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The use of biologics for the elbow: a critical analysis review

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There is significant interest in biologic treatment options to improve the healing environment and more rapidly decrease symptoms in many conditions around the elbow. Despite fairly widespread use of biologic agents such as platelet-rich plasma (PRP) in the elbow, there is a lack of clear evidence in the literature to support its use. The potential impact of these biologic agents must be evaluated with evidence from high-quality studies, particularly considering the high financial burden these treatments often impose on patients. The aim of this review is to provide an evidence-based summary of the biologic augmentation options available for use by the physician treating painful conditions of the elbow and to identify areas where further research is warranted.

Keywords: Elbow; orthobiologics; PRP; epicondylitis; tendinopathy; MSC

There is significant interest in biologic treatment options to improve the healing environment and more rapidly decrease symptoms in many conditions around the elbow. Despite fairly widespread use of biologic agents such as PRP in the elbow, there is a lack of clear evidence in the literature to support its use, except in the case of lateral epicondylitis. The potential impact of these biologic agents must be evaluated with evidence from high-quality studies, particularly considering the high financial burden these treatments often impose on patients. The aim of this review is to provide an evidence-based summary of the biologic augmentation options available for use by the physician treating painful conditions of the elbow and to identify areas where further research is warranted.

Methods

A search of PubMed, EMBASE, CINAHL, and CENTRAL databases was performed in November 2018. Search terms of *lateral epicondylitis*, *medial epicondylitis*, *elbow osteoarthritis*, *ulnar collateral ligament*, *distal biceps*, and *capitellar osteochondral defect*, as well as *platelet rich plasma*, *mesenchymal stem cell*, *bone marrow aspirate*, and *adipose derived stem cell* were used, as appropriate, along with synonyms and filters for humans, English language, research or clinical research papers, and peer-reviewed research journals. Abstracts were screened and relevant manuscripts reviewed. Best available level of evidence was included for each platelet-rich plasma (PRP) therapy intervention in the treatment of lateral epicondylitis, medial epicondylitis, ulnar collateral ligament injuries, and distal biceps tendinopathy. Additionally, best available level of evidence was included for the use of mesenchymal cell (MSC)–containing therapy in the treatment of lateral epicondylitis; no studies were available describing the use of MSCs in the remaining elbow pathologies. Manuscripts included in the PRP review for lateral epicondylitis were required to include experimental groups and a control group without

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PRP-containing therapy. Given the paucity of literature regarding the use of PRP or MSCs in other conditions about the elbow, all relevant manuscripts for medial epicondylitis, ulnar collateral ligament pathology, and distal biceps tendinosis were included. Additional articles were found by reviewing citations of relevant manuscripts. Exclusion criteria included case reports, pilot studies, unpublished manuscripts, editorials, and manuscripts without available full English-language text.

Platelet-rich plasma

PRP is a concentrate derived from autologous blood that has been centrifuged to separate out platelets, which contain growth factors and cytokines, from other components of whole blood.[6] The concentration of platelets as well as the formulation of PRP, including presence or absence of leukocytes, is variable and dependent on the technique of centrifugation. Leukocyte-rich PRP (PRP_{LR}) retains leukocytes and has pro-inflammatory effects, whereas leukocyte-poor PRP (PRP_{LP}) has the neutrophils removed and is anti-inflammatory.[15] Many of the cytokines that are found at the site of tendon healing have been demonstrated to also exist in high concentrations in PRP.[35] Additionally, basic science research suggests that PRP induces tendon cell proliferation and induces angiogenic factors.[1,18] As a result, PRP has been a popular target of investigation in the hopes of identifying a biologic treatment that will create an environment conducive to healing.

Lateral epicondylitis

Lateral epicondylitis is a common cause of pain and disability about the elbow, affecting 1%-3% of adults annually.[41] Although the true cause of lateral epicondylitis remains unknown, the symptoms have been attributed to microtrauma to the extensor carpi radialis brevis muscle, with resultant angiofibroblastic dysplasia. Notably, acute inflammation is typically not present on histology,[28] but is present when local inflammatory mediators are analyzed, and pathology is thought to be related to a failure of the normal tendon repair mechanisms.[16] Multiple methods have been used to treat epicondylitis, including rest, physical therapy, bracing, nonsteroidal anti-inflammatory medications, corticosteroid injections, and surgical management.[7] Although there are myriad studies regarding the use of PRP in the treatment of lateral epicondylitis, the majority are poorer quality studies without a control group. However, prospective randomized trials have been performed to investigate the effect of PRP in lateral epicondylitis. Unfortunately, the exact composition of the PRP used was not always clearly outlined (PRP_{UNKN}), and the reader must always consider the methods of preparation to determine if PRP_{LR} or PRP_{LP} was delivered. Furthermore, the measures used to assess outcomes were not standard across all studies, making conclusions more difficult to generalize. It should also be noted that although steroid injections were previously the gold standard of treatment for lateral epicondylitis, recent data suggest that this treatment modality has limited long-term benefit and may have detrimental effects.[7,29,42] The literature suggests that dexamethasone inhibits tenocyte proliferation and progenitor cell recruitment, causing decreased collagen synthesis and enhancing fatty tissue changes.[36] Thus, corticosteroids may not be the most appropriate control group to assess PRP efficacy, and studies that compare outcomes of PRP and steroid injections should be interpreted with caution.

When evaluating the highest level of evidence and considering only well-designed, prospective randomized trials, there are several studies that support the use of PRP in the treatment of lateral epicondylitis. Peerbooms et al examined the effect of 3-mL PRP_{UNKN} vs. a 3-mL preparation of triamcinolone/bupivacaine in 100 patients with lateral epicondylitis. They found that the steroid cohort initially improved in the short term, with improved visual analog scale (VAS) and Disabilities of the Arm, Shoulder and Hand (DASH) scores as compared to the PRP_{UNKN} group at 4 and 8 weeks, but then declined. At 1 year, the PRP_{UNKN} cohort had a significantly greater number of patients with a ''satisfactory outcome'' defined as a greater than 25% improvement in outcomes scores as compared to baseline without reintervention (49% in the steroid group vs. 73% in the PRP group).[30] Gosens et al later reported the 2-year follow-up data for this same patient cohort, as well as an intent-to-treat analysis of the previously reported data by Peerbooms. The authors noted that at time points between 8 and 26 weeks, the VAS pain scores worsened as compared to baseline in the corticosteroid group, whereas VAS scores in the PRP_{UNKN} group consistently improved. They again noted that the PRP_{UNKN} group had significantly worse VAS scores at 4 weeks; however, scores were significantly improved as compared to the corticosteroid cohort at 26, 52, and 104 weeks. Additionally, DASH scores in the corticosteroid cohort improved at 8 and 12 weeks but subsequently declined, whereas scores in the PRP_{UNKN} group significantly improved throughout the duration of the study. As with VAS score, the DASH score in the PRP_{UNKN} group was significantly better than in the corticosteroid group at 26, 52, and 104 weeks after treatment. Furthermore, the authors reported that at 2-year follow-up, 9 patients in the corticosteroid group and 2 patients in the PRP_{UNKN} group had a deterioration of VAS scores, and 23 patients in the corticosteroid group vs. 7 patients in the PRP_{UNKN} group had a deterioration of DASH scores. The authors concluded that although corticosteroids may offer short-term relief, PRP_{UNKN} injections are beneficial in the long term for treatment of lateral epicondylitis.[17] Similarly, Lebiedzinski et al compared DASH scores at 6 weeks, 6 months, and 1 year in patients

who were randomized to receive either PRP_{LP} or an injection of betamethasone/lidocaine. The authors also noted improved scores in the corticosteroid group as compared to the PRP_{LP} group at 6 weeks and 6 months; however, scores were significantly better in the PRP_{LP} group at the 1-year time point.[21]

In the largest, multicenter, prospective study of PRP_{LR} vs. corticosteroid injections, Mishra et al randomized 230 patients to receive 2-3 mL of either PRP_{LR} or bupivacaine. The authors measured VAS pain scores, Patient-Rated Tennis Elbow Evaluation (PRTEE) scores, and success rate defined as either a 25% or 50% reduction in pain at 4, 8, 12, and 24 weeks postintervention. They reported a statistically significant improvement in the VAS pain score at both 8 and 24 weeks; however, no significant differences were noted in PRTEE scores at any time point. Although only 119 of the initial 230 patients were available for the 24-week follow-up, the authors reported a significantly greater success rate in the PRP_{LR} cohort as compared to the control group using the >25% pain reduction parameter (89.3% vs. 68.3%, $P = .037$) and >50% pain reduction parameter (82.1% vs. 60.1%, $P = .008$). Although this study is limited by a short duration of follow-up and a large number of patients lost to follow-up, the data do suggest efficacy of PRP_{LR} injections as opposed to local anesthetic.[25]

Additionally, Montalvan et al performed a randomized study examining the effect of 2 injections of PRP_{LP} as compared to 2 saline injections administered 4 weeks apart. The authors noted no statistically significant differences in outcomes, including VAS pain score and Roles-Maudley score, at any time point up to 12 months.[27] In another of the few studies with saline as a control, Krogh et al compared the outcomes of injections of PRP_{LR}, corticosteroids, and saline in a randomized cohort of 60 patients. However, although the study followed patients out to 1 year, the authors used the 3-month data as the primary endpoint because of a significant study dropout after 3 months, with only 16 of 60 patients remaining in the study at 12 months. Thus, this study was not included in our review of high-level evidence given the low patient retention.[19]

Multiple randomized studies have also been performed comparing various formulations of PRP with autologous whole blood (AB) in lateral epicondylitis; however, only 1 study followed patients out to 1 year postintervention. Creaney et al and Raeissadat et al found no significant differences in outcomes between the groups at any time point using PRP_{LP} and PRP_{LR}, respectively.[10,33] On the other hand, Thanasas et al found that pain scores were significantly improved in the PRP_{LR} group as compared to AB at 6 weeks, but there were no differences thereafter. The authors concluded that although PRP_{LR} may have improved short-term effects, these are not sustained in the longer term.[39] Merolla et al compared the effects of treatment with 3-5 mL of PRP_{UNKN} vs. outcomes of arthroscopic débridement for chronic lateral epicondylitis. The authors randomized 50 patients to each treatment group and evaluated VAS pain scores, PRTEE, and grip strength at multiple intervals up to 2 years. They found that although both groups improved from baseline, both pain scores and grip strength were significantly better in the surgical group vs. the PRP_{UNKN} group.[23]

When critiquing results of PRP studies, it is important to recognize that the concentration, volume, and makeup of PRP formulations are not all standardized and often not reported. In addition, levels of growth factors in PRP have been reported to vary widely in preparations made in similar fashion. Furthermore, chronicity of symptoms and prior intervention differs between studies, making results even more challenging to generalize (Table I).

Despite the heterogeneity of the literature, several meta-analyses with differing inclusion criteria have been performed examining the effectiveness of PRP in the treatment of lateral epicondylitis. Two systematic reviews found that although corticosteroids may provide short-term benefit, patients treated with PRP have improved outcomes in the long term.[5,24] Furthermore, in a systematic review of and meta-analysis evaluating PRP, AB, and corticosteroid injections that included 10 primary studies, the authors found that PRP was superior to AB and steroids with regard to VAS and PRTEE scores.[2] However, de Vos et al performed a systematic review of the relevant literature and concluded that there is strong evidence that PRP injections do not improve pain or function in cases of chronic lateral epicondylitis.[12] Chen et al performed a recent systematic review and meta-analysis of PRP use in multiple tendon and ligament injuries, including an assessment of study bias. With regard to PRP and lateral epicondylitis, they found that PRP significantly decreases pain as compared to other treatment modalities in both the short and long term. However, the authors did note significant heterogeneity in study populations and PRP preparation, as well as publication bias among the included studies, making the results somewhat difficult to interpret.[8] Based on these findings, the use of PRP injections is recommended instead of corticosteroid injections. More specifically, we recommend the use of PRP_{LR}, as the randomized controlled trials that show the best efficacy use the PRP_{LR} formulation. Although the literature does support the use of PRP in lateral epicondylitis, further research is needed to determine the optimal formulation and administration of PRP injections, and additional high-quality studies are necessary to provide definitive data.

Medial epicondylitis

Medial epicondylitis is similar to its lateral counterpart, affecting the flexor tendon insertion at the medial epicondyle. However, unlike lateral epicondylitis, there is a general paucity of literature examining the efficacy of

Table I Results of Level I prospective randomized trials with ≥1-year follow-up for PRP in lateral epicondylitis

Study	Journal	PRP type	Control type	No. of patients	Follow-up, mo	Outcome scores	
						Control	PRP
Merolla (2017)[23]	Arthroscopy	Unknown	Scope/ débridement	101	24	VAS: 2.1* PRTEE: 21.2* Grip strength: 48.4*	VAS: 7.1 PRTEE: 69.2 Grip strength: 22.8
Lebiedziński (2015)[21]	Int Orthop	Leukocyte-poor	Betamethasone /lidocaine	99	12	DASH: 9.9 ± 17.1	DASH: 14.4 ± 25.2*
Raeissadat (2014)[33]	BMC Sports Sci Med Rehabil	Leukocyte-rich	Autologous whole blood	64	12	VAS: 3.94 ± 2.42 PPT: 22.5 ± 5.7 MEPS: 73.16 ± 18	VAS: 3.29 ± 2.41 PPT: 26.9 ± 6.3 MEPS: 78.18 ± 18
Mishra (2014)[25]	Am J Sports Med.	Leukocyte-rich	Bupivacaine	230	6†	VAS (% improvement): 56.1 PRTEE: 21.06	VAS (% improvement): 71.5* PRTEE: 16.17
Gosens (2011)[17]	Am J Sports Med	Unknown	Triamcinolone/ bupivacaine	100	24	VAS: 42.4 ± 26.8 DASH: 36.5 ± 23.8	VAS: 21.3 ± 28.1* DASH: 17.6 ± 24.0*
Peerbooms (2010)[30]	Am J Sports Med	Unknown	Triamcinolone/ bupivacaine	100	12	VAS: 50.1 ± 28.1 DASH: 108.4 ± 82.2	VAS: 32.6 ± 31.5* DASH: 54.7 ± 73.2*
Montalvan (2016)[27]	Rheumatology	Leukocyte-poor	Saline	50	12	VAS: 1.8 ± 2.1 Roles-Maudley: 2.2 ± 0.9	VAS: 1.7 ± 1.5 Roles-Maudley: 2.3 ± 1.1

PRP, platelet-rich plasma; *VAS*, visual analog scale; *PRTEE*, Patient-Rated Tennis Elbow Evaluation; *DASH*, Disabilities of the Arm, Shoulder and Hand; *PPT*, pressure pain threshold; MEPS, Mayo Elbow Performance Score.

* Significant at $P < .05$.

† Did not have 1-year follow-up.

treatment with PRP in cases of medial epicondylitis. Varshney et al compared outcomes of treatment with PRP_{UNKN} and corticosteroid injections in a cohort of 83 patients with both medial (20) and lateral (63) epicondylitis. Although the authors reported a significant improvement in VAS scores in the PRP_{UNKN} group as compared to the steroid group (91% vs. 42.2% improvement, $P = .0001$), the authors failed to stratify the results based on medial vs. lateral epicondylitis. Further research is necessary to determine the effect of PRP in treatment of medial epicondylitis.[40]

Ulnar collateral ligament injuries

The ulnar collateral ligament (UCL) provides the primary restraint to valgus stress at the elbow and is at risk for injury in repetitive overhead throwing. Interest in treatment for ulnar collateral ligament injuries has grown in recent years because of an increasing epidemic among young athletes, as well as the rise of ulnar collateral ligament reconstructions in professional sports.

Podesta et al reported a case series of 34 athletes with magnetic resonance imaging (MRI)–confirmed partial UCL tears who underwent a PRP_{LR} injection after failing a 2-month period of rest and rehabilitation. Of the 34 included patients, 32 had injuries at the proximal insertion site, and 2 had partial tears at both the proximal and distal insertion. Each patient underwent a single injection of leukocyte-rich, unactivated PRP with a mean platelet concentration of $780.2 \pm 246.5 \times 10^3$ μL, under ultrasonographic guidance, followed by a rehabilitation program that incorporated progressive throwing at 8-10 weeks. The authors reported an 88% return to play rate at 70 weeks postinjection, and the average time to return to play was 12 weeks. They also noted a significant improvement in Kerlan-Jobe Orthopedic Clinic shoulder and elbow and DASH scores. Only 1 player subsequently required a UCL reconstruction. However, it should be noted that the study subjects had significant variability in their level of play, and only 16 of the included patients were pitchers.[32] Deal et al reported a retrospective case series of 25 collegiate and high school athletes treated with a 2-injection series of PRP_{LR} in conjunction with bracing and physical therapy. Of their cohort, 23 patients had grade 2 proximal or distal UCL injuries, and 2 patients had persistent symptoms following a prior UCL reconstruction. The study included 21 baseball pitchers, and all but 1 patient had an acute-on-chronic UCL injury. Each patient received 2 injections of PRP_{LR} spaced 2 weeks apart, performed under ultrasonographic guidance. At 4 weeks after the second injection, the patients underwent a repeat MRI to evaluate for ligament reconstitution. The authors reported a 96% return to play rate in those patients with grade 2 injuries. Additionally, 91% demonstrated reconstitution of the ligament on follow-up MRI. One patient from the primary injury group required UCL reconstruction, and both patients from the operative failure group required revision surgery.[13]

Table II Level IV case series of PRP use for partial ulnar collateral ligament tears

Study	Journal	PRP type	No. of patients	Follow-up, mo	Scores, preinjection	Outcomes, postinjection	Return to play
Deal (2018)[13]	Orthop J Sports Med	Leukocyte-rich (2 injections)	25 (23 primary, 2 failed reconstruction)	Not included	N/A	91% had reconstitution of tendon at 6-W MRI 100% of patients with prior reconstruction failed PRP	96% (of primary injury patients)
Dines (2017)[14]	Am J Orthop	Leukocyte-poor	44	11	N/A	34% excellent 39% good 4% fair 23% poor	4/6 (67%) of professional players
Podesta (2013)[32]	Am J Sports Med	Leukocyte-rich	34	17.5	KJOC: 46 ± 15 DASH: 21 ± 16	KJOC: 93 ± 7 DASH: 1 ± 6	88%

N/A, not available; *KJOC*, Kerlan-Jobe Orthopedic Clinic shoulder and elbow score; *DASH*, Disabilities of the Arm, Shoulder and Hand; *MRI*, magnetic resonance imaging.

Dines et al subsequently published a retrospective case series of 44 baseball players who underwent treatment with PRP_{LP} for partial UCL tears or diffuse signal noted on MRI. The authors used the Autologous Conditioned Plasma (ACP) system (Arthrex, Naples, FL), which generates PRP_{LP}. Patients with recalcitrant pain after 3 weeks were eligible for repeat injections, so 16 patients underwent 1 single injection, 6 had 2 injections, and 22 had 3. Only 15 patients had an excellent outcome (34%), 17 had a good outcome, 2 had a fair outcome, and 10 had a bad outcome. Furthermore, only 4 of the 6 included professional players (67%) were able to return to play. Notably, all 7 patients with a distally based partial UCL tear had a poor outcome, whereas in patients with diffuse signal without partial tear, 9 had an excellent outcome and 10 had a good outcome.[14] Although there are some data to suggest that the use of PRP_{LP} in the treatment of partial UCL injuries may improve outcomes, the significant heterogeneity of injury severity, level of play, and PRP preparation and administration makes it difficult to make definitive clinical recommendations from the current literature (Table II). Further research is needed to determine the efficacy of PRP in treating UCL injuries, particularly in high-level athletes.

Distal biceps tendinopathy

Despite distal biceps tendinopathy being a relatively uncommon cause of pain about the elbow, symptoms are characterized by pain at the anterior aspect of the elbow, particularly with resisted flexion and supination. Treatment typically consists of activity modification and physical therapy, particularly given the concern about injections in this anatomic area because of the proximity of the neurovascular structures.[4,26] There are only 2 studies to date reporting the use of PRP in the treatment of distal biceps tendinopathy, both of which are small case series.

Barker et al reported a series of 6 patients who received PRP_{LR} under ultrasonographic guidance for distal biceps tendinopathy, including 1 patient who had an MRI-diagnosed partial tear. At the same time, the authors performed a dry needling technique to create cleavage planes in the tendon for PRP ingress. Four of the 6 patients received 1 injection, and 2 had 2 injections. The authors reported an improvement in mean modified Mayo Elbow Performance Scores from 68.3 to 95 ($P = .03$), with VAS at rest improving from 2.25 to 0 and VAS with movement improving from 7.25 to 1.3 at the 16-month follow-up.[4] Sanli et al subsequently published a prospective case series of 12 patients with distal biceps tendinopathy treated with a single ultrasound-guided injection of PRP_{UNKN}. Of note, 6 of the patients had a partial tear at the insertion site, and 2 had a partial tear at the musculotendinous junction. It should also be noted that multiple different PRP collection systems were used in this study, so the PRP itself was not standardized. The authors reported statistically significant improvements in VAS at rest (6 to 0.5, $P < .002$), VAS with activity (8 to 2.5, $P < .002$), and elbow functional assessment (EFA) scores (63 to 90, $P < .004$). They also reported that no patients had recurrence of symptoms at a median follow-up of 47 months.[34] Thus, although these studies demonstrate promising results of PRP use in distal biceps tendinopathy, further research with appropriate control groups is necessary to determine the optimal patient population and PRP preparation.

Table III Recommendations for care based on grades of recommendation for summaries or reviews of orthopedic surgical studies

Treatment	Grade
The application of platelet-rich plasma has superior results to corticosteroids for long-term pain relief in lateral epicondylitis	A
First-line use of platelet-rich plasma in lateral epicondylitis can be recommended on the basis of the current literature	B
The use of platelet-rich plasma has been shown to reduce pain secondary to tendinopathies about the elbow	B
Stem cell augmentation in lateral epicondylitis cannot be universally or definitively recommended	I

Grade A: Good evidence (Level I studies with consistent findings) for or against recommending intervention.
Grade B: Fair evidence (Level II or III studies with consistent findings) for or against recommending intervention.
Grade C: Conflicting or poor-quality evidence (Level IV or V studies) not allowing a recommendation for or against intervention.
Grade I: There is insufficient evidence to make a recommendation.

Cellular therapy for the elbow

Tendinopathy is believed to result from a failure of the local repair mechanism following microtrauma. Thus, there is interest in cell-based biologic treatment using undifferentiated multipotent mesenchymal cells (MSCs) to potentially improve healing potential. MSCs can be isolated from bone marrow, adipose tissue, skin, synovial fluid, umbilical cord blood, placenta, and amniotic fluid[9,38] and can differentiate into bone, cartilage, tendon, muscle, and adipose tissues in vitro.[31] The most common tissue sources of MSCs are from bone marrow aspiration to produce bone marrow aspirate concentrate (BMAC) as well as adipose tissue producing adipose-derived progenitor cells (ADSC).[20] Only 0.001%-0.01% of the nucleated cells in bone marrow aspirate concentrate are MSCs,[11] whereas 1%-4% of the nucleated cells are MSCs in ADSC preparations.[3] There are very few studies describing the use of cell preparations in the treatment of pathology about the elbow. Only 2 Level IV studies described the use of MSCs for lateral epicondylitis, whereas no reports have been published using MSCs for other elbow pathology.

Singh et al described a series of 30 patients injected with BMAC obtained from the anterior iliac crest; 4 of the patients were lost to follow-up and not included in data analysis. The authors injected approximately 4-5 mL of BMAC at the point of maximal tenderness without additional dry needling, though the system of BMAC was not specified. The authors reported significant improvements in PRTEE scores from baseline (72.8 $\pm$ 6.97) at 2 weeks (40.93 $\pm$ 5.94, $P < .0001$), 6 weeks (24.46 $\pm$ 4.58, $P < .0001$), and 12 weeks (14.86 $\pm$ 3.48, $P < .0001$) postinjection. However, no control group was used, nor did the authors calculate the number of nucleated cells or platelets in the BMAC.[37] The other available relevant study was performed by Lee et al, who examined the safety and efficacy of allogeneic ADSCs mixed with fibrin glue in the treatment of lateral epicondylitis. Twelve patients were included in the study, with 6 receiving 1×10^6 cells and 6 receiving 1×10^7 cells in 1 mL along with thrombin and fibrinogen. The injection was administered into the largest hypoechoic region of the tendon on ultrasonography. No serious adverse events occurred at any time point throughout the study, although 2 patients were reported to have a mild elbow joint effusion at the 2-week time point, which may signify that the joint capsule was violated at the time of injection. However, both patients were asymptomatic, and the effusions subsequently resolved. Both groups demonstrated progressive and significant improvements in VAS pain scores at 6, 12, 26, and 52 weeks as compared to baseline. Although there were no significant differences between the treatment groups, the authors noted a trend toward faster pain relief in the group receiving the 10^7/1 mL dose. The Modified Elbow Performance Index demonstrated statistically significant improvement at 6 weeks that was sustained throughout the study period; however, the scores plateaued at 6 weeks and did not demonstrate further significant improvements. They also noted significantly smaller ultrasound measurements of tendon defects, assessed as hypoechoic regions on ultrasound, 26 and 52 weeks, with no differences between groups.[22] Although these studies support the safety of BMAC and allogeneic ADSCs in the treatment of lateral epicondylitis, the small sample sizes and lack of control groups do not allow for definitive conclusions regarding efficacy or dose-dependent effects.

Conclusion

Biologic augmentation in the treatment of tendinopathy has been an area of increased interest, with the goal of enhancing the healing environment to facilitate recovery. Although there has been significant research regarding the use of PRP for lateral epicondylitis, studies focusing on other areas of elbow pathology are generally lacking. In the highest-level trials, treatment of lateral epicondylitis with PRP_{LR} has improved outcomes in the long term compared to corticosteroid injection. Overall recommendations for the use of biologic treatments for elbow pathology are limited by the heterogeneity of PRP formulations and delivery, as well as patient cohorts,

described in the current literature. Our current treatment recommendations are outlined in Table III. Additional, more rigorously designed trials will allow for more definitive treatment recommendations in the future.

Disclaimer

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