Chapter 9
Regenerative Medicine for the Elbow

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Bones/Joints

The elbow joint consists of articulations between the humerus proximally and radius and ulna distally. The distal humerus fans out to form the medial and lateral epicondyles, which serve as an attachment point for ligaments and tendons. The trochlea of the humerus (medial condyle) articulates with the ulna forming the ulnohumeral joint, and the capitellum of the humerus (lateral condyle) articulates with the radial head forming the radiocapitellar joint. The proximal radioulnar joint is formed between the radius and the ulna. Conditions affecting the elbow joint include arthritis, which is more common in older adults, and osteochondritis dissecans, which is more common in adolescents.

Arthritis

Arthritis of the elbow joint can result from rheumatoid arthritis, primary osteoarthritis, or post-traumatic arthritis but is less common than arthritis of other joints [1]. Osteoarthritis commonly presents with pain, swelling, stiffness, and sometimes loss of passive ROM in an older individual who often has a history indicative of traumatic elbow injury or rheumatological disease.

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G. Cooper et al. (eds.), *Regenerative Medicine for Spine and Joint Pain*,
https://doi.org/10.1007/978-3-030-42771-9_9

Osteochondritis Dissecans (OCD)

OCD is a disease process that results in separation of a focal lesion of cartilage from subchondral bone and is most commonly seen on the capitellum of male adolescent throwing athletes [2, 3]. OCD typically presents with progressively worsening activity-related pain and stiffness in the dominant arm of an overhead throwing athlete [4]. Patients often lack 15–30 degrees of full extension, which should point to the need for further evaluation with X-rays and subsequent MRI if X-rays are normal [4].

Ligaments

All ligaments about the elbow are extra-articular and provide the main source of stability. These include ulnar (medial) collateral ligamentous complex, radial (lateral) collateral ligamentous complex, anterior ligament, posterior ligament, and the joint capsule.

Ulnar Collateral Ligament (UCL)

The UCL originates from the medial condyle of the humerus and inserts on the sublime tubercle on the ulna. It consists of three distinct bands: the anterior bundle, posterior bundle, and transverse ligaments [5]. The anterior bundle runs from the medial humeral epicondyle to the sublime tubercle on the medial side of the coronoid process of the ulna and is thought to be the most clinically relevant as these fibers provide resistance to valgus instability, especially during the late cocking phase of throwing, and are most commonly injured with repetitive overhead throwing [5, 6]. Injury to the UCL commonly presents with pain and improved throwing performance, and acute injury may be associated with a “pop.” Physical exam is notable for laxity with valgus stress.

Lateral Collateral Ligamentous Complex

The lateral collateral (radial) ligamentous complex consists of the annular ligament which surrounds the radial head, the radial collateral ligament (RCL) that spans from the lateral epicondyle to the annular ligament in a fan shape, and the lateral ulnar collateral ligament (LUCL) that runs from the lateral humeral epicondyle to the supinator crest. This complex plays a key role in preventing posterolateral and varus instability and is most commonly injured in overhead athletes with repeated varus stress or traumatic elbow dislocations [5, 7]. Injury to this complex commonly presents with pain and may result in mechanical symptoms with laxity to varus stress seen on physical examination.

Tendons

Tendons about the elbow at highest risk of injury include the proximal common extensor tendons (extensor carpi radialis brevis and extensor digitorum) and common flexor/pronator tendons (flexor carpi radialis and pronator teres), as well as the distal biceps and triceps tendons. Injury to these tendons results in tendinopathy that encompasses a spectrum of acute inflammation (tendinitis) to chronic inflammation and degeneration (tendinosis) to partial- or full-thickness tear. Most patients present with sustained pain and functional impairment with tendinosis due to repetitive microtrauma resulting in collagen disarray, necrotic tenocytes, and neovascularization that ultimately results in impaired healing and fibrotic scarring that is difficult to treat with conventional modalities. Acute rupture results in tendon defect.

Common Extensor Tendon

The extensor carpi radialis brevis, extensor digitorum, extensor carpi ulnaris, and extensor digiti minimi originate from the lateral epicondyle of the humerus and make up the common extensor tendon. Tendinopathy of the common extensor tendon at the lateral elbow is one of the most common tendon injuries in the upper extremity and occurs in 1–3% of the general population from repetitive contraction and micro-tearing of the tendon with pain most commonly located about 1–2 centimeters distal to the lateral epicondyle in the dominant extremity of middle-aged adults; it worsens with resisted wrist extension or passive stretch on the tendons [8–10].

Common Flexor/Pronator Tendon

The pronator teres, flexor carpi radialis, palmaris longus, flexor carpi ulnaris, and flexor digitorum superficialis originate from the medial epicondyle of the humerus and from the common flexor/pronator tendon. Tendinopathy of the common flexor/pronator tendon also occurs in middle-aged adults from an overuse mechanism but is less common, occurring in only 0.4% of the general population, and presents as pain over the medial epicondyle that worsens with resisted wrist flexion or passive stretch on the tendons [8].

Distal Biceps Tendon

The distal biceps tendon inserts on the radial tuberosity. Tendinopathy of the distal biceps is thought to be rare but typically occurs from repetitive microtraumas in those between the ages of 40 and 50 years that perform a large eccentric load, resulting in anterior elbow pain that worsens with resisted elbow flexion and supination [11].

Distal Triceps Tendon

The distal triceps tendon attaches on the olecranon process of the ulna. Distal triceps tendon injury is less commonly observed but can occur with overuse or trauma, resulting in partial avulsion of the medial portion of the tendon or complete rupture at the osteotendinous junction [12].

Treatment: The Standard of Care and Evidence

A thorough diagnostic evaluation must precede treatment. Making an accurate diagnosis is the most important step in the treatment process. All patients should be screened for alarm symptoms that would prompt consideration for further workup or imaging evaluation. Traumatic injury, history of dislocation, joint swelling without trauma, and mechanical symptoms should be considered, and, if present, further workup should be pursued.

In general, the standard of care for treatment of nontraumatic injuries at the elbow begins with rest, ice, nonsteroidal anti-inflammatory drugs (NSAIDs), activity modification, and physical therapy to address the underlying pathology. The use of corticosteroid injections is controversial, as they typically result in improved short-term outcomes but have similar or worse outcomes at 1year and may negatively affect long-term tendon health or lead to rupture [13–15]. Typical surgical indications include displaced or intra-articular fractures, tendon or ligament ruptures, unstable or complete osteochondral lesions, or failure of injuries to respond to conservative treatment after 6–12 months.

Bone/Joint

Arthritis

Elbow osteoarthritis is typically treated conservatively with rest, nonsteroidal anti-inflammatory drugs, activity modification, and dynamic hinged or static splinting along with physical therapy [1]. Intra-articular steroid injections can also be considered [16]. Injections should be performed under ultrasound guidance (100% accuracy), which has been shown to be more accurate than use of landmark guidance (77.5% accuracy) [17]. Injection of hyaluronic acid has not been shown to be effective in the elbow albeit the small sample size in one study [18]. Surgery is reserved for those that fail conservative management, with total elbow arthroplasty as a last resort since it is associated with complications in 11–38% of cases, including persistent minor infection, persistent contracture, and transient nerve palsies [1, 19, 20].

OCD

Stable OCD lesions can be treated conservatively, but unstable lesions require surgical repair [21]. Conservative treatment involves an initial period of rest with avoidance of aggravating activities (throwing, weightlifting, gymnastics), with or without the use of a hinged elbow brace, followed by progression to strengthening exercises when patients are pain free [22]. Typically, athletes can start gentle overhead throwing at 3–4 months if they remain pain free, and 84.2% of patients return to play at 6 months if they are compliant with conservative management [22, 23]. Operative treatment is necessary in patients who fail conservative management, have unstable lesions, or have loose bodies associated with mechanical symptoms [22]. Surgical options vary and depend on several factors (lesion size, cartilage cap presence, etc.) and include loose body removal/chondroplasty [24], microfracture/retrograde drilling [22, 24], fixation (with wires, screws, bone pegs) [4, 25], or osteochondral allograft transplantation system [26]. Despite complications being rare, reported rates of return to sport in throwing athletes are less than 50% [27]. A detailed discussion of surgical management is beyond the scope of this chapter.

Ligaments

UCL

Nonoperative treatment is often first line and includes rest (for 6 weeks) followed by initial physical therapy for flexor/pronator strengthening and then a progressive throwing program, but only 42% of athletes returned to sport after nonoperative treatment [28]. Surgery is indicated in complete tears and partial tears that are not responsive to conservative management. Reconstruction using a palmaris longus autograph is typically preferred over repair. Eighty-three percent of athletes were able to return to sport at the same or a higher level at an average of 11.6 months after surgery [29]. Repair is typically reserved for partial tears near the UCL origin or insertion in young athletes and consists of direct suture repair of the injured ligament with placement of an augmentation device with 87% of patients returning to sport [30].

Tendons

Common Extensor Tendon

Common extensor tendinopathy, commonly known as "tennis elbow" or lateral epicondylosis, is typically self-limiting with 90% of patients recovering by 1 year with conservative multimodal treatment consisting of physical therapy with modalities, use of counterforce brace or wrist splint, nonsteroidal anti-inflammatory drugs (NSAIDs), topical nitroglycerin, and extracorporeal shock wave therapy, though there is no consensus treatment algorithm [31–36]. Nitroglycerin patches have been shown to significantly reduce activity-related elbow pain and epicondylar tenderness and improve long-term functional outcomes but have side effects including headaches, facial flushing, and contact dermatitis [37, 38]. Corticosteroid injections are still commonly used to address pain associated with common extensor tendinopathy and show short-term benefits and functional improvements, but tenotoxic effects and increased incidence of recurrence have been reported [13, 39]. Percutaneous needle tenotomy (PNT) is an office-based procedure where a needle is used to repeatedly fenestrate the diseased portions of tendon under sonographic guidance with local anesthesia [40]. In a case series, subjects were treated using PNT, and 80% of these subjects reported good to excellent results at an average follow-up duration of 28 months, and a subsequent corticosteroid injection was not necessary [41]. PNT is also referred to as a "peppering" technique and is sometimes performed in conjunction with regenerative medicine procedures, as discussed later in this chapter. Other studies point to efficacy of dry needling or acupuncture to treat common extensor tendinopathy [42, 43].

Surgery is typically reserved for those who do not improve with conservative therapy by 6 months or those who have complete tendon rupture. Several surgical techniques (open, arthroscopic, and percutaneous microtenotomy) have been described with no differences in postoperative pain, recurrence rate, or procedural failure among the different surgical techniques [44, 45]. The general surgical principle consists of first identifying the affected portion of the tendon which is excised to further facilitate a biologic response and is then usually repaired. Those undergoing arthroscopic treatment have greater functional outcomes or more rapid return to work with utilization of less postoperative physical therapy compared to those undergoing an open procedure [46, 47]. Those more likely to have residual symptoms after surgery are those with a high level of baseline symptoms, acute occurrence of symptoms, or long duration of symptoms [48]. Patients typically recover in 4–12 weeks with 95% achieving good to excellent results and only about 1.5% of patients requiring surgical revision surgery, which is usually successful [49].

Common Flexor/Pronator Tendon

Common flexor/pronator tendinopathy, commonly known as "golfer's elbow" or medial epicondylosis, is often treated in a similar manner to common extensor tendinopathy, as described above.

Distal Biceps Tendon

For distal biceps tendinopathy or partial tear, nonoperative management consists of rest, analgesia as needed, and a rehabilitation program. Studies have shown that patients with complete rupture that are treated using the above options can have continued pain and up to 40% loss of supination strength and 30% loss of range of motion strength compared to their normal side [50]. Corticosteroid injections are rarely used. A cadaveric investigation has shown that sonographically guided distal biceps tendon injections are feasible and can be done through multiple approaches, with the posterior approach being technically easiest, safest, and most accurate [51]. Accuracy and safety are unclear for landmark-guided injections to this tendon. Case series report success of surgical repair for symptomatic refractory distal biceps tendon complete tears [52, 53], but surgical fixation has been shown to be associated with complications, most commonly nerve dysfunction and radioulnar synostosis in up to 27% of patients [54].

Distal Triceps Tendon

The treatment of triceps tendinopathy or partial distal triceps tears is somewhat controversial, and conservative treatment consisting of an initial period of immobilization can be attempted based on the patient's tear severity (<50%), functional demands (low demands), and improvement with conservative management [12, 55]. Complete distal triceps tendon tears require immediate surgical repair in healthy patients, but postoperative range of motion restrictions and rehabilitation is variable [56]. Injury to the ulnar nerve is a reported complication [56].

Regenerative Treatments

Regenerative treatments are currently considered for refractory symptoms of tendinopathy or partial tears of the tendon, partial symptomatic tears of the ligaments, or refractory osseous or chondral pathologies about the elbow, particularly in patients who are poor surgical candidates or wish to avoid surgery.

Bone/Joint

Arthritis

There are no studies that have investigated the use of regenerative therapies to treat elbow osteoarthritis, but regenerative therapies have shown promise in other joints (as discussed in other chapters in the book).

OCD

One small surgical study examined the use of regenerative therapies to treat OCD. In this case series, three adolescent boys (ages 12, 15, and 17) with MRI diagnosis of osteochondral lesions of the elbow (stage not described) were treated with arthroscopy or arthroscopy plus a mini-open procedure augmented with autologous platelet gel and bone marrow aspirate concentrate [57]. After progression through a rehabilitation protocol beginning with passive range of motion and ending with sports-specific drills, all three subjects returned to sport pain free by 9 months [57]. There are no studies examining the use of regenerative medicine therapies without arthroscopy, and it is difficult to draw a conclusion from this small surgical study.

Ligament

Elbow Ulnar Collateral Ligament (UCL)

With the advancement of ultrasound technology, the ability to visualize partial tears of the ulnar collateral ligament, especially dynamically, has drastically improved, and there is increasing interest in nonoperative management with the use of regenerative medicine. A survey of American elbow and shoulder surgeons showed that 36.3% of responders currently use PRP to treat UCL injuries where 43.9% of those using PRP prefer leukocyte-poor PRP, 16.6% prefer leukocyte-rich PRP, and the remaining 39.9% had no preference [58]. In the same survey, 8% reported using stem cell therapies with bone marrow lipoaspirate concentrate being most commonly used (31.3%) [58].

Two case series of a combined 78 athletes with UCL partial tears who failed conservative management and who were treated with sonographically guided leukocyte-poor PRP injection(s) showed improvement in pain and function with a mean return to play of 12 weeks [10, 59]. An additional small case series showed more rapid return to play (mean 36 days) in non-throwing professional athletes (hockey players) who sustained a mid- to high-grade traumatic UCL injury that was treated with two sonographically guided injections of leukocyte-poor PRP a mean of 9 days apart and resulted in improved pain and decreased laxity on follow-up sonographic imaging [60]. Despite showing promise in case series, the use of PRP to treat UCL injuries in 133 major and minor league baseball players who had failed conservative management showed a significantly more rapid return to play in those treated conservatively than those that received PRP injection (51 vs. 64 days), but this study did not mention the use of sonographic guidance, which may improve the efficacy of an injection if it is accurately placed [61]. With proper patient selection, treatment of partial UCL injuries with sonographically guided PRP injection offers a viable treatment option with a more rapid return to play than surgical reconstruction, though RCTs are lacking.

The use of other regenerative treatments for UCL injury has not been studied.

Annular Ligament and Radial Collateral Ligament

Isolated annular ligament and radial collateral ligament tears are very rare, and there are no studies on regenerative medicine to treat injuries to these structures in isolation. Two RCTs studying prolotherapy for the common extensor tendon also involved injection into the annular ligament or the annular ligament and radial collateral ligament and are described later in this chapter [62, 63].

Tendon

Common Extensor Tendon

The use of regenerative treatments for elbow injuries has been most extensively studied in patients with common extensor tendinopathy.

Platelet-Rich Plasma (PRP)

Initial uncontrolled studies have shown promising benefits and safety of PRP used to treat common extensor tendinopathy which inspired level 1 studies comparing PRP to corticosteroids, percutaneous needle tenotomy, saline, and surgery that will be discussed here. It is important to note that the formulation of PRP (leukocyte rich vs. leukocyte poor, platelet count and use of an activating agent), use of additional procedures (percutaneous needle tenotomy), use of sonographic guidance, and postinjection rehabilitation protocol varied across studies [64]. In general, leukocyte-rich PRP is preferred over leukocyte-poor PRP in the treatment of tendon injury [65], but when compared directly to treat common extensor tendinopathy, no difference was found between the two [66]. Though the optimum rehabilitation protocol has yet to be determined, animal studies show improved efficacy when PPR injections are combined with mechanical loading of the tendon, indicating that rehabilitation should be performed after injection [67]. Specific discussion of the details of the methods of each RCT is beyond the scope of this chapter.

In randomized control trials (RCTs) that compare one injection of leukocyte-poor PRP to corticosteroids, similar improvement in pain and function was noted in the short term (2 weeks–6 months) [68–70], but leukocyte-rich or leukocyte-poor PRP tends to provide continued improvement in pain and function leading to superiority in the intermediate to long term (6 months–2 years) [71–73] with sonographic structural improvements in tendinosis seen in those treated with leukocyte-poor PRP at 6 months [74]. When used in isolation, PRP has been shown to have slightly superior outcomes to PNT (5–10 passages with a 22- to 27-gauge needle is most commonly used) at up to 1 year, but the two treatments are complementary, leading to greatest improvement in pain and function when used in combination in RCTs [75–78]. RCTs comparing PRP to autologous blood injection (ABI) with associated

PNT have shown clinically equal efficacy at up to 1 year [79–82]. Although retrospective studies show equality or superiority of PRP injections to surgery to treat common extensor tendinopathy at 1 month–1 year follow-up [83, 84], the only RCT comparing PRP to surgery notes significantly better overall pain, night pain, and functional scores at 2 years after surgery, despite more similar outcomes in efficacy in the short and midterm [64]. It should also be noted that in this study, only the surgical group received physical therapy while the PRP injection group did not, negating the direct comparison between the two groups. Overall, PRP is safe and can be an effective treatment for common extensor tendinopathy and should be considered in the appropriate clinical context.

Autologous Blood Injection (ABI)

There are several case series and prospective clinical studies that have indicated that ABI is a safe and effective treatment for recalcitrant common extensor tendinopathy [80, 85–91], but the evidence in RCTs does not show superiority when compared to other treatments, including PRP [80–82], extracorporeal shockwave therapy (received once a week for 3 weeks) [92], and saline injection [93]. When comparing corticosteroid and ABI, small RCTs have shown superiority of corticosteroid at 1 month [92] with better results using ABI at 6 months [93] and up to 2 years [92]. Though high-level evidence is lacking, ABI seems to be a safe and effective treatment for common extensor tendinopathy.

Prolotherapy

A few studies examining prolotherapy for the treatment of common extensor tendinopathy have shown promising results, but small sample sizes, variability in contents of the "prolotherapy" mixture, number of injections given, and lack of sonographic guidance for the injections limit our ability to draw definitive conclusions on an optimum protocol. Two RCTs compared multiple injections of different formulations of prolotherapy (consisting of sodium morrhuate, dextrose, lidocaine, Sensorcaine, and normal saline or phenol 1.2%, glycerine 12.5%, dextrose 12.5% in sterile water, and sodium morrhuate) to normal saline [94] or corticosteroid [62] into the tendon near the lateral epicondyle and surrounding structures, including the annular ligament, with prolotherapy showing superiority to normal saline from 8 weeks to 52 weeks but non-superiority to corticosteroids at up to 6 months, though the shorter follow-up in this study limits the ability to draw conclusions. In an attempt to directly compare prolotherapy formulations, there was no difference in functional improvement between prolotherapy consisting of dextrose and prolotherapy consisting of dextrose morrhuate, but both were superior to "watchful waiting" from 4 to 16 weeks [63]. Treatment with prolotherapy can be considered given the low risks of use of an inert substance but may require multiple injections; the duration of follow-up to see clinical efficacy and the optimum formulation are still not known.

Autologous Tenocyte Injection

Autologous tenocyte injection (ATI) is a novel therapy that has been studied to treat chronic, refractory common extensor tendinopathy. One case series of 17 patients examined the use of culturally expanded patellar-tendon-derived autologous tenocytes that were injected under sonographic guidance and showed improvement in pain, self-reported function, grip strength, and level of tendinosis seen on MRI at 12 months. Clinical measures also remained significantly improved at final follow-up at a mean of 4.5 years [95, 96]. Notably, no adverse events were observed, and only one patient progressed to surgery after a subsequent work-related injury [95, 96]. In another small case series, laboratory-prepared collagen-producing cells derived from dermal fibroblasts were injected under sonographic guidance into the site of intrasubstance tears of the common extensor tendon which resulted in improvement in patient-reported function and tendinosis severity on ultrasound at 6 weeks, 3 months, and 6 months with only one patient proceeding to surgery at 3 months [97]. In these small case series, ATI shows promise, but larger studies are needed to better determine its safety and efficacy and to gain FDA approval.

Mesenchymal Stem Cells (MSCs)

Bone marrow aspirate concentrate (BMAC) and allogenic adipose-derived mesenchymal stem cells are promising procedures that involve injection of MSCs into the area of disease/disrepair and have been examined in pilot studies. A case series of 30 patients with refractory common extensor tendinopathy who received landmark-guided injection of BMAC showed a highly significant improvement in self-reported functional outcomes at 2, 6, and 12 weeks of follow-up [98]. In another case series, 12 subjects underwent sonographically guided injection of enzymatically digested culturally expanded adipose-derived cells and reported improvement in pain and function with sonographic evidence of improvement in tendon defects at up to 52 weeks without significant adverse events [99]. Though treatment with MSCs shows promise, it is important to note that treatments that contain tissue that has been “more than minimally manipulated” are not currently approved by the FDA outside of the research setting.

Amniotic Membrane Injection

Amniotic membrane allograft injection has shown benefit in small case series, but FDA homologous use guidelines pose a barrier to future use of this injection clinically. A retrospective case series of 10 patients with common extensor tendinopathy treated with micronized dehydrated human amniotic chorionic membrane allograft showed improvement in self-reported function, with a 77% improvement of pain at 24–36 weeks [100]. In a case series of 40 patients with joint or tendon pathology treated with dehydrated human amnion/chorion membrane allograft injection under ultrasound guidance, 7 patients with lateral epicondylitis were treated [101]. There was no subgroup analysis that examined only those with lateral epicondylitis, but treatment of all conditions resulted in improved pain and function in all patients without significant adverse events at up to 3 months [101]. Utility of amniotic membrane allograft is still up for debate.

Percutaneous Ultrasonic Tenotomy

Percutaneous ultrasonic tenotomy is a device that uses a rapidly vibrating needle tip to emulsify diseased tendon and promote tendon fiber growth and reorganization that is performed under ultrasound guidance and is a promising treatment for tendinopathy at the elbow. A case series of 12 patients with common extensor tendinopathy and 7 patients with common flexor tendinopathy showed improvement in pain and function at 6 weeks that continued at 12 months without adverse events [102]. When retrospectively compared to PRP, patients who received percutaneous ultrasonic tenotomy for common flexor and extensor tendinopathy had equally significant improvements in pain, function, and patient satisfaction [103]. Percutaneous ultrasonic tenotomy shows promise though higher-level studies are needed and, theoretically, patients may benefit from percutaneous ultrasonic tenotomy in combination with other regenerative procedures such as PRP.

Common Flexor/Pronator Tendon

Clinical use of regenerative therapies to treat common flexor/pronator tendinopathy is primarily translated from studies on common extensor tendinopathy. Nevertheless, there are a few studies that specifically examine the use of regenerative medicine therapies to treat common flexor/pronator tendinopathy. A small case series showed that 1–2 injections of leukocyte-poor PRP showed overall functional improvement in the group that received a single injection (8 patients), but there was no functional improvement noted in the group that received two injections (6 patients) [104]. An earlier study showed that two injections with autologous blood injection (ABI) under sonographic guidance and combined with percutaneous needle tenotomy showed a significant reduction in pain and function, as well as a reduction in the amount of hypoechoic tendon and neovascularity seen on ultrasound at 10 months post-procedure [87]. Percutaneous ultrasonic tenotomy has been shown to be effective for treatment of medial elbow tendinosis, as stated above [102, 103]. These studies suggest that the use of regenerative therapies combined with a mechanical debridement of the tendon (percutaneous needle tenotomy or percutaneous ultrasonic tenotomy) may be beneficial, but subsequent injections without mechanical debridement may not be efficacious in treating common flexor/pronator tendinopathy.

Use of other regenerative therapies has not been described for treatment of common flexor/pronator tendinopathy.

Distal Biceps Tendon

Ultrasound-guided PRP injection to treat biceps tendinopathy (confirmed on imaging) has been described in a cohort and case series study of 18 total patients and may be an alternative to traditional conservative nonoperative treatment for refractory tendinopathy [105, 106]. In the cohort study, a single sonographically guided injection of leukocyte-rich PRP (10 patients) or leukocyte-reduced PRP (2 patients) resulted in significant improvement in pain at rest and with activity, function, and biceps strength at median final follow-up of 47 months [105]. In a small case series, 6 patients with distal biceps tendinopathy confirmed by MRI or ultrasound that was refractory to conservative management were treated with needle tenotomy and leukocyte-rich nonactivated PRP with platelet concentration < 5 times serum concentration [106]. With the use of sonographic guidance to accurately evaluate the location of the tendon and target the area of injury [51], regenerative treatments have shown promise for the treatment of distal biceps tendon injury.

Use of other regenerative therapies has not been described for treatment of distal biceps tendon injury.

Distal Triceps Tendon

Only one case reports on the use of regenerative medicine to treat triceps tendon injury in a 47-year-old male weight lifter who suffered an acute partial rupture of the distal triceps tendon with MRI confirmation of the injury [107]. After failure to improve with physical therapy 5 weeks after the injury, the patient was treated with a landmark-guided leukocyte-poor PRP injection followed by physical therapy at 2 weeks postinjection; he was pain free at rest and able to return to weight lifting with minimal pain at 4 weeks postinjection [107].

Conclusion

Regenerative treatments for injuries about the elbow are best supported by many RCTs that examine outcomes in the treatment of common extensor tendinopathy. Studies suggest that PRP injections have long-term therapeutic benefit when compared to corticosteroid injection, local anesthetic injections, and conservative management alone, but the efficacy of PRP compared to mechanical debridement with percutaneous ultrasonic tenotomy or surgery has not been described in well-controlled studies. There is variability in the literature in the formulation of PRP, inconsistent use of additional procedures (percutaneous needle tenotomy) and sonographic guidance to perform the injection, as well as varied postinjection rehabilitation protocols across studies. There is limited evidence for the use of ABI, prolotherapy, ATI, BMAC, adipose tissue, amniotic membrane, and PUT with none of these treatments consistently showing superiority to other management options. Beyond treatment for common extensor tendinopathy, the data is limited by small sample sizes and case series or case studies but suggest that regenerative treatments such as PRP, prolotherapy, and BMAC might have promise in treating other injuries involving the elbow including common flexor/pronator tendinopathy, UCL injury, distal biceps tendinopathy, and distal triceps tendinopathy. There is limited evidence for the use of regenerative therapies to treat elbow arthritis, but based on our knowledge of the use of PRP to treat arthritis of other joints, it may also show efficacy in the elbow. Lastly, regenerative therapies have only been used to augment surgery for OCD and are less likely to be beneficial when injected in the setting of stable OCD.

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