Ultrasound guidance allows accurate needle placement and aspiration from small joints in patients with early inflammatory arthritis

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Objectives. To compare the accuracy of palpation-guided and high frequency ultrasound-guided needle placement in small joints and to develop a technique to obtain synovial fluid from these joints for diagnosis and research.

Methods. The accuracy of needle placement during palpation-guided proximal interphalangeal (PIP) or metacarpophalangeal (MCP) joint injection was assessed. This was compared with the accuracy of ultrasound-guided needle placement. A joint lavage technique was developed to obtain synovial fluid from these joints.

Results. Needle positioning was intra-articular in 59% of palpation-guided injections (6/12 PIP and 4/5 MCP joints). No fluid could be aspirated prior to injection. With ultrasound guidance, initial needle placement was intra-articular in 96% of cases (24/26 PIP and 27/27 MCP joints). Synovial fluid cells were lavaged from 63% of joints (19/25 PIP and 14/27 MCP joints). In only one case was a large effusion seen and this was aspirated directly.

Conclusions. The use of high frequency ultrasound to guide needle placement within a small joint allows for significantly greater accuracy than a palpation-guided approach. When followed by lavage, synovial fluid cells and diluted synovial fluid can be obtained from the majority of small joints. This has important clinical and research implications.

KEY WORDS: Ultrasound guidance, Joint injection, aspiration, Small joints, Early inflammatory arthritis.

The ability to place a needle accurately within the joint space is important to allow synovial fluid aspiration for diagnosis and research, and for therapeutic joint injection. Palpation has been the approach traditionally used by rheumatologists to guide needle placement. However, the accuracy of such an approach is poor even with large joints such as the knee [1]. Joints such as the proximal interphalangeal (PIP) and metacarpophalangeal (MCP) represent a particular challenge owing to their small size, making accurate needle placement problematic. The small volume of fluid within these joints makes aspiration difficult even if the needle is appropriately placed.

We aimed to determine the accuracy of palpation-guided needle placement in small joints of the hand, and to compare this with the accuracy achieved using high frequency ultrasound to guide needle placement. Additionally, we aimed to assess whether we could aspirate fluid from inflamed small joints into which a needle had been accurately placed. We found that even with intra-articular needle placement, joint aspiration for diagnosis and research was almost always unsuccessful. To overcome this, we assessed a joint lavage technique and found that we could obtain synovial fluid cells in the majority of cases.

Patients and methods

Ethical approval was obtained from the West Birmingham Local Research Ethics Committee and all patients gave written consent.

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informed consent. The accuracy of palpation-guided needle placement was assessed in patients with small joint synovitis undergoing MCP or PIP joint injection, with 12.5 mg (0.5 ml) hydrocortisone, by a rheumatologist with 6 yr experience in clinical rheumatology and 3 yr experience routinely assessing, aspirating and injecting small joints with early synovitis. Needle placement was determined by high resolution ultrasound using a 5–12 MHz linear transducer (ATL HDI 3000, ATL Ultrasound, Bothwell, WA, USA). The ultrasonographer was a musculoskeletal radiologist with 4 yr experience in musculoskeletal ultrasound. Visualization of the needle tip within the joint space and the subsequent distension of the joint capsule following steroid injection defined intra-articular positioning of the needle. Seventeen small joints were injected (12 PIP and 5 MCP joints).

In an attempt to increase the accuracy of needle placement for intra-articular injection and to obtain synovial fluid cells from inflamed small joints, we assessed the use of ultrasound to guide needle placement into PIP and MCP joints, followed by joint lavage/aspiration.

Fifty-three joints were lavaged from a total of 30 patients. All individuals had clinical evidence of synovitis affecting at least one MCP or PIP joint as assessed by the rheumatologist above. They were assessed as part of longitudinal and cross-sectional studies of early (within 12 weeks of symptom onset) and chronic inflammatory arthritis, respectively. Patients in the longitudinal study underwent small joint lavage at initial presentation and at 4, 8, 12, 24 and 48 weeks, assuming persistence of any degree of clinically apparent small joint synovitis. In addition, clinical and laboratory assessments were performed, including a 66 joint swollen joint count [2] and C-reactive protein (CRP) measurement. One further patient with known osteoarthritis (OA) was seen for diagnostic lavage/aspiration of a swollen PIP joint to exclude a crystal or septic arthritis.

Prior to joint lavage/aspiration, the skin over the affected joint was cleaned with iodine and sterile sonographic gel (Aquagel, Adams Healthcare, Leeds, UK) applied. The joint was imaged in longitudinal section and images were captured on a PC using Matrox-PC-VCR software (Matrox, Stoke Poges, UK) (Fig. 1a). In all patients, the clinical diagnosis of active synovitis was supported by evidence of synovial thickening on ultrasound. A large effusion was seen only in the patient with OA assessed for a swollen PIP joint (Fig. 1e). In all other patients the effusion was either small or not detectable. The position of the joint space was identified by interposing a sterile needle between the transducer and the skin and moving the needle to the site overlying the joint space (Fig. 1b). In the patient with a significant joint effusion, synovial fluid was aspirated directly by introducing a 29 Ch needle (Becton Dickinson, Cowley, UK) attached to a 1 ml syringe into the pocket of fluid under ultrasound guidance. In all other patients, a 29 Ch needle (Becton Dickinson, Cowley, UK) attached to a 1 ml syringe containing 1 ml of lavage fluid was introduced into the joint space under ultrasound guidance (Fig. 1c). Initial lavages were performed with normal saline (B. Braun Melsungen, Melsungen, Germany). For subsequent procedures, 0.5% lignocaine (B. Braun Melsungen, Melsungen, Germany) in normal saline was introduced to relieve any post-aspiration discomfort (see Discussion). Under ultrasound guidance, the joint was injected with lavage fluid up to a volume of 1 ml, or until resistance was felt or the patient described discomfort. The intra-articular position of the needle was confirmed by visualizing a diffuse lifting of the joint capsule during injection. The injected fluid was then aspirated.
Results

Of the 17 small joints (12 PIP and five MCP) injected under palpation guidance, needle positioning was intra-articular in 59% of cases (six PIP and four MCP joints). No fluid could be aspirated prior to injection in any of these cases. As needle placement was extra-articular in many cases it was not considered appropriate to attempt lavage under palpation guidance.

One patient with a large effusion (Fig. 1e) underwent direct small joint aspiration. A total of 0.3 ml of clear synovial fluid was aspirated. There were no crystals on compensated polarized light microscopy, culture was sterile and the predominant cells were macrophages and synoviocytes, consistent with a diagnosis of OA. In the joints of the 30 patients who underwent 53 small joint lavage procedures (26 PIP and 27 MCP joints), the effusion was either small or not detectable. At the time of lavage, patients had a median of 5 (1–22) swollen joints and a median CRP of 13 mg/l (<5–238 mg/l) (normal range <10 mg/l). Needle placement was intra-articular on initial needle passage in 51 of 53 cases. In one of the two cases in which initial needle placement was extra-articular the needle was introduced successfully into the joint space on a second attempt. In those joints in which the needle tip was placed intra-articularly, the median volumes of injected and aspirated fluid were 0.9 ml (0.3–1.0 ml) and 0.1 ml (0–0.6 ml), respectively. Synovial fluid cells were obtained from 76% of PIP joint lavages (19/25) and 52% of MCP joint lavages (14/27) (Fig. 2). This difference was not statistically significant (P = 0.07; χ²-test). No complications of the procedure were observed.

Discussion

The ability to place a needle accurately within an MCP or PIP joint space is important for diagnosis, therapy and research. The diagnosis of crystal or septic arthritis, for example, requires synovial fluid analysis, and intra-articular therapy requires accurate needle positioning prior to injection. In addition, much of the research addressing pathophysiological mechanisms in inflammatory arthritis is carried out on synovial fluid. This is a particular challenge for arthritides such as early rheumatoid arthritis which usually begin with the small joints of the hands and feet and where work has been hindered by difficulty in obtaining samples from such joints.

In view of the importance of needle placement within the joint space of MCP and PIP joints we assessed the accuracy of current standard practice—palpation-guided needle placement. This revealed that the needle tip was extra-articular in 41% of cases when the procedure was performed by an experienced rheumatologist. However, even in the 10 patients in whom the needle was placed intra-articularly, it was not possible to aspirate synovial fluid. It is interesting to note that resting intra-articular pressure, measured following the intra-articular insertion of a 21 Ch needle, has previously been found to be elevated in MCP joints of patients with chronic established RA compared with normal controls (medians 14 mmHg and –2 mmHg, respectively) [3]. We had anticipated that a raised intra-articular pressure would have facilitated direct aspiration in our patients. However, the small volume of intra-articular fluid in most of our patients, and the small gauge of the needle that we used, to minimize discomfort, are likely to account for the inability to aspirate in the vast majority of cases.

The difficulty of accurate intra-articular needle placement has long been appreciated, even for large joints, when the procedure is performed without radiological guidance. In a study of 108 joint injections (79 to the knee or shoulder), 31 were confirmed as extra-articular [1]. Recently, the potential for high frequency ultrasound to image joints, to guide intra-articular needle placement, and, if appropriate, to allow peri-articular structures such as tendons to be avoided, has been recognized [4]. This approach has been utilized on an ad hoc basis to aid intra-articular steroid injection as described in a report of a patient with psoriatic arthritis and MCP joint involvement [5] and to take biopsies of bone from the base of MCP and PIP joint erosions in patients with RA [6]. A recent paper in which ultrasound was used to

![Fig. 2. Synovial fluid lymphocytes, neutrophils and macrophages from (a) an MCP joint lavage of a patient with an early inflammatory arthritis, (b) a PIP joint lavage from a patient with ankylosing spondylitis and (c) a PIP joint lavage from a patient with psoriatic arthritis.](https://academic.oup.com/rheumatology/article-abstract/42/8/976/1774194/1774194)
guide needle placement in a range of joints and soft tissue structures describes successful aspiration on 31 of 32 attempts, whereas with palpation guidance, successful aspiration was achieved in only 10 of 32 cases [7]. In the present study, using high frequency ultrasound to guide needle placement, the needle tip was placed intra-articularly in 96% of cases on initial needle passage.

In the one patient in whom a significant joint effusion was seen, direct aspiration was successful. In the remainder of patients, to enable the retrieval of synovial fluid and its constituent cells, we utilized joint lavage. The PIP or MCP joint was injected with a volume of up to 1 ml. Following injection, as much fluid as possible was aspirated. A number of the initial patients we studied experienced post-aspiration discomfort lasting for several hours. To relieve this during subsequent procedures, the joint was lavaged with 0.5% lignocaine in normal saline in place of normal saline. Synovial fluid cells were obtained from 63% (33/52) of small joints in which the needle was judged to be intra-articular. In 14% of cases it was not possible to aspirate any of the injected fluid. In 4% of cases, there were no cells in the aspirated fluid. In 19% of cases there were a significant number of contaminating peripheral blood cells and it was not possible to determine whether there were any synovial fluid cells within the retrieved population. Chemical analysis of the dilute synovial fluid obtained by lavage must be tempered by the difficulty of determining the degree of dilution accurately. However, comparison of protein ratios, for example, is feasible.

The ability to place a needle tip accurately within a small joint using high frequency ultrasound guidance is a significant advance over palpatation-guided approaches. It allows therapy to be administered accurately and reliably to the intra-articular compartment, and, when combined with lavage, allows the joint content to be sampled for diagnosis and research.

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**References**