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INTERVENTIONAL MSK PROCEDURES SPECIAL FEATURE: REVIEW ARTICLE

Image-guided elbow interventions: a literature review of interventional treatment options

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ABSTRACT

Over the years, a wide range of image-guided interventional therapies have been used in treating different elbow pathologies, many of which are predominantly based on anecdotal and low-level study findings. This article critically assesses the existing literature and discusses the efficacy of the most commonly utilized interventional procedures for elbow pathology.

INTRODUCTION

The elbow joint is a non-weight bearing hypermobile joint, which is prone to a variety of pathological processes that include epicondylitis (insertional tendinopathy), bursitis, arthritis, neuropathic entrapment, and traumatic ligamentous and tendon injury. Patients present with varying degrees of pain and motion restriction. A plethora of different injection therapies are utilized by medical practitioners for managing these conditions. It has become a common practice to perform these procedures under image guidance, particularly ultrasound. Although there are numerous publications in the literature regarding musculoskeletal interventional therapy, large robust randomized controlled studies are generally lacking. This article critically assesses the current literature for the most commonly utilized interventions in treating elbow pathology.

Epicondylitis

Epicondylitis of the elbow is a condition, which is caused by repetitive motion at elbow and forearm over a prolonged period of time.¹ There is a higher prevalence in certain occupations and athletic activities. Smoking and obesity are also recognized risk factors.² The term “epicondylitis” is widely used by clinicians and in the medical literature. It implies an inflammatory process, but histological studies have shown that it is predominantly a non-inflammatory degenerative condition.^{3,4} The term insertional “tendinosis” or “tendinopathy” is more accurate.⁵ Microtears due to recurrent trauma in hypovascular areas of the tendon and failure of the normal tendon repair

process with angiofibroblastic degeneration of the tendons are the main contributing factors for the pathophysiology of this condition.^{5–7} Epicondylitis can be subdivided depending on the anatomical location as follows.

Lateral elbow tendinopathy (lateral epicondylitis)

This is commonly referred to as tennis elbow. Usually, patients present with chronic lateral elbow pain which is exacerbated by supination or wrist extension with focal lateral epicondyle tenderness on clinical examination. It is estimated that about 10–50% of people who play tennis regularly will develop this condition during their life time.⁷ It also affects up to 1.3–3.0% of the general population.^{2,8} Individuals in the 40–50 years age group are at the highest risk, regardless of their sex and ethnicity.^{2,7,9}

Tendinosis usually affects the extensor carpi radialis brevis tendon, which typically arises slightly superomedial to the lateral edge of the capitellum, making the undersurface vulnerable to contact and abrasion against the outer edge of the capitellum during elbow motion.^{7,10} The extensor digitorum communis and extensor carpi radialis longus tendons are less commonly involved.

Medial elbow tendinopathy (medial epicondylitis)

Medial epicondylitis (Golfer’s elbow) is caused by repetitive wrist flexion and pronation with valgus strain at the elbow joint. It is less common than lateral epicondylitis,

with a prevalence of 0.4% in a population sample of people aged 30–64 years.² In 30% of patients, there is a history of acute injury, with insidious onset in the remaining 70%.

The diagnosis of insertional tendinopathy is usually clinical. Most patients respond to conservative management with a combination of rest, ice, bracing, eccentric exercise programmes and non-steroidal anti-inflammatory drugs (NSAIDs). Imaging may be used to confirm the diagnosis and to exclude other pathological processes in recalcitrant cases.

Ultrasound examination is often used as the imaging modality of choice not only to assess the status of the tendons but also to guide injection therapy. The sonographic appearances of insertional tendinopathy are focal tendon thickening with loss of fibrillar architecture and low reflective change. Microtears are manifest as areas of focal deficiency of the tendon. In addition, there may be associated neovascularity on Doppler imaging and enthesopathic changes, with bone formation, arising from lateral epicondyle.

Injection therapies that have been used most commonly for the treatment of epicondylitis include corticosteroid, tendon fenestration (dry needling) which may be supplemented with autologous blood injection and platelet-rich plasma (PRP), prolotherapy and sclerotherapy.

Corticosteroid injection Corticosteroid injection is still widely used as first-line therapy, particularly in primary care. This practice is largely supported by anecdotal evidence rather than strong scientific evidence.

Whilst the short-term efficacy is well described, the use of corticosteroid injection for long-term management of patients with tendinosis is of questionable benefit.^{11–13} A systematic review of 13 randomized controlled trials showed that intra-tendinous corticosteroid injection was superior to placebo, local anaesthetic and conservative management for pain relief and improved grip strength at short-term follow-up (<6 weeks). However, no statistically significant differences were seen at medium-term (6 weeks–6 months) or long-term (>6 months) follow-up.¹² Similarly, in another recent systemic review and meta-analysis of 10 randomized controlled trials, glucocorticoid injection beyond 8 weeks was found no more effective than a placebo.¹⁴

It could be argued that steroid could be used as one-off therapy to reduce elbow pain in the short term to facilitate physiotherapy. However, repeated use is not recommended due to lack of supportive evidence for medium- to long-term efficacy and the concomitant risk of steroid flare, skin discolouration and subcutaneous fatty atrophy.^{15,16}

Tendon fenestration Percutaneous ultrasound-guided tendon fenestration, also termed dry needling or tenotomy, is also used for treating chronic tendinopathy. This is a technique that involves repetitive needle puncturing of the area of focally thickened tendon. This is thought to initiate tendon healing by breaking down the chronic degenerative changes within the tendinopathic area.

Limited peer-reviewed studies^{15,16} are available to date which show that image-guided tendon fenestration can improve patient symptoms. However, dry needling is often performed in combination with other percutaneous therapies such as autologous whole blood, prolotherapy and PRP injections, making it difficult to be certain about the effectiveness of this procedure as a therapy used in isolation.

Autologous blood injection Autologous blood injection is used as an adjunct to tendon fenestration. It is hypothesized that autologous blood injection triggers an inflammatory response in the degenerative areas of the tendons, as blood is rich in growth factors such as fibroblast and transforming growth factors. These growth factors produce granulation tissue at the site of injection which subsequently organize and increase overall tendon resistance.¹⁷

In a study of refractory lateral epicondylitis, 35 patients (female 12, male 23, mean age 40.9 years) underwent sonographic assessment prior to treatment with ultrasound-guided dry needling and autologous blood injection. The Nirschl and visual analogue scores (VAS) were taken pre-procedure and post-procedure, at 4 weeks and 6 months. Significant pain relief was recorded at 4-week and 6-month follow-up with the median pre-procedure Nirschl score reduced from 6 to 4 at 4 weeks and 0 at 6 months. Similarly, the median VAS was also reduced from 9 pre-procedure to 6 at 4 weeks and 0 at 6 months. In addition, ultrasound abnormalities, including fluid clefts, hyporeflexive change and tendon thickening were reduced at 6 months' follow-up.¹⁸

In another case series of 28 patients, who failed other conservative therapy, 9 patients received >1 autologous blood injection (2–3 injection procedures) and had a 79% improvement on their pain scores over a period of 9.5 months.¹⁹

A systematic review of 3 randomized controlled trials with a total 96 patients concluded the superior effect of autologous blood injection to placebo with a standard median deviation of -1.43 , confidence interval -2.15 to -0.71 and $p = 0.001$.¹⁴ However, it is not possible to determine from these studies whether the symptomatic response is primarily due to the dry needling, autologous blood injection or a combination of both.^{17,20}

Platelet-rich plasma PRP is a preparation autologous blood of high platelet concentration, typically five times or higher than the normal platelet concentration in whole blood.²¹ Various platelet concentration levels and composition can be obtained by modifying certain factors, such as the time and force of centrifugation. Four types of PRP preparations are widely recognized: leukocyte-poor PRP, leukocyte PRP, pure platelet-rich fibrin clot and leukocyte platelet-rich fibrin clot. These PRP preparations have different biological effects, and currently there are no robust evidence-based guidelines to support the use of any one given PRP preparation.

PRP has been used as an alternative to autologous blood injection. It is thought to trigger the healing process within degenerative

tendons owing to the high concentration of the growth factors and ability to release cytokines which block undesirable catabolic process and enhance repairing mechanism within the tendons.²²

In a cohort study of 20 patients with recalcitrant lateral epicondylitis, patients were given either a single percutaneous injection of PRP (active group, $n = 15$) or bupivacaine (control group, $n = 5$). At 8-week follow-up, the patients treated with PRP noted 60% improvement in their VAS vs 16% improvement in control patients. At 6 months, the patients treated with PRP noted 81% improvement in their VAS.²³

In a randomized double-blinded multicentered trial, patients ($n = 230$) with chronic lateral epicondylitis were treated with dry needling, with and without PRP. No significant differences in VAS pain scores were demonstrated between the two groups at 12 weeks. At 24 weeks, however, clinically significant improvements were found in patients treated with leukocyte-enriched PRP compared with the control group.²⁴

A smaller randomized controlled study ($n = 28$ patients) demonstrated VAS pain score improvement in patients who received PRP injection at 6 weeks in comparison with a group who were injected with autologous blood. However, no statistically significant differences were seen at 3- and 6-month follow-up between the two groups.²⁵

Prolotherapy Prolotherapy is a percutaneous injection of an irritant substance into degenerative areas of tendons (or ligaments) to stimulate a healing process through cellular proliferation and collagen formation.²⁶ Hyperosmolar dextrose and sodium morrhuate are the most two commonly utilized agents. No large Level 1 randomized trials have been undertaken to assess the efficacy in treating tendinopathy. However, several case series studies and small randomized trials have shown promising results.²⁷

In a randomized controlled trial of 20 patients with refractory lateral epicondylitis, the subjects who received hyperosmolar dextrose or sodium morrhuate injections had significantly better pain relief and improved wrist extension strength at 16 weeks compared with those who only received saline injection.²⁸

A systematic review also showed prolotherapy to be more efficacious than placebo in treating lateral epicondylitis.¹⁴ These findings were supported in a recent systemic review²⁹ of three further small pilot-evidenced trials which suggested effectiveness of the prolotherapy in treating chronic lateral epicondylitis. However, these studies are limited by their small size (52 patients in total) and lack of consistent standardized technique and long-term follow-up.

Sclerosing therapy Sclerosing agents such as polidocanol are widely used for treating varices and vascular malformations. These agents have a direct effect on the intima of blood vessels, resulting in thrombosis and vessel occlusion. Sclerotherapy has also been advocated to target neovascularization that is often present in tendinopathy. Although pain frequently correlates with tendon neovascularization on ultrasound, it is likely that pain is secondary to

the associated neural ingrowth within the areas of tendinopathy.³⁰ Thus, sclerotherapy may reduce tendinopathic pain by eliminating nociceptive nerve fibres, which are found adjacent to the neovessels either directly (by destruction) or indirectly (by ischaemia).³¹

In a pilot study³² of 11 patients (13 elbows) with lateral epicondylitis, treated with polidocanol injection, there was a clinical improvement in 11/13 elbows at 8 months. The elbow pain was significantly reduced (mean VAS decreased from 75 to 34; $p < 0.003$), and grip strength was significantly improved (from 29 to 40 kg; $p < 0.025$).

A subsequent small size cross-over randomized controlled trial (30 patients) was performed by the same research group. In this study, Group 1 received image-guided polidocanol injection only, whereas Group 2 received lidocaine plus epinephrine. Subsequently, both groups had polidocanol injection at 3-month follow-up. This study showed no statistically significant differences ($p < 0.05$) in the outcomes between the two groups. In both groups, there was a significantly lower VAS at 3-month and 12-month follow-up, and grip strength was significantly higher at 12 months.³³ Furthermore, a systematic review and network meta-analysis found no benefit of polidocanol compared with placebo.¹⁴

In summary, the different injection therapies that have been assessed for the treatment of chronic epicondylitis have shown varying outcomes. There are a limited number of high-quality unbiased randomized controlled trials on which to assess the efficacy of these therapies. There is some evidence to support the use of intratendinous injection of autologous blood, PRP and prolotherapy, compared with placebo. However, it remains unclear whether there is any real difference in the efficacy between these different procedures. It is also unclear whether tendon fenestration alone is as effective as other therapies.

Sclerotherapy with polidocanol appears to be no more effective than placebo. Intratendinous corticosteroid injection can provide short-term symptomatic relief but is no more effective than placebo at long-term follow-up. Further Level 1 evidence is required to evaluate whether any one technique has significant advantage, particularly in the case of PRP, which is considerably more expensive at present than other procedures.

Elbow arthropathy

Primary osteoarthritis (OA) of the elbow is less common than arthropathy secondary to trauma. Osteonecrosis, crystal disease, rheumatoid and seronegative inflammatory arthritis also occur relatively frequently.³⁴ Pain is typically present throughout the full motion arc in inflammatory and post-traumatic arthrosis. In primary OA, pain is usually present at the extremes of elbow extension and flexion.³⁵ The primary objectives in management of elbow arthropathy are symptomatic relief and functional improvement, by alleviating pain and inflammation.

Analgesics, such as NSAIDs for primary or post-traumatic OA, and disease-modifying antirheumatic drugs for inflammatory arthritis are commonly used as first-line therapy. This may be combined with physiotherapy. Supplementary

intra-articular injection may be considered in patients resistant to medical therapy and in those who are not suitable candidates for arthroplasty. Corticosteroid and hyaluronic acid (HA) are both used, either alone or in combination with local anaesthetic.

There is paucity of data in the literature to demonstrate improved efficacy for any specific corticosteroid type and dose and the frequency of intra-articular injection. A recent systemic review of a limited number of studies suggests some benefit for the use of triamcinolone hexacetonide (TH) over the other corticosteroids such as triamcinolone acetonide (TA), methylprednisolone (MP) and betamethasone in treating knee arthrosis.³⁶

There is no evidence base for the optimal corticosteroid dose and frequency for various pathologies but anecdotally 40–80 mg of Kenalog® (TA) (triamcinolone acetonide; Bristol-Myers Squibb, New York, NY) or Depo-medrone® (MP) (methylprednisolone acetate; Pfizer, New York, NY) is used for treating large joint arthrosis. The number and frequency of injections are also not standardized. One injection per month for 3 months, with a maximum of 4 injections per year for a large joint affected by rheumatoid arthritis (RA) has been recommended.³⁷ In joints affected by OA, usually no more than one injection will be offered every 3 months, and only if no other therapy is effective.³⁸

The inclusion of local anaesthetic in the injectate not only provides instant pain relief, which may be important to differentiate between local and referred pain, but also facilitates intra-articular distribution of the corticosteroid.

Intra-articular therapy with HA has been used for OA in large weight bearing joints, especially the knee, but is now also being utilized in non-weight bearing joints.³⁹ HA is normally present within the intra-articular synovial fluid, which through its viscoelastic property acts as a joint lubricant with some chondroprotective properties. *In vitro* studies, showed protective effects of HA on cartilage, which may be mediated by its molecular and cellular effects. The exogenous HA enhances chondrocyte HA and proteoglycan synthesis, reducing the production and activity of the proinflammatory mediators.⁴⁰ HA is artificially synthesized and is available with different derivatives and concentrations. It is difficult to assess the optimal dose and frequency of injection, and its use remains controversial.

There is limited evidence demonstrating the efficacy in relieving pain in patients with OA of the knee.^{41,42} However, other studies^{43,44} have shown no benefit over placebo in treating OA knee.

One study⁴⁵ assessed patients with post-traumatic OA of the elbow ($n = 18$). Intra-articular sodium hyaluronate was injected into the elbow joint, with each patient who received 3 injections at 4-week intervals. Patients had limited pain relief, with no beneficial effect at 6 months.

Bursitis

Bursae are synovial lined “sacks” situated between musculoskeletal structures, such as tendons and bones, that facilitate ease

of movement or have a cushioning effect. Bursae are prone to inflammation due to overuse, trauma, rheumatoid arthritis, infection and crystal arthropathy. The elbow joint has two major bursae (olecranon and bicipitoradial).

Olecranon bursitis is a common condition, which is usually treated conservatively. Intrabursal glucocorticoid injection can be used in resistant cases but carries a higher risk of skin atrophy than joint injection, owing to the superficial location. Other complications of olecranon bursal cortisone injection include chronic localized tenderness development of draining sinus tracts and secondary infection, particularly in the presence of overlying cellulitis.⁴⁶ A retrospective review compared diagnostic bursal fluid aspiration with 20-mg TH intrabursal injection for olecranon bursitis. The steroid group responded more rapidly, although both groups were symptoms free after 6 months, and more complications were observed in the steroid group. Conservative therapy is therefore recommended for the primary management of olecranon bursitis.⁴⁶ Image-guided bursal fluid aspiration can alleviate pressure symptoms caused by the distended bursa, and aspirated fluid can also be analysed when there is a clinical concern of infection or crystal disorders.

The bicipitoradial bursa is a thin synovial lined sac, which envelops the distal biceps tendon and limits contact with the subjacent radial tuberosity, and allowing free movement of the biceps tendon during supination and pronation of the forearm.⁴⁷ Bicipitoradial bursitis occurs most frequently in association with distal biceps tendinopathy and in patients with rheumatoid arthritis.

There are no well-designed studies available to confirm the efficacy of bursal fluid aspiration and glucocorticoid injection into the inflamed bicipitoradial bursa. However, in a very small patient study ($n = 3$), two patients treated with an intrabursal injection of a 2-ml mixture of 40 mg Kenalog, 0.5% bupivacaine and 1% lidocaine had good clinical outcome.⁴⁸

Entrapment neuropathy

Compressive neuropathy results from the entrapment of a peripheral nerve as it traverses a fibro-osseous or fibromuscular tunnel. It is imperative to diagnose and treat compressive neuropathy promptly, to prevent permanent neural histopathological changes. Diagnosis is typically made by a combination of clinical history, the distribution of the paraesthesia and sensory loss and electrophysiology studies. However, MRI and ultrasound imaging have an increasingly important role and improve diagnostic accuracy by visualising the affected nerve, identifying the underlying aetiology and location of the primary abnormalities.^{49–51}

The commonest type of neural entrapment at elbow is cubital tunnel syndrome (CTS) affecting the ulnar nerve with an incidence of 25 per 100,000 per year. The pronator and supinator syndromes which affect the median and radial nerves, respectively, are much rarer conditions.⁵²

A small pilot study has evaluated eight patients (nine elbows) with clinical symptoms of CTS, who had compatible nerve

conduction studies, or sonographically thickened ulnar nerves. All patients were treated with ultrasound-guided injection of 1 ml containing 40-mg methylprednisolone acetate (Depo-Medrol®; Pfizer) and 10-mg lidocaine hydrochloride delivered in the subcutaneous tissues adjacent to the thickest portion of the affected ulnar nerve. No patients reported a deterioration of the symptoms immediately after the injection. No complications of infection or haematoma at the site of injection were observed. At 3-month follow-up, five patients showed symptomatic improvement. One patient's symptoms had deteriorated and three cases showed no improvement.⁵³

In another small study, 10 patients ($n = 12$ nerves) with CTS were randomly assigned into two groups. Five affected nerves were treated with splinting only while the other seven nerves were treated with splinting and local injection of a mixture of 40-mg triamcinolone and 1 ml lidocaine. Splint application alone provided adequate symptomatic relief with ulnar conduction improvement.

No additional benefit was observed in the steroid group.⁵⁴ Whilst ultrasound-guided cortisone injection for CTS appears to be safe, and its long-term efficacy remains controversial. Further trials are needed to standardize the steroid dose, frequency of injections and confirm the efficacy in the medium and long term. In addition, there are also no well-designed studies in the literature that assess the efficacy of ultrasound-guided steroid injection in other entrapment neuropathy syndromes at the elbow.

Ulnar collateral ligament injuries

The ulnar collateral ligament (UCL) of the elbow consists of three bundles. The anterior bundle is the primary contributor to

medial elbow stability.⁵⁵ UCL injuries are most common in athletes participating in overhead and contact sports, resulting in valgus instability, which can be disabling.

A case series study of 34 athletes with MRI-proven partial thickness UCL tear, who failed to return to play after non-surgical treatment for at least 2 months, were treated with PRP injection. At up to 70-week follow-up, 30 out of 34 athletes had returned the same level of play without any complaints, and the mean time to return to play was 12 weeks. However, there was no control group.⁵⁶

There are case reports in the literature that advocate the use of prolotherapy in the treatment of complete rupture of anterior cruciate ligament and anterior talofibular ligaments and patellar tendon partial tears.^{57,58} At present, there are no studies that assess the use of prolotherapy in treating UCL tears.

CONCLUSION

There are a variety of elbow disorders for which various injection therapies have been advocated in the literature. Agents can be delivered at the desired anatomical landmarks with precision using ultrasound guidance, potentially maximizing the clinical effectiveness, although ultrasound guidance has not yet been proven to provide extra clinical benefit in outcome.

Whilst there are studies supporting the use of image-guided procedures, they are mostly of low evidence level. Robust randomized studies with sufficient sample size are required to assess the efficacy and safety of injection therapies, using validated clinical, biomechanical and radiological parameters.

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