

Ulnar Collateral Ligament Reconstruction: Current Philosophy in 2016

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Abstract

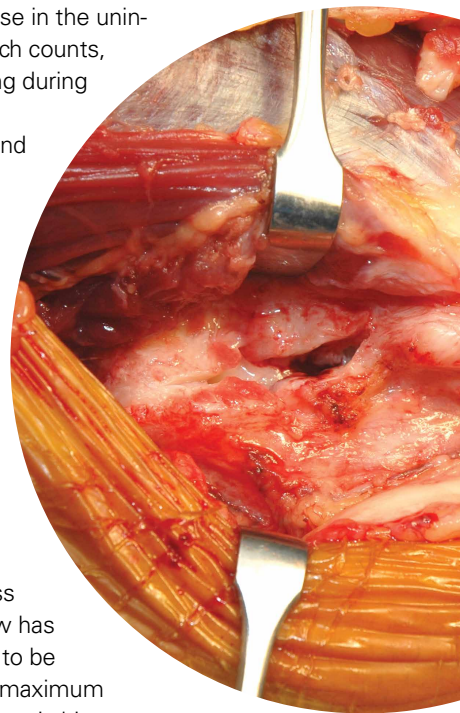
The ulnar collateral ligament (UCL) is the primary static restraint to valgus stress at the elbow. Since Jobe pioneered reconstruction in 1974, thousands of throwers have undergone UCL reconstruction, and good results have been achieved. The high-profile nature of the elite pitcher has brought this technique into the spotlight, and extensive research has been performed with new techniques emerging. The standard reconstruction, modified only slightly since Jobe's original description, remains the gold standard for treatment of UCL insufficiency. Throwers are able to return to the same or even higher levels of competition in the majority of cases. In this article, we present our standard technique and results and discuss emerging techniques for treatment of UCL injuries.

The ulnar collateral ligament (UCL) is the primary restraint to valgus stress between 20° and 125° of motion.¹⁻⁵ Overhead athletes, most commonly baseball pitchers, are at risk of developing UCL insufficiency, and dysfunction presents as pain with loss of velocity and control. Some injuries may present acutely while throwing, but many patients, when questioned, report a preceding period of either pain or loss of velocity and control.

Authors have documented a significant rise in elbow injuries in young athletes, especially pitchers.⁶ Extended seasons, higher pitch counts, year-round pitching, pitching while fatigued, and pitching for multiple teams are risk factors for

elbow injuries.⁷ Pitchers in the southern United States are more likely to undergo UCL reconstruction than those from the northern states.⁸ Pitchers who also play catcher are at a higher risk due to more total throws than those who pitch and play other positions or pitch only. Throwers with higher velocity are more likely to pitch in showcases, pitch for multiple teams, and pitch with pain and fatigue, and these are all risk factors.⁶ Also, in one study of youth baseball injuries, individuals in the injured group were found to be taller and heavier than those in the uninjured group.⁶ Pitch counts, rest from pitching during the off-season, adequate rest, and ensuring pain-free pitching can lessen the risk of injury.⁶ As expected with the rise in throwing injuries, the rise in medial elbow procedures has risen.⁹

While throwing, stress across the medial elbow has been measured to be nearly 300 N. A maximum varus force during pitching was measured to be 64 N-m at 95° ± 14°.¹⁰ Morrey and An⁴ determined that the UCL generated 54% of the varus force at 90° of flexion. During active pitching, this value is likely reduced due to simultaneous muscle contraction, but if one assumes the UCL bears 54% of the maximal



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load, the UCL must be able to withstand 34 N-m. The UCL can withstand a maximum valgus torque between 22.7 and 34 N-m¹¹⁻¹³; therefore, during pitching, the UCL is at or above its failure load. After thousands of cycles over many years, one can imagine how the UCL might be injured.

Multiple techniques have been proposed in the surgical treatment of UCL injuries. Jobe¹⁴ pioneered UCL reconstruction in 1974 in Tommy John, a Major League Baseball pitcher. John returned to pitch successfully, and both the UCL and the reconstruction are commonly called by his name. Jobe¹⁴ reported his technique in 1986, and it has remained, with a few modifications, the primary method for reconstruction of the UCL (**Figure 1**). Primary repair has been reported, and the best results have been in younger pitchers with acute injuries.¹⁵ Cain and colleagues¹⁶ reported a 70% return to same or higher level with repair alone, which was an improvement on Azar's series¹⁷ with 63% return to same or higher level. Recent advancements have included primary repair with augmentation using grafts or anchored suture or tape¹⁸ (**Figure 2**).

The modified Jobe and docking techniques remain the most commonly used techniques with reproducible and reliable results.^{19,20}

Evaluation

A standard evaluation with physical examination and imaging is completed in all throwers with elbow pain. In our prior study,¹⁶ we found that 100% of patients experienced pain during athletic activity and that 96% of throwers complained of pain during late cocking and acceleration phases of the throwing motion. Nearly half reported an acute onset of pain, while 53% were unable to identify a single inciting event. Seventy-five percent of the acute injuries were during competition. Delayed diagnosis was very common, with an average time to diagnosis after onset of symptoms of 6.4 months. Neurologic symptoms were seen in 23% of athletes, most of which were ulnar nerve paresthesias during throwing.¹⁶

Physical examination includes inspection for swelling, hand intrinsic atrophy, neurovascular examination, range of motion, shoulder examination, and elbow stress examination. Range of motion at presentation averaged 5° to 135° with 85° of supination and pronation.¹⁶ All patients need neurologic evaluation for ulnar nerve dysfunction. Tinel test of the cubital tunnel was positive in 21%.¹⁶ Significant ulnar nerve dysfunction, including hand

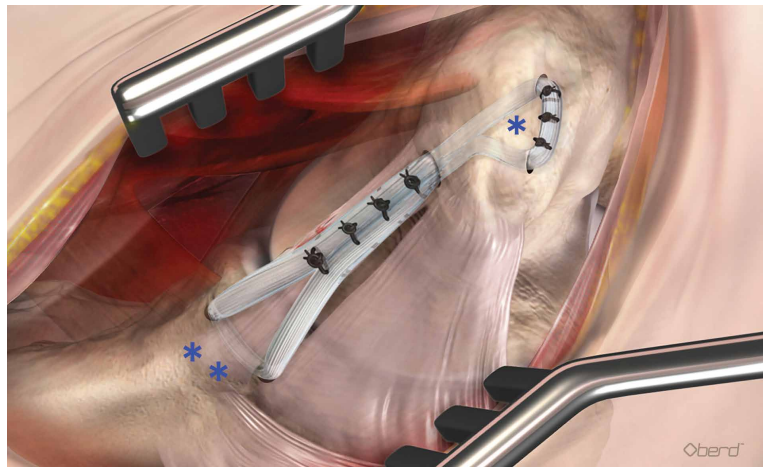


Figure 1. Artist rendering of medial side of right elbow. Ulnar collateral ligament reconstruction with autograft through sublime tubercle (**) and medial epicondyle (*). Fixation is with nonabsorbable No. 1 suture tied between the 2 limbs and into the periosteum of the medial epicondyle. The parallel limbs are tied side-to-side to solidify the repair and increase the tension. This is tied into the underlying native ligament. If enough graft length is available, one or both limbs are passed back through the tunnels and incorporated into the side-to-side fixation. Image used with permission of The American Sports Medicine Institute.

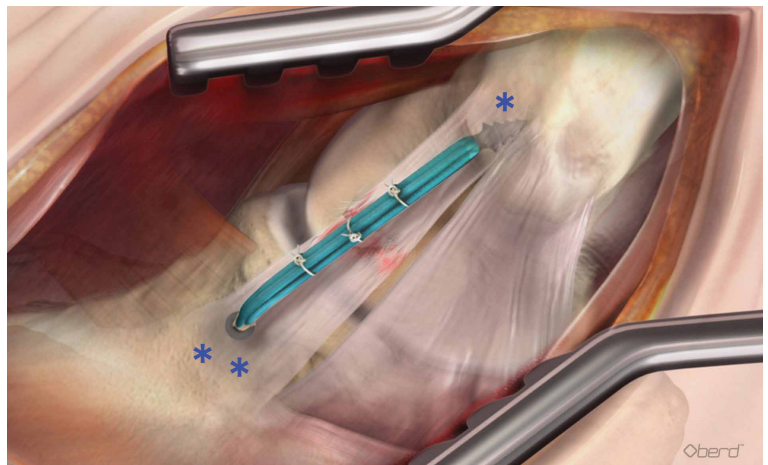


Figure 2. Artist rendering of medial side of right elbow. Ulnar collateral ligament repair with augmentation using an InternalBrace (Arthrex). Sutures tied into the ligament for repair are incorporated into the anchor and seated into the epicondyle (*) and/or sublime tubercle (**). Image used with permission of The American Sports Medicine Institute.

weakness, is much less common but must be well examined and documented. The shoulder must also be evaluated for loss of rotation, which can lead to increased stress on the elbow. An evaluation of mechanics may point out flaws in technique, which may be contributing to elbow stress. The UCL stress examination includes static stress at 30° of flexion, the milking test at 90°, and the moving valgus stress test. The presence of pain directly over the UCL or laxity compared to the uninvolved side is suggestive of UCL injury.



Figure 3. Coronal magnetic resonance imaging of the right elbow with intra-articular contrast. The elevation of the most proximal ulnar attachment forms the T-sign (arrow) as described by Timmerman and colleagues.²²

Radiographic evaluation is completed in all patients with concern for UCL injury. Standard x-rays of the elbow, including anteroposterior, medial, and lateral obliques, axial olecranon, and lateral views, are obtained to evaluate bony abnormalities. Fifty-seven percent of our series showed some abnormality, most commonly olecranon osteophyte formation or ectopic calcification within the UCL substance. Stress radiography rarely changed the treatment course and is somewhat difficult to interpret because of the reports documenting normal increased medial elbow opening in the dominant arm of throwing athletes.²¹ Magnetic resonance imaging (MRI) is obtained very commonly in this patient population, and intra-articular contrast is crucial. Partial, undersurface tears are common, and a contrasted study better demonstrates undersurface tears or avulsions. The T-sign as described by Timmerman and colleagues²² using computed tomography (CT) arthrography shows partial undersurface detachment, which can be difficult to see without intra-articular contrast.²² This finding is very well visualized on MRI arthrogram as well (**Figure 3**). Sensitivity in partial tears is also highly favorable for CT arthrogram over noncontrasted MRI, detecting 71% vs 14%.²² MRI with arthrogram provides further detail to better detect tears and to determine the condition of the ligament, and is currently the gold standard diagnostic test for UCL evaluation.

Nonoperative Management

Nonoperative treatment is recommended for 3 months prior to performing reconstruction.

Patients are given complete rest from throwing, but rehabilitation is initiated immediately. Rehabilitation exercises and nonsteroidal anti-inflammatory medications are prescribed, and activities that place valgus stress across the elbow are avoided. After resolution of symptoms, an interval throwing program is initiated, and the athlete is gradually returned to sport. Unfortunately, due to season-specific schedules and time-sensitive demands in high-level throwers, operative treatment is often chosen without an extended period of conservative treatment.

Platelet-rich plasma (PRP) therapy has recently been shown to improve healing rates and promote healing in partial UCL tears,²³ and as orthobiologics are advanced, they will likely play a larger role in the treatment of UCL injuries.

Surgical Technique

At our institution, UCL reconstruction is performed with the modified Jobe technique as described by Azar and colleagues.¹⁷ Arthroscopy prior to reconstruction was routinely performed at our institution until we recognized that arthroscopy rarely changed the preoperative plan.¹⁶ Currently, the presence of anterior pathology such as loose bodies or osteochondral defect is our only indication for arthroscopy before reconstruction.

Ipsilateral palmaris autograft is our current graft of choice. This must be examined preoperatively because 16% of patients have unilateral absence and 9% have bilateral absence.²⁴ In revision cases or in patients with insufficient or absent palmaris, contralateral palmaris followed by contralateral gracilis tendon is used. The contralateral gracilis is chosen because of ease of setup and position of the surgeon during the harvest. Gracilis tendon is also used in cases with bony involvement of the ligament based on the results from Dugas and colleagues.²⁵ Toe extensors, plantaris, and patellar tendon grafts have also been used. One recent study showed that neither graft choice nor diameter affected resistance to valgus stress, and that all reconstruction types restored strength at 60° to 120° of flexion.²⁶

Ulnar nerve transposition is performed in all cases regardless of the presence of preoperative nerve symptoms. A complete decompression is completed proximally to the Arcade of Struthers and distally to the deep portion of the flexor carpi ulnaris. A single fascial sling of medial intermuscular septum originating from the epicondylar attachment is used to stabilize the nerve without compression. At wound closure, the deep fascia on

the posterior skin flap is also sewn into the cubital tunnel to prevent the nerve from subluxating back into the groove. A single suture is placed distally closing the groove. A single suture is placed distally closing the muscle fascia to prevent propagation of the fascial incision, which can lead to herniation. Transposition is necessary because of the ulnar nerve exposure required in the modified Jobe technique to allow elevation of the deep flexor muscle mass for ligament exposure.

The reconstruction is completed as described by Jobe¹⁴ but with a few modifications as described by Azar and colleagues¹⁷ and slight adaptations implemented since that time. The flexor-pronator mass is retracted laterally instead of detachment or splitting as described by Thompson and colleagues.²⁷ A subcutaneous rather than a submuscular ulnar nerve transposition is used.

The patient is positioned supine using an arm board. If gracilis tendon is chosen, the contralateral leg is prepped and draped simultaneously. A tourniquet is inflated after exsanguination. A medial approach is performed, and the medial antebrachial nerve is located and protected. The ulnar nerve is then located in the cubital tunnel and mobilized. The neurolysis extends to the deep portion of the flexor carpi ulnaris distally and proximally to the Arcade of Struthers, and the nerve is retracted with a vessel loop. The flexor muscle mass is not elevated from the medial epicondyle; rather, it is retracted anteriorly by small Hohmann retractors. The dissection is carried down to the UCL and found at its attachments to the medial epicondyle and sublime tubercle. If no tear is seen on the superficial surface of the ligament, a longitudinal incision is made through the ligament. Undersurface tears, partial tears, and avulsions can then be identified (**Figure 4**). Often, a portion of the ligament is degenerative and is excised, leaving only healthy-appearing ligament.

The autologous graft of choice is then harvested. Our technique for palmaris harvest is performed with three 1-cm transverse incisions. The palmaris is palpated and marked with the first incision made near the distal wrist crease, and the second incision is made 3 to 4 cm proximal to the first. The tendon is found in both distal incisions and cut distally with the wrist flexed to maximize tendon length. The tendon is then pulled through the second incision and tensioned to identify the most proximal location the tendon can be palpated. A third incision is made directly over this point and carried down to cut the tendon. This usually provides a graft length of 15 to 20 cm; 13 cm is the

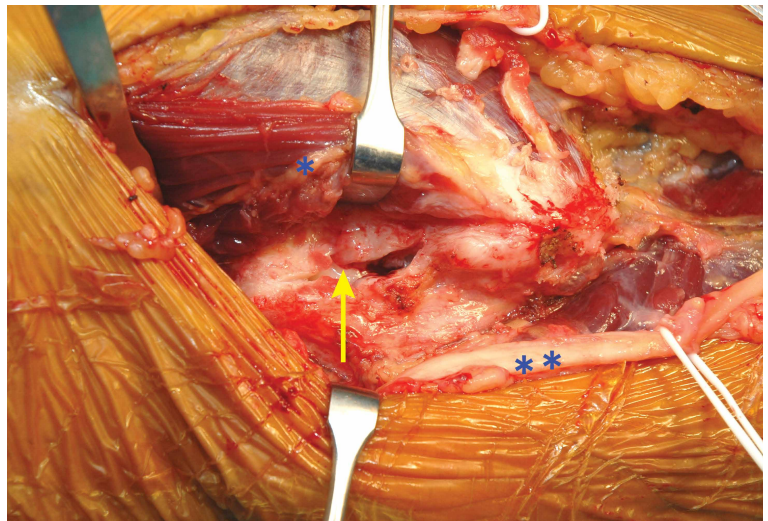


Figure 4. Medial view of the right elbow. The ulnar collateral ligament tear is visible with incompetent ligament tissue seen when split longitudinally (arrow). The flexor/pronator mass (*) is retracted laterally, and the ulnar nerve (**) is protected and retracted with the vessel loop.

minimum graft length to ensure good graft fixation. Muscle is removed from the tendon and each end is secured with a No. 1 nonabsorbable suture in a locking fashion.

If posterior osteophytes are present, they are removed through a posterior, vertical arthrotomy. Over-resection of the olecranon must be avoided, as this can further destabilize the elbow and place increased stress on the reconstruction. Posterior loose bodies can also be removed through this arthrotomy. The arthrotomy is then closed with absorbable suture.

Tunnel placement is critical to success. A 3.2-mm drill bit is used with palmaris grafts and a 4-mm drill bit is used with gracilis grafts. Two convergent tunnels are drilled in the medial epicondyle in a Y fashion and 2 convergent tunnels are drilled at the sublime tubercle in a U or V fashion. After drilling the first tunnel on each side, a hemostat is placed in the tunnel as an aiming point to ensure a complete tunnel is made. The junction is smoothed with a curette, leaving a 5-mm bone bridge between the articular surface and the tunnels. A bent Hewson suture passer is used to pass one end of the graft through the ulna. The 2 limbs of the tendon graft are then passed through the humeral tunnels, creating a figure-of-eight. A varus stress is applied with the elbow at roughly 30° and the 2 limbs are tied together with a No. 1 nonabsorbable suture. If enough graft remains, one or both limbs are passed back through the tunnels and secured again with No. 1 nonabsorbable suture. The 2

limbs are then tied side-to-side, incorporating the native ligament to further secure and tighten the reconstruction.

The ulnar nerve is then secured using a strip of medial intermuscular septum left intact to its insertion at the medial epicondyle. This is attached to the flexor-pronator muscle fascia with a 3-0 nonabsorbable suture. Enough length should be harvested from the septum to ensure there is no compression on the nerve. The deep posterior fascial tissue is then sewn to the periosteum of the medial epicondyle to further prevent subluxation of the nerve back into the groove. The skin is then closed in layered fashion over a superficial drain. The patient is placed in a well-padded posterior splint for 1 week, then the rehabilitation protocol is initiated as discussed below.

Postoperative Rehabilitation

A standardized postoperative 4-phase rehabilitation program for ulnar collateral reconstruction is followed as described by Wilk and colleagues.²⁸⁻³⁰ The first phase begins immediately after surgery and continues for 4 weeks. During surgery, the patient's elbow is placed in a compression dressing with a posterior splint to immobilize the elbow in 90° of flexion with wrist motion for 1 week to allow initial healing. Full range of motion of the elbow joint is restored by the end of the fifth to sixth week after surgery.

During phase II (weeks 4-10), a progressive isotonic strengthening program is initiated. Exercises are focused on scapular, rotator cuff, deltoid, and arm musculature. Shoulder range of motion and stretching exercises are performed during this phase and the Thrower's Ten exercise program is initiated. Any adaptations or strength deficits are addressed during this phase.

During the advanced strengthening phase (phase III), from weeks 10 to 16, a sport-specific exercise/rehabilitation program is initiated. During this phase, stretching and flexibility exercises are performed to enhance strength, power, and endurance. During this phase the patient is placed on the advanced Thrower's Ten program. Isotonic strengthening exercises are progressed, and at week 12, the athlete is allowed to begin an isotonic lifting program, including bench press, seated rowing, latissimus dorsi pull downs, triceps push downs, and biceps curls. In addition, the athlete performs specific exercises to emphasize sport-specific movements. At week 12, overhead athletes begin a 2-hand plyometric throwing

program, and at 14 weeks, a 1-hand plyometric throwing program. Furthermore, endurance exercises, core stability, and leg strengthening are emphasized during phase III. Phase IV, the return to activity phase (week 16 and beyond), is characterized by the initiation of an interval throwing program. The patient is instructed to continue his stretching and strengthening program. An interval throwing program off the mound is gradually initiated at 5 to 6 months postoperative and a gradual return to competition is initiated for pitchers at 9 months and for position players 6 to 7 months postoperative.

Discussion

Results after ulnar collateral reconstruction have been good. In our series of 743 patients, 83% returned to the same or higher level at an average of 11.6 months.¹⁶ There was a 4% major complication rate and 16% minor complication rate. Major complications included medial epicondyle fracture (0.5%), significant ulnar nerve dysfunction (1 patient), rupture of graft (1%), and graft site infection. Sixteen percent of patients had ulnar nerve dysfunction, and 82% of these resolved within 6 weeks. All but 1 patient's paresthesias resolved within 1 year.¹⁶ The 10-year follow-up of this group of patients included 256 patients and was reported by Osbahr and colleagues³¹ in 2014. Retirement from baseball was due to reasons other than the elbow in 86%, and 98% were still able to throw on at least a recreational level. The overall longevity was 3.6 years, with 2.9 years at pre-injury level or higher. Statistically, pitchers performed at a higher level after reconstruction.³¹

A recent review by Erickson and colleagues⁹ showed an overall 82% excellent and 8% good result when evaluating different techniques, including the American Sports Medicine Institute (ASMI) modification of Jobe's technique, docking technique, and Jobe's technique. With an overall complication rate of 10% (75% of which was transient ulnar neuritis), the procedure was deemed overall a safe surgical option. Collegiate athletes had the highest return to sport (95%) compared with high school athletes (89%) and professional athletes (86%). The docking technique had the highest rate of return to play (97%) compared with ASMI technique (93%) and Jobe technique (66%).⁹ Results after repair have not been as good as reconstruction, as reported in 2 studies.^{16,32} Savoie and colleagues,¹⁵ however, reported 93% good/excellent results after primary UCL repair alone.

Another recent review of outcomes showed an overall return to same or higher level was best with docking or modified docking techniques (90.4% and 91.3%, respectively).¹⁹ Overall return with modified Jobe technique was 77%.¹⁹ O'Brien and colleagues²⁰ performed a review of 33 patients with either modified Jobe or docking technique that showed 81% return to same or higher level with modified Jobe vs 92% with docking technique. The Kerlan-Jobe Orthopaedic Clinic scores were higher in the modified Jobe group (79 vs 74) and the docking technique group returned to play nearly 1 month sooner (12.4 months vs 11.8 months).²⁰ However, comparing different techniques in a heterogenous patient population over 40 years is difficult. Many of the modified Jobe technique cases were performed in the early evolution of the rehabilitation and return-to-play programs. We believe that the current modified Jobe technique has results equal to any other variation.

Despite good results with reconstructions, the recovery is lengthy and most pitchers cannot fully return to competition level for 12 to 18 months. Extensive research has been performed in exploring alternatives to the traditional reconstruction. Advancements in orthobiologics and development of new surgical options seem to provide an alternative to reconstruction, and may allow faster return to competition with less morbidity.

PRP has been at the forefront of orthopedic research for the last 2 decades, mostly focused in tendon and bone healing. Due to the release of many inflammatory mediators, PRP is theorized to initiate a healing response with growth factors that can direct healing towards normal tissue.³³ Two main types of PRP are reported based on the presence or absence of leukocytes. PRP has been studied in many applications, but only one clinical study on the UCL has been published to date. Podesta and colleagues²³ injected PRP into the elbow of 34 baseball players with MRI-confirmed partial UCL tear. The athletes then underwent a rehabilitation program, which limited stress across the UCL. Type 1A PRP was used (leukocyte-rich, unactivated, 5x or greater platelet concentration³³). Athletes were allowed to return to sport based on symptoms and examination findings. Eighty-eight percent returned to same level of play without complaints at average 70 week follow-up, and average return to play ranged from 10 to 15 weeks.²³ No specific data were given on the 16 pitchers in the group, but with such a high rate of return, PRP needs to be further evaluated in the treatment of UCL injuries.

Another recent study from Dugas and colleagues¹⁸ presented primary UCL repair using a tape augment (InternalBrace, Arthrex). Nine matched cadaver elbows underwent UCL sectioning and then either modified Jobe reconstruction or primary repair of the UCL with placement of the InternalBrace. The biomechanical data showed the repair with internal brace to have slightly less gap, more stiffness, and higher failure strength, although these findings were not statistically significant.¹⁸ This bone-preserving technique with less exposure and healing of the native ligament may be another step towards good results with a quicker return to throwing.

Conclusion

UCL injuries can be disabling in throwers. Reconstruction has afforded throwers a high rate of return to preinjury function or better, and several techniques have been presented that produce acceptable results. Overall complication rates range from 10% to 15%, and the majority of complications are transient ulnar neuropraxias. Orthobiologics and repair with augmentation have more recently offered additional options that may improve success of nonoperative treatment or allow less-invasive surgical treatment. Increased involvement in youth sports and early specialization is driving injury rates in young athletes. The orthopedic community must continue to look for better ways to prevent these injuries and investigate better methods to return athletes to high-level competition.

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