and may therefore benefit from longer allowable recovery periods between pitches[17]. Lavi et al. performed a comparable analysis examining injury outcomes across the 2 MLB seasons preceding and the 2 seasons following implementation of the pitch clock[18]. Although the overall number of reported injuries declined after adoption (244 vs. 194, p 5 0.001), the incidence of elbow injuries remained unchanged (42 vs. 43, p 5 0.181)18. In addition, pitchers faced a significantly greater number of batters postimplementation (575 vs. 525, p, 0.001), whereas total pitch counts (1,977 vs. 2,054, p 5 0.095) and pitches per inning (16.53 vs. 16.50, p 5 0.734) did not differ significantly[18]. Collectively, these findings indicate that pitchclock implementation was not associated with increased pitch volume per pitcher and therefore does not appear to correspond to an increased burden of elbow injury within the observed timeframe[18].

Nonsurgical Treatment Options

Nonsurgical management of UCL injuries depends on multiple patientspecific factors and demonstrates varying degrees of effectiveness.

Patients with partial tears or sprains of the UCL often respond well to a multimodal approach, which may include physical therapy, a period of rest from overhead throwing, nerve stimulation, NSAIDs, and orthobiologics3. Numerous collegiate and professional pitchers undergoing initial nonoperative management adopt an “active rest” rehabilitation protocol integrated with structured physical therapy, as these strategies function as complementary components of treatment3. Active rest consists of cessation of throwing for approximately 2 to 6 weeks following injury, permitting correction of underlying muscular deficits that contribute to valgus stress on the healing elbow3. Physical therapy is initiated concurrently and typically progresses through 3 phases. The first phase focuses on inflammation control and restoration of elbow ROM, NSAIDs, cryotherapy, and bracing[3]. The second phase emphasizes progressive strengthening and endurance development in preparation for return to sport3. Upon restoration of adequate ROM and flexorpronator strength, the third phase advances to a graded returntoplay through implementation of an interval throwing program3.

Throughout rehabilitation, adjunctive interventions such as blood flow restriction (BFR), electrical stimulation, and instrument assisted soft tissue techniques may be used to support recovery3. BFR is an emerging rehabilitation technique involving placement of a proximal up perextremity tourniquet to partially restrict venous outflow while maintaining arterial inflow3. This produces distal hypoxia and venous pooling, promoting anabolic signaling and protein synthesis3. Bowman et al. studied this concept by randomly assigning 14 healthy individuals to have BFR on one of their upper extremities while completing a low weight training program for 6 weeks, while 10 individuals were in the control group without BFR19. Compared with control limbs, BFR limbs demonstrated significantly greater increases in arm circumference (BFR: 5.2, control: 2.5, p , 0.01) and forearm (BFR: 4.2, control: 1.4, p 5 0.01), as well as shoulder flexion (BFR: 39, control: 16, p 5 0.01), shoulder scaptation (BFR: 48, control: 17, p 5 0.05), and shoulder abduction (BFR: 33, control: 10, p 5 0.02)19. Similarly, within subject comparisons of BFR limbs to non BFR limbs yielded an increase in circumference of the arm (BFR: 5.2, control: 3.7, p 5 0.01), forearm (BFR: 4.2, control: 1.3, p , 0.01), shoulder flexion (BFR: 39, control: 26, p 5 0.03), scaptation (BFR: 48, control: 30, p 5 0.02), and abduction (BFR: 33, control: 16, p 5 0.02)[19]. These results indicate that low load resistance training with BFR produces greater gains in muscle hypertrophy and strength in distal and proximal musculature relative to the cuff compared with low load training alone, supporting its application in UCL rehabilitation.

Transcutaneous electrical nerve stimulation (TENS) and electrical muscle stimulation (EMS) are established noninvasive modalities used in physical therapy as adjuncts for managing symptoms associated with UCL injury. TENS delivers low voltage electrical impulses through surface electrodes placed at or near the site of injury[20]. These impulses preferentially stimulate large diameter sensory afferent fibers, modulating nociceptive transmission at the spinal cord through segmental inhibitory mechanisms that compete with pain signaling from injured tissues[20]. Both low frequency and high frequency TENS have also been associated with increased concentrations of endorphins within the lumbar cerebrospinal fluid, suggesting an additional analgesic effect mediated by endogenous opioid release[20]. Although TENS does not address the structural pathology of the UCL, it may be applied over the flexorpronator mass to assist with symptomatic pain control. By contrast, EMS targets motor rather than sensory nerves, producing depolarization of motor neurons and subsequent muscle fiber contraction[20]. Whereas TENS is primarily intended for analgesia, EMS is employed to mitigate disuse atrophy and facilitate strength recovery following injury[20]. Colson et al. demonstrated significant improvements in muscle strength following both EMS and voluntary isometric training, indicating that EMS may induce strength adaptations comparable with voluntary contraction across multiple contraction modalities[20]. Notably, EMS produced greater enhancements in isometric torque than voluntary training alone, suggesting potential utility for improving dynamic strength capacity[20]. This consideration is particularly relevant in overhead athletes, such as elite baseball pitchers, who generate substantial valgus torque at the elbow during throwing.

Orthobiologics are biologically derived materials sourced from endogenous tissues that are used to enhance ligament healing and regenerative processes, including—but not limited to—PRP and mesenchymal stem cell therapy3. PRP therapy is a conservative treatment option that uses the patient’s own blood to concentrate and deliver growth factors and proteins from alpha granules directly to the injured UCL[3]. Podesta et al. followed 34 baseball pitchers with partial thickness UCL tears that failed 6 weeks of conservative therapy[21]. Each patient received a PRP injection by the same physician under ultrasound guidance and was required to complete physical therapy as a part of returntoplay protocol. An average of 12 weeks was needed to return to play, and by 70 weeks, 88% of athletes had returned to the same level of pitching before injury without any pain21. Another study indicating the usefulness of PRP injections was highlighted by Dines et al., 44 professional, collegiate, and high school baseball pitchers with MRI confirmed partialthickness UCL tears were treated with PRP injections22. Once asymptomatic, subjects started an interval throwing program and followed up in 11 months. Of the 44 patients, 34% had an excellent outcome and 39% had a good outcome based on the Conway scale[22]. In addition, 67% of the professional players returned to play within those 11 months[22].

While PRP promotes tissue repair through delivery of concentrated hematologic growth factors, MSC based therapies involve the administration of progenitor cells capable of differentiating into native musculoskeletal tissues[4]. Although stem cell therapies may originate from multiple cellular lineages, MSCs are of particular interest in orthopaedics due to their capacity to differentiate into osteogenic, tenogenic, chondrogenic, and adipogenic cell types4. In the setting of UCL injury, MSCs are most commonly harvested from bone marrow or adipose tissue4. Bone marrow aspirate concentrate (BMAC) is typically obtained from the iliac crest, processed with anticoagulant, and injected at the site of ligament injury under fluoroscopic guidance4. Despite growing interest, clinical evidence supporting BMAC use for UCL pathology remains limited, as these therapies are investigational and lack Food and Drug Association approval for this indication[23]. Hoffman et al. described a case study of a 25yearold professional baseball pitcher with UCL instability and concomitant ulnar neuritis who underwent UCL reconstruction with graft augmentation using PRP and MSCs, followed by structured rehabilitation and valgus bracing[23]. The athlete ultimately returned to professional throwing; however, interpretation of these findings is constrained by several limitations. The absence of a control comparator precludes attribution of outcomes to orthobiologic augmentation vs. the comprehensive multidisciplinary treatment strategy. In addition, because reconstruction rather than nonoperative management was performed, the results do not clarify the independent efficacy of orthobiologics as standalone therapies. Finally, limited followup reporting and lack of returntoplay timeline restrict comparison with existing outcome data.

Surgical

Reconstructive Techniques

For highdemand overhead athletes, surgical management is often recommended for complete tears of the anterior bundle or after failed conservative therapy in throwing athletes with partial tears to effectively return athletes to their preoperative level of play. UCL reconstruction was first performed in 1974 by Dr. Frank Jobe on former MLB pitcher Tommy John[23]. Termed the original Jobe technique, Dr. Jobe made a 3–4inch incision to visualize the damaged UCL. The flexorpronator origin was detached from the medial epicondyle, and the ulnar nerve was submuscularly transposed to avoid irritation. He then drilled 3 holes in the humerus and 2 in the ulna (the 2 bones connecting the original UCL) and secured an allograft or autograft of the palmaris longus, hamstring, or tibialis anterior tendon with sutures, buttons, or screws via a figureofeight configuration[24].

The introduction of the original Jobe technique was revolutionary in the 1970s, transforming what was a careerending injury into a 1year hiatus from competition. Unfortunately, this procedure came with numerous complications. Routine transposition of the ulnar nerve increased the likelihood of ulnar neuropathy, resulting in numbness in the hand and fingers. In Dr. Jobe's original study of 16 baseball pitchers, 10 returned to their preinjury level of play, while 6 (38%) developed postoperative ulnar neuropathy[24]. Two of these 6 required revision surgery to decompress the ulnar nerve, whereas the remaining 4 resolved spontaneously.

The detachment of the flexorpronator origin also heightened the risk of soft tissue complications, prolonging rehabilitation. Tommy John himself experienced a traumatic rupture of the flexorpronator origin and persistent ulnar neuropathy lasting more than 3 months, necessitating a second surgery for repair and nerve decompression[24]. In addition, the large humeral bone tunnels created in the procedure increased the risk of medial epicondyle fractures, stress fractures within the tunnels, or avulsion fractures at the UCL origin due to added strain on the distal humerus[24]. Fortunately, advances in surgical technique over the past several decades have addressed many of the limitations of the original Jobe procedure. The Modified Jobe Technique, introduced by Dr. James Andrews and Dr. Richard Thompson in 2001, preserves the ulnar nerve unless the patient presents with preoperative neuropathic symptoms—a scenario seen in roughly 20% of baseball pitchers undergoing UCL reconstruction24. In addition, rather than detaching the flexorpronator muscles, this approach splits them, reducing soft tissue trauma and shortening rehabilitation time from the 18 months originally recommended by Dr. Jobe to approximately 12 months[24]. Another widely used UCL reconstruction method is the Docking technique, developed in 2002 by Dr. David Altchek as a less invasive alternative[24]. Like the Modified Jobe procedure, it preserves the flexorpronator origin through a musclesplitting approach and spares the ulnar nerve unless preoperative symptoms are present. The key difference between the 2 techniques lies in graft fixation: The tendon graft is looped through 2 tunnels in the ulna and then "docked" into a single, smaller tunnel in the humerus, where it is secured with sutures tied over a bone bridge[24]. One major advantage of this method is the use of a single, smaller humeral tunnel, which reduces the risk of fracture and minimizes bone disruption24. A potential drawback is slightly less bonetograft contact compared with the figureofeight weave used in the Modified Jobe technique, which could theoretically affect graft healing[24]. Bonetograft contact is important for ligamentization—the process by which the tendon graft remodels and integrates into bone—and greater contact surfaces can enhance biological incorporation24. However, in practice, this rarely affects clinical outcomes, as the sutures provide strong initial fixation and reliable stability during healing.

Jobe vs. Modified Jobe vs. Docking

Direct comparisons between the modified Jobe and docking techniques for UCL reconstruction have been conducted to evaluate differences in performance outcomes and graft longevity. In a 2019 study by Arner et al., a single surgeon performed 25 modified Jobe and 26 docking procedures with a 2year followup to assess performance outcomes and returntoplay timelines5. Interestingly, no statistical or clinical differences were observed between the 2 techniques in terms of return to play, recurrence requiring future surgery, sport played, or position in overheadthrowing athletes[5]. More recently, Ciccotti et al. conducted a randomized controlled study in 2025 examining clinical and patientreported outcomes following UCL reconstruction using the modified Jobe and docking techniques performed by the same orthopaedic surgeon8. Each surgical group included 40 baseball players, and results again demonstrated no differences in returntoplay time, patientreported baseball metrics, or complication rates[8]. The only notable distinction was greater graft thickness in the modified Jobe group, which was not clinically significant. Biomechanically, this is expected, as the modified Jobe technique folds the graft 2 to 3 times through the bone tunnels, increasing the tendon diameter.

On a broader scale, Erickson et al. conducted a systematic review including 2,019 participants of whom 95% were baseball players and approximately 80% were pitchers[25]. Returntoplay rates were higher among athletes undergoing reconstruction with the docking technique compared with the Jobe technique, likely reflecting flexorpronator mass splitting rather than transection (97% vs. 66.7%; p 5 0.001)[25]. Similarly, Looney et al. performed a metaanalysis comparing clinical outcomes and return to play following modified Jobe vs. docking techniques[26]. Among 1,842 participants who underwent UCL reconstruction, 320 received the modified Jobe procedure and 1,466 underwent docking reconstruction26. Although returntosport and complication rates were not clinically different between techniques, a significantly greater proportion of excellent outcomes was observed in the docking cohort compared with the modified Jobe cohort (86.58% vs. 76.76%; p 5 0.031)[26].

Surgical Internal Brace Repair Technique

The most recent advancement in the surgical management of UCL injuries emerged in 2015, when Dr. Jeffrey Dugas of the Andrews Sports Medicine & Orthopedic Center in Birmingham, Alabama, performed the first UCL repair with internal brace augmentation6. He adapted the Arthrex InternalBrace system, originally developed for ankle ligament repairs, to reinforce the UCL following repair6. Unlike traditional reconstruction, this technique can be performed when there is sufficient healthy native ligament tissue to repair[27]. The procedure begins with a small medial elbow incision, followed by a split between the flexor carpi ulnaris and flexor digitorum superficialis to expose the UCL and identify the site of injury[27]. Any torn or frayed ligament edges are debrided, and pilot holes are drilled at the humeral and ulnar attachment sites for suture anchors[27]. The ligament is then reattached to its anatomic insertion using nonabsorbable sutures[27]. Finally, an internal brace composed of ultra high molecular weight polyethylene fibers and collagen is anchored across the ligament, serving as a protective reinforcement against valgus stress during early rehabilitation[27].

The goal of UCL repair with internal brace augmentation is to offer an alternative to traditional reconstruction techniques by potentially allowing for quicker returntoplay timelines and enhanced biomechanical strength[28]. This approach may accelerate rehabilitation by preserving the native ligament and eliminating the morbidity associated with graft harvest. By maintaining healthy portions of the UCL, the procedure avoids the prolonged biological processes of graft incorporation and ligamentization, as well as the additional healing required at the graft donor site[27]. The absence of graft harvest also reduces surgical trauma, lowers complication risk, and facilitates faster recovery of forearm function28.

Reconstruction vs. Internal Brace Repair

In a study by Dugas et al. in 2016, 9 cadaveric arms were dissected to expose the UCL[6]. Valgus rotational torque was applied to each humerus with the ligament intact and then repeated after surgical disruption. Five specimens underwent internal brace–augmented repair, while 4 received modified Jobe reconstruction. Following the procedures, the elbows were again subjected to valgus rotational torque at 90° of flexion. Results demonstrated that the internal brace repair group had significantly greater resistance to medial ulnohumeral joint separation (0.35 mm) compared with the modified Jobe group (0.53 mm), suggesting a potential biomechanical advantage for the internal brace technique6. In 2018, Jones et al. published a comparative biomechanical study evaluating UCL reconstruction vs. UCL repair with internal brace augmentation, with a specific focus on fatigue resistance and failure mechanics[29]. Ten matched pairs of cadaveric elbows were positioned at 90° of flexion, and the native UCLs were subjected to 500 cycles of subfailure valgus loading using an axialtorsional materials testing system29. Following baseline testing, standardized distal UCL avulsion tears were created and treated with either internal brace–augmented repair or modified Jobe reconstruction using a palmaris longus autograft. Under cyclic loading simulating rehabilitation and throwing stresses, internal brace repair demonstrated less medial ulnohumeral joint gapping than reconstruction, with differences apparent by the 10th cycle (2.51 vs. 5.45 mm; p 5 0.08) and remaining significant at the 100th cycle (3.20 vs. 6.09 mm; p 5 0.02) and after 500 cycles of fatigue loading (3.54 vs. 6.48 mm; p 5 0.004)[29]. Collectively, these results indicate enhanced resistance to gap formation and improved valgus stability with internal brace augmentation29. Considering the historically elevated failure rates reported following UCL reconstruction, repair with internal bracing may represent an appealing alternative for highlevel overhead throwing athletes, particularly under fatiguedependent loading conditions inherent to sport participation. Importantly, no significant differences between treatment groups were observed in torsional stiffness, gap formation at ultimate failure, or failure torque29. Failure mechanisms in the repair cohort most frequently involved ulnar screw pullout or bone tunnel compromise, likely related to suboptimal bone or softtissue quality. These patterns suggest that internal brace–augmented repair may be most appropriate for younger athletes with adequate bone stock and ligament integrity[29].

Arciero et al. conducted a singlesurgeon retrospective study in 2023 evaluating outcomes of medial UCL with internal brace augmentation in 56 patients treated between 2016 and 202228. Of the included patients, 43 were baseball pitchers, including 23 collegiate and 1 professional athlete. Partial UCL tears were identified in 39 patients, while 17 sustained complete tears. Overall, 51 patients (91.0%) successfully returned to play at a mean of 7.8 months postoperatively, with no reported intraoperative or postoperative complications28. When compared with the reconstruction cohort reported by Dugas et al., which demonstrated a mean return tocompetition time of 13.4 months, these findings suggest that UCL repair with internal brace augmentation may offer a favorable return to play timeline with a low complication profile[6].

In 2025, Dugas et al. published a comparative study evaluating UCL repair with internal brace augmentation vs. modified Jobe UCL reconstruction in overhead throwing athletes2. The study included 155 athletes who underwent UCL reconstruction and 268 who underwent UCL repair with internal brace augmentation, with outcomes assessed across multiple returntoplay metrics2. Athletes treated with UCL repair returned to practice significantly earlier than those undergoing reconstruction (mean 6.7 months vs. 10.2 months; p , 0.01). The repair cohort was composed primarily of partial UCL tears (77%), with 18% complete tears, whereas the reconstruction group demonstrated a significantly higher proportion of complete tears (43%) and 54% partial tears (p , 0.01)[2]. Time to return to competition was likewise shorter in the repair group, averaging 9.2 months compared with 13.4 months in the reconstruction cohort (p , 0.01)[2].

These findings suggest that in appropriately selected overhead throwing athletes, UCL repair with internal brace augmentation may facilitate a more rapid return to both practice and competitive play compared with traditional UCL reconstruction.

Despite its promise, internal brace repair carries several important limitations. First, chronic UCL injuries often lack sufficient healthy native tissue, making older pitchers with degenerative ligaments poor candidates for this approach. Second, midsubstance tears cannot be adequately reinforced with an internal brace, restricting the procedure to discrete proximal or distal avulsions24. Third, this technique is not an option following a failed Tommy John reconstruction, as the residual tissue is typically scarred and unsuitable for repair[2]. Given that most MLB and collegiate pitchers requiring revision surgery have already undergone reconstruction, this further narrows its applicability. Fourth, as a relatively new procedure, available outcomes are limited to shortterm and midterm followup (25 years). Robust longterm data on career durability and performance beyond 10 years remain lacking—an especially important consideration for elite pitchers whose livelihood and career longevity depend on reliable elbow function. By contrast, UCL reconstruction is supported by decades of longitudinal data characterizing durability, revision rates, and performance outcomes. Finally, although internal brace repair may facilitate accelerated returntoplay timelines, expedited return does not necessarily translate to sustained performance. Additional investigation is required to determine whether repaired ligaments augmented with collagen fiber tape can maintain structural durability across multiple seasons and tolerate the extreme valgus stresses associated with highlevel pitching workloads.

Conclusion

Understanding the full spectrum of treatment options for UCL tears empowers patients to make informed, individualized decisions about their care. As emerging therapies continue to evolve, it is essential to guide patients with the most current, evidencebased information. One promising advancement—UCL repair with internal brace augmentation—offers the potential for a quicker return to sport, while also reducing the risk of reinjury, particularly in overhead athletes like baseball pitchers. At present, available cadaveric and retrospective evidence indicates that younger patients with preserved ligamentous integrity and adequate bone quality are the most suitable candidates for internal brace augmentation. However, highquality comparative studies, including randomized controlled trials and prospective human clinical investigations, are needed to more definitively evaluate outcomes across surgical treatment modalities.

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