Case3 Ultrasound Radial Tunnel Syndrome Lisa Ho Cuiying

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A 43-year-old female was seen in the Orthopaedic Upper limb clinic for follow-up of her left lateral elbow pain. She had been under follow-up by the Orthopaedic department for a 2-year duration of left elbow pain which is worse on wrist or finger dorsiflexion. The pain has hindered her job and daily activities of living; she had to stop work as a housekeeper and needed assistance to shower. She was previously diagnosed as left tennis elbow, for which she had an unguided steroid and lignocaine injection around the common extensor origin at the lateral epicondyle. However, her pain still persisted, requiring daily NSAIDs and opioids despite the injection and physiotherapy hence she was referred to the upper limb orthopaedic surgeon for consideration of surgical treatment options. She works as a housekeeping supervisor with no other medical problems of note and is left hand dominant.

On examination, she had full range of motion of her left elbow. There was tenderness over the radial tunnel 3-4cm distal to lateral epicondyle. There was no tenderness at the lateral epicondyle. The pain was reproduced on resisted finger and wrist extension, supination and passive pronation with the elbow flexed. There was no 1st dorsal webspace numbness and no weakness to resisted wrist extension.

The impression was radial tunnel syndrome (RTS). She was given a Muenster splint and referred for an MRI left elbow. MRI Left elbow confirmed diagnosis; showing left common extensor origin tendinosis with entrapment of the deep branch of the radial nerve at the arcade of Frosche with swelling of the nerve (see image 1). There were no abberent muscles or bursa.

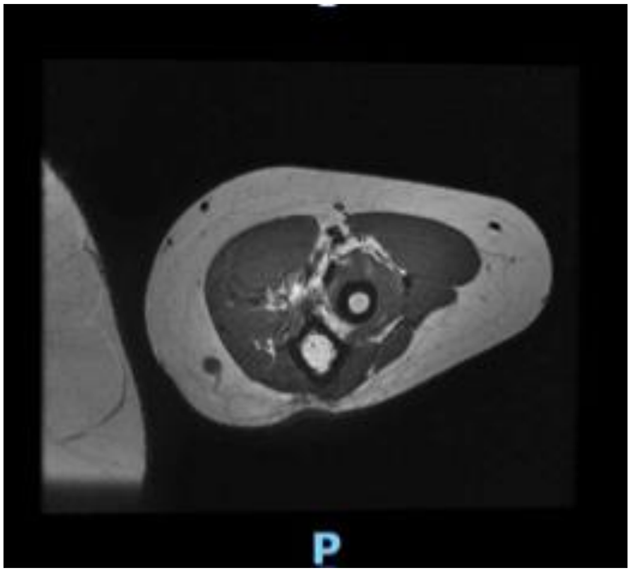

Image 1: MRI left elbow showing entrapment of radial nerve at arcade of Frosche

She had a trial of conservative management first with rehabilitation with the occupational therapist and was referred to the Radiology department for an ultrasound-guided injection of the posterior interosseous nerve (PIN).

Ultrasound findings

A GE Logiq E9 machine with a high frequency linear array transducer(6-15MHz) was used to perform the scan. She was positioned with her elbow extended and left forearm in supination. Preliminary ultrasound was performed to confirm pathology and localize the injection site to avoid the superficial radial nerve and radial recurrent artery and veins. The hypoechoeic left PIN was localised in the proximal forearm just distal to the elbow joint between the left brachioradialis and supinator muscles at the arcade of Forsche (See Image 2).

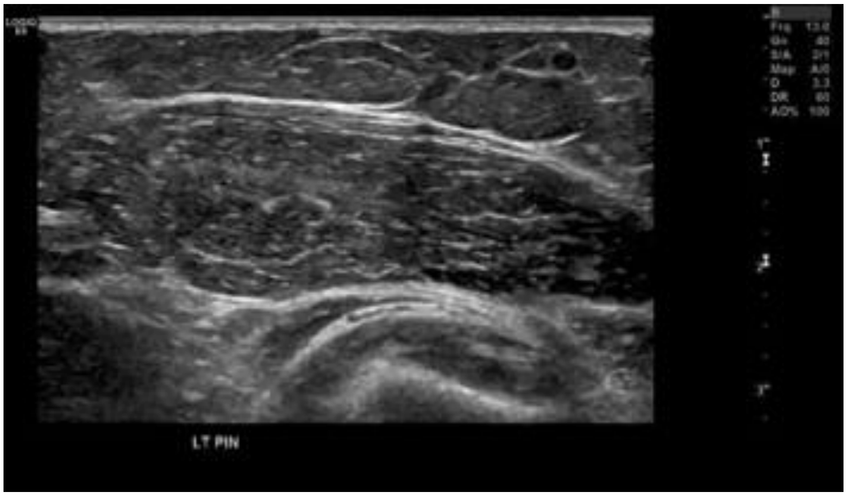

Image 2: Left PIN located between 2 heads of supinator muscle and inferior to brachioradialis muscle.

The skin was cleaned and draped. A 21G needle was advanced with a lateral to medial approach to the brachioradialis fascia but superficial to the left PIN. Perineural injection was done with 20mg triamcinolone and 2ml of 1% lignocaine superficial to the nerve (See image 3). Deep injection to the nerve was not performed due to patient discomfort.

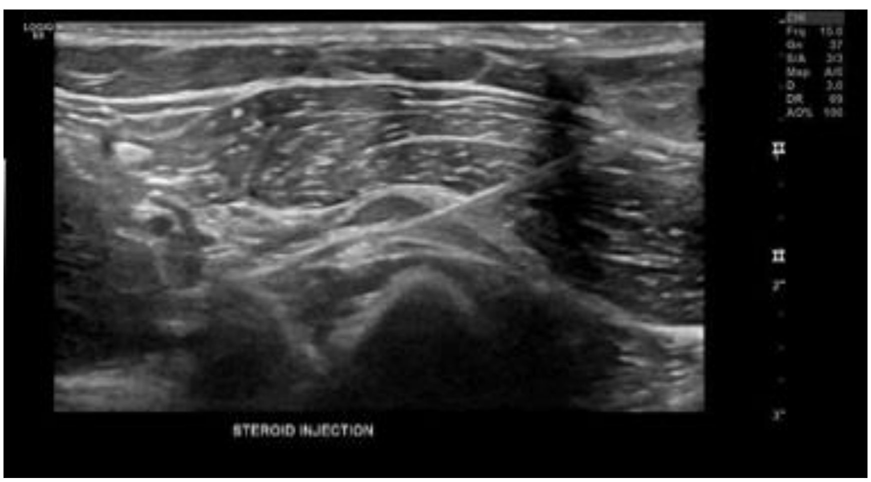

Image 3: Ultrasound-guided perineural injection of the left PIN.

The patient had 50% reduction in pain for 24 hours but subsequently recurred. She was referred to the pain clinic and given Gabapentin, lignocaine patches and oral steroids, however this did not abate her pain and affected her sleep.

On the next follow-up visit, she was counselled for left elbow radial tunnel decompression surgery. The success rate was estimated to be 50-70%, the main surgical risks were nerve injury, weakness of supinator, failure to relieve symptoms and recurrence of pain. Intraoperatively, there was inflammation noted around the arcade of Frohse, the supinator and arcade was dissected to expose the PIN distally and proximally. Triamcinolone was irrigated around nerve before closure. She was given a wrist cock-up splint post-operatively and told to avoid heavy lifting, and forceful pronation/supination. She reported improved symptoms 2 months post-operatively.

Approach to lateral elbow pain

Lateral elbow pain is a common presentation in clinic. The most common cause is lateral epicondylitis, which occurs in 1-3% of the population (Kane *et al*., 2014). Other possible differentials include nerve compression neuropathies (RTS and posterior interosseous nerve (PIN) syndrome), bony lesions (osteochondritis dissecans of the capitellum, radiocapitellar arthritis or ligamentous injury resulting in posterolateral rotatory instability of the elbow (Connell *et al*., 2001).

A careful history is paramount to getting an accurate diagnosis. Contrary to its moniker "tennis elbow", lateral epicondylitis is more commonly a result of an occupational overuse injury involving excessive pronation and supination rather than a recreational activity (Kane *et al.* , 2014). In relation to sports, the pain usually occurs in the late phase of a backhand serve in tennis or striking a golf club against the ground before hitting the ball. In addition, osteochondritis dissecans is more common in athletes whose sports involving excess valgus or compressive forces such as baseball or gymnastics. Symptoms of weakness and/or numbness points towards a diagnosis of nerve entrapment neuropathies. Symptoms of locking and/or catching are more suggestive of loose bodies or osteochondritis dissecans and range of motion may be reduced. A previous history of dislocation or trauma also point towards a diagnosis of instability.

On examination, the area of tenderness can be diagnostic. Lateral epicondylitis is usually tender at the common extensor origin on the lateral epicondyle; pain 1cm below this is more specific to extensor carpi radialis brevis (ECRB) tendinitis (Kane *et al*,. 2014). Tenderness 3-5cm distal to the lateral epicondyle is more indicative of radial tunnel syndrome (Dang and Rodner, 2009). Nevertheless, radial tunnel syndrome is difficult to distinguish from lateral epicondylitis and coexists in 5% of patients (Inagaki, 2013). There may also be a positive Tinel's sign at the radial tunnel. Other provocative tests to elicit radial tunnel syndrome would be pain on passive pronation with wrist flexion as that increases the pressure in the radial tunnel from 50mmHg to 250mmHg (Naam and Nemani, 2012). There may also be weakness as a result of pain to resisted wrist extension and finger extension which could make it difficult to distinguish between radial tunnel syndrome, lateral epicondylitis and PIN syndrome.

Radial tunnel syndrome

RTS is pain in the lateral elbow as a result of intermittent compression of the posterior interosseous nerve at the proximal forearm (Garcia *et al*,. 2019). The incidence is 1.4 in women and 3.0 in men per 100,000 people in the United Kingdom (Latinovic, Gulliford and Hughes, 2006). It makes up 0.7% of all upper limb compression neuropathies (Bevelaqua *et al*., 2012), annual incidence 0.003% (Dang and Rodner, 2009). The borders of the tunnel are brachioradialis, extensor carpi radialis longus and ECRB laterally; biceps tendon and brachialis medially; radiocapitellar joint capsule inferiorly

(Naam and Nemani, 2012). The posterior interosseous nerve is a terminal motor branch of the radial nerve; the radial nerve splits at the level of the elbow joint into the superficial radial sensory nerve and the posterior interosseous nerve (Sigamoney, Rashid and Ng, 2017).

Causes of PIN neuropathy include mechanical and intrinsic causes. Potential areas of compression are the proximal apnoeurosis of the supinator muscle (arcade of Frohse), medial edge of ECRB, the radial recurrent blood vessels and inferior margin of the superficial layer of the supinator muscle (Obuchowicz and Bonczar, 2016)). Other pathological structures such as lipomas, ganglions, fibrous adhesions or cysts can also contribute to compression (Sigamoney *et al*., 2017). Intrinsic causes include inflammatory conditions such as parsonage-turner syndrome or spontaneous hourglass constriction of the PIN (Sigamoney, Rashid and Ng, 2017).

It is important to distinguish posterior interosseous nerve syndrome from radial tunnel syndrome; the latter has normal electrophysiological tests and there is no neurological deficit (Dang and Rodner, 2009). Sometimes it is difficult to distinguish if weakness is due to pain versus true motor deficit, hence additional electrodiagnostic tests such as a positive electromyography result would favour a diagnosis of PIN syndrome over to RTS. This has further implications for management which will be discussed below.

Investigations for lateral elbow pain

First-line imaging on first presentation can be simple X-rays at initial visit to exclude any gross bony abnormalities e.g. fractures. The role of CT is limited in the evaluation of lateral elbow pain; it can be used in cases where myositis ossificans or intra-articular bodies is suspected.

Ultrasound can be a useful diagnostic tool in evaluating soft tissues, tendinopathy and performing dynamic tests such as tendon snapping or nerve subluxation (Obuchowicz and Bonczar, 2016). Lateral epicondylitis is diagnosed on ultrasound where normal fibrillary fibres are replaced by anechoecic scar tissue and there is lack of vascularity (Obuchowicz and Bonczar, 2016). Ultrasound can also be useful for diagnosing nerve pathology. Sonographic findings would include nerve enlargement, change in diameter, echogenicity and vascularity (Dietz *et al*., 2016). This can be complementary to electrodiagnostic studies, where ultrasound can identify a loss of nerve continuity or nerve tumours in cases where the electrodiagnostic study was abnormal (Dietz *et al*., 2016).

In cases where the elbow pain is chronic, MRI has value in looking at bone marrow oedema, chronic tendinopathy, joint effusion or nerve entrapments. Of note, distal bicep insertional tendinitis can be a mimic for radial tunnel syndrome as such patients would not benefit from surgical intervention (Wilson *et a*l. 2019). Magnetic Resonance Arthrogram can provide even more information about any ligament tears, osteochondritis dissecans and loose bodies (Stevens and McNally, 2010).

In comparison to MRI, ultrasound can be a cheaper mode of investigation and is more accessible as it can be done bedside. It is also a more amenable form of imaging for patients with claustrophobia. Ultrasound is also non-invasive when compared to elbow arthroscopy. Ultrasound has a sensitivity of 64-82% for elbow tendinopathy compared to MRI, which is 90-100% (Walz et al. 2010). Specificity ranged from 67-100% for ultrasound and 83-100% for MRI (Walz et al. 2010). However, accuracy of the ultrasound is operator dependent, machine dependent and transducer dependent (Latham and Smith, 2014).

For upper limb peripheral nerve neuropathy, turbo spin echo T2 weighted MR sequence had a higher sensitivity of 95.31% compared to ultrasound which had a sensitivity of

81.25% (Aggarwal *et al.,* 2017). Sensitivity for nerve continuity and thickening of the nerve caliber was comparable for both (Aggarwal et al. 2017). Ultrasound was not as good as MRI in cases where there were a lot of fibrosis and distortion of normal anatomical architecture due to trauma. In 3 cases of supinator syndrome, it was difficult to visualise the posterior interosseous nerve after it entered the supinator muscle as it was deep and thin. MRI is better at picking up thinner nerve calibres and secondary denervation changes. In 11.5% of cases (7/61), MRI picked up signal alternation in the nerve while US did not. In this study MRI findings correctly identified lesions with surgical findings (100%) and with NCS (95.3%), suggesting MRI could be the first line of investigation for peripheral neuropathy. However, in cases of atraumatic neuropathy, the MRI coil had to be repositioned to find the site of the abnormal nerve, which led to longer scan time. In addition, the Superman position was not tolerated well leading to premature termination of the scan or repeated sequences due to motion artefact. It is suggested that ultrasound can be used as an initial screening tool for diagnosing peripheral neuropathies followed by focused MRI with TSE T2W FS scans. If surgical intervention is to be carried out, MRI would help to prognosticate by classifiying the denervation changes as acute or chronic (Aggarwal *et al*., 2017).

Nerve conduction studies could also be done when suspecting a PIN entrapment. It could localize the level of the lesion, distinguish between RTS and PIN and prognosticate nerve recovery post-intervention. However, it has been suggested nerve conduction studies can also be falsely negative, as PIN carries unmyelinated Group IV fibers and myelinated Group IIA afferent fibers, which cannot be evaluated by NCS thus resulting in a falsely normal study (Dang & Rodner, 2009). In RTS, static electromyogram (EMG) is negative, however a decrease in speed of motor conduction can be seen during resisted supination (Simon Perez et al. 2014).

Ultrasound vs MRI to diagnose RTS

Ultrasound to diagnose RTS involves meticulous scanning of the radial tunnel with a high frequency probe of up to 16MHz. The diameter of the PIN should not exceed 1mm and an increase in this indicates swelling from the compression (Obuchowicz and Bonczar, 2016). In chronic cases of compression, dynamic slow forearm supination during ultrasound may show an increase in nerve flexion angle which is diagnostic of RTS (,lska and Sudol-Szopinska, 2012). However, the diameter of the PIN is not consistent throughout its course; it can also increase proximally to the arcade of Frosche as part of a normal variant (Obuchowicz and Bonczar, 2016).

There is little evidence on landmark versus ultrasound-guided injection of the elbow joint, much less radial tunnel syndrome. Cunnington *et al.* (2010) did a study comparing landmark versus ultrasound guidance injection of 22 elbows and the accuracy was 64% versus 91%, however, the numbers were too small to reach statistical significance.

MRI for RTS can be variable; Ferdinand *et al*. (2006) demonstrated that 13/25(52%) of patients with clinical RTS had denervation odema or atrophy of supinator and extensor muscles, 1/25 had isolated pronator teres oedema, 7/25 had mass effects along the posterior interosseous nerve (thickened leading edge of ECRB, prominent radial recurrent vessels, schwannoma or bicipital bursa), 4/25 had normal MRI imaging and 2/25 had lateral epicondylitis. Of note, 2/10 asymptomatic controls were noted to have borderline thickening of the leading edge of the ECRB.

Management of RTS

RTS is usually managed conservatively as first line for at least one year before resorting to surgical decompression. This includes activity modification, temporary splinting and a trial of non-steroidal anti-inflammatories(NSAIDs). There are anecdotal studies to suggest other conservative treatment options such as soft tissue manipulation may be beneficial in terms of deep soft tissue mobilization and neural flossing (Saratsiotis and Myriokefalitakis, 2009).

Garcia et al. (2019) described a study with 54 patients diagnosed with RTS that were managed ultrasound-guided perineural infiltration with corticosteroid. Their injecting solution was 1ml of steroid (5mg betamethasone dipropionate acetate and 2mg betamethasone sodium phosphate), 2ml of 2% Lidocaine and 1-2ml of normal saline. The approach was lateral-medial, with the patient's forearm in midprone position. The radial nerve was traced down superficial to the humeral capitellum to the level of the supinator muscle where the PIN lay between the 2 heads of the supinator muscle. A 23-gauge needle was inserted in the plane of between the PIN and arcade of Frohse with a needle inclination of 45 degrees. They reported good results with only 1.9% of their patients reporting pain post-procedure and attributed this to the larger volume of injecting solution used to displace any compressing anatomical structure in the arm. However, their study had a short follow-up period of just 4 weeks hence the long term efficacy of this treatment is not known.

Other similar studies include Sarhadi et al. (1998) which demonstrated 18/25(72%) patients improved at 6 weeks, 16/25 (62%) patients were pain-free at 2 years, however 9/25(36%) required surgical decompression. They used 40mg triamcinolone (1ml) and 2ml of 1% lidocaine in their study, however these injections were done blind and not via ultrasound. Similarly, Marchese *et al*., (2018) also reported statistically significant decrease in quick Disabilities of the arm, Shoulder and Hand (qDASH) at the 1-year mark, however, 8/35 (23%) patients who required surgical decompression following corticosteroid injections to the PIN.

Surgical decompression is offered when patients have failed conservative treatment; 50-90% have good results and there is a delayed maximal recovery of 9-18 months. This further decreases when there is concomitant lateral epicondylitis, entrapment neuropathy or work compensation patients (Knutsen *et al*., 2015). Surgery is usually via a posterior-external approach to visualize the entire PIN. All areas of potential compression need to be visualized and freed; most commonly this is the proximal entry of the radial tunnel, but the distal exit needs to be visualized too (Simon Perez *et al*., 2014). However, the results for surgical decompression are variable. Hence as far as possible, all conservative treatment options should be exhausted before resorting to surgical intervention. However, the management of PIN syndrome differs where prolonged neglect results in muscle fibrosis thus leaving tendon transfers as a surgical option rather than a simple release. Thus PIN syndrome needs to be determined for the outset and referred for surgery early rather than later.

Conclusion

RTS is a rare but debilitating cause of lateral elbow pain. Careful history and examination is paramount and differential diagnosis of lateral elbow pain need to be always kept in mind when managing a seemingly routine patient with “chronic tennis elbow”. The investigation of choice is not a clear-cut one; MRI and ultrasound both have their benefits in terms of sensitivity of picking up neuropathies and finding a mechanical cause for RTS. These must be used in conjunction with electrodiagnostic studies. Ultrasound is useful for diagnostic and therapeutic purposes in RTS. Surgical decompression is last line in RTS and does not always have successful results hence it is important for an accurate ultrasound-guided injection of the PIN to determine response to corticosteroid therapy as well as provide symptom relief and possibly negate need for surgery.

(2851 words)

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