Diagnostic Musculoskeletal Ultrasound and Guided Injection: A Practical Guide

Peter Resteghini

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Contents

Preface

The popularity of ultrasound in the diagnosis and management of musculoskeletal pathology has witnessed a considerable increase in recent years. Given the ability for ultrasound to be utilized in an "office setting," the enhanced resolution with high-frequency probes, and the relative affordability of newer machines, this perhaps is not surprising. In addition, ultrasound has the advantage of allowing clinicians to incorporate the modality into their practice with relative ease, thus forming an essential adjunct to their routine clinical examination and allowing a direct and real-time comparison between clinical and anatomical findings.

There is no doubt that skilled clinicians have great benefit in utilizing ultrasound in their clinical practice, facilitating their ability to answer specific questions regarding a patient's pathology and anatomical relationships as well as being able to monitor disease and increase the accuracy of interventional procedures. Although several specific training programs exist for non-musculoskeletal ultrasound, very few programs exist particularly for musculoskeletal medicine. Taken with this is the fact that the correct use of ultrasound has a relatively long learning curve, which means that clinicians struggle to achieve competency. Indeed, it is reckoned that less than 5% of rheumatologists are able to correctly use ultrasound in their daily clinical practice (Grassi et al 2004).

It is the aim of this book to provide a pragmatic and accessible guide for the use of ultrasound in both the diagnosis and management of musculoskeletal and sports pathologies. The book is aimed at clinicians from a wide variety of backgrounds, including chiropractic, orthopaedics, osteopathy, physiotherapy, rheumatology, sonography, and sports medicine. The book is intended for both the novice clinician who has only recently started to incorporate ultrasound into her/his clinical practice and the experienced clinician as a handy reference guide.

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Introduction

The last decade has seen a considerable increase in interest in the use of ultrasound in the management of musculoskeletal pathologies, which is reflected in the volume of literature published regarding its applications in both the diagnosis and treatment of musculoskeletal conditions. Papers have highlighted its use particularly in shoulder pathology (Arslan et al 1999, Bouffard et al 2000, Ostlere 2003, Teefey et al 2004) and as a form of interventional radiology, guiding the placement of needles for aspiration or local injection (Ghozlan and Vacher 2000, Koski 2000, Weidner et al 2004). This increase in interest has come from a wide variety of clinical specialties, including chiropractic, orthopaedics, osteopathy, physiotherapy, rheumatology, sonography, and sports medicine (Balint and Sturrock 1997, Tan et al 2003).

The reasons for the increase in the popularity of musculoskeletal ultrasound are many. A lack of ionizing radiation makes the technique more acceptable, readily usable, and repeatable (Grassi et al 2004). It is capable of high spatial resolution, has multiplanar imaging capability, and is considered patient friendly due to its ease of tolerance and noninvasiveness (Backhaus et al 2001, Grassi et al 2004, Tan et al 2003, Wakefield et al 1999). With experience, scanning time is short, 5 to 15 minutes for an experienced clinician compared to approximately 40 minutes for a magnetic resonance imaging (MRI; Swen et al 2001). This has the advantage of enabling multiple joints to be examined in one sitting, if necessary, and in increasing throughput of patients (Wakefield et al 1999). For specific anatomical structures, ultrasound and MRI are comparable in both sensitivity and specificity (de Jesus 2009). In the assessment of the shoulder and rotator cuff pathology, ultrasound has been demonstrated to have 98.6% sensitivity and 99.3% specificity for full-thickness tears and 97.9% sensitivity and 94.4% specificity for partial-thickness tears (Al-Shawi et al 2008).

Unlike other imaging modalities, ultrasound may be performed as a bedside procedure (Grassi et al 2004). In particular, and in contrast to other imaging modalities, it not only provides anatomical information, but also informs on the physiological state of the joint, being particularly sensitive to inflammatory changes and subsequent response to treatment intervention (Grassi et al 2001).

Ultrasound is also unique in that scanning occurs in real time (Tan et al 2003), making it possible to discuss reproduction of symptoms with the patient and to view dynamic images of the structures under examination. This is particularly useful for evaluating tendons (Ellis et al 2002, Grassi et al 2000), and adds significantly to the diagnostic accuracy of many clinical tests (Shirtley 1999). Indeed, it is considered to represent the gold standard for evaluation of tendon pathology, in part due to this quality (Grassi et al 2000).

References

Al-Shawi A, Badge R, Bunker T. The detection of full thickness rotator cuff tears using ultrasound. J Bone Joint Surg Br 2008;90(7):889–892

Arslan G, Apaydin A, Kabaalioglu A, Sindel T, Lüleci E. Sonographically detected subacromial/subdeltoid bursal effusion and biceps tendon sheath fluid: reliable signs of rotator cuff tear? J Clin Ultrasound 1999;27(6): 335–339

Backhaus M, Burmester G-R, Gerber T, et al.; Working Group for Musculoskeletal Ultrasound in the EULAR Standing Committee on International Clinical Studies including Therapeutic Trials. Guidelines for musculoskeletal ultrasound in rheumatology. Ann Rheum Dis 2001;60(7):641–649

Balint P, Sturrock RD. Musculoskeletal ultrasound imaging: a new diagnostic tool for the rheumatologist? Br J Rheum 1997;34(11):1141–1142

Bouffard JA, Lee SM, Dhanju J. Ultrasonography of the shoulder. Semin Ultrasound CT MRI 2000;21(3): 164–191

de Jesus JO, Parker L, Frangos AJ, Nazarian LN. Accuracy of MRI, MR arthrography, and ultrasound in the diagnosis of rotator cuff tears: a meta-analysis. Am J Roentgenol 2009;192(6):1701–1707

Ellis JRC, The JL, Scott PM. Ultrasound of tendons. Imaging 2002;14:223–228

Ghozlan R, Vacher H (2000). Where is imaging going in rheumatology? Baillieres Best Pract Res Clin Rheumatol 2000;14(4): 617–633

Grassi W, Filippucci E, Busilacchi P. Musculoskeletal ultrasound. Best Pract Res Clin Rheumatol 2004; 18(6):813–826

Grassi W, Filippucci E, Farina A, Cervini C. Sonographic imaging of tendons. Arthritis Rheum 2000;43(5): 969–976

Grassi W, Filippucci E, Farina A, Salaffi F, Cervini C. Ultrasonography in the evaluation of bone erosions. Ann Rheum Dis 2001;60(2):98–103

Koski JM. Ultrasound guided injections in rheumatology. J Rheumatol 2000;27(9):2131–2138

Ostlere S. Imaging the shoulder. Imaging 2003; 15:162–173

Shirtley GS. Musculoskeletal ultrasound: its current use and its place in the ADF. ADF Health 1999;1(25):33–41

Swen WA, Jacobs JWG, Bussemaker FE, de Waard JW, Bijlsma JW. Carpal tunnel sonography by the rheumatologist versus nerve conduction study by the neurologist. J Rheumatol 2001;28(1):62–69

Tan AL, Wakefield RJ, Conaghan PG, Emery P, McGonagle D. Imaging of the musculoskeletal system: magnetic resonance imaging, ultrasonography and computed tomography. Best Pract Res Clin Rheumatol 2003; 17(3):513–528

Teefey SA, Rubin DA, Middleton WD, Hildebolt CF, Leibold RA, Yamaguchi K. Detection and quantification of rotator cuff tears. Comparison of ultrasonographic, magnetic resonance imaging, and arthroscopic findings in seventy-one consecutive cases. J Bone Joint Surg Am 2004;86-A(4):708–716

Wakefield RJ, Gibbon WW, Emery P. The current status of ultrasonography in rheumatology. Rheumatology (Oxford) 1999;38(3):195–201

Weidner S, Kellner W, Kellner H. Interventional radiology and the musculoskeletal system. Best Pract Res Clin Rheumatol 2004;18(6):945–956

Local Anesthetics and Corticosteroids

The musculoskeletal injections described in this book involve a combination of local anesthetics, which provide some immediate analgesia, confirmation of diagnosis, and correct needle placement, and corticosteroids, which have a more long-term therapeutic effect.

Local Anesthetics

In the normal resting state, the axon membrane of a nerve is polarized and permeable to potassium ions while remaining relatively impermeable to sodium ions. This results in the inside of the axon being negatively charged in relation to the outside, which is relatively positively charged. Stimulation of the axon changes this resting state so that the permeability of the nerve is altered and the axon becomes depolarized. This change in permeability of the axon membrane opens channels allowing the influx of sodium ions, which results in the inside of the axon becoming positively charged. Excitation of the axon is brought about by a sequential opening and closing of the sodium and potassium channels in the cell membrane. The variation in the cell membrane potential which accompanies these changes is called an action potential, with the result that each region of the axon in turn excites the next region and the impulse is propagated along the axon fiber.

Local anesthetics are membrane-stabilizing drugs which are able to penetrate the nerve sheath and axon membrane reversibly, decreasing the rate of depolarization and repolarization of excitable membranes. Local anesthetics act mainly by inhibiting sodium influx through sodium-specific ion channels in the cell membrane. When this sodium influx is interrupted, an action potential is unable to be initiated and the signal conduction is inhibited.

Although all nerve fibers are sensitive to the effects of local anesthetics, due to a combination of axon diameter and myelination, different fibers have different sensitivities to local anesthetic blockade, termed differential blockade. Type B fibers (sympathetic) are the most sensitive, followed by type C (pain), type A delta (temperature), type A gamma (proprioception), type A beta (sensory touch and pressure), and type A alpha (motor). Although type B fibers are thicker than type C fibers, they are myelinated and therefore are blocked before the unmyelinated thin C fibers (Rang et al 1995).

The local anesthetics frequently used in musculoskeletal medicine are lidocaine hydrochloride (lignocaine hydrochloride) and Marcaine (bupivacaine hydrochloride). Lidocaine is the most commonly used local anesthetic; it acts rapidly, with the effects becoming manifest in seconds, and the duration of the block is approximately 30 minutes. Marcaine has a slower onset of action, taking approximately 30 minutes to reach maximum effect; however, duration of block is up to 8 hours.

In this book, the use of lidocaine (1%, Braun) is advocated as the delayed onset of Marcaine in an outpatient setting prevents the immediate diagnostic effect of the local anesthetic afforded by lidocaine. In addition, there is little evidence to support any long-term advantage of Marcaine over lidocaine (Sölveborn et al 1995). More recent evidence also suggests that intra-articular injection of high-dose local anesthetic, particularly Marcaine, may cause cartilage damage. This chondrotoxicity resulted in cellular death rates which were higher in osteoarthritic compared with intact cartilage (Breu et al 2013). Chondrotoxicity of local anesthetics appears to be enhanced if administered with vasoconstrictors, and the use of either lidocaine or Marcaine with added adrenaline is not recommended (MacMahon et al 2009).

Local Anesthetic and Musculoskeletal Injections

The use of local anesthetics during musculoskeletal injections helps ensure that the procedure is well tolerated by the patient and increases the confidence of the patient with the clinician performing the injection. In addition, their use has a number of other functions, including the following.

- *Aid to diagnosis*: Immediate pain relief following injection helps establish the diagnosis (Crawford et al 1998), differentiate local from referred pain (Rifat and Moeller 2002, Tallia and Cardone 2003), and confirm correct needle positioning.

- *Volume effect*: Stretching of the joint capsule, bursa, or tendon sheath may help with disruption of adhesions (Buchbinder and Green 2004).
- *Dilution effect*: Increasing the injectable volume by the addition of local anesthetic may help spread the corticosteroid around the joint, bursa, or tendon sheath (Inês and da Silva 2005).

Corticosteroids

The injectable corticosteroids commonly used in musculoskeletal medicine are synthetic analogues of the adrenal glucocorticoid hormone cortisol, which is secreted naturally by the zona reticularis of the adrenal cortex. The primary action of corticosteroids is in the modulation of the transcription of a number of genes involved in both the immune and inflammatory responses. They achieve this by their direct action on nuclear steroid receptors to control the rate of mRNA synthesis in addition to reducing the number of proinflammatory mediators including cytokines.

A number of corticosteroids are commonly used as injectable agents in musculoskeletal medicine, including methylprednisolone acetate (Depo-Medrone, 40 mg/mL) and triamcinolone acetonide (Kenalog, 40 mg/mL, and Adcortyl, 10 mg/mL—Squibb & Sons Ltd). Both methylprednisolone and triamcinolone have a similar duration of action of up to 3 weeks and a similar potency.

There is little evidence to guide the selection of corticosteroids used in musculoskeletal medicine injections, and most recommendations are based on personal preference and clinical experience. The corticosteroid described in this book is Depo-Medrone (40 mg/mL—Pfizer Ltd). The exact dose will be dependent on the structure to be injected, with 40 mg being injected into larger joints such as the hip and shoulder, while smaller joints and bursae are injected with 10 to 20 mg.

Corticosteroids and Musculoskeletal Injections

Although injectable corticosteroids have been used in the management of musculoskeletal pathologies for several decades, being first described in the 1950s in the United States to treat arthritic joints (Hollander et al 1951), little is known about their exact pharmacological effects. They are thought to act by a number of mechanisms, including the following.

- *Inflammatory suppression*: Corticosteroids are able to suppress inflammation in cases of inflammatory and degenerative arthritis (Franz and Burmester 2005, Kirwan and Rankin 1997). They are able to reduce blood flow and lower the local leukocyte and inflammatory response (Lavelle et al 2007).
- *Chondroprotective*: Corticosteroids may also have a chondroprotective effect via direct action on the metabolism of the cartilage at low dose and short culture duration which is not directly due to their anti-inflammatory action (Wernecke et al 2015).
- *Analgesia*: In cases of tendinopathy when the pain experienced by patients may be caused by the stimulation of nociceptors through chemicals such as substance P and glutamate released by the damaged tendon, corticosteroids may inhibit the release of these chemicals and hence reduce pain (Gialanella and Prometti 2011).

Risks and Side Effects

Corticosteroid and local anesthetic injections used in musculoskeletal medicine are largely very safe procedures and adverse events are rare. However, there are several possible issues that need to be considered and declared to the patient when consenting prior to injecting. These include the following:

- *Post-injection flare*: Some patients may experience a degree of post-injection inflammation and pain. This inflammation is caused by the corticosteroid crystals mimicking a septic arthritis (Cole and Schumacher 2005). However, a true septic arthritis would usually occur later than a post-injection flare and be more enduring. The incidence of a post-injection flare seems to vary between 2% (Kumar and Newman 1999) and 10.7% (Gaujoux-Viala et al 2009).
- *Septic arthritis*: Although a serious possible complication following intra-articular injection, the risk of septic arthritis is very low with a reported incidence of less than 0.03% (Charalambous et al 2003). There does not seem to be any clinical evidence in the literature to suggest that anything more than skin cleansing needs to be employed prior to injection in an office-based setting, with reported infection rates for this approach of approximately 1:50,000 (Gray et al 1981).

- *Hyperglycemia*: Diabetic patients may experience a modest and transient rise in their blood sugars following corticosteroid injection (Black and Filak 1989). This usually lasts no more than 2 weeks when it does occur (Mader et al 2005).
- *Hypopigmentation and fat atrophy*: In a meta-analysis looking at injections given into the shoulder and elbow, skin changes were said to have a frequency of approximately 4% (Gaujoux-Viala et al 2009). Nichols (2005), in a study evaluating the complications associated with the use of corticosteroids in the treatment of athletic injuries, described a risk of fat atrophy of 2.4% and skin depigmentation of 0.8%. Skin changes are more likely to be seen in superficial injections and when the patient has dark skin. If manifest, local fat atrophy appears within a 1- to 4-month period and may take 2 years or more to resolve (Cassidy and Bole 1966).
- *Tendon rupture*: Tendon and fascia rupture have been reported as complications following corticosteroid injection (Boussakri and Bouali 2014, Mahler and Fritschy 1992, Saxena and Fullem 2004). However, so long as repeated injections into load-bearing tendons are avoided, the risk of rupture appears to be small and low-dose peritendinous injections are relatively safe (Gills et al 2004).
- *Facial flushing*: A systemic side effect, this may occur 24 to 48 hours postinjection and last for up to 2 days. It has a reported incidence of less than 1% (Stephens et al 2008).
- *Bleeding*: Some bleeding at or around the injection site may occur. This is more likely in patients who are anticoagulated or who are taking an oral anti-inflammatory medicine with an antiplatelet activity (e.g., naproxen). Overall, the risk of hemarthrosis is small even in those taking antiplatelet medicines (Goupille et al 2008, Thumboo and O'Duffy 1998). However, it would be advisable to either discontinue or reverse the effects of these anticoagulation medicines prior to injection following discussion with the patient's general practitioner.

It should be noted that there is little evidence of intra-articular corticosteroid injections leading to a progression of osteoarthritis (Creamer 1999, Raynauld et al 2003). Repeated corticosteroid injections into the knee joint every 3 months were reported as being safe over a 2-year period (Raynauld et al 2003).

Contraindications to Corticosteroid Injections

Corticosteroid injections should not be given in the following cases:

- Local or intra-articular sepsis. If there is any doubt, the joint should be aspirated, with a sample sent to pathology for analysis, prior to any injection being given.
- Intra-articular fracture.
- Known hypersensitivity to one of the constituents of the injection.

References

Black DM, Filak AT. Hyperglycemia with non-insulin-dependent diabetes following intraarticular steroid injection. J Fam Pract1989;28(4):462–463

Boussakri H, Bouali A. Subcutaneous rupture of the extensor pollicis longus tendon after corticosteroid injections for DeQuervain's stenosing tenovaginitis. Case Rep Orthop 2014;2014:934384. doi: 10.1155/2014/934384. Epub 2014 Oct 12

Breu A, Rosenmeier K, Kujat R, Angele P, Zink W. The cytotoxicity of bupivacaine, ropivacaine, and mepivacaine on human chondrocytes and cartilage. Anesth Analg 2013;117(2):514–522

Buchbinder R, Green S. Effect of arthrographic shoulder joint distension with saline and corticosteroid for adhesive capsulitis. Br J Sports Med 2004;38(4): 384–385

Cassidy JT, Bole GG. Cutaneous atrophy secondary to intra-articular corticosteroid administration. Ann Intern Med 1966;65(5):1008–1018

Charalambous CP, Tryfonidis M, Sadiq S, Hirst P, Paul A. Septic arthritis following intra-articular steroid injection of the knee: a survey of current practice regarding antiseptic technique used during intra-articular steroid injection of the knee. Clin Rheumatol 2003;22(6):386–390

Cole BJ, Schumacher HR Jr. Injectable corticosteroids in modern practice. J Am Acad Orthop Surg 2005; 13(1):37–46

Crawford RW, Gie GA, Ling RS, Murray DW. Diagnostic value of intra-articular anaesthetic in primary osteoarthritis of the hip. J Bone Joint Surg Br 1998; 80(2):297–281

Creamer P. Intra-articular corticosteroid treatment in osteoarthritis. Curr Opin Rheumatol 1999;11(5): 417–421

Franz JK, Burmester GR. The needle and the damage done. Ann Rheum Dis 2005;64(6):798–800

Gaujoux-Viala C, Dougados M, Gossec L. Efficacy and safety of steroid injections for shoulder and elbow tendonitis: a meta-analysis of randomised controlled trials. Ann Rheum Dis 2009;68(12):1843–1849

Gialanella B, Prometti P. Effects of corticosteroids injection in rotator cuff tears. Pain Med 2011;12(10): 1559–1565

Gills S, Gelbke MK, Matson SL. Fluoroscopically guided low-volume peritendinous corticosteroid injection for Achilles tendinopathy. A safety study. J Bone Joint Sur Am 2004;86-A(4):802–806

Goupille P, Thomas T, Noël E; GREP. A practice survey of shoulder glucocorticoid injections in patients on antiplatelet drugs or vitamin K antagonists. Joint Bone Spine 2008;75(3):311–314

Gray RG, Tenenbaum J, Gottlieb NL. Local corticosteroid injection treatment in rheumatic disorders. Semin Arthrits Rheum 1981;10(4):231–254

Hollander JL, Brown EM Jr., Jessar RA, Brown CY. Hydrocortisone and cortisone injected into arthritic joint; comparative effects of and use of hydrocortisone as a local antiarthritic agent. J Am Med Assoc 1951; 147(17);1629–1635

Inês LP, da Silva JA. Soft tissue injections. Best Pract Res Clin Rheumatol 2005;19(3);503–527

Kirwan JR, Rankin E. Intra-articular therapy in osteoarthritis. Baillieres Clin Rheumatol 1997;11(4): 769–794

Kumar N, Newman RJ. Complications of intra- and peri-articular steroid injections. Br J Gen Pract 1999; 49(443):465–466

Lavelle W, Lavelle ED, Lavelle L. Intra-articular injections. Med Clin North Am 2007;91(2):241–250

MacMahon PJ, Eustace SJ, Kavanagh EC. Injectable corticosteroid and local anesthetic preparations: a review for radiologists. Radiology 2009;252(3): 647–661

Mader R, Lavi I, Luboshitzky R. Evaluation of the pituitary-adrenal axis function following single intraarticular injection of methylprednisolone. Arthritis Rheum 2005;52(3):924–928

Mahler F, Fritschy D. Partial and complete ruptures of the Achilles tendon and local corticosteroid injections. Br J Sports Med 1992;26(1):7–14

Nichols AW. Complications associated with the use of corticosteroids in the treatment of athletic injuries. Clin J Sport Med 2005;15(5):370–375

Rang HP, Dale MM, Ritter JM. Pharmacology. 3rd ed. New York, NY: Churchill Livingstone; 1995

Raynauld JP, Buckland-Wright C, Ward R, et al. Safety and efficacy of long-term intraarticular steroid injections in osteoarthritis of the knee: a randomized, double-blind, placebo-controlled trial [published correction in Arthritis Rheum 2003;48(11):3300]. Arthritis Rheum 2003;48(2):370–377

Rifat SF, Moeller JL. Injection and aspiration techniques for the primary care physician. Compr Ther 2002; 28(4):222–229

Saxena A, Fullem F. Plantar fascia ruptures in athletes. Am J Sports Med 2004;32(3):662–665

Sölveborn SA, Buck F, Mallmin H, Adalberth G. Cortisone injection with anesthetic additives for radial epicondylalgia (tennis elbow). Clin Orthop Relat Res 1995;(316):99–105

Stephens MB, Beutler AI, O'Connor FG. Musculoskeletal injections: a review of the evidence. Am Fam Physician 2008;78(8):971–976

Tallia AF, Cardone DA. Diagnostic and therapeutic injection of the shoulder region. Am Fam Physician 2003;67(6):1271–1278

Thumboo J, O'Duffy JD. A prospective study of the safety of joint and soft tissue aspirations and injections in patients taking warfarin sodium. Arthritis Rheum 1998;41(4):736–739

Wernecke C, Braun HJ, Dragoo JL. The effect of intraarticular corticosteroids on articular cartilage: a systematic review. Orthop J Sports Med 2015;3(5): 2325967115581163

1 Diagnostic Ultrasound and Guided Injection

Abstract
Given its comparative ease of availability, short scanning time, and ability to dynamically assess tissue and structure interplay, ultrasound is rapidly becoming the investigation of choice for many musculoskeletal conditions. This chapter outlines both the normal and common pathological ultrasound appearance of tendons, joints, bursae, muscles, and nerves as well as the use of ultrasound to ensure accurate needle placement during interventional procedures.

In addition to the diagnostic capabilities of ultrasound in the assessment and management of musculoskeletal conditions and in contrast to magnetic resonance imaging (MRI), ultrasound also has the capacity to be used as an interventional modality enhancing the accuracy of injection techniques.

Eustace (1997) demonstrated that even in the hands of musculoskeletal specialists only a minority of injections for shoulder pain were performed accurately with only 29% of subacromial and 42% of intra-articular injections reaching their intended target. Similar results have been demonstrated in patients with de Quervain's tenosynovitis (Zhingis 1998). Perhaps, not surprisingly, outcome has been demonstrated to significantly correlate with accuracy of injection with a systematic review and meta-analysis demonstrating that ultrasound-guided shoulder girdle injections are more accurate and more effective than landmark-guided injections (Aly et al 2014). Needle placement into smaller joint spaces is of particular difficulty, a fact in part due to the lack of aspirate from smaller joints, such as the carpometacarpal joint of the thumb, making accurate needle placement in these joints extremely difficult. For this reason injections performed under imaging are becoming more popular (Balint 1997, Ghozlan 2000, Koski 2000, Weidner 2004). ▶Fig. 1.1 and ▶Fig. 1.2 demonstrate the accuracy possible with ultrasound-guided injection. In ▶Fig. 1.1 an injection is given between the flexor tendon sheath and the tendon of flexor pollicis longus at the level of the metacarpophalangeal joint of the thumb. In ▶Fig. 1.2 a needle is placed immediately deep to the median nerve in the carpal tunnel.

Accurate needle placement is also of importance in more deeply placed structures such as the hip joint in order that both the correct target is injected and that neurovascular structures are avoided. A study by Leopold (2001) assessed the accuracy of needle placement with intra-articular hip injection using only anatomical landmarks as a guide. Using this "blind" approach the needle pierced or contacted the femoral nerve in 27% of anterior injections and was within 5 mm of the femoral nerve in 60% of all anterior attempts. Using a lateral approach the needle was never within 25 mm of any neurovascular structure in any injection; however, only 80% of injections managed to reach the joint cavity. ▶Fig. 1.3 demonstrates injection of the anterior aspect of the hip joint.

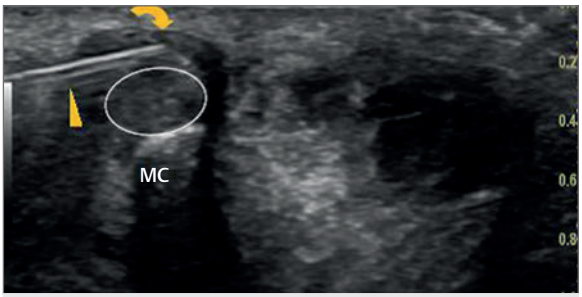

Fig. 1.1 Ultrasound-guided injection of the tendon sheath of flexor pollicis longus at the level of the metacarpophalangeal joint of the thumb (MC). The needle (*yellow arrowhead*) may be seen approaching from the left of the image. The needle rests between the flexor sheath (*yellow curved arrow*) and the tendon itself (*white oval*). In this image the sheath measures approximately 1 mm in depth and demonstrates the accuracy of needle placement possible with ultrasound guidance.

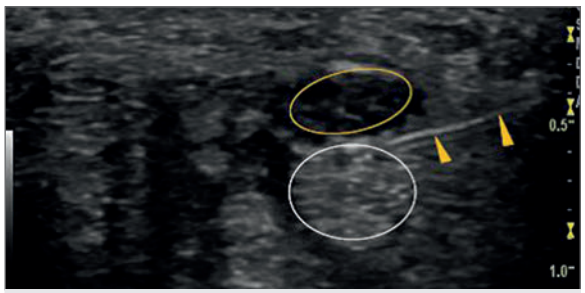

Fig. 1.2 Transverse ultrasound image of the carpal tunnel. The median nerve appears as a low echo oval-shaped foci (*yellow oval*). The tendons of flexor digitorum superficialis (*white oval*) may be seen deep to the median nerve. A needle may be seen immediately between the two (*yellow arrowheads*).

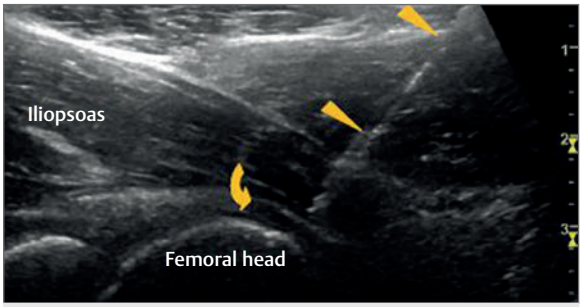

Fig. 1.3 Longitudinal image of the anterior hip joint. A needle (*yellow arrowheads*) may be seen lying up against the anterior joint capsule (*curved arrow*) prior to injection.