



Research article

Image guided injection therapies in athletes—Do they work and what should we be using?[☆]Justin C. Lee^{a,*}, Na'eem Ahmed^b, Gina M. Allen^c^a Fortius Clinic, London, UK^b Chelsea and Westminster NHS Foundation Trust, London, UK^c St Lukes Radiology Oxford Ltd and University of Oxford, UK

ARTICLE INFO

Keywords:

Athlete
Injury
Imaging
PRP
Prolotherapy
Hyaluronic acid

ABSTRACT

In the modern management of the injured elite athlete, the goals of guided injection therapies have extended beyond simple reduction of pain to enhancement of tissue healing and accelerated return to competition, faster than natural healing can allow. This article will review the injection therapies which are frequently used in elite sports injury management and describe other less commonly used injection therapies that are available to the treating clinician and athlete. The evidence base, where available, for each treatment option will be summarised.

1. Introduction

In both elite professional and elite amateur sport, the clinicians involved in injury management are under increasing pressure to return the athlete to the playing environment as quickly as possible. Depending on the contractual arrangements, the financial implications of loss of playing time may be significant for the player, the organisation that he represents, or both. The success or otherwise of the team may be particularly dependent on the presence or absence of certain “key” players. The manager, or head coach may lose his employment status if his “star man” is out for a long period. A delayed or slow return to play, or injury recurrence during the rehabilitation phase results in loss of confidence in the player and the medical team. The athlete may be under personal pressure to achieve a specific goal such as Olympic qualification. Further external influences may arise from the player's agent or sponsor, the club directors or owners. With all of these pressures facing the sports clinician in charge of an injured athlete, it is almost inevitable that various interventions will be sought to get the athlete back to fitness and return to play (RTP) as quickly as possible. It can be very challenging for the player and his team to adopt an entirely “do nothing” approach to his injury.

The radiologist's role in the management of these athletes has evolved from simple diagnostic imaging, to image guided interventions, to prognostication of injury return to play (RTP) times [1–4].

Although the highest level of sports organisations will employ at least one full time sports medicine physician who will make the

decision on which injection therapy is best for their athlete, it is not uncommon that a radiologist with specialist sport experience will be the main decision maker on which injection is best for the athlete in his care. Although athletic injury can affect any member of the population, the management of the elite athlete provides a relatively unique experience for the radiologist who will have to face the pressures normally applied to the sports medicine doctor as above. This article will review the indications and evidence base for the various interventions that a radiologist is likely to consider in the management of the injured elite athlete. Overall athletic-related injury can be sub-divided into muscular, ligamentous and intra-articular types, or a combination of these. This article will cover the image guided interventions available to treat injuries at these locations.

2. Intramuscular injections

Injuries to muscle are the single most common cause of loss of playing time in English soccer [5]. Over a two season period, 6030 injuries were recorded by 91 clubs in the football league equating to 1.3 injuries per player per season. Of these injuries, 37% were muscle strain injury which was the largest injury group. Ligament sprains comprised 19%. 87% of the injuries occurred in the lower limb and 58% were non-contact, which is perhaps understandable given the nature of that particular sport. Similar to elite athletes in other sports, the re-injury rate was 7% and in these athletes the severity of the re-injury was greater than the original injury. Of interest, injuries in competition

[☆] This paper did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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were more common than training ground injuries (63% vs 37%) and the majority of injuries occurred towards the later stages of the first and second halves of the matches. Illustrating the role of overall player fitness in injury risk, training injuries incidence peaked in July (pre-season), whilst competition injuries peaked in August (first month of season).

Over the last several years, there has been an increase in interest in the role of imaging in muscle injury assessment and percutaneous management. The original descriptions of muscle injury on MRI discussed the location and incidence patterns and attempted to correlate these with return to play times. However, the study numbers were usually low and subsequent larger studies have become more detailed in the prognostic factors that may influence decision to inject or not. The early work by Peetrons, who described a three-point grading system on ultrasound forms the basis of subsequent MRI grading systems in use today [6]. A modification of that system was used by this author and his colleagues in assessing the largest number of hamstring injuries to date via the UEFA Elite Club Injury Surveillance Hamstring Study which concluded that most injuries were either grade 0 or grade 1 (63%) and that in grade 3 injuries return to play time was three times that of grade 1 and 2 injuries [1,2]. With the advent of high field strength MRI units and other developments in improved imaging techniques of muscle, the British Athletics Muscle Injury Classification (BAMIC) system was subsequently developed to highlight the role of the intramuscular tendon in injury assessment, prognosis and management. Validation studies of the BAMIC system have shown that significant injury to the intramuscular tendon has a significant impact on return to full training times and to re-injury rates [3,4]. Although other classification systems are available, they are not in common use in the UK (Munich Consensus system, Barcelona system and Chan system) but are used today by some organisations and radiologists should be aware of them in case their referring organisation wishes them to include it in their reporting [7–9]. Although published data is not available currently, most clinicians are more likely to refer their athletes for injection therapy if there is involvement or disruption of the intramuscular tendon (BAMIC grade “c” injury).

Controversy still exists as to the optimum management pathway of these injuries and the role of injection therapies remains debated. Amongst the therapies available to the treating clinician, there are two which are in common use in the UK: platelet rich plasma (PRP) and Actovegin/Traumeel™ injections.

2.1. Evacuation of a liquefying haematoma

Aspiration of a liquifying haematoma has been advocated to draw the muscle fibres together. There is little evidence that this is effective, as there are no controlled trials and some concerns regarding infection as blood is a good culture medium for bacteria, so a strict aseptic technique using ultrasound guidance is advocated [10].

2.2. Platelet rich plasma (PRP) for muscle injury

Platelet rich plasma injections for acute eccentrically loaded muscle injury are commonly performed in elite sports medicine practice (Fig. 1). Compared to autologous blood, PRP contains increased concentrations of growth factors such as platelet-derived growth factor, epidermal growth factor, insulin-like growth factor, transforming growth factor β -I, vascular endothelial growth factor, hepatocyte growth factor, and basic fibroblast growth factor. These growth factors help modulate the healing of tissue through enhancement of anabolism, cell proliferation, angiogenesis, inflammation control, cell differentiation, and coagulation [11]. Platelet rich plasma (PRP), autologous conditioned serum (ACS) or plasma rich in growth factors (PRGF) have been shown to enhance muscle repair in animal models in vitro.

In a study of 20 professional athletes who underwent ultrasound guided PRP injection into the injured muscle following haematoma

evacuation, PRGF was shown to reduce swelling and pain with function being restored as early as half the expected recovered time [12]. Sonographic correlation demonstrated fully regenerated muscles tissue and no evidence of fibrosis or re-injury on recommencing exercise [12]. In vivo, local delivery of platelet-rich plasma has been demonstrated in rat models to reduce recovery time after a muscle strain injury [13].

A study by Wright-Carpenter et al compared recovery time and MR imaging correlation in professional athletes with muscle strain (Fig. 2). They found a significant reduction in recovery time in the group receiving autologous conditioned serum versus the control group that received Actovegin/Traumeel injections of 16 days versus 22 days respectively [14].

Rossi et al published a level 1 double blind randomised control trial (DB-RCT) in 2017 comparing two groups of injured hamstring athletes treated by single PRP injection with rehabilitation programme versus rehabilitation programme alone [15]. The study demonstrated a significant reduction in time to return to play (TTRTP) in the PRP group. Although apparently marginal, the reduction of 4 days (from 25 to 21) would allow that athlete to return to competition one game before the control group assuming a two-match per week demand. In a smaller study, Hamid et al published a level 2 RCT in 28 patients which showed a TTRTP of 26.7 days in the PRP group with a TTRTP of 42.5 days.

Conversely, Hamilton et al performed a DB-RCT of 90 athletes comparing no injection, PRP and PPP (platelet poor plasma) who all underwent intensive physiotherapy programmes and found no statistical difference in RTP times between the groups [16]. Similarly, Reurink et al performed a DB-RCT in 80 athletes and found no benefit of PRP injection over placebo injection in TTRTP in hamstring injured patients [17].

2.3. Traumeel S/Actovegin

Traumeel S is a homeopathic preparation that is used to treat muscle injuries [18]. Its mechanism of action is poorly understood but is thought to work on inhibiting inflammatory mediators and promote the release of anti-inflammatory cytokines [18]. Traumeel S has been shown to be similar in effectiveness to non-steroidal anti-inflammatory drugs in reducing inflammation, enhancing recovery and improving mobility [19]. Actovegin is injected intramuscularly and created from calf blood products [20]. A study of use of Actovegin in sports players found that it helped players recover 8 days faster from muscle injury versus physiotherapy [20]. The bovine spongiform encephalopathy (BSE) outbreak in the early 2000s led to much reduced use of Actovegin in the UK and now most practitioners will now only inject Traumeel S.

Traumeel S injections are commonly performed by experts in Germany in which it is common practice amongst sports medicine doctors. These injections are usually performed without image guidance. The protocol varies but the technique most commonly used involves a combined injection of Traumeel/Actovegin at the injury site and in a vertical line above and below the injury within the same muscle. The corresponding area of the lumbar spine to which the myome refers is then injected in the central and paravertebral position with the Traumeel/Actovegin combination. The process is repeated at day 2 and 4 after the initial injections. There are no published trials on its use compared to placebo.

3. Tendinous and peritendinous injections

The management of acute tendon injuries in the elite athlete, whether partial or full-thickness, rarely involves the use of an ultrasound guided intervention. In such cases, the only treatment options that would be considered are those involving proliferative / regenerative therapies such as PRP or prolotherapy (Fig. 3). Most acute tendon injuries in athletes are managed conservatively with rehabilitation or surgery if indicated.

Chronic tendinopathies and paratendinopathies are common in elite

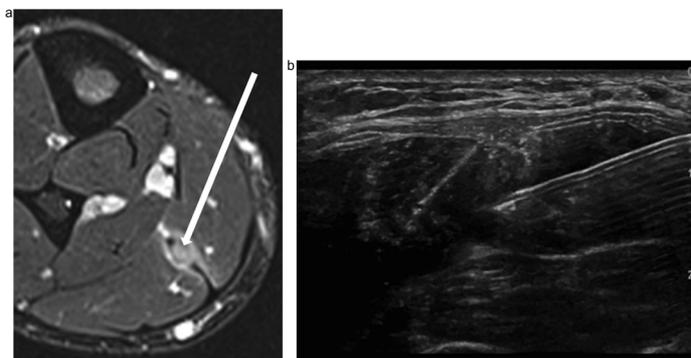


Fig. 1. 28-year old male soccer player with calf pain undergoing platelet rich plasma (PRP) intramuscular injection. (a) Axial STIR MRI image showing tear of the central intramuscular tendon of soleus (arrow). (b) Transverse sonogram showing 23 gauge needle with tip located in intra-muscular tendon of soleus at injury site.

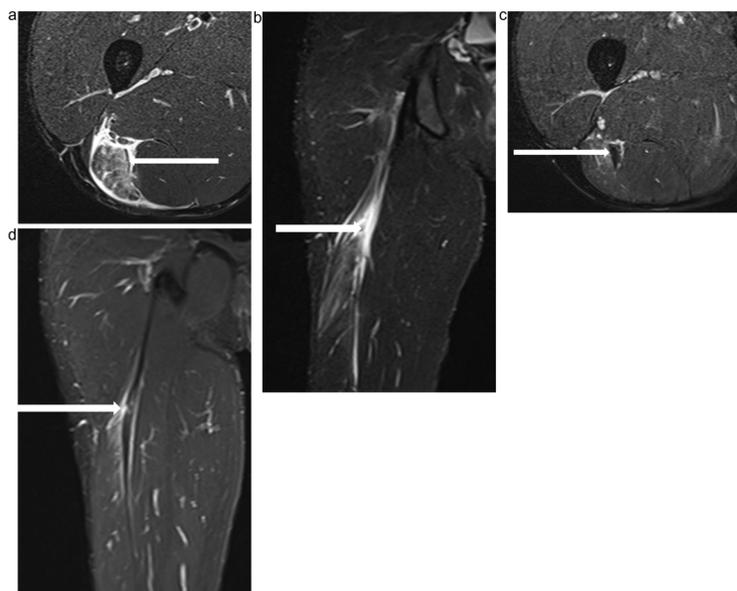


Fig. 2. 24-year old male soccer player with acute hamstring injury (arrow on each image). Axial (a) and coronal (b) STIR MRI demonstrating high grade injury to the proximal right biceps femoris muscle involving the intramuscular tendon. Follow up axial (c) and coronal (d) STIR MRI at 4 weeks following single dose PRP injection demonstrating reconstitution of the intramuscular tendon and marked reduction in intramuscular oedema.

athletes comprising 5–10% of all athlete related injuries [5]. These injuries often present great challenges to the medical team as they are hard to treat and the athletes often have protracted symptoms. Similarly to muscle, there remains controversy as to the optimal treatment for these conditions in elite athletes and the population in general.

The main percutaneous treatments available for the management of tendinopathies include injections of corticosteroids, platelet rich plasma, hyaluronic acid, high volume injections and prolotherapy. Outside of the UK, there is an increasing interest in the use of ultrasound-guided galvanic electrolysis technique (USGET), mesenchymal stem cell (MSC) therapy and percutaneous tendon “shaving” for patellar

tendinopathy. Of these, the USGET has become popular with some athletes and clinicians, particularly in Spain. All three, and other innovative techniques, are currently in development worldwide but currently lack clinical trial evidence.

3.1. Corticosteroid injection for tendinopathy

Although, steroid injections for tendinopathy have traditionally been the initial treatment of choice in athletes and non-athletes alike, their use in tendon disease management has significantly decreased over the last decade. This is a reflection of the growing evidence base

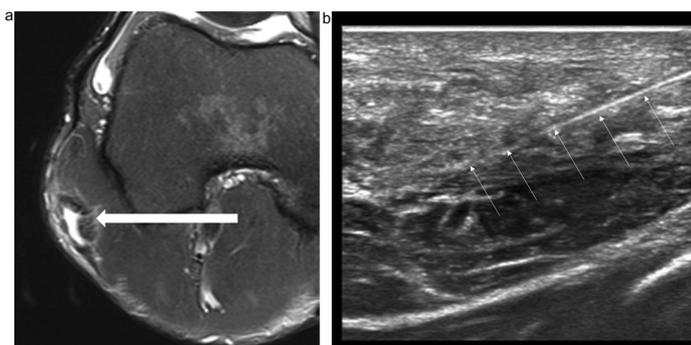


Fig. 3. 31-year old male rugby player 2 weeks post distal biceps tendon injury. (a) Axial STIR MRI showing injury to the distal biceps femoris tendon with intra-substance delamination (arrow). (b) Axial sonogram showing 21 gauge needle insertion for PRP injection into tendon (small arrows).

that their effects are often temporary and may be detrimental to tendon integrity and strength.

The mechanism of action of corticosteroids as an anti-inflammatory is complex; they work on nuclear steroid receptors and affect the inflammatory and immune cascade. This reduces vascular permeability and inhibits the build-up of inflammatory cells and disrupts other processes such as the secretion of prostaglandin and leukotrienes [21].

In a systematic review by van Ark et al in 2011, six different treatments for patellar tendinopathy were reviewed including steroid injections, PRP, sclerotherapy, aprotinin, dry needling and autologous blood and high volume injections [22]. Steroid injection studies had the best evidence in terms of study quality and it was suggested that the early stages of tendinopathy may be appropriately treated with steroid injections. However, the effects were shown to be short term with high relapse rate and there was a risk of tendon rupture [22].

Pain and dysfunction in the overhead throwing athlete has a number of causes, including the rotator cuff. In rotator cuff tendinopathy, some authors suggest that early intervention with a sub-acromial corticosteroid injection, followed by 2–4 days of rest can help (Fig. 4) [23]. However, a more recent study concluded that steroid injection did not reduce pain levels in adult patients with rotator cuff tendinosis more than a placebo injection at the 3-month assessment and described its effect as transient [24]. In the management of tennis elbow (lateral epicondylitis), several RCTs demonstrate that cortisone injections in the short-term improve outcomes against control for the first six weeks but in the longer-term cause harm when compared against controls [25].

Plantar fasciitis (PF) is estimated as being between 3.6 and 7% in general population of runners and it accounts for 8% of the sports associated injuries [26]. PF can be a very debilitating condition for the professional athlete leading to very protracted RTP times (Fig. 5). A Cochrane Review concluded that low quality evidence exists for the efficacy of local steroid injections in PF compared with placebo or no treatment and it may reduce pain for no longer than one month [27]. The other problem with corticosteroids are the side effects including fat atrophy of the heel pad and skin overlying these injections. This can lead to more long term problems in the running athlete when the plantar fasciitis has subsided.

3.2. Dry needling

Is an effective therapy in the treatment of plantar fasciitis, lateral epicondylitis and insertional tendinosis. Some advocate it in patellar and mid-substance Achilles tendinosis. It causes bleeding within the structure that promotes the influx of growth factors leading to an inflammatory response and the repair. It is often the used in conjunction with PRP and therefore the literature is flawed as some articles do not discriminate between the 2 treatments. It is also called peppering, fenestration and percutaneous tenotomy in the literature. It is also used to treat enthesopathy by peppering the bony cortex. This however is a



Fig. 4. 34 year old female tennis player with shoulder impingement. Longitudinal sonogram showing 25 gauge needle in subacromial bursa for corticosteroid-local anaesthetic injection.

rather painful procedure [28].

3.3. High volume injections (HiVI)

Chan and team pioneered the use of high volume injections (HiVI) in the management of Achilles and patellar tendinopathy in the mid to late 2000s (Fig. 6) [29]. Their described technique involved an ultrasound guided deep surface paratenon strip using 10 ml bupivacaine, 25 mg hydrocortisone and up to 40 ml normal saline. The proposed mechanism of action in HiVI is the disruption of abnormal vascular ingrowth with subsequent denervation of the accompanying painful nerve, and/or adhesiolysis of fibrous tissue between the Achilles tendon, paratenon, crural fascia and possibly adjacent plantaris. Irrespective of the mechanism, the treatment was shown to successfully reduce pain scores in 70% of patients. The treatment response was often rapid compared to other tendinopathy treatments and as a result, its use rapidly became widespread in the elite athlete group. Many practitioners remove the steroid component of the injection to avoid the risks described above and anecdotally still get good results. Studies are currently ongoing in Copenhagen to determine the need for the steroid component in HiVI treatments.

3.4. Prolotherapy for tendinopathy

Proliferation therapy (prolotherapy) involves the injection of irritant substances such as hyperosmolar dextrose or sodium morrhuate [30]. Small aliquots are injected directly into the tendinopathy. The mechanism of action is thought to involve the hyperosmolar glucose hyperpolarising nerves by opening potassium channels reducing pain transmission [30]. The hypertonic solutions can cause an inflammatory response and stimulate healing of tissues through inflammatory mediators including ILGF, EGF, PDGF, TGF-beta, CTGF [16]. Other proposed mechanism include disruption of sodium and calcium cation pathways which can reduce neuropathic pain [30]. In vivo data demonstrates that exogenous dextrose injections increase ligament and tendon size, extracellular matrix and fibroblast proliferation.

Maxwell et al performed prolotherapy on 33 patients with chronic non-insertional Achilles tendinopathy with reduced pain scores at rest and activity in over 80% patient at 6 months and 61% pain free at 12 months [31]. Hauser et al performed a systematic review of the use of prolotherapy in musculoskeletal pain which included 17 studies on prolotherapy for tendinopathy and concluded that there was low level evidence that prolotherapy can be an effective component of tendinopathy treatment (Fig. 7) [32].

3.5. Platelet rich plasma for tendinopathy

Similarly to acute muscle injury management, controversy exists in the role of PRP injections in acute and chronic tendon injury management. The lack of standardisation of the technique and the type of PRP used contributes to the mixed evidence base regarding the efficacy of this treatment. There are no published studies on PRP injections in an acute tendon tear in the elite athlete. Nevertheless, it is often felt that is little to be lost from including the treatment in the management of such injuries if they do not require surgical repair (Fig. 8).

In chronic cases, there is again mixed evidence for its use but Fitzpatrick et al performed a meta-analysis on PRP use for tendinopathy of the Achilles, rotator cuff, patellar tendon and common extensor origin of the forearm, and concluded that PRP was an effective treatment for tendinopathy on the basis of 5 out of 6 positive systematic reviews [33]. He also concluded that those PRP systems that included the “buffy layer” in their preparation had better outcomes. The “buffy layer” includes platelets in the leukocyte rich zone (LR-PRP). Conversely, Filardo et al, showed benefit following PRP injections in patellar tendinopathy and tennis elbow but not for Achilles or rotator cuff tendinopathy [34].

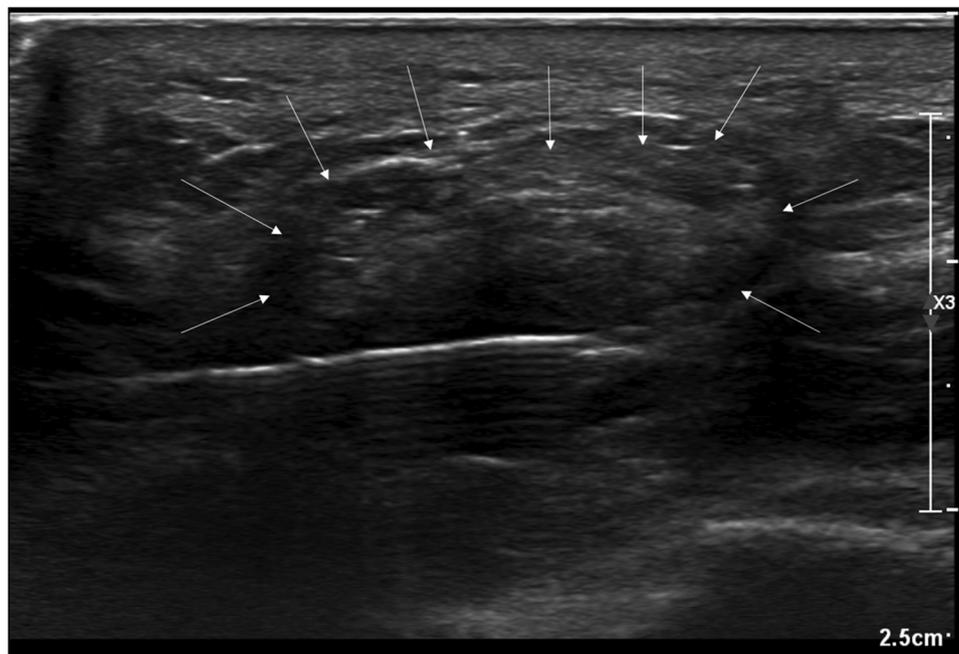


Fig. 5. 32-year old male soccer player with plantar fasciitis. Transverse sonogram showing 23 gauge needle placed on deep surface of plantar fascia (outlined by arrows) immediately prior to corticosteroid-local anaesthetic injection.

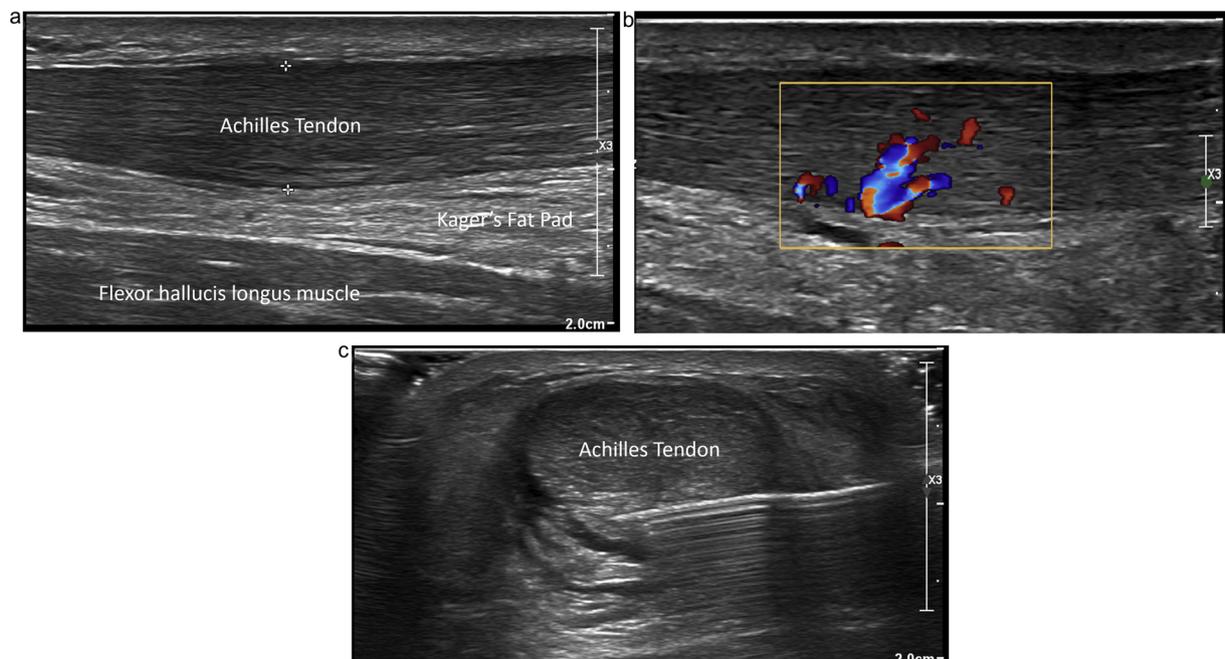


Fig. 6. 33-year old male marathon runner with mid-Achilles pain. (a) Longitudinal B-mode sonogram demonstrating fusiform expansion of the Achilles tendon consistent with non-insertional tendinopathy. (b) Longitudinal Doppler sonogram demonstrating branching neovascularisation. (c) Transverse sonogram demonstrating 21 gauge needle tip position on ventral surface of Achilles tendon during high volume injection (HiVI).

3.6. Ultrasound guided galvanic electrolysis technique (USGET)

Ultrasound-guided Galvanic Electrolysis Technique (USGET) has recently gained popularity in the treatment of recalcitrant tendinopathies. Published data is available for its use in the treatment of adductor, patellar and subacromial pain syndrome with favourable outcomes seen when measured against other conservative treatments [35–37].

USGET uses a non-thermal electrochemical ablation technique to the clinical focus of tendon degeneration. The treatment produces a dissociation of water, salts and amino acids in the extracellular matrix

around the needle, producing a localized inflammation in the region dealt with [35]. There is initiation of an inflammatory response and inhibition of IL-1, TNF and COX-2 which is responsible for tendon degeneration [35].

3.7. Peritendinous sodium hyaluronic acid injections

There has been a recent increase in use of peritendinous sodium hyaluronic acid injections in the treatment of tendinopathy. The treatment is popular with the athlete population as it is a low risk technique compared to corticosteroid, can be effective and is not

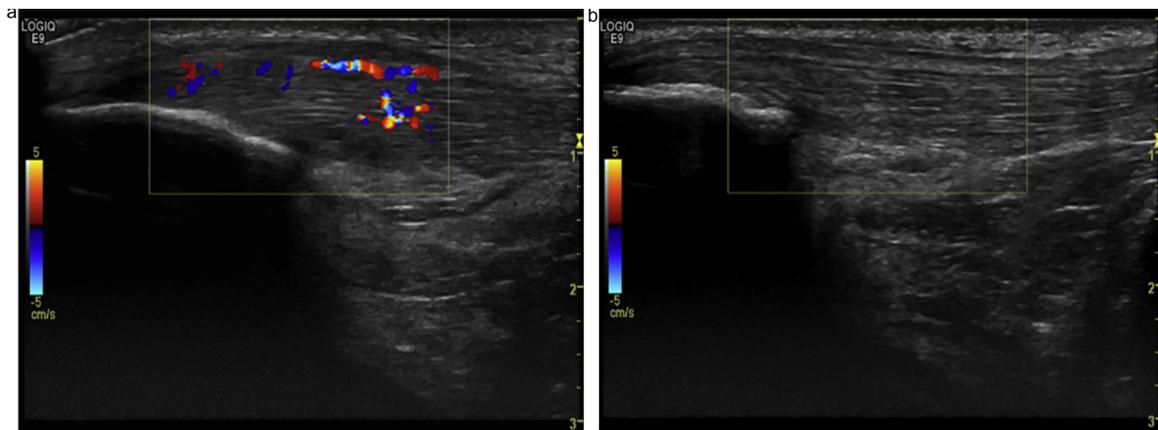


Fig. 7. 34-year old female basketball player with anterior knee pain. Longitudinal sonogram images of the patellar tendon (a) before and (b) 4 weeks after undergoing 3 courses of prolotherapy using 25% glucose injections in to the tendon. Initial image demonstrates tendon thickening and neovascularisation. Subsequent image demonstrates normal tendon morphology and obliteration of neovessels.

restricted by WADA. Hyaluronic acid (HA) is a high-molecular weight visco-elastic polysaccharide found in the extracellular matrix of connective tissues and synovial fluid. It is known to have analgesic, anti-inflammatory, and lubricant properties and has been shown to be efficacious in the treatment of tendon disorders. A recent DB-RCT comparing two-HA injections one week apart versus standard extra-corporeal shock wave therapy (ESWT) in the treatment of chronic non-insertional Achilles tendinopathy demonstrated significant improved outcome scores in the HA group [38].

4. Intraarticular injection

Physical activity puts stress on the joints leading to microtrauma and degeneration of the articular cartilage. The onset of articular cartilage damage correlates with the frequency, intensity and duration of physical activity [39]. Osteochondral injuries are common in athletes. A multitude of surgical techniques exist but are clearly very invasive and frequently require a significant period of non-weight-bearing post-surgery which has implications for post-surgical rehabilitation and

strength. Subsequently, there has been a surge in interest in alternative therapies to avoid the need for surgery, of which PRP and HA are the main treatments of choice.

Chronic chondral lesions are very common in elite athletes, particularly in the more senior players [40]. Short term symptom control may be desired at certain points during the season and this can be achieved with corticosteroid injection. In elite athletes, who are consistently taking part in high impact sports and training, there is greater risk of developing osteoarthritis (OA) [39]. A systematic review of the prevalence of OA in former elite athletes found that the prevalence of OA especially in their lower limbs was high amongst former elite athletes and was higher than when compared to the general population and other occupational groups [41].

4.1. Corticosteroid injections for cartilage damage

Corticosteroid injections lead to decrease in erythema, swelling and tenderness within inflamed joints and increases the viscosity by elevating the hyaluronic acid concentration (Fig. 9) [42]. Intra-articular

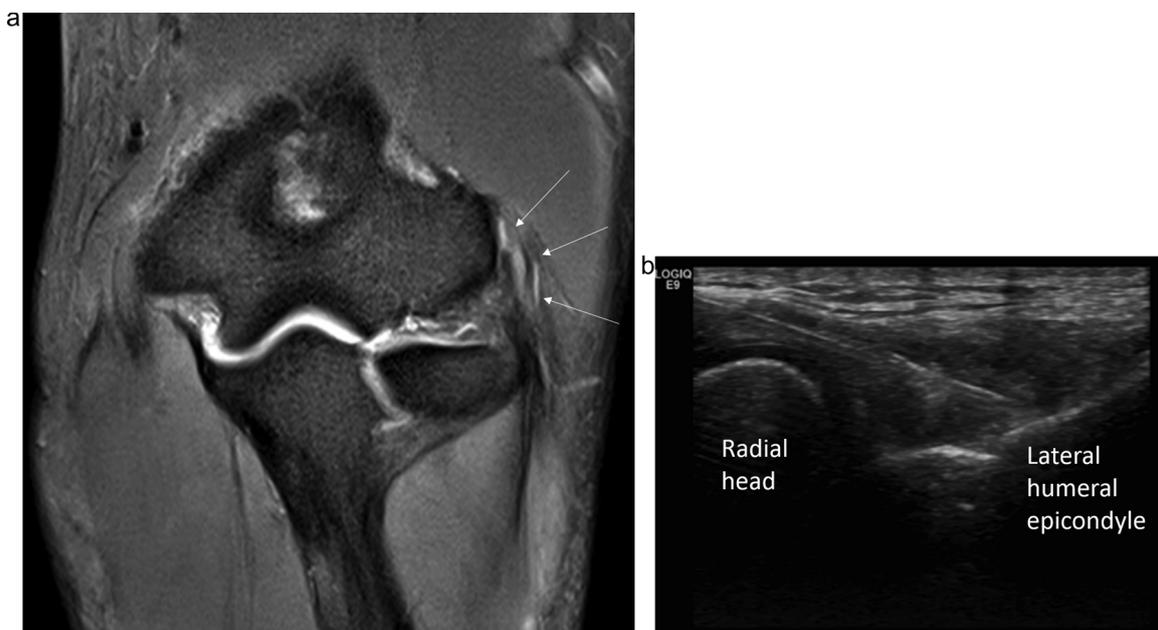


Fig. 8. 28-year old male golfer with lateral elbow pain. (a) Coronal fat-saturated proton density weighted MRI of the elbow demonstrating inflammation, expansion and delamination of the common extensor origin consistent with tennis elbow. (b) Longitudinal sonogram showing 25 gauge needle in common extensor tendon during PRP injection procedure.

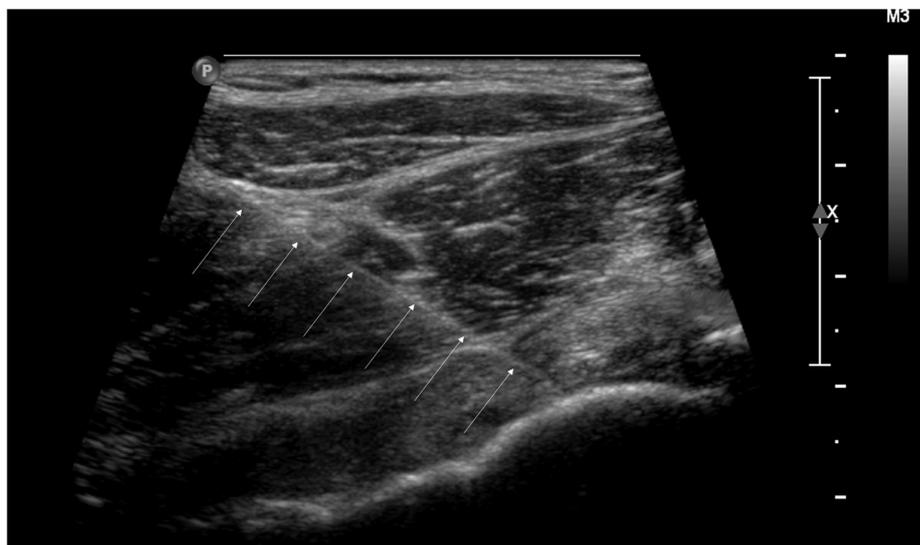


Fig. 9. 33-year old male soccer player with right hip pain. Longitudinal sonogram showing injection technique for joint injection. 22 gauge “spinal” needle in situ with tip at the femoral head 2 cm inferior to the acetabulum (arrows). Patient received a corticosteroid-local anaesthetic injection via the 22-gauge needle.

corticosteroid for OA treatment has been shown to be more effective than intra-articular placebo for pain reduction at one week [43]. After one month, there is a reported difference of 13% in terms of improvement in pain in people that have undergone intra-articular injection of corticosteroid versus placebo and 10% of people reported an improvement in function [44]. A comparison of intra-articular corticosteroids showed that triamcinolone hexacetonide was more efficacious than betamethasone with patients reporting pain reduction up to four weeks post injection [43]. Despite the apprehension of using corticosteroid, specifically amongst sports people, and due to evidence that there is a longer term deleterious effect on cartilage [45], a randomised, double blind trial, in which subjects were given intra-articular injections of triamcinolone acetone 40 mg versus saline every 3 months for up to 2 years found no difference in loss of joint space over time and steroid injected knees showed symptom improvement at 1 year [46]. What is perhaps more worrying is the use of local anaesthetic into the joint at the same time as the steroid. There is good evidence that some anaesthetics such as lidocaine should be avoided due to chondrolysis [47]. Their use may be limited by restrictions given by the World Anti-Doping Agency (WADA) [48].

4.2. Hyaluronic acid (HA) for cartilage damage

Viscosupplementation with hyaluronic acid replaces lost HA in the arthritic joint and also can be a stimulant for HA production which has been shown to provide improvement in symptoms and biomechanical function [49]. The mechanism of action is not well understood and may be secondary to a number of causes including protective effects on the cartilage, anti-inflammatory, mechanical and analgesic effects [50].

In athletes, intra-articular injection of HA for symptomatic treatment of osteochondral lesions has been shown to improve function and reduce pain [51]. Meta-analyses have confirmed the efficacy of HA in knee osteoarthritis [52]. A comparison of the use of intra-articular HA versus corticosteroid found that in the initial stages of treatment, up to week 4, intraarticular corticosteroids appear to be more effective for pain relief than HA. At week 4 they are similar in effectiveness and beyond week 8, HA has been shown to have a greater efficacy [53]. In ankle osteoarthritis, HA has been shown to significantly reduce pain when compared to conservative therapy [54]. The optimal injection volume per dose and multiplicity of injections must be achieved for maximal therapeutic benefit [54]. Unfortunately this is not always straightforward at the outset of injection therapy.

A systematic review of ten studies demonstrated a significant improvement in pain, function and increased range of movement both in the short and longer term [55]. The results of the review also demonstrate better patient satisfaction [55].

4.3. Platelet rich plasma (PRP) for cartilage damage

PRP has been shown to be an effective therapy in both osteoarthritis and osteochondral lesions of the knee and ankle [56,57]. Purported mechanisms of action include inhibition of metalloproteinases which degrade collagen, in addition to preventing the breakdown of cartilage aggrecan. PRP also improves the quality of synovial fluid by inducing the endogenous secretion of HA by synovial cells [58]. As a result, PRP exerts an anti-inflammatory action, augmenting the flow of synovial fluid and normalizing its synthesis, inhibiting the degradation of endogenous HA, and relieving joint pain. A meta-analyses assessing the efficacy of intra-articular PRP in treating knee osteoarthritis found that when compared with HA and saline, intra-articular PRP has added benefit in relief of pain and improved function with symptomatic knee OA at 1 year post-injection [59]. Smaller RCT showed benefit of PRP over HA injection in the treatment of osteochondral lesions of the talar dome (OLT) [56].

5. Ligament injections

Ligamentous injuries are common in all sports and ankle ligament injury is the most common sports-related injury of all. Most ligament injuries involve the lower limb but elbow, wrist and shoulder injuries are common in overhead throwing athletes such as in baseball and javelin. Assuming surgical intervention is not necessary, percutaneous injections may be performed early in the recovery phase to enhance healing or in the late phase to control pain. Late phase pain control is achieved by corticosteroid injection as described for intra-articular injections above.

5.1. Platelet rich plasma injections for ligament injury

Published data has shown PRP injections can be successfully used to augment healing in partial tears of the ulnar collateral ligament of the elbow in professional baseball players [60,61]. Whilst full thickness tears of the UCL in the elite athlete are optimally treated with surgery, the partial tears can be managed non-operatively. Many sports have

extrapolated from this data and many athletes are treated with PRP in the early phase post injury (typically day 10–14). Laver et al performed an RCT assessing the role of PRP in the treatment of isolated anterior syndesmosis ligament tear in 16 elite athletes and determined that the addition of a PRP injection to the rehabilitation protocol resulted in a significant reduction in the RTP time from 59.6 to 40.8 days and significant reduction in residual pain from 62.5 to 12.5% [62]. Similar positive outcomes were seen following PRP injections in syndesmosis injury in professional rugby players [63].

5.2. Prolotherapy for ligament injury

Similar to tendon injury management, ligament injuries can be treated with prolotherapy to induce fibroblastic activity and increase ligament strength at the enthesis. In the elite athlete group, prolotherapy injections are frequently used for injuries to the ankle collateral ligaments, the syndesmosis, collateral ligament injuries at the knee and groin injuries involving the pubic ligaments and capsule (Fig. 10). Strong evidence base is lacking but case reports, short series and review articles are available in the literature [64,65].

6. Which therapies to choose for your athlete

Trying to speed up the recovery phase is always difficult.

Physiotherapy, osteopathy or chiropractic may be all that is needed to achieve this and these were key health professionals working at the London Olympics 2012.

The use of steroid is prohibited by World Anti-Doping Authority (WADA) and therefore if you are going to use this in your athlete make sure that they have a Temporary Use Exemption (TUE) so they are not banned from their sport.

The rehabilitation programme should also be considered post injection, so that if the injection is near a weight bearing tendon then load is avoided for 3 weeks when the effects of reduced collagen repair due to the steroid is at its peak. [66] All injections should be performed at a convenient time in the athletes schedule and with the support of the physiotherapist and coach who will be guiding the athlete.

Steroid next to weight bearing tendons is ill advised unless a surgical boot is worn to protect the tendon during this time, such as the tibialis posterior or peroneal tendons. Steroid used next to Achilles tendon is to be avoided and is quoted in the “British National Formulary” of drugs as unacceptable treatment. A careful consent process will be required as litigation may result if the patient has a rupture following your injection.

Our favoured regime for Achilles tendinosis if eccentric or isometric loading has failed is Saline stripping without using a high volume without steroid using a maximum of 25 ml of fluid (saline and bupivacaine). If this is not effective then PRP has a place.

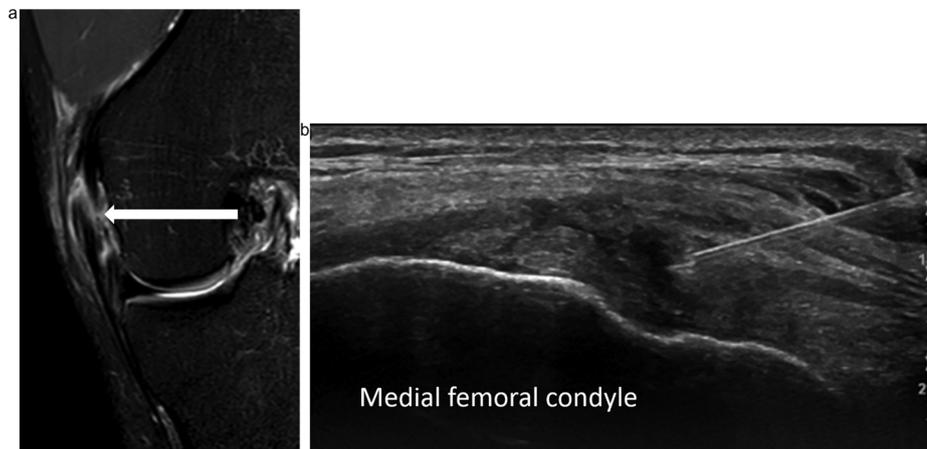


Fig. 10. 28-year old soccer player 4 weeks post injury to the medial collateral ligament. (a) Coronal STIR MRI demonstrating a tear through the superficial and deep band fibres of the medial collateral ligament. (b) Longitudinal sonogram demonstrating 23-gauge needle within the medial collateral ligament at the injury site. The ligament was injected with 3 ml of 25% glucose (1.5 ml 50% glucose in 1.5 ml 1% lidocaine).

Dry needling may be effective in the treatment of insertional tendinosis.

HA is useful in tendons that have tendon sheaths. If not contained it can lead to pain around the site of injection for 48 h. In the Achilles tendon it is not a useful drug for this reason.

HA does not seem to be effective in the subdeltoid subacromial bursal injections for bursitis or supraspinatus tendinosis [67].

In joints steroids are useful as a quick pain relief especially if there is synovitis as seen on ultrasound. HA and PRP have more lasting benefit and in our experience, HA has a good effect in joint related pain and is less difficult undertake than PRP. In some patients it does bring instant relief of pain like steroid but in others it may take a longer time to act.

It is important at the outset to have a plan of injection therapy and rehabilitation so that you know what the next step will be if your injection does not give benefit. Usually it is another percutaneous therapy that is needed but the radiologist must be mindful of the role of surgery as a part of the algorithm.

Whatever drug you decide to use, make sure you consent your athlete appropriately and record this with the procedure and drugs used. Also make sure your medical indemnity insurance covers you to perform injections on elite athletes in case things do not go to plan!

7. Conclusion

Image-guided interventions are becoming increasingly used in the management of injuries in elite athletes. The requirement for rapid return to play, and the desire to avoid surgery, provides the impetus for effective guided interventions. Radiologists and sports physicians are now able to offer a range of image guided techniques and the principles and evidence base for their use will allow them to make the best choice for the athlete.

Acute muscle injury is the most common cause of loss of playing time in elite sport and most of the work in the last few years has concentrated on how we, as clinicians, may accelerate the healing process in this condition. Similarly, acute ligament injuries have also been subject to similar scrutiny. Both of these conditions have led to an explosion in the use of platelet rich plasma injections in elite sport, despite conflicting evidence base in the literature. Prolotherapy has far less evidence base than other treatments used in this group but despite this, is becoming an increasingly popular treatment choice in elite athletes.

The use of both intra-articular and more recently, extra-articular sodium hyaluronic acid injections has also significantly increased in the last 5 years. Their role in the treatment of tendinopathy in particular has seen a large increase in their use in the elite athlete population.

Despite the potential negative effects following corticosteroid injections, these are still regularly performed to provide rapid symptom control at key points in the athlete's season. Careful and selective use of

steroid injections can allow the athlete to return to the high levels of performance quickly.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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