Case 9 Carpal Tunnel Syndrome Ultrasound Diagnosis and Injection Valentina Treskavica

Introduction

Carpal tunnel syndrome (CTS) is the most common compressive peripheral neuropathy. It arises from compression of the median nerve where it passes through the carpal tunnel in the wrist (Sternbach, 1999). The annual incidence of the syndrome in the UK is estimated as 99 per 100 000 with a female to male ratio of 3:1 (Latinovic et al, 2006).

An early diagnosis is essential in preventing permanent nerve damage. CTS diagnosis is usually established based on clinical and electrodiagnostic findings and more recently ultrasonography has been shown to be a useful tool in CTS diagnosis (Klauser et al, 2009).
Ultrasound enables detection of changes in the nerve shape, vascularity, anatomical variants and is able to exclude compression from space occupying lesions as in ganglion cysts and tenovaginitis (Martinoli et al, 2000).

The treatment of CTS with local corticosteroid injection is a very classic and commonly used strategy (Aroori and Spence, 2008). Steroid injection exerts its function mainly through reducing oedema to improve the spatial relation between the carpal tunnel and the median nerve and flexor tendons (Padua et al, 2016)
The efficacy of this intervention irrespective of delivery method (anatomically or US guided) is well established according to Marshall et al (2007) however there is only strong evidence for benefits of steroid injection in the short term and about half of the patients require further treatment within one year (Huisstede et al, 2010).
Recent studies have shown that US-guided steroid injection may be more effective than blind injections in treating CTS (Evers et al, 2017 and Üstün et al, 2013).
US guided injection not only prevents direct needle injury to the median nerve but also ensures accurate delivery thus preventing leakage of injectate from carpal tunnel causing the complications of fat tissue atrophy and skin depigmentation (Lee et al, 2014).

This case report details a single patient with CTS, process of assessment aided by ultrasonography, clinical reasoning and diagnosis, concluding with a detailed account of treatment by ultrasound guided corticosteroid injection and the reasoning underpinning the treatment.

Case History

Clinical Assessment

A 58-year old female was referred by her GP to the musculoskeletal clinic for assessment and management of what was suspected to be CTS. She presented with 18 month history of progressive nocturnal paraesthesia and pain in her right hand. The left hand was only sporadically affected. The pain was described as 'burning' and on occasions tended to radiate proximally as far as the elbow. Paraesthesia was mainly feature at night and it was claimed that it affects the entire hand. Only on detailed questioning and following the use of hand diagram it became apparent that the little and possibly ring fingers were spared. Since the little finger receives all of its sensory supply from the ulnar nerve, it should not be involved in the true CTS (Elfar et al, 2010).
The hand symptom diagram has been shown to have 80% sensitivity and 90% specificity for diagnosis of CTS (Katz et al, 1990).

Strenuous use of the hand aggravated the symptoms although tingling in the fingers was usually noted after several hours of rest.

Vigorous shaking of the hand usually relieved the symptoms. Pryse-Phillips (1984) found the presence of this 'flick sign' to have a sensitivity and specificity of over 90% in diagnosis of CTS. The patient did not report any weakness or clumsiness. The numbness in the tips of the fingers was intermittent feature. The initial treatment with NSAIDs and night splints had only mildly improved the symptoms.
This patient did not have any neck pain, leg paraesthesia or problems with dexterity.
There were no known allergies and she was otherwise in good general health.
Tortland (2003) suggest the use acronym PRAGMATIC (pregnancy, rheumatoid arthritis, acromegaly, glucose metabolism disorder, myxedema, amyloidosis, thyroid disease, idiopathic, chrystal in gout or pseudo gout) when screening for the possible causes of symptoms of CTS. The patient has had a diagnosis of hypothyroidism for the past 12 years and she was medicating on Levothyroxine. Her recent blood test including FBC, ESR, CRP, TSH, T3 and T4, Vitamin D3 and B12 was satisfactory.

The patient was married with grown up children. She reported working as a machinist in a cloths making factory and was 14 months away from the retirement.
She had intermittent numbness in her fingers when working. Having to stop to shake and move her fingers to alleviate the symptoms was not looked upon favourably by her employer.
She was a keen gardener.

Examination
Although CTS is primarily a symptomatic disorder and physical findings are reported to have a poor correlation with the presence of the condition (Szabo, 1992), it is important to use clinical exam to exclude other differential diagnosis namely radiculopathic causes likes of cervical root compression, thoracic outlet syndrome with other brachial plexopathies and cervical myelopathy.
The patient had a full, pain free range of neck movement. Spurling's test for cervical radiculopathy was negative.

The principal clinical tests for carpal tunnel syndrome are Phalen's maneuver and Tinel's sign. Phalen's manoeuvre was positive on the right and negative on the left hand. Tinel's sign was rather inconclusive. Katz (1990) reported their sensitivity to be in range of 25% to 75%, but 70% to 90% range of specificity.
There was no evidence of the thenar atrophy or abductor policies brevis weakness. Besides, atrophy of the thenar eminence is a late finding and is therefore unreliable as an early diagnostic measure (Katz, 1990).

Typically nerve conduction studies (NCS) are used to confirm the diagnosis and establish the severity of carpal tunnel lesion. Although NCS are highly specific (Nathan et al, 1993) they have a substantial false-negative rate of between 10% and 20% (Wright, 1992). Although NCS indicate the level of the lesion, they do not provide spatial information about the nerve or its surroundings that could help in determining aetiology.
Drawback of NSC is its expense and currently a very long waiting list locally. In the light of the patient's symptom severity and now chronically disturbed sleep, it has been decided not to refer for NCS and to utilise the US scan in clarifying and confirming the CTS diagnosis.

Ultrasound Scan
Ultrasound scan has been shown to be a precise method to display the anatomy of the median nerve (Kamolz et al, 2001) and several studies have shown US to have high sensitivity and specificity for the diagnosis of idiopathic CTS (Swen et al,2001; Ziswiler et al, 2005; Wong et al, 2004).

A range of US measurements can be used to diagnose CTS, e.g. the cross-sectional area of the nerve at the entrance of the carpal tunnel, the flattening ratio (defined as the ratio of the major axis of the

median nerve to its minor axis), the increased palmar bowing of the flexor retinaculum and the cross-sectional area of the nerve at the outlet of the tunnel (Hammer et al, 2006). Among these assessments, the cross-sectional area at the entrance of the carpal tunnel seems to have the highest sensitivity and specificity for CTS (Swen et al, 2001; Ziswiler et al, 2005; Wong et al, 2004). Examination at this level may also be performed most reliably by recently trained US users.

A Sonosite MicroMaxx scanner with a high frequency linear array transducer (6-13 MHz) was used to perform the scan (Figure 1).
The machine was appropriately adjusted in terms of gain, frequency and depth, which were set to provide optimal imagery. Carr et al (2001) highlighted that transducers up to 20MHz may be desirable to achieve high spatial resolution, current equipment restriction only allowed for the transducer head of 13MHz. Small linear head was selected for viewing the small parts of allow for the best contact.

Figure 1 *Sonosite MicroMaxx Scanner*

The patient was positioned in comfortable sitting position with arms resting on the examination couch in supinated position, and her fingers semiflexed. The longitudinal image was first obtained (Figure 2). This view was helpful as an overview of the median nerve and orientation to allow for the optimal transverse image. The length of the nerve was imaged from proximal 4 cm to 2 cm distal to wrist crease on both sides. There was evidence of median nerve thickening on the right side.
No measurements were taken in this view. Wiesler et al (2006) suggest that the reliability of the measurements in longitudinal view is inconsistent in cadavers.

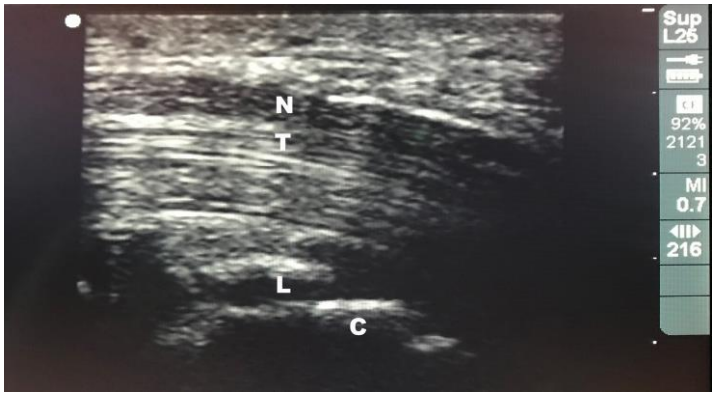
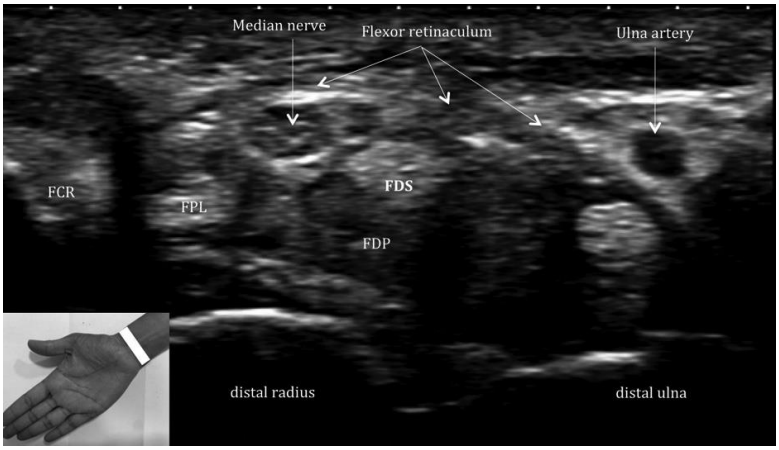


Figure 2 *Midline longitudinal view, median nerve and flexor tendons are visible.*



Next a transverse view was obtained. The probe was placed in the line with the distal wrist crease. Median nerve, flexor retinaculum, flexor tendons and vascular structures were identified. Figure 3 displays the probe positioning over flexor compartment (imported from Wiesler et al, 2006).

Figure 3. *Transverse section of flexor compartment.*

There was evidence of median nerve proximal dilatation and flexor retinaculum bowing on the right wrist. Left flexor compartment and median nerve appeared intact. There was no significant proximal dilatation, or flattening the nerve on the left.

The smallest cross-sectional area at this level was measured to ensure that the probe was positioned in the most perpendicular plane at this level. The nerve was traced along the hyper-echoic perineurium (Figure 4 and 5). Right, symptomatic median nerve measured 0.13 cm2 and left 0.07cm2.

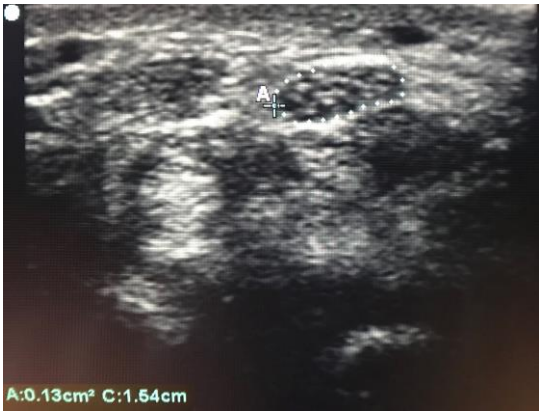


Figure 4 *Right median nerve CSA*

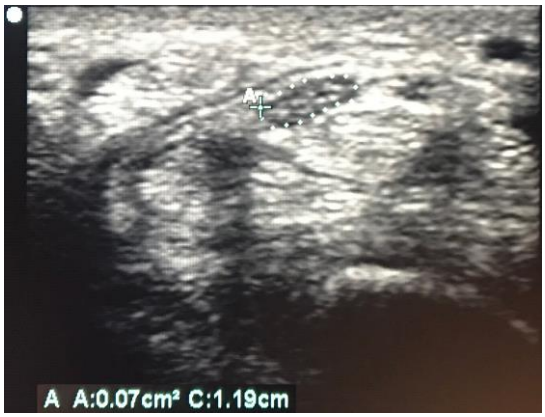


Figure 5 *Left median nerve CSA*

Cross-sectional area greater than 9 mm² at the level of the proximal tunnel seems to be the best criterion for diagnosis of carpal tunnel syndrome according to Duncan et al (1999). Most MRI studies of carpal tunnel syndrome have found a similar degree of swelling of the median nerve.

Khanbhai et al, 2015 had stipulated additional accuracy when comparing measurements of cross sectional area of the median nerve at level of the carpal tunnel, pronator teres and and 12 cm proximally in the forearm.

On reflexion the measurements were not taken at the different sites on this examination due to the clear clinical evidence of CTS.

Most other studies propose CSA larger of either 9 mm2 (Sernik et al, 2008 and Yecel et al, 2008) or 10 mm2 (Buchberger et al, 1991 and Chen et al, 1997) as a cut off value for establishing the diagnosis of CTS.

The obtained images were labelled appropriately annotated and then stored on the machine for future viewing and second opinion if required.

Diagnosis

The working diagnosis of idiopathic CTS was confirmed on ultrasound scan.
The proposed diagnosis was disclosed to the patient with explanation of pathophysiology and natural progression. The usual three stepped approach was discussed including conservative management with night splinting, corticosteroid injection and carpal tunnel release surgery. The patient was involved into management decision and her views made an integral part of this decision making process.

Considering that she failed to improve with simpler measures of using a night splint, NSAIDs and exercises, CT injection was the next logical step.

Nonetheless it could be argued that the patient's symptom severity should trigger an earlier referral for decompression surgery. Delaying the surgery in severe median nerve compression may lead to prolonged demyelination and irreversible axonal damage (Chandra et al, 2013).
This lady was not in the position to be able to take the time off work for post surgical recovery hence symptom management with corticosteroid injection was a reasonable step even if it offered short term symptom relief only. She would be happy to consider surgical decompression once the retirement has been reached.

Treatment-US guided injection

Accurate injection into carpal tunnel is an effective and safe way in treatment of CTS symptoms (Huisstede, 2010).
Systemic steroids have numerous and serious side effects which is not the case with local steroid injection. The systemic side effects of local steroid injection are rare at low doses. None the less, the patient was warned of potential facial flushing and menstrual irregularity. These are extremely rare side effects but have been mentioned in the literature (Saunders and Longworth, 2006).

The patient was also taken through the symptoms of anaphylactic shock and advised on need for immediate medical attention if those occur. The standard practice is that patients are kept for half an hour following the procedure in the clinic to ensure there are no immediate side effects. The anaphylactic kit is kept in the clinic and the clinician undergoes yearly mandatory training to ensure competence in dealing with such serious and life-threatening complication.

Local side effects such as post-injection flare, transient pain, irritation, sterile abscesses, hyper- or hypo-pigmentation and fat atrophy were also discussed with the patient. The small possibility of infection was discussed and ensured the patient could recognise the symptoms and seek medical help.

Following a screen for relative and absolute contraindications and precautions, written consent was obtained.
The injection kit was prepared and 20 mg of Depomedrone was drawn up. The local anaesthetic was not used. There is no consensus in the literature for the use of local anaesthetic for carpal tunnel. Graham et al (2004) advocated anaesthetising the median nerve to ensure accurate delivery of

steroid into the carpal tunnel. On the other hand median nerve block could potentially lead to the nerve injury especially with blind injection. There was no specific perceived benefit to use local anaesthetic in this case.

Neurotoxicity of the most injectable corticosteroids is well documented. Hydrocortisone was least and Triamcinolone most toxic. Metylprednisolone was found to cause less nerve degeneration than the most neurodegenerative Triamcinolone (MacKinnon et al, 1982). The neurotoxicity of those agents is another strong argument for delivering the injection with US guidance.

The patient maintained the position she was scanned in, the wrist was placed in slight dorsiflexion. The in-plane ulnar approach in transverse plane was selected for a few reasons. Firstly, imaging the wrist in the transverse plane enables visualisation of all of the carpal tunnel contents and tendon structure around the nerve and vascular structures, facilitating an accurate perineural injection. Secondly the needle shaft and the bevel can be visualised in plane relative to the transducer throughout the procedure.

The skin and the probe were cleaned with chlorohexidine surgical scrub solution. A small footprint probe was used. The probe was placed transversely on the distal wrist crease. The nerve and vessel was visualised. The ulnar end of the transducer was floated on a small amount of sterile ultrasound gel. The gel stand-off facilitated a better needle trajectory into the carpal tunnel.
A 25-gauge was advanced to a position adjacent to the nerve. The half of corticosteroid solution was injected inferior to the nerve separating it from flexor tendons below. The needle was then repositioned more superficially and the remaining injectate delivered under the overlying flexor retinaculum separating it from the nerve. The patient tolerated the procedure well.

The figure 6 and 7 were taken as an illustration from Wiesler et al, (2006) who described this technique. It was not possible to save the images during the procedure due to the clinician working alone in the clinic and with both hands occupied it was not feasible to reach across and to press the store button located on the machine.
The needle was withdrawn, followed by a usual injection site aftercare.

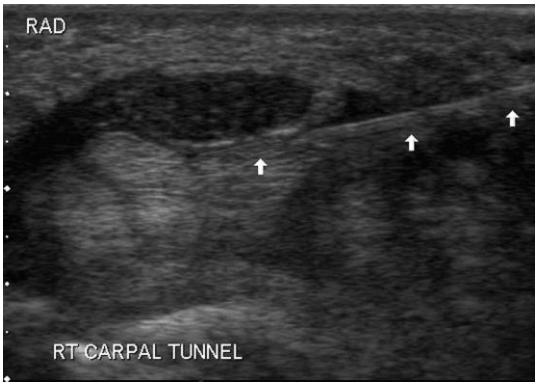


Figure 6 *Infiltration deep to the median nerve*

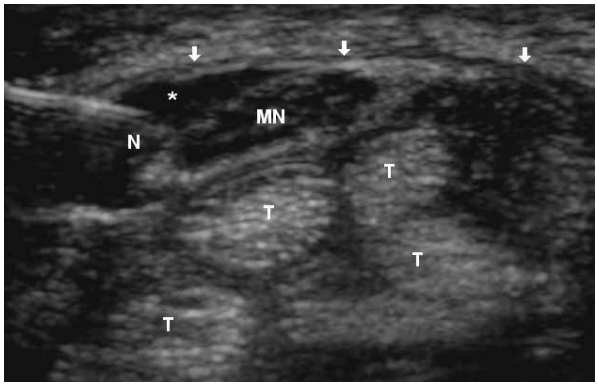


Figure 7 *Infiltration superficial to the median nerve*

Following the procedure the patient was advised on relative rest of 1 week duration after which normal activities could be resumed. The advice was based on current best practice as there is not strength of evidence to support any specific timeframe for period of rest. There is a general consensus that either relative or absolute rest should be introduced to allow the tissues to begin the healing process.

The patient was followed up by telephone at one week post injection and had reported a full resolution of symptoms. The effects were maintained at 3 weeks. The patient was given the option of an open appointment for further 3 months.

Depo-medrone (Metylprednisolone) used in injection therapy is a synthetic gluco-corticoid.. It is believed to reduce inflammation and pain locally. It depresses formation, release and activity of endogenous mediators of inflammation. Glucocorticoids stabilise phospholipid membrane by inhibiting phospholipase A2, and therefore decrease formation of arachidonic acid and further inflammatory mediators from prostaglandin and leukotriene pathways (Dale & Haylett, 2004).

The optimal corticosteroid dosage remains to be determined. The dose used in this case (20 mg of Metylprednisolone) was based on the best current practice and common guidelines in orthopaedic medicine. In the current literature doses range from 25 mg of Hydrocortisone (Phalen, 1966) to 30 mg of Triamcinolone (Gelberman et al, 1980), a six fold difference when compared to an equivalent dose of Prednisolone (BNF 66, p.470). Despite this variation, the efficacy of these studies is similar, resulting in symptomatic relief in about two thirds of subjects.

Cartwright et al (2011) have investigated sonographic charges in median nerve post injection. They reported significant changes in median nerve cross-sectional area, mobility, and vascularity at the distal wrist crease after steroid injection within 1 week.
Further more Ustun et al (2013) found superior outcomes with US guided injection compared to blind or anatomically guided injection. Although the outcomes were similar at 6 weeks, the improvement in US guided group at 12 weeks was superior. Additionally the average time to symptom relief was shorter in the US group.
Similarly in a more recent study Evers et al (2017) ultrasound guided injections were associated with a 55% reduced odds of re-treatment when compared to blind injections.
The current patient was no scanned post the injection due to the time constraints. It would be useful to observe changes in the nerve size and presentation post successful injection.

Although many approaches and methods to carpal tunnel injection have been described, there is no sufficient evidence of one technique being superior to the others (Wilson and Sevier, 2003).
The most commonly used method is longitudinal approach, with needle insertion parallel to the median nerve in sagittal plane, proximal to distal (Smith et al, 2008). However, this method cannot offer the benefits of carpal tunnel contents images in transverse plane and needle shaft and tip simultaneously. Therefore even an accurately placed needle within the carpal tunnel following the technique may injure the median nerve because of anatomic variations such as a bifid median nerve or a median nerve in an abnormal location (Swan and Oestreich, 2009).

The in plane ulnar approach used in this case was initially described by Smith et al (2008). It combines the advantages of longitudinal needle visualisation with the flexibility of transverse carpal tunnel imaging. In addition, novice practitioners can approach the median nerve more easily from basic anatomy of the target tissue (Lee et al, 2014).

Although in-plane and out-plane US-guided carpal tunnel injection were more effective in improving electrodiagnostic, sonographic findings, and symptoms than blind injection, the in-plane ulnar approach was superior to the out-plane and blind injection in median-to-ulnar sensory nerve distal latency ratio, median nerve cross sectional area and Boston Carpal Tunnel Questionnaire (Lee et al, 2014).

Conclusion

Ultrasound guided corticosteroid injection is a safe and effective way in treating CTS particularly in mild to moderate compressive lesions.
This case study supported those observations in literature.

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