Ultrasound Guided Versus Conventional Joint and Soft Tissue Fluid Aspiration in Rheumatology Practice: A Pilot Study

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ABSTRACT. ***Objective.*** To compare joint and soft tissue aspiration using a conventional technique with an ultrasound (US) guided technique.

Methods. In the conventional group, 32 joints in 30 consecutive patients referred for joint aspiration and injection to an experienced consultant rheumatologist were aspirated. In the US guided group, 31 consecutive patients were examined by US to confirm the presence and location of fluid. Following US examination, aspiration was performed by a second rheumatologist based on the US localization of fluid or under direct US guidance.

Results. In the conventional group, successful aspiration was achieved in 10 (32%) joints. In the US guided group, successful aspiration was achieved in 31 (97%) joints. The mean volume of fluid obtained from successful aspirations was similar in both groups (11.7 ml in the US group and 14 ml in the conventional group).

Conclusion. The use of US to localize joint and soft tissue fluid collection greatly improves the rate of diagnostic synovial fluid aspiration, particularly in small joints. This has important implications for accurate administration of local steroid therapy and emphasizes the importance of US as a useful tool in clinical rheumatological practice. (J Rheumatol 2002;29:2209–13)

Key Indexing Terms:

ULTRASONOGRAPHY INTERVENTIONAL ASPIRATION
FLUID JOINT MUSCULOSKELETAL

The aspiration of joint effusion or soft tissue fluid collection is a routine diagnostic and therapeutic procedure in clinical rheumatology. When performing intraarticular and soft tissue injection of corticosteroid, confirmation of accurate needle placement is usually obtained by successful aspiration of synovial fluid. Most rheumatologists recognize that aspiration or injection performed without imaging guidance is not always successful, particularly in the case of small or infrequently aspirated joints. In 3 studies that used radiographic contrast material to confirm accurate intra and periarticular needle placement, the successful injection rates were surprisingly low, with as little as 42% of glenohumeral joint injections and 32% of tendon sheath injections being accurately placed[1-3].

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In 1988, Christensen, *et al* published the first overview of interventional musculoskeletal ultrasound (US)[4]. In the last decade a number of radiologists have described the success of several techniques of US guided joint and soft tissue injection[5-9]. Recently, a number of rheumatologists have also described and advocated the use of US guidance in joint and soft tissue aspiration and injection technique in clinical rheumatology[10-12]. While the use of US has the potential to become a routine tool in rheumatology, the majority of rheumatologists currently practice joint and soft tissue aspiration and injection without US guidance. This is due to the limited availability of musculoskeletal ultrasonographic equipment and training. It is likely that demonstration of the practical advantages of musculoskeletal US in clinical practice will lead to greater interest and support for this technique.

There is limited data evaluating US guided joint and soft tissue aspiration. In the radiological literature, only 4 reports evaluate US guided musculoskeletal intervention on a large spectrum of joints and soft tissue lesions. Van Dalen performed US guided fine needle aspiration on 14 soft tissue fluid collections, but only one, a ganglion, was joint related[13]. Rubens aspirated 12 musculoskeletal inflammatory lesions under US guidance but only 2 were joint related[14], while Wu aspirated 33 soft tissue fluid collections using US guidance but only 3 were intraarticular[15]. More recently Sofka, *et al* published the largest series of 15

intraarticular US guided aspirations in different joints[16]. All 4 studies confirm the successful application of US guided percutaneous soft tissue and joint aspiration, but no study has compared US guided with conventional aspiration as performed in routine rheumatology practice.

MATERIALS AND METHODS

Patients. Two patient groups were selected for comparison of US guided and conventional clinical aspiration of joint and soft tissue fluid collections. In each group 32 consecutive joint aspirations or soft tissue aspirations were attempted. Thirty-one patients (17 women, 14 men) with an average age of 60 years (range 29–95 yrs) were referred for US guided aspiration after examination by a referring rheumatologist had determined the presence of an effusion of the joint or a soft tissue fluid collection of the extremities. Seventeen patients had rheumatoid arthritis (RA) (including one who had 2 joints aspirated), 5 patients had osteoarthritis (OA), 8 had seronegative arthritis (6 had monoarthritis of unknown aetiology, one had psoriatic arthritis (PsA), one had juvenile chronic arthritis, and one patient had a repetitive strain injury. Four of the joints aspirated were prosthetic. US guided aspiration was performed after a further physical and US examination. For US examination, an ATL (Advanced Technology Laboratories, Bothell, WA, USA) HDI (High Definition Imaging) 3000 US machine with a linear (L) 7-4 MHz and a compact linear (CL) 10-5 MHz probe was used. One patient was selected twice (initially for knee aspiration and then for Baker's cyst aspiration). Patients referred for US guided aspiration with no US evidence of fluid were excluded from this study. Of the 31 patients referred, 6 patients had a previous unsuccessful conventional fluid aspiration despite physical findings of a joint effusion or fluid collection. One patient (an intravenous drug abuser) had unsuccessfully attempted self-aspiration of an ankle joint. The remaining patients were referred for US examination based on either the clinical assumption of a small effusion, atypical locations of fluid collections, a high priority aspiration to identify infection or crystal disease, prevention of Baker's cyst rupture, or for more complete aspiration of a collection.

US examination and aspiration. The US examination and physical examination were performed by 2 different rheumatologists, who were not blinded to each other's findings. The following criteria were used for determination for fluid collection: (1) an anechoic or hypoechoic lesion without a power Doppler, color Doppler, or spectral Doppler sign, and which was compressible by probe pressure; (2) an anechoic or hypoechoic area containing material that was ballotable by US probe pressure; (3) a so-called cartilage sign (hyperechoic interface) between the anechoic or hypoechoic area and hyaline cartilage; or (4) acoustic enhancement behind an anechoic area.

The presence of any one of the 4 criteria was accepted as a high suspicion of fluid collection and US guided aspiration was performed to confirm this assumption. During the US examination, the 2 rheumatologists agreed on the entry point, needle size, and approach of joint or soft tissue aspiration depending on the position of the fluid collection and the depth of the fluid collection from the skin surface. Either direct needle guidance under sonographic visualization (Figure 1, n = 14 aspirations) or skin surface marking and aspiration without direct needle visualization (Figure 2, n = 18 aspirations) was used. Direct needle guidance was used for fluid collections in deeper joints (e.g., hip) and when neurovascular structures were close to the entry point or approach used. These 2 methods have been described in detail[10]. The direct method may be performed as a freehand method or with the use of a biopsy guidance kit. We used the freehand technique in this study. During the direct method, sterile gel or only antiseptic liquid was used as a coupling material. In each case the approach to the joint and the amount of fluid obtained was recorded. Successful aspiration was defined by the ability to remove recordable amount of synovial fluid. If there was no contraindication, intraarticular or intralesional steroid injection was administered after the aspiration.

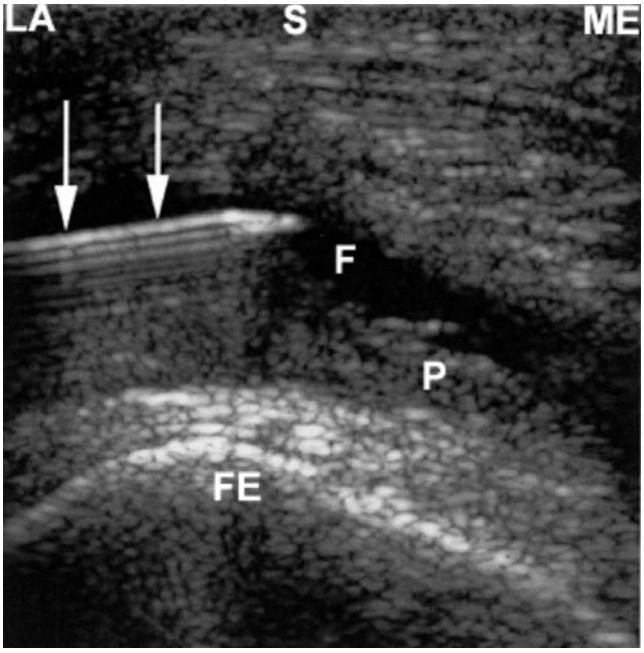

Figure 1. Transverse anterior US image. Direct needle guidance. Suprapatellar bursa aspiration from superolateral. LA: lateral, ME: medial, S: skin, F: fluid, P: pannus, FE: femur. Arrows show the needle. Note the needle tip is in the fluid, the pannus was avoided.

Conventional examination and aspiration. For comparison, another 30 consecutive patients (25 women, 5 men) with an average age of 55 years (range 22–92 yrs) who underwent joint or soft tissue aspirations were documented prospectively from a joint injection clinic and rheumatology outpatient clinic. Seventeen patients had RA (including both patients who underwent 2 aspirations), 6 patients had OA, and 6 had seronegative arthritis (2 had PsA, 2 reactive arthritis, one seronegative spondyloarthropathy, one undifferentiated inflammatory arthritis, and one juvenile chronic arthritis). Two patients had bilateral joint aspiration (one in both elbows, one in both wrists). A different senior rheumatologist with over 15 years' experience in joint injection examined and attempted to aspirate these patients' joints. The approach selected for joint aspiration in each joint was based on the clinician's judgement of the localization of joint fluid. This patient group was not examined by ultrasonography. The injection approach to the joints and amount of fluid obtained were also recorded. The 2 groups of rheumatologists were aware of the purpose of the study but were blinded to each other's results until the study was completed.

RESULTS

In the US guided group, 31 of 32 attempted aspirations were successful, giving a 97% success rate in this series (Table 1). In the conventional group, 10 of 32 attempted aspirations were successful, giving a 32% success rate. In the US guided group, synovial fluid was obtained from 6/6 (100%) joints that had previously proved unsuccessful using the conventional technique.

A wider range of joints were successfully aspirated in the US guided group including small joints of the hands and feet, deep structures such as the hip joint, and soft tissue collections (Table 1). In the US guided group, aspiration was attempted in 4 small joints [3 metatarsophalangeal

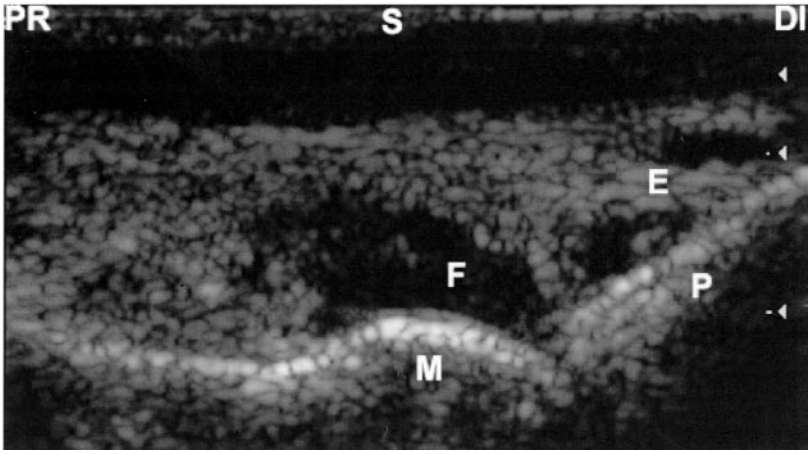

Figure 2. Longitudinal dorsal US image of the first MTP joint with intraarticular effusion. PR: proximal, DI: distal, S: skin, E: extensor tendon, F: fluid, M: metatarsal head, P: phalangeal bone. Note the fluid collection mainly in proximal position and not in the midline position.

Table 1. Comparison of success rate of conventional and US guided joint aspiration (numbers in parentheses are successful aspirations).

Aspiration Site	Conventional	US Guided
Shoulder	4 (1)	2 (2)
Elbow	8 (3)	1 (1)
Wrist	4 (1)	—
Hip	—	1 (1)
Knee	10 (4)	19 (18)
Ankle	5 (1)	1 (1)
Small joints (CMC, MTP, PIP)	1 (0)	4 (4)
Soft tissue (bursa, tendon sheath, cyst, wound)	—	4 (4)
Total	32 (10)	32 (31)

(MTP) and one proximal interphalangeal (PIP) joint] and joint aspiration was successful in all 4 cases. In the conventional group only one small joint aspiration was attempted (one carpometacarpal joint) and this failed to obtain fluid. Four soft tissue lesions were aspirated in the US guided group with a 100% success rate (Table 1). Soft tissue aspiration was not performed in the conventional group.

When corrected for successfully aspirated joints in each group, the mean volume of fluid obtained in the US guided group was 11.67 ml versus 13.97 ml in the conventional group, although a greater number of small joints were aspirated in the US guided group. Sufficient synovial fluid for diagnostic evaluation was obtained from 27/28 joints using US guidance: knee (range 0.5–100 ml), shoulder (5–9 ml), elbow (4.5 ml), ankle (10 ml), hip (5 ml), MTP (1–1.5 ml), PIP (0.2 ml); and from 4/4 soft tissue fluid collections: iliotibial bursa (3 ml), tibialis anterior (2 ml), medial thigh cyst (25 ml), postoperative knee wound (3 ml).

Knee joint arthrocentesis was the most frequent procedure in both groups, with a 95% success rate in the US guided group and a 40% success rate in the conventional group. Conventional arthrocentesis of the knee was performed using a medial midline approach in 7 (70%) cases, a superolateral approach in 2 cases, and a lateral midline approach in one case. In contrast, US guided arthrocentesis of the knee was performed using a superolateral approach in 12 cases, a lateral midline approach in 3 cases, a medial midline approach in one (6.25%) case, and a posterior approach into enlarged semimembranosis gastrocnemius bursae (Baker's cysts) in 3 cases. The posterior approach was not attempted by the conventional technique. In one case the posterior approach for injection was used as a symptomatic Baker's cyst had persisted following a conventional superolateral joint injection. In a second case, 100 ml of synovial fluid was obtained from a large Baker's cyst under US guidance in order to prevent cyst rupture. If the 3 Baker's cysts aspirated via a posterior approach are excluded from the 19 US guided knee aspirations then 12/16 (75%) knees were aspirated from the lateral part of the suprapatellar bursa. In the conventional group only 2/10 (20%) were aspirated from this direction.

DISCUSSION

Cadaver studies show that US has a high sensitivity for the detection of fluid in joints. In the cadaver ankle and hip, as little as 2 ml of fluid can be detected by US[17,18]. The volume threshold for clinical detection of joint effusions is not known, although clinical examination underestimates the presence of intraarticular fluid when compared to US[19]. Ultrasonography can also reveal small amounts of residual fluid following aspiration. This study confirms that US is extremely sensitive for the detection of fluid in or around a wide range of synovial joints in clinical rheumatology practice. The volume of synovial fluid observed on US in this series was sufficient for diagnostic analysis in all 31

successfully aspirated joints and soft tissue fluid collections.

In a comparison of 2 series of patients undergoing arthrocentesis, US guided aspiration was found to be superior to conventional guided aspiration in obtaining synovial fluid. There are a number of possible sources of error when using the conventional aspiration technique. All patients had been examined by an experienced rheumatologist who suspected a fluid collection on clinical examination. However, the clinical determination of a fluid collection may be incorrect. We did not independently confirm whether a fluid collection was present in the conventional group. In a separate study, US of the knee in patients with RA confirmed that the clinical finding of a knee effusion was correct in 64% of patients[19]. No data exist on the relationship of clinical examination and US in the detection of effusion in other joints. If the clinical finding of a joint effusion is assumed to be correct in 64% of joints, this would still give only a 48% (10/21) success rate for conventional guided aspiration. Further studies of conventional joint aspiration when the presence of fluid is confirmed independently are planned to clarify these results but this would require careful consideration by an ethics committee.

Based on clinical examination, the approach selected for aspiration may be inappropriate for the location of the fluid collection. During conventional aspiration, rheumatologists use superficial skin and bony landmarks for deciding the most suitable entry point, usually aimed towards the radiological joint space. Knowledge of the surface anatomy is applied in selecting the shortest route to the joint and in avoiding trauma to neurovascular bundles. As applied in this study, conventional aspiration was predominantly performed using a midline approach with a poor success rate. A magnetic resonance imaging (MRI) study of 5 unsuccessful knee aspirations suggested that accurate placement in viscous fluid or inaccurate placements in adipose tissue are the principal causes of a dry tap. The authors propose that this may be more likely to occur using a medial midline approach directed at the radiological joint space[20]. Using ultrasonography we observed that joint recesses other than those at the radiological joint space contain sufficient fluid for safe aspiration. This led to preference for the superolateral approach to knee arthrocentesis. Directing the needle accurately to these recesses resulted in a superior success rate and minimized trauma to both the neurovascular and the hyaline cartilage. In small MTP joints of the foot it was observed that the effusion is mainly located proximal to the joint space (Figure 2) with less fluid at the radiological joint space. This was also observed in PIP joint effusions. This is possibly due to the influence of the overrunning extensor tendon on the boundary of the joint capsule. Ultrasonography allows the joints to be visualized as a 3 dimensional structure where the real boundary of aspiration is the capsule and the real joint space is not the deeper space between the bones comprising the joint but the entire space within the joint capsule. US guided aspiration is the method of choice to aspirate fluid from this space.

Conventional guided aspiration may be unsuccessful due to the use of an inadequate needle diameter for viscous synovial fluid. During US examination, the depth of the fluid collection from the skin surface and the viscosity of the effusion influenced the selection of the appropriate needle size (diameter and length) for arthrocentesis. In one case the needle that was originally selected was changed because fluid was not obtained despite direct visualization of correct needle placement. A larger bore needle was selected for a second attempt. During this second attempt 10 ml of pus was aspirated, confirming a diagnosis of septic arthritis. Without US it is likely that this diagnosis would have not been made without significant delay, particularly as the patient had a total hip replacement, making interpretation of MRI or computer tomographic imaging difficult in this setting.

US guided intervention is a safe method[21] with ordinary antisepsis[22]. There are no data in the musculoskeletal field comparing the complication rates of direct and nondirect visualization methods of US aspiration. In this study, 2 different methods of US guidance were used. Direct visualization of the needle is considered to be the superior technique as it confirms the correct position of the needle within the fluid collection. The best evidence of accurate placement is when fluid is successfully obtained. In applying this criterion, there was no difference in the success rate of the 2 methods of US guidance used in this study. If the nondirect method fails, the operator can simply switch to the direct method. This mixed approach was not necessary in our series as all nondirect aspirations were successful. The advantage of the nondirect visualization method is that we find it to be quicker and technically simpler. In this study, the majority of US guided aspirations were nondirect and required an additional 5 to 10 minutes for US examination.

Direct visualization is preferred when the fluid collection is closely related to a neurovascular bundle and allows the spatial relationship of needle and structure to be controlled during the aspiration. The disadvantage is that the needle must be placed in a nearly parallel position to the linear probe surface for the best reflection. Using a curvilinear probe the operator needs to obtain a needle–probe angle of 55°–60° for the best visualization of the needle[23]. This may necessitate a longer needle and a longer approach through the surrounding tissues.

The single failed aspiration in the US guided group occurred during a direct visualization of the needle in a hypoechoic area of the suprapatellar bursa in a patient with RA. No needle change was implemented, so it is not known if the US lesion was a thickened fluid collection or a compressible synovial proliferation. In this case there was no suspicion of infection and steroid was injected into the bursa without resistance. This case shows the possibility of

confusing a hypoechoic fluid collection for hypoechoic synovial proliferation due to their similar US appearances. In the other cases synovial proliferation and fluid collection were readily differentiated. A new method called remote palpation using acoustic streaming will eventually solve the problem of differentiating fluid from solids[24].

In this pilot study, US guided aspiration was superior to conventional joint aspiration. US guided aspiration allowed synovial fluid to be obtained for diagnostic evaluation in a wider range of settings including small joints of the hands and feet, deep joints such as the hip, soft tissue fluid collections, and joints with a previous dry tap by conventional techniques. This was due to accurate localization of fluid and the improved understanding of joint anatomy obtained by ultrasonography. The use of ultrasonography in routine rheumatology practice will allow improved aspiration of joint effusions, particularly after a dry tap by the conventional technique. As US also allows detection and localization of effusions not detected on clinical examination, it is likely that rheumatologists will increasingly apply US in their clinical practice.

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