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Case Study: Ultrasound guided glenohumeral joint injection for an individual presenting with frozen shoulder.

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Introduction

This essay explores the use of ultrasound guided injection therapy (USGI) in a 53-year-old male (Mr X) whom presented to a musculoskeletal service with a 10-week history of atraumatic right shoulder pain with reduced range of movement (ROM). Mr X reported worsening resting pain and sleep disturbance. Past medical history included type 2 diabetes mellitus (T2DM) (HbA1C 6.9% 4 months prior). Physical examination demonstrated pain and stiffness into glenohumeral joint (GHJT) abduction, external and internal rotation. X-ray on the day demonstrated no bony abnormality. Findings were consistent with a clinical diagnosis of frozen shoulder (FS) (Rangan, Hanchard and McDaid, 2016). After discussing management options, USGI was agreed upon and a corticosteroid intra-articular (IA) shoulder injection was performed using triamcinolone acenotide (TA).

This essay will aim to discuss the pathophysiology of FS and critically explore the use of IA USGI, TA and its mechanism of action in context of FS. Potential side effects and contraindications will be evaluated, making reference to the ongoing COVID-19 precautions. Additionally, the medico-legal framework of which allied health practitioners practice will be discussed.

Frozen Shoulder

FS is a common condition that causes considerable shoulder pain and disability (Wang and Gong, 2020). Prevalence varies between 2-5% with greater incidence in females and in the 5th decade of life (Lewis, 2015). Key symptoms include; shoulder pain, sleep disturbance and shoulder stiffness (Andronic *et al.*, 2020). Diagnosis is largely clinical with stiffness into external rotation, unremarkable X-ray and exclusion of sinister causes (Rangan *et al.*, 2015); factors consistent with Mr X. FS is recognised as primary idiopathic or secondary due to predisposing factors (intrinsic; extrinsic or systemic) (Georgiannos *et al.*, 2017). Diabetes mellitus is the most prevalent predisposing factor (as observed in Mr X), increasing FS incidence to 28-40% (Roh *et al.*, 2012).

Reeves (1975) proposed FS was self-limiting, following 3 distinct phases of pain, stiffness and eventual resolution. However, evidence suggests up to 50% of patients have ongoing symptoms 7 years after onset (Shaffer, Tibone and Kerlan, 1992) and 41% of patients have persistent symptoms beyond 4 years (Hand *et al.*, 2008). Furthermore, in a systematic review of 7 articles, Wong *et al.* (2017) found no evidence to support either a progression through phases or complete resolution with up to 4 years follow-up. Considering a more recent clinical classification designed to assist decision-making, Mrs X presented with a pain-dominant FS (Lewis, 2015).

The exact aetiology and pathophysiology of FS remains disputed and poorly understood (Challoumas *et al.*, 2020). Histological studies have identified significant increases in inflammatory markers including mast cells, lymphocytes and macrophages (Hand *et al.*, 2007). High numbers of fibroblasts and myofibroblasts have also been identified confirming a fibrotic process (Bunker *et al.*, 2000). Elevated levels of inflammatory cytokines are thought to modulate the fibrotic cascade and capsular contracture (Le *et al.*, 2017).

Pathoanatomically, magnetic resonance imaging (MRI) studies have identified thickening of the capsule in the rotator interval (RI) and coroacohumeral ligament (CHL) alongside reduced intra-capsular volume (Le *et al.*, 2017). In a systematic review of radiological studies, Ryan *et al*. (2016) confirmed pathological changes in the CHL, axillary recess (AR) and RI. Efforts were made to reduce potential influence of previous tissue exposure by excluding studies that involved invasive treatment. However, the majority of studies had moderate to high risk of bias. The role of ultrasound in assessing and diagnosing FS has not been extensively studied. A recent study of 61 participants by *Do et al.* (2021) measured relationships between ultrasound parameters and clinical features of FS. Of note, CHL, RI and AR in affected shoulders were significantly thicker than unaffected shoulders; with cut off values of 2.2mm for CHL thickness (77% sensitivity and 91.8% specificity) and 4mm for AR thickness (58.62% sensitivity and 100% specificity) yielding optimal diagnostic values. However, confounding factors (e.g. risk factors such as diabetes) were not accounted for in the retrospective design.

<u>Management</u>

Uncertainty exists over the most efficacious treatment(s) for FS (Rangan, Hanchard and McDaid, 2016). A recent large, multicentre randomised control trial (RCT) with long-term follow-up concluded no clinical superiority between manipulation under anaesthetic, capsular release and early structured physiotherapy (Rangan *et al.*, 2020). Interestingly, all three groups were offered a corticosteroid injection (CSI), highlighting its current acceptance in FS management. Meta-analysis of non-surgical treatment has indicated that IA CSI yielded

statistical and clinical superiority for FS in the short-term compared to placebo, physiotherapy and no treatment (Challoumas *et al.*, 2020).

The drug selected for Mr X was TA (40mg/ml); a synthetic glucocorticoid that can be administered IA containing anti-inflammatory and immunomodulation characteristics (eMC, 2021). A lipophilic structure allows it to readily diffuse across cell membranes and bind to cytoplasmic glucocorticoid receptors (Macfarlane, Seibel and Zhou, 2020). Dissociating usually bound proteins allows transportation to the nucleus and binding to DNA, directly regulating gene expression (Cushman *et al.*, 2018). Inhibitory effects are observed across multiple cell pathways including pro-inflammatory cytokine production and on phospholipase A2, preventing prostaglandin and collagen synthesis (Pekarek et al., 2011). Within synovial joints, there is a reduction in accumulating monocytes, lymphocytes and fibroblast activity, reduced synovial perfusion and vascular permeability (Cushman *et al.*, 2018). TA is metabolised predominantly in the liver and excreted via the kidneys (eMC, 2021).

Different glucocorticoids are used for CSI across clinical practice (Shah *et al.*, 2019). Low aqueous solubility of TA and methylprednisolone acetate (MA) make them both favourable for IA injections as the duration and effect within the joint is prolonged (Sakeni and Al-Nimer, 2007). In a prospective study of 210 patients, Goswami and Gogoi (2015) concluded both were effective in reducing pain at 6-week follow-up but TA was statistically more effective for more severe symptoms and diabetics; factors consistent with Mr X. However, convenience sampling and poorly documented randomisation impact external validity. Injections of hyaluronic acid or platelet-rich plasma for FS are not supported by current literature, as they do not provide statistically significant improvements compared to physiotherapy (Hsieh *et al.*, 2012) or IA CSI (Lim *et al.*, 2014; Park *et al.*, 2014).

The dose selected of TA via injection is largely clinician led (Cushman *et al.*, 2018). A TA dose of 40mg was used with Mr X, justified clinically by his pain intensity, body structure and long-term effective T2DM control. Yoon *et al.* (2013) used a triple blinded RCT to compare 40mg TA with 10mg lidocaine (high-dose), 20mg TA with 10mg lidocaine (low-dose) and 50mg lidocaine (placebo). Both interventional groups demonstrated statistically significant improvements in pain, ROM and function (shoulder pain and disability index, SPADI) over placebo. However, no statistical difference was observed between high and low-dose interventional groups. These findings are echoed in a more recent double blind prospective study (Kim *et al.*, 2017) and bring the dosage used for Mr X into question. However, whilst statistical significance was not achieved, greater reductions in pain (and improvements in function) were observed within the high-dose groups. These improvements could have

represented a minimal important difference which carries greater meaning, largely for the suffering patient (Johnston *et al.*, 2015).

IA Injections

A common site of CSI administration in FS is IA (Chen, Jiang and Huang, 2019). However, sub-acromial (SA) injection has also been proposed with research suggesting equivalent improvements in pain at 6 and 12 weeks follow-up when compared to IA (Oh *et al.*, 2011). Clinical inference is limited through lack of placebo, no blinding or long-term follow up. The primary goal for Mr X was pain reduction, a finding consistent with qualitative research (Jones *et al.*, 2013). In a recent systematic review of seven RCTs (421 participants) with meta-analysis, Chen, Jiang and Huang (2019) concluded that IA was associated with statistically significant improvements in pain compared to SA. These findings supported by two previous meta-analysis of IA CSI on FS (Sun *et al.*, 2017; Wang *et al.*, 2017); strengthening the decision made for IA to reduce pain, increase ROM and improve functional performance.

It is debated whether the accuracy of needle placement influences the effectiveness. Previous investigations report that inaccurate injections are less effective at reducing shoulder pain and improving function (Naredo *et al.*, 2004; Sibbitt *et al.*, 2009), including FS (Raeissadat *et al.*, 2017). While a Cochrane review was unable to establish advantage for USGI over landmark guided injection in shoulder pain (Bloom *et al.*, 2012). A recent RCT displayed no difference in pain and functional outcome between USGI versus landmark CSI for FS with accuracy rates of 100% and 71% respectively (Cho *et al.*, 2021). This has been postulated due to a systemic effect of injected corticosteroids (Kvarstein, 2015). Landmark guided CSI can be easily performed without additional cost of image guidance. Nevertheless, the reported accuracy of these landmark based injections approaches varies widely (42%-100%) (Simoni *et al.*, 2017). Tobola *et al.* (2011) prospectively evaluated the accuracy of three landmark-guided GHJT injection approaches: the posterior, supraclavicular, and the anterior approach. Accuracy, regardless of experience of the injection provider, was 46%, 46% and 65% respectively. Furthermore, Sethi, Kingston and Elattrache (2005) noted only 26.8% of unassisted injections intended for the GHJT were successfully IA. Hence, current trials indicating no difference may be biased towards the null due to inaccurate placement of corticosteroid in the GHJT. The few studies that have assessed image-guided corticosteroid injections for FS by ultrasound or fluoroscopy have reported rapid pain reduction and increased ROM (Lee *et al.*, 2009; Lorbach *et al.*, 2010; Song *et al.*, 2014). Lee *et al.* (2009), noted significantly greater ROM and pain improvements in USGI compared to unassisted injection group at 2 weeks using a posterior approach, in an RCT of 43 subjects with stage II FS. However, by week six the results were comparable. Sample size was small and further 5 weekly IA injections of sodium hylauronate

were completed as part of the study, thus limiting transferability in a National Health Service (NHS) setting. Song *et al.* (2014) noted significant pain reduction and function relief in the short-term (2.1 months) that is maintained, and improved at follow up (10.4 months). However, no control arm and again small sample size (67 participants) limits comparability to unassisted injections. Although USGI IA CSI can rapidly improve shoulder outcomes of FS, there is still not general consensus in the literature on the overall effectiveness of these injections in the long term, particularly after 12 weeks.

USGI IA CSI may be preferred, as landmark guided injections have a high incidence of inaccuracy and USGI reduces pain significantly in the short-term. Furthermore, there are additional influences that have resulted in an exponential increase in the use of guided injections in the last decade. These include; 1) a medico-legal record of needle placement (Innes *et al.*, 2015), 2) Improved safety, avoiding neurovascular structures and less needle trauma (Bhatia and Brull, 2013), 3) associated with increased detection of effusion and increased volume of aspirate (Sibbitt *et al.*, 2009), and 4) Influences patient experience by reducing procedural pain, increasing patient involvement in the procedure and improving patient satisfaction (Wheeler, 2010). Collectively, this may result in decreased number of procedures that are required, exposing the patient to less risk as well as improving efficacy of the procedure.

<u>Potential side effects, precautions and contraindications</u>

Diagnostic clarity encompassing a comprehensive medical history is essential before CSI. Known precautions and potential side effects of TA mean the 'benefits, risks, alternatives, and option of doing nothing' should be explored collaboratively with the patient utilising a shared decision making process (Hoffmann, Lewis and Maher, 2020). Known hypersensitivity to TA (and/or local anaesthetic) is a well-defined contraindication because of anaphylaxis risk (eMC, 2021). Other absolute contraindications include systemic or local infection, fracture, unstable liver failure or an unstable joint (eMC, 2021). Having a live vaccine in the last 2 weeks has long been considered a contraindication, however in the current COVID-19 pandemic, CSI is contraindicated if a COVID-19 vaccination (non-live) has been received within the previous 2 weeks (ARMA, 2021). Mr X had had his second vaccine 2 months prior.

Precautions need to be taken with diabetic patients as TA disrupts systemic diabetic control (eMC, 2021). Diabetes' close association with FS means precautionary efforts become even more paramount in this population. A systematic review concluded the majority of studies demonstrated a substantial increase in blood glucose, with peak values reaching 500 mg/dL at 24-72 hours post CSI (Choudhry, Malik and Charalambous, 2016). This can be mitigated

by using a minimally effective dosage of steroid (Habib and Abu-Ahmad, 2007; Younes *et al.*, 2007). As Mr X's DM was well controlled at HbA1C 6.9% (52mmol) USGI IA CSI was deemed and acceptable modality. Elevated blood glucose levels can last up to 3 weeks (Shah *et al.*, 2019). As such, Mr X was advised to monitor blood glucose post CSI, seeking medical advice with any signs of hyperglycaemia (e.g. increased thirst, tiredness, nausea and blurred vision).

The COVID-19 pandemic caused significant changes to MSK injection service provision. A risk stratification system exists locally whereby patients deemed 'high risk' and therefore extremely vulnerable are not considered for CSI. 'Moderate risk' patients are considered on a case-by-case basis and after thoroughly exploring the risks versus benefits. Mr X was deemed 'medium risk' secondary to his diabetes. However, Mr X had a long-term record of well controlled T2DM with evidence of recent HbA1C within accepted levels (HbA1C <10%, <86mmol). Additionally, alongside routine diabetic post injection advice, vigilance with COVID-19 government guidelines was discussed.

Alongside risk of anaphylaxis and altered glycaemic control previously mentioned, other risks include skin depigmentation and fat atrophy although more common with superficial injection sites. The most common side effect following IA CSI is 'steroid flare', a temporary increase in inflammation lasting 2-3 days. Incidence varies from 2-25% (Freire and Bureau, 2016) to 35% specifically at the shoulder (Fawi, Hossain and Matthews, 2017). Risk of steroid-induced arthropathy exists, especially with repeated TA CSI, however criticism surrounds theoretical foundations within animal literature and human prospective study has focussed on weight-bearing joints. Additionally, the detrimental effect of prolonged joint inflammation needs to be weighed against the potential harm of corticosteroid on hyaline cartilage. Risk of infection or joint sepsis poses greatest concern but has low prevalence of 1 in 3000-100,000 (Holland *et al.*, 2012). Adhering to strict aseptic no-touch techniques help minimise risk of infection. Any adverse effects should be documented via yellow card scheme (MHRA, 2021).

<u>Administering CSI as an allied health professional (AHP's)</u>

The landmark Crown Report in 1999 proposed a robust framework enabling healthcare professionals such as physiotherapists to work under 'group protocols' with defined criteria (DoH, 1999). It prompted legislation amendments ensuring health professionals working under approved group protocols acted as such within the law. The Health Service Circular (2000/026) provided additional guidance within England and introduced the new legal term: Patient Group Directions (PGD). Current PGD legislation is included within The Human Medicines Regulations (MHRA, 2012).

A PGD is a written instruction for the supply and/or administration of medicines to patient groups whom may not be individually identifiable (known to service) prior to treatment (MHRA, 2012). The legal framework provided by a PGD allows appropriately registered named clinicians, whom are authorised, to supply and/or administer specific medicine(s) to pre-defined groups of patients and clinical situations (NICE, 2017). A PGD is not a form of prescribing, a distinction that needs to be understood and recognised by all parties involved in the PGD development and maintenance (CSP, 2021). Mixing medicine(s) is not permitted under a PGD, as this would create an unlicensed drug (CSP, 2021). As such, to administer two different drugs (for example Lidocaine 1% and TA 40mg/mL), both would need to be covered by a PGD and administered separately (e.g. two syringe technique). Only the specified drug, at the specified strength for the specified clinical conditions can be administered. For example, the PGD used locally within the musculoskeletal department specifies a strength range for TA of 5mg-40mg. Dosage administered outside of this would not be covered by the PGD and would have medico legal ramifications.

Upon successfully completing injection therapy training that meets CSP requirements, physiotherapists can be named on their local PGD and thus perform subsequent injection therapy under this legal framework (CSP, 2021). However, other forms of medicines use exist. The Crown report (1999) facilitated changes in legislation empowering better use of AHP's diverse skillset. A key component of this was the extension of prescribing responsibilities that enabled professional bodies to apply for the ability to prescribe and individual healthcare clinicians to complete appropriate training to qualify as non-medical prescribers (NICE, 2017). This meant that a physiotherapist for example could work under the legal framework of independent prescribing as a non-medical prescriber.

Patient Specific Directions (PSDs) allow physiotherapists to administer medicines via injection but only with direct written instruction of an appropriate prescriber. This could be a doctor, dentist or recognised non-medical prescriber (CSP, 2021). The PSD only applies to a singular named patient and after the prescriber has assessed the patient individually (NICE, 2017). In the included case study, injection was administered under a PSD utilising an independent non-medical prescriber within the team.

Given the clear legal differences between the various options for prescribing and/or administering medicines, it is paramount that all clinicians understand the governance structure they are working under.

The Procedure

With consideration of the evidence base and Mr X's symptoms and expectations. It was considered appropriate and safe to implement an USGI IA CSI.

After clinical history, physical examination and X-ray were performed. Initial high-resolution ultrasound examination of the shoulder was performed with a LOGIQ e R7 portable ultrasound system (GE Healthcare, Milwaukee, US) using a 12MHz linear array transducer. Standard protocol for scanning shoulder structures to exclude rotator cuff and bursa lesions was performed (Lee *et al.*, 2016).

To administer a posterior approach USGI IA CSI. The Mr X was positioned in side lying onto the contralateral shoulder with the ipsilateral arm resting on a pillow in a modified scarf position. The ultrasound machine was placed in front of the patient on the opposing side of the plinth. This gave a clear and direct line of sight to the needle insertion, patients shoulder, probe position and machine to accurately and safely perform the procedure. Preparation included selection of a green 21G 0.8 X 50mm needle (REF 301155) and drawing up of 40mg of TA (Kenalog®, Bristol-Myers Squibb Pharmaceutical limited, 12/2021, ABV6443) and 4ml 1% lidocaine (Fresenius Kabi®, 07/2023, 18T2967) using a no-touch 1-syringe technique. The injection site was prepared with cholerhexidince and isopropylr alcohol solution with sterile gel and probe cover, as probes and gel can present risk for contamination (Lawrence *et al.*, 2014; Mullins *et al.*, 2020).

The injection was performed using a no-touch transverse axis in-plane approach lateral-medial to target the articular junction between the humeral head and the boney glenoid fossae (figure 1). Initial bolus noted inaccurate trajectory and depth as injectate was distributed into the infraspinatus muscle (figure 2). The needle was repositioned obliquely to the humeral head and injectate gently distributed into the posterior GHJT; the successful injection was indicated by recognition of little resistance to injectate flow and gradual capsular distension (figure 3).

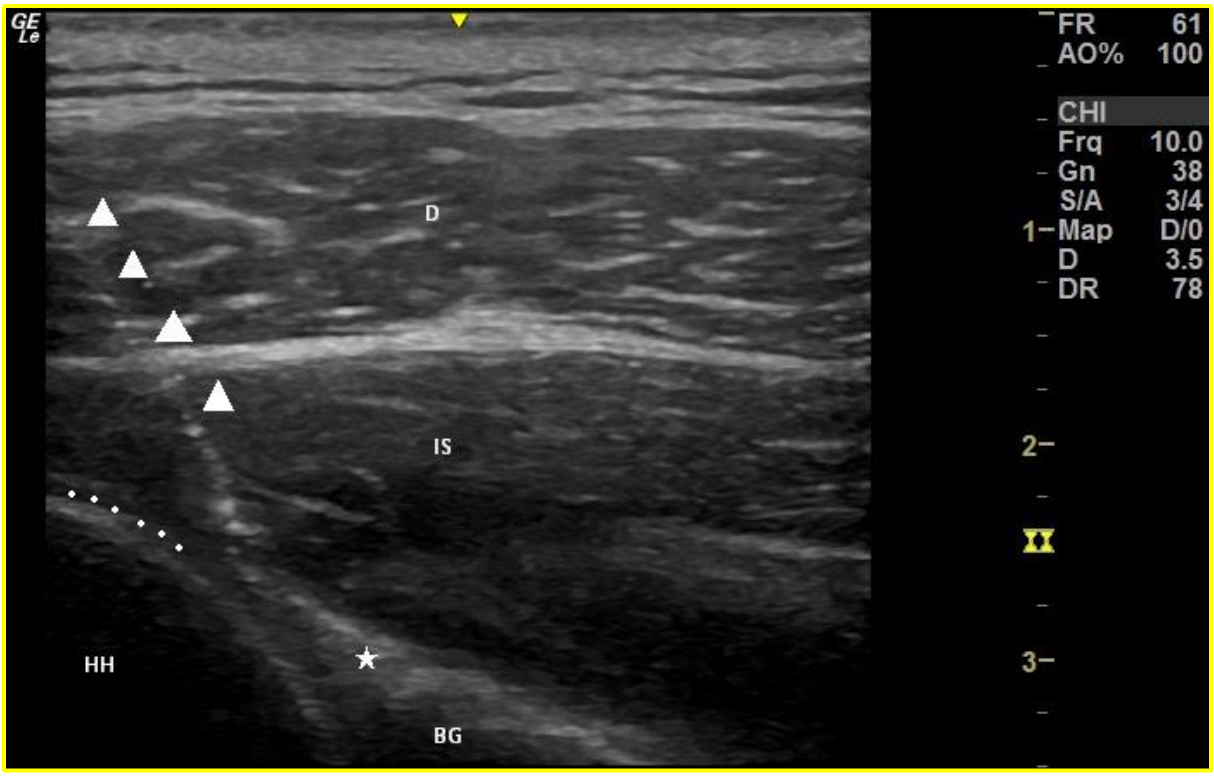

Figure 1: Ultrasound image of the posterior glenohumeral joint with needle visualisation approach from lateral-medial. The boney glenoid and humeral head both appear as hyperechoic structures with anechoic shadow. D, deltoid; IS, infraspinatus muscle; HH, humeral head; BG, boney glenoid; *, glenoid labrum; •, the articular cartilage of the humeral head; ◂, needle visualisation.

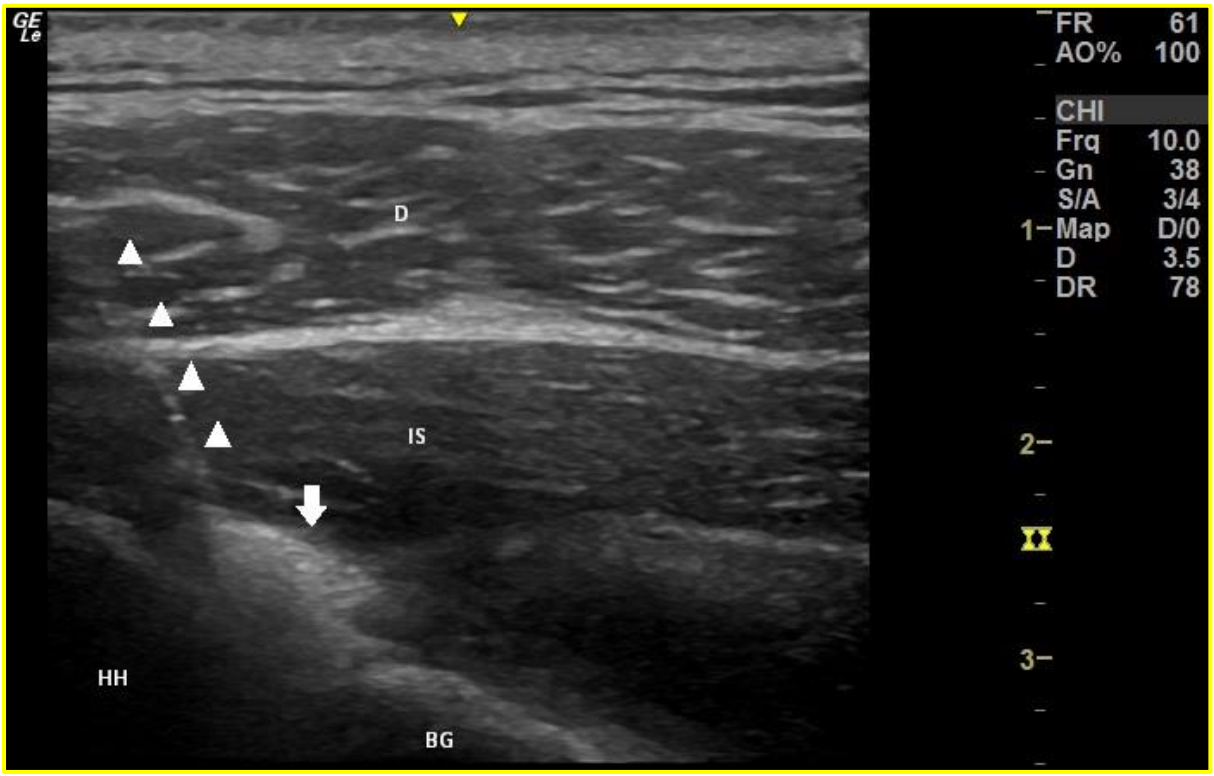

Figure 2: Ultrasound image of the posterior glenohumeral joint with needle visualisation approach from lateral-medial and injectate bolus into the infraspinatus muscle. D, deltoid; IS, infraspinatus muscle; HH, humeral head; BG, boney glenoid; ◄, needle visualisation; ↓, injectate bolus into the infraspinatus muscle.

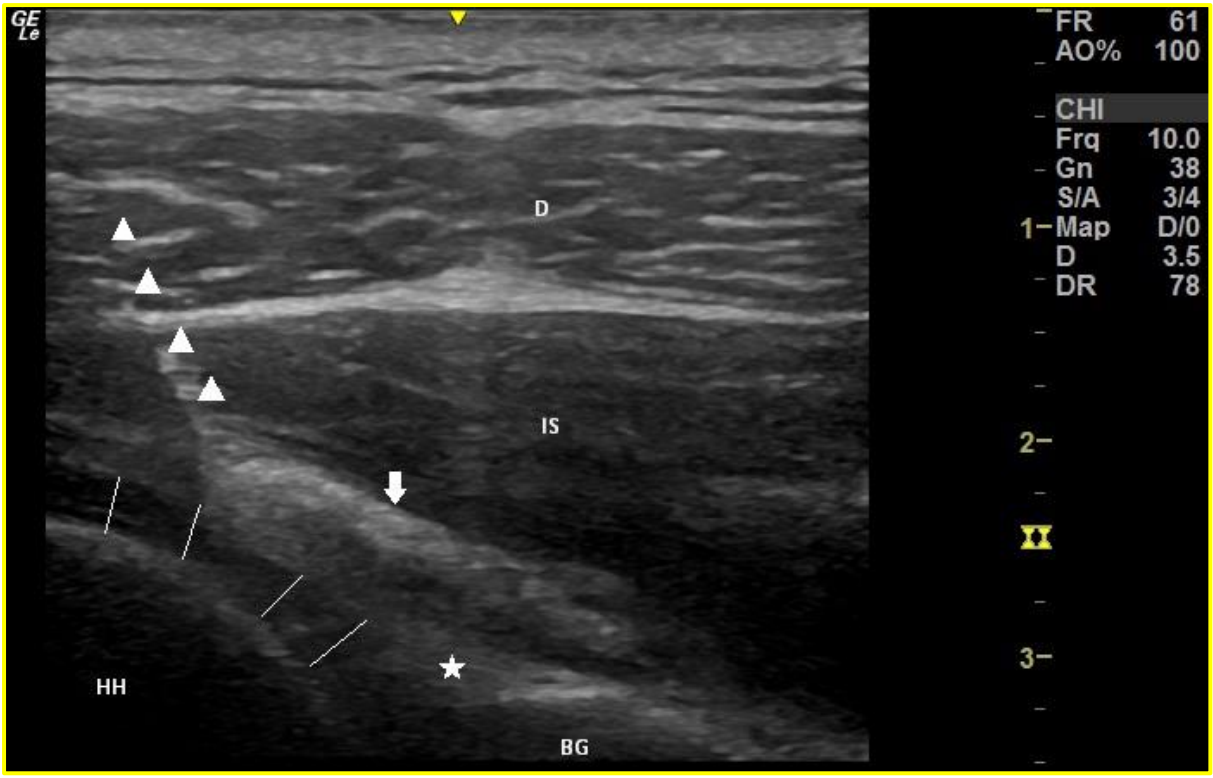

Figure 3: Figure 2: Ultrasound image of the posterior glenohumeral joint with needle visualisation approach from lateral-medial and injectate distending the capsule. D, deltoid; IS, infraspinatus muscle; HH, humeral head; BG, boney glenoid; *, glenoid labrum; ◄, needle visualisation; ↓, previous injectate bolus into the infraspinatus muscle; ⟋, Capsule distension between the humeral cartilage and innermost synovial line of the infraspinatus post injection is demonstrated.

Immediate aftercare included reviewing the area for any local reaction and asking the patient to remain in the waiting room for 20mins to monitor adverse events (McNeil *et al.*, 2016). As the patient was diabetic they were reminded to monitor blood glucose levels over the next 3 weeks as possible spikes in glycaemic control (Shah *et al.*, 2019). Mr X was prescribed a series of physiotherapy exercises and planned telephone follow up appointment for 6 weeks post injection. At follow up Mr X reported marked reduction in pain documented with the Numerical Pain Rating Scale (NRS) of 0-4 vs 3-8 and gradually improving ROM. The NRS is easy to administer, complete and score in a busy clinical setting (Hawker *et al.*, 2011).

Conclusion

In conclusion, FS remains a poorly understood yet prevalent condition that causes marked pain and disability. Contrary to initial thoughts, the effects of FS are observed many years after onset and chronological progression through phases is far from certain. Mr X presented with a pain-dominant FS alongside controlled T2DM and whilst uncertainty exists over the most efficacious treatment for FS, there is sufficient evidence demonstrating the benefits of USGI IA CSI for pain and function in the short-term. The solubility of TA leads to favourable IA injections and evidence supports its use over MA, especially in diabetics.

Reflecting on the technique, the needle was advanced parallel to the long axis of the transducer such that the needle shaft and transducer are collinear (figure 1). The in-plane technique can be performed freehand or with the assistance of a needle guide. Needle guide was available to the clinician and may have enhanced needle visualisation, but not used in this case. The in-plane technique is often preferred during USGI procedures because the needle tip and shaft are visualized throughout the entire procedure. During the in-plane approach, the conspicuity of the needle is primarily dependent on the angle of the needle with the transducer face. A larger angle was utilised (with steeper trajectory), but renders the needle less conspicuous (figure 3). This could have been mitigated by using a heel-toe manoeuvre to bring the transducer face into a more parallel arrangement with the needle. Also an oblique standoff manoeuvre could have been used to increase needle-transducer colinearity and therefore needle conspicuity. USGI technical skills will develop with increased sonography utilisation, nonetheless subjectively and objectively (figure 3) this was a successful outcome.

The benefits observed in Mr X post injection are likely to have resulted from the inhibitory effects on pro-inflammatory cell pathways. Mr X had no contraindications to CSI, and HbA1C was within accepted levels. Explanation of potential side effects were required, with appropriate actions, especially altered glycaemic control and in context of COVID-19. Different legal frameworks exist for the administration of medicines with PGD being more commonly employed within physiotherapy, as opposed to the PSD used in this case. Thus, understanding the framework from which you work is paramount for safe and legal clinical practice.

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