

# Does ultrasound guidance improve the outcomes of arthrocentesis and corticosteroid injection of the knee?

WL Sibbitt Jr<sup>1</sup>, LG Kettwich<sup>2</sup>, PA Band<sup>3</sup>, NR Chavez-Chiang<sup>1</sup>, SL DeLea<sup>1</sup>, LJ Haseler<sup>4</sup>, AD Bankhurst<sup>1</sup>

<sup>1</sup>Department of Internal Medicine, Division of Rheumatology and <sup>2</sup>School of Medicine, University of New Mexico Health Sciences Center, Albuquerque, NM, <sup>3</sup>Orthopaedic Surgery and Pharmacology, New York University Hospital for Special Surgery, New York, NY, USA, and <sup>4</sup>Griffith Health Institute, Griffith University, Gold Coast, Australia

**Objective:** The present randomized controlled trial compared arthrocentesis of the effusive knee followed by corticosteroid injection performed by the conventional anatomic landmark palpation-guided technique to the same procedure performed with ultrasound (US) needle guidance.

**Methods:** Sixty-four palpably effusive knees were randomized to (i) palpation-guided arthrocentesis with a conventional 20-mL syringe (22 knees), (ii) US-guided arthrocentesis with a 25-mL reciprocating procedure device (RPD) mechanical aspirating syringe (22 knees), or (iii) US-guided arthrocentesis with a 60-mL automatic aspirating syringe (20 knees). The one-needle two-syringe technique was used. Outcome measures included patient pain by the Visual Analogue Scale (VAS) for pain (0–10 cm), the proportion of diagnostic samples, synovial fluid volume yield, complications, and therapeutic outcome at 2 weeks.

**Results:** Sonographic guidance resulted in 48% less procedural pain (VAS; palpation-guided:  $5.8 \pm 3.0$  cm, US-guided:  $3.0 \pm 2.8$  cm,  $p < 0.001$ ), 183% increased aspirated synovial fluid volumes (palpation-guided:  $12 \pm 10$  mL, US-guided:  $34 \pm 25$  mL,  $p < 0.0001$ ), and improved outcomes at 2 weeks (VAS; palpation-guided:  $2.8 \pm 2.4$  cm, US-guided:  $1.5 \pm 1.9$  cm,  $p = 0.034$ ). Outcomes of sonographic guidance with the mechanical syringe and automatic syringe were comparable in all outcome measures.

**Conclusions:** US-guided arthrocentesis and injection of the knee are superior to anatomic landmark palpation-guided arthrocentesis, resulting in significantly less procedural pain, improved arthrocentesis success, greater synovial fluid yield, more complete joint decompression, and improved clinical outcomes.

Arthrocentesis is useful for the diagnosis of septic or inflammatory arthritis, and is the basic underlying procedure for intra-articular therapy, including therapeutic arthrocentesis, needle lavage, and intra-articular injection (1–8). Complete arthrocentesis before injection of corticosteroid or hyaluronan confirms the diagnosis, reduces the possibility of superimposed infection, reduces patient pain, and improves the response to the injected drug (5–12). Despite the importance of arthrocentesis to the diagnosis and management of arthritis, arthrocentesis with conventional methods can be unsuccessful, painful, and unnecessarily traumatic (11–21).

Ultrasound (US) is increasingly used to detect synovial effusions and to guide the needle for arthrocentesis and intra-articular injections (21–30). However, it remains controversial whether US guidance is beneficial for diagnostic arthrocentesis, therapeutic arthrocentesis, or intra-

articular injections (21–33). Certain recent studies have found that US guidance does not improve the outcomes of arthrocentesis or intra-articular injections, although these negative results may have been due to technique and selection of syringe device rather than to a primary failure of US guidance (21, 30, 33, 34).

We hypothesized that US-guided arthrocentesis of the knee followed by corticosteroid injection would be superior to the conventional technique. The present randomized controlled study examined the outcomes of arthrocentesis and injection of the effusive knee using conventional methods compared to US-guided aspiration and injection.

## Methods and materials

### Subjects

This project was in compliance with the Helsinki Declaration and approved by the institutional review board (IRB), and was registered at ClinicalTrials.gov (Clinical Trial Identifier NCT00651625). Inclusion criteria included: (i) palpable symptomatic effusion of the knee with suprapatellar distention, (ii) indications for

Wilmer L Sibbitt, Jr., MSC 10 5550 5th FL ACC, University of New Mexico Health Sciences Center, Albuquerque, NM 87131, USA.  
E-mail: wsibbitt@salud.unm.edu

Accepted 19 June 2011

therapeutic-diagnostic arthrocentesis, (iii) indication for corticosteroid injection, and (iv) formal consent of the patient to undergo the procedure and participate in the research. Sixty-four palpably effusive knees were randomized to (i) palpation-guided arthrocentesis with a conventional 20-mL syringe (22 knees), (ii) US-guided arthrocentesis with a 25-mL reciprocating procedure device (RPD) mechanical syringe (22 knees), or (iii) US-guided arthrocentesis with a 60-mL automatic syringe (20 knees). Forty-three of the subjects had rheumatoid arthritis and 21 osteoarthritis of the knee randomized and evenly distributed between the treatment groups. Age and gender were similar between the treatment groups ( $p > 0.4$  for all).

#### Needle introduction technique for US-guided arthrocentesis

The straight leg lateral suprapatellar bursa (superiolateral) approach was used to insert the needle and perform arthrocentesis (Figures 1–4) (13–15). Prior to the procedure, the presence of suprapatellar bursal distention was confirmed by physical examination. The knee was placed in the extended position, and the US probe placed transversely over the quadriceps tendon to image the distended suprapatellar bursa (Figure 1).

The one-needle multiple-syringe technique was used, where (i) one needle is used for anaesthesia, arthrocentesis, and intra-articular injection; (ii) a first syringe or syringes are used to anaesthetize the synovial membrane and completely aspirate effusion, and (iii) a final syringe is used to inject the intra-articular therapy (19). For the US-guided procedures, a 25-gauge 1.5-inch needle (305783 BD Eclipse Safety Needle; BD, Franklin Lakes, NJ, USA; www.bd.com) was mounted on a 5-mL RPD mechanical syringe (3-mL RPD procedure syringe; AVANCA Medical Devices, Inc, Albuquerque, NM, USA; www.avancamedical.com) filled with 5 mL of 1% lidocaine (Xylocaine® 1%, AstraZeneca Pharmaceuticals LP, Wilmington, DE, USA). Using a 25-gauge needle on the mechanical syringe, 3 mL of lidocaine was used to first anaesthetize the skin, subcutaneous tissues, and synovial membrane. The needle was then extracted and inactivated, and rotated off of the mechanical syringe. Subsequently, an 18-gauge 1.5-inch needle was placed on the 5-mL mechanical syringe, and introduced into the knee, expelling the remaining 2 mL of lidocaine into the synovial membrane, and then the lateral parapatellar recess of the suprapatellar bursa was penetrated and 5 mL of synovial fluid aspirated into the mechanical syringe (Figures 1 and 2). The 5-mL mechanical syringe was then rotated off of the intra-articular needle and the needle left in place.

#### Arthrocentesis with the RPD mechanical syringe

The mechanical syringe for arthrocentesis was a 25-mL RPD mechanical syringe (AVANCA Medical Devices,



Figure 1. Needle introduction and anaesthesia with a 5-mL mechanical syringe. This photograph demonstrates an RPD mechanical syringe being used in a one-handed fashion after surface anaesthesia for introduction of the 18-gauge 1.5-inch arthrocentesis needle. The larger plunger is depressed with the thumb for injection and the smaller plunger is depressed with the thumb for aspiration. The free hand is used to steady the patient, feel the surface anatomy, or operate other devices. After filling the 5-mL mechanical syringe, syringe exchange is performed, placing either the 25-mL RPD mechanical syringe or the 60-mL vacuum syringe on the indwelling intra-articular needle.

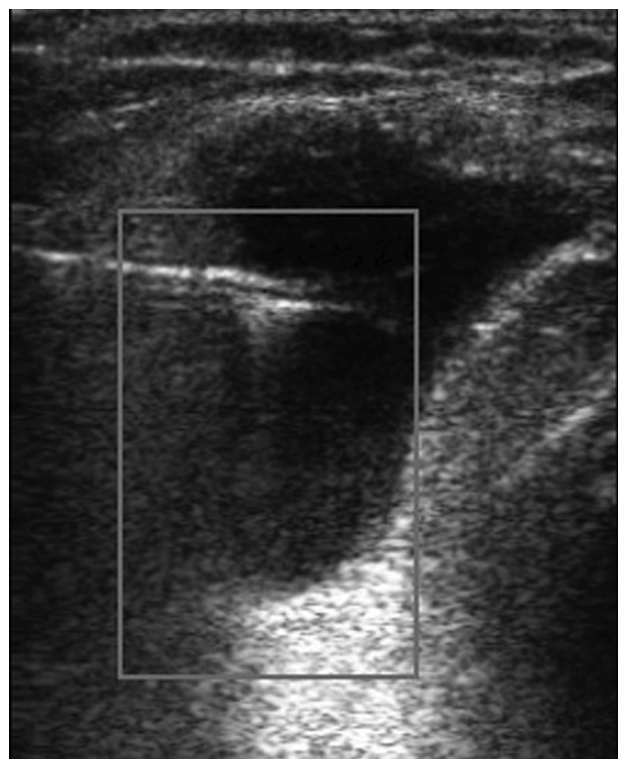


Figure 2. Ultrasound-guided needle introduction. This sonographic image shows the needle introduced into the effusion of the suprapatellar bursa from the superiolateral portal with a straight positioning.



Figure 3. Arthrocentesis with a 25-mL mechanical syringe. This photograph demonstrates the mechanical syringe being used in a one-handed fashion for aspiration and drainage of a knee effusion. The 25-mL device has been attached to the introduced intra-articular needle as shown in Figures 1 and 2. The larger plunger is depressed with the thumb for injection and to clear the needle, and the smaller plunger is depressed with the thumb for aspiration. As shown here, the smaller plunger is depressed gently for continuous aspiration. The free hand is used to feel the anatomy, steady the syringe, apply pressure to the effusion, or to operate an ultrasound transducer.



Figure 4. Arthrocentesis with a 60-mL automatic syringe. This photograph demonstrates a 60-mL automatic aspirating syringe being used in a one-handed fashion for aspiration and drainage of a knee effusion. The flow valve is opened with the thumb, and then the syringe is passively held as it performs large volume arthrocentesis.

Inc). The mechanical syringe is formed around the core of a conventional syringe barrel and plunger but has a parallel accessory plunger and an accessory barrel to control the motion of the accessory plunger (Figure 3). The two plungers are linked mechanically by a pulley in an opposing fashion, resulting in a set of reciprocating plungers. Thus, when the aspiration plunger is depressed with the thumb, the syringe aspirates, and when the injection plunger is depressed with the thumb, the syringe injects. This permits the index and middle fingers to remain in one position during both aspiration and injection, while

the thumb only needs to move in a horizontal plane to the alternative plunger to change the direction of aspiration or injection. This device permits greater control when used with sonography and easy detection of small amounts of synovial fluid that flash back into the barrel confirming true intra-articular positioning (21, 35–40).

For more complete arthrocentesis, a 25-mL mechanical syringe was first cycled to break the bond of the plunger stopper with the barrel, and the air was then expelled. The mechanical syringe was then rotated on the indwelling needle (or the needle rotated on the syringe) and then the aspiration plunger was gently depressed. The mechanical syringe was then filled with 25 mL of synovial fluid while controlling the needle with US guidance. If the joint was not completely decompressed, the mechanical syringe was rotated off of the intra-articular needle, and the syringe emptied into a sterile specimen container. The mechanical syringe was then reattached and filled again as above. After the joint had been aspirated as completely as possible by sonography, the mechanical syringe was rotated off of the needle, and a 3-mL conventional syringe prefilled with 80 mg triamcinolone acetonide suspension [Kenalog® 40, Westwood-Squibb Pharmaceuticals, Inc (Bristol-Myers Squibb), New York, NY, USA] was rotated onto the intra-articular needle, and the treatment was injected. The needle was then extracted, and firm pressure applied to the puncture site.

#### Arthrocentesis with the automatic syringe

The automatic syringe consisted of a conventional 60-mL syringe (309653 60-mL Syringe, Luer-Lok™ Tip; BD) that was fitted with a sterile flow switch and locking plunger (AVANCA Medical Devices, Inc). To create a vacuum in the 60-mL syringe, the flow switch was closed, the plunger pulled back to the 60-mL mark and the plunger locking mechanism activated, fixing the plunger in the aspiration position (Figure 4). This 60-mL automatic syringe achieved a vacuum level of 650 Torr (mmHg).

The 60-mL automatic syringe was rotated onto the 18-gauge indwelling intra-articular needle. The flow switch was then opened and synovial fluid began flowing automatically into the syringe (Figure 4). Movement of fluid could be observed in the transparent portion of the flow switch. The syringe was then filled automatically with up to 60 mL of fluid. If more fluid remained, the flow switch was closed, and the vacuum syringe and switch were rotated off of the indwelling needle. Then a second automatic syringe was attached and the flow switch opened and the process was repeated. After complete arthrocentesis (Figure 5), the automatic syringe was rotated off and corticosteroid injected as above.

#### Conventional landmark palpation-guided arthrocentesis

The palpation-guided injection procedure was also performed in a standardized manner using the one-needle

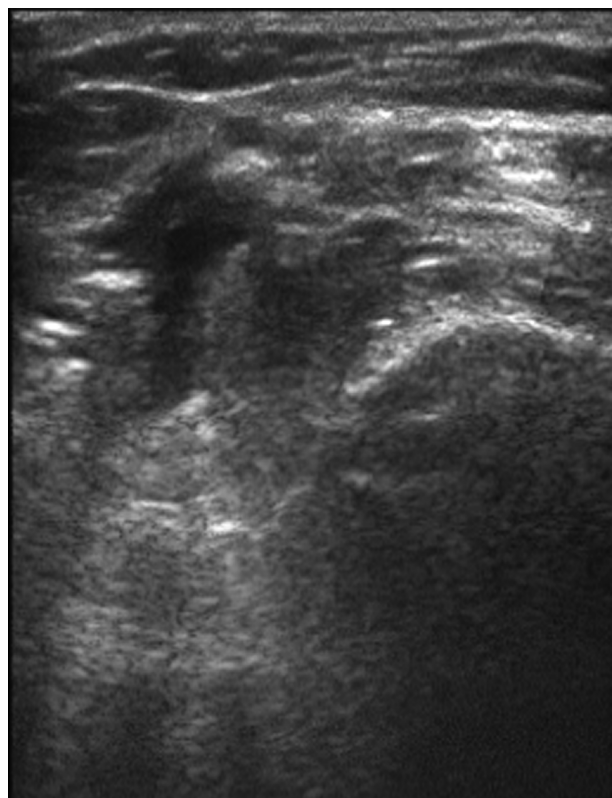


Figure 5. Complete arthrocentesis. This sonographic image shows collapse of the suprapatellar bursa after full aspiration and injection with corticosteroid.

two-syringe technique as above but using conventional syringes without sonographic guidance. A 5-mL or 20-mL conventional syringe (309604; BD), as appropriate, was operated with two hands and was used for all palpation-guided procedures.

**Outcome measures**

Aspirated fluid volume was quantified in millilitres. Adequate diagnostic fluid was defined as 2.5 mL (0.5 mL

for crystal examination, 1 mL for culture, and 1 mL for cell counts). Patient pain was measured with the standardized and validated 0–10 cm Visual Analogue Scale (VAS) for pain, where 0 cm = no pain and 10 cm = unbearable pain (21, 34–43). Significant pain was defined as a VAS score  $\geq 5$  cm (19). Pain by VAS was determined prior to the procedure (baseline pain), during arthrocentesis (procedural pain), and 2 weeks post-procedure (pain at primary outcome). The pain scores at the primary outcome were obtained by an observed blinded to treatment arm. Two weeks has been demonstrated as the outcome measurement time most likely to detect maximum clinical effect of injected corticosteroid (44–47); thus, the 2-week observation was considered the primary outcome measure (21).

**Statistical analysis**

Data were entered into Excel and analysed in SAS. The primary comparison was between anatomic landmark palpation-guided procedures and pooled US-guided procedures, and the secondary comparison between the automatic syringe and the RPD mechanical syringe. Measurement data were compared post-hoc with the Student t-test, and categorical data with Fisher’s exact test with corrections for multiple comparisons. A power calculation was made using preliminary data at this level, where  $\alpha = 0.0001$ , power = 0.9, and allocation ratio = 1.0 indicated that  $n = 10$  in each group would provide statistical power at the  $p < 0.001$  level and  $n = 20$  in each group at the  $p < 0.0001$  level.

**Results**

Other than procedural pain, there were no complications in any of the treatment groups. US-guided arthrocentesis was superior in all outcome measures (Table 1). Direct clinical comparisons between the two US-guided techniques are shown in Table 2. Both techniques permitted

Table 1. Clinical outcomes of US-guided arthrocentesis.

	Conventional palpation-guided arthrocentesis	US-guided arthrocentesis	Percentage difference	95% CI	p-value
Number of subjects	22	42			
Pre-procedure baseline pain (10 cm VAS), cm	7.7 $\pm$ 1.8	7.5 $\pm$ 2.0	–3	–15 to +9.8	0.68
Procedural pain (10 cm VAS), cm	5.8 $\pm$ 3.0	3.0 $\pm$ 2.8	–48	–74 to –22	0.001
Significant procedural pain (10 cm VAS $\geq$ 5 cm), %	68 (15/22)	31 (13/42)	–54	–169 to –83	0.004
Percentage of successful diagnostic aspiration ( $\geq$ 2.5 mL)	82 (18/22)	100 (42/42)	+22	5 to 47	0.003
Mean aspirated synovial fluid, mL	12 $\pm$ 10	34 $\pm$ 25	+183	110 to 276	0.0001
Pain at outcome (2 weeks) (10 cm VAS), cm	2.8 $\pm$ 2.4	1.5 $\pm$ 1.9	–46	–88 to –5	0.034

CI, Confidence interval.

Values given as number, percentage, or mean  $\pm$  standard deviation.

Table 2. Clinical outcomes of aspirating syringes.

	60-mL automatic syringe	25-mL mechanical syringe	Percentage difference	95% CI	p-value
Number of subjects	22	20			
Pre-procedure baseline pain (10 cm VAS), cm	7.5 ± 1.8	7.4 ± 2.2	-1	-18 to +15	0.87
Procedural pain (10 cm VAS), cm	2.9 ± 3.1	3.1 ± 2.5	+7	-54 to +68	0.82
Significant procedural pain (10 cm VAS ≥ 5 cm), %	32 (7/22)	30 (6/20)	-6	-87 to +79	0.87
Mean aspirated synovial fluid, mL	35 ± 23	34 ± 27	-3	-47 to +42	0.90
Inability to clear needle, %	9 (2/22)	0 (0/20)	-100	-306 to +91	0.35
Pain at outcome (2 weeks) (10 cm VAS), cm	1.5 ± 1.8	1.6 ± 2.1	+7	-75 to +88	0.87

CI, Confidence interval.

Values given as number, percentage, or mean ± standard deviation.

facile large volume body fluid aspiration, and were equivalent in procedural pain, aspirated fluid volume, and pain outcome. In two cases with the automatic syringe, the 18-gauge needle became clogged with a loculated effusion, and could not be cleared without disengaging the locking plunger. By contrast, when the needle became clogged on the mechanical syringe, it could be easily cleared by depressing the injection plunger and then aspiration could be resumed by gently depressing the aspiration plunger.

## Discussion

The present study compared US-guided arthrocentesis to conventional anatomic landmark palpation-guided arthrocentesis and demonstrated improved patient outcomes with US guidance, including significantly less procedural pain, greater aspirated fluid volume, a greater percentage of successful diagnostic arthrocentesis, and improved response to corticosteroid injection (Tables 1 and 2). Thus, the present study demonstrates that US-guided arthrocentesis of the effusive knee is superior to conventional anatomic landmark palpation-guided arthrocentesis.

A number of prior studies have examined the use of US guidance for arthrocentesis and/or intra-articular injection specifically of the knee. Im et al demonstrated that US increased the accuracy of needle placement for successful intra-articular injection into the knee (48). Kane et al, Delaunoy et al, and Ike et al have demonstrated that US can detect small effusions in the knee, and may assist with more successful arthrocentesis (22, 23, 27). Wiler et al reported that US-guided arthrocentesis of the knee did not significantly increase fluid yield (30). Cunnington et al, in a large study of inflammatory arthritis that included knees, found that US significantly improved intra-articular accuracy but did not improve injection outcomes (33). Thus, the prior literature is inconsistent regarding the role of US guidance in arthrocentesis and injection of the knee.

The present study demonstrates that US guidance significantly reduces the procedural pain of arthrocentesis (Table 1), confirming prior reports (30). Although the causes of reduced procedural pain are uncertain, better control and direction of the needle tip away from pain-sensitive structures into the target structure are likely explanations (18, 21, 34–41). Im et al demonstrated that US increased the accuracy of needle placement, and this increased accuracy into the joint and away from pain-sensitive structures could result in less pain (48). Reduction of procedural pain has also been demonstrated with better control of the needle (33–41). An alternative explanation is that the cooling effect of US gel, the pressure from the US transducer, and the patient observing the sonographic image may have a distracting effect at the neurocognitive level, significantly reducing pain and anxiety (17, 49, 50).

The present study also demonstrated a significant increase in successful diagnostic arthrocentesis and a significant increase in aspirated fluid volume, unlike the previous reports of arthrocentesis of the knee (Table 2). The increased synovial fluid yield in the present study compared to Wiler et al (30) is probably the result of different patient populations; the Wiler et al study was performed in an emergency department where the knees were extremely symptomatic and massively and acutely distended, whereas the present study was performed in a rheumatology clinic with more chronic effusions with typically less acute distention (30). This is confirmed by comparing the fluid yields of the Wiler et al study in which the US group yielded 32% more fluid than the present study, indicating more massive acute effusions presenting a much larger target for the needle and, thus, less need for US guidance (9–11, 30).

The current study demonstrated that US-guided arthrocentesis and intra-articular injection of the knee improved outcomes compared to the conventional anatomic landmark palpation-guided technique (Table 1). By contrast, the recent Cunnington et al study demonstrated no improvement in intra-articular injection outcomes with

US guidance (33). The reasons for these differing results are almost certainly due to the diverging methods of the two studies. In contrast to the Cunnington et al study, which used direct one-step injection, the present study used a two-step one-needle two-syringe technique including complete US-guided arthrocentesis prior to injecting the intra-articular medication (33). Arthrocentesis is important, as aspirating synovial fluid into the syringe further confirms true intra-articular positioning of the needle tip, and complete decompression of the joint by arthrocentesis prior to injection increases effective intra-articular concentrations of the injected drug, improving clinical outcomes (9–11). Thus, the present study further emphasizes the need for complete arthrocentesis and decompression of the joint prior to injection of intra-articular medications.

The negative results of the Cunnington et al study could also have been due to differences in the injected medications. In the Cunnington et al study, the iodinated radio-opaque contrast agent iohexol was injected into the joints along with corticosteroid (33). Iodinated contrast agents, although useful to determine intra-articular accuracy, are highly irritating to cartilage and synovial membrane and are known to induce synovitis, which might obscure the beneficial effects of intra-articular corticosteroids and thus would have a negative effect on the US-guidance group relative to the palpation group (46, 51–54). The Cunnington et al study also used lower amounts of triamcinolone acetonide, which would tend to converge the results of the US-guided and palpation-guided groups, as was in fact observed (33, 44–47, 55).

Conventional arthrocentesis is usually carried out by one operator using a conventional syringe with two hands. However, it is difficult to control and operate a conventional syringe with one hand while operating the US transducer with the other hand and, as Cunnington et al and others have demonstrated, results in less improvement than would be expected (16, 33, 36, 37, 41, 56). By contrast, the present study combined US with highly controlled mechanical aspirating syringes that permitted one-handed operation with improved needle control (16, 36, 37, 41, 56). With a mechanical aspirating syringe, US-guided arthrocentesis can be performed with two operators (as shown in Figures 1 and 4), one holding the probe and the other aspirating the synovial fluid; or it can be performed with one operator operating the US probe with one hand and the aspirating syringe with the other hand (as shown in Figure 3). Thus, the use of highly controlled one-handed aspirating syringes that provide better needle control and accuracy with US may have also contributed to better outcomes in the US-guided group (16, 21, 34, 36, 37, 41, 56).

In summary, US-guided arthrocentesis of the knee is superior to anatomic landmark palpation-guided arthrocentesis, resulting in significantly less procedural pain, a greater percentage of successful diagnostic arthrocenteses, greater synovial fluid yield, more complete joint decompression, and improved clinical outcomes.

## References

1. Aceves-Avila FJ, Delgadillo-Ruano MA, Ramos-Remus C, Gomez-Vargas A, Gutierrez-Urena S. The first descriptions of therapeutic arthrocentesis: a historical note. *Rheumatology (Oxford)* 2003;42:180–3.
2. Guggi V, Calame L. Contribution of digit joint aspiration to the diagnosis of rheumatic diseases. *Joint Bone Spine* 2002;69:58–61.
3. Manadan AM, Block JA. Daily needle aspiration versus surgical lavage for the treatment of bacterial septic arthritis in adults. *Am J Ther* 2004;11:412–15.
4. Lee AH, Chin AE, Ramanujam T, Thadhani RI, Callegari PE, Freundlich B. Gonococcal septic arthritis of the hip. *J Rheumatol* 1991;18:1932–3.
5. Kesteris U, Wingstrand H, Forsberg L, Egund N. The effect of arthrocentesis in transient synovitis of the hip in the child: a longitudinal sonographic study. *J Pediatr Orthop* 1996;16:24–9.
6. Schumacher HR, Chen LX. Injectable corticosteroids in treatment of arthritis of the knee. *Am J Med* 2005;118:1208–14.
7. American College of Rheumatology Subcommittee on Rheumatoid Arthritis Guidelines. Guidelines for the management of rheumatoid arthritis: 2002 update. *Arthritis Rheum* 2002;46:328–46.
8. Hochberg MC, Altman RD, Brandt KD, Clark BM, Dieppe PA, Griffin MR, et al. Guidelines for the medical management of osteoarthritis. Part II. Osteoarthritis of the knee. American College of Rheumatology. *Arthritis Rheum* 1995;38:1541–6.
9. Weitoft T, Uddenfeldt P. Importance of synovial fluid aspiration when injecting intra-articular corticosteroids. *Ann Rheum Dis* 2000;59:233–5.
10. Jones A, Regan M, Ledingham J, Patrick M, Manhire A, Doherty M. Importance of placement of intra-articular steroid injections. *Br Med J* 1993;307:1329–30.
11. Waddell DD, Marino AA. Chronic knee effusions in patients with advanced osteoarthritis: implications for functional outcome of viscosupplementation. *J Knee Surg* 2007;20:181–4.
12. Tanaka N, Sakahashi H, Sato E, Hirose K, Ishima T, Ishii S. Intra-articular injection of high molecular weight hyaluronan after arthrocentesis as treatment for rheumatoid knees with joint effusion. *Rheumatol Int* 2002;22:151–4.
13. Roberts WN, Hayes CW, Breitbach SA, Owen DS Jr. Dry taps and what to do about them: a pictorial essay on failed arthrocentesis of the knee. *Am J Med* 1996;100:461–4.
14. Roberts WN. Primer: pitfalls of aspiration and injection. *Nat Clin Pract Rheumatol* 2007;3:464–72.
15. Roberts WO. Knee aspiration and injection. *Phys Sports Med* 1998;26:93–4.
16. Moorjani GR, Michael AA, Peisjovich A, Park KS, Sibbitt WL Jr, Bankhurst AD. Patient pain and tissue trauma during syringe procedures: a randomized controlled trial. *J Rheumatol* 2008;35:1124–9.
17. Gardner GC. Teaching arthrocentesis and injection techniques: what is the best way to get our point across? *J Rheumatol* 2007;34:1448–50.
18. Draeger HT, Twining JM, Johnson CR, Kettwich SC, Kettwich LG, Bankhurst AD. A randomised controlled trial of the reciprocating syringe in arthrocentesis. *Ann Rheum Dis* 2006;65:1084–7.
19. Dabke HV. Accuracy of needle placement into the intra-articular space of the knee. *J Bone Joint Surg Am* 2004;86-A:433–4; author reply 434.
20. Jackson DW, Evans NA, Thomas BM. Accuracy of needle placement into the intra-articular space of the knee. *J Bone Joint Surg Am* 2002;84-A:1522–7.
21. Sibbitt WL Jr, Peisajovich A, Michael AA, Park KS, Sibbitt RR, Band PA, et al. Does sonographic guidance influence the outcome of intraarticular injections? *J Rheumatol* 2009;36:1892–902.
22. Kane D, Balint PV, Sturrock RD. Ultrasonography is superior to clinical examination in the detection and localization of knee joint effusion in rheumatoid arthritis. *J Rheumatol* 2003;30:966–71.

23. Delaunoy I, Feipel V, Appelboom T, Hauzeur JP. Sonography detection threshold for knee effusion. *Clin Rheumatol* 2003;22:391–2.
24. Balint PV, Kane D, Hunter J, McInnes IB, Field M, Sturrock RD. Ultrasound guided versus conventional joint and soft tissue fluid aspiration in rheumatology practice: a pilot study. *J Rheumatol* 2002;29:2209–13.
25. Pendleton A, Millar A, O’Kane D, Wright GD, Taggart AJ. Can sonography be used to predict the response to intraarticular corticosteroid injection in primary osteoarthritis of the knee? *Scand J Rheumatol* 2008;37:395–7.
26. Raza K, Lee CY, Pilling D, Heaton S, Situnayake RD, Carruthers DM, et al. Ultrasound guidance allows accurate needle placement and aspiration from small joints in patients with early inflammatory arthritis. *Rheumatology (Oxford)* 2003;42:976–9.
27. Ike RW, Somers EC, Arnold EL, Arnold WJ. Ultrasound of the knee during voluntary quadriceps contraction: a technique for detecting otherwise occult effusions. *Arthritis Care Res (Hoboken)* 2010;62:725–9.
28. Punzi L, Oliviero F. Arthrocentesis and synovial fluid analysis in clinical practice: value of sonography in difficult cases. *Ann N Y Acad Sci* 2009;1154:152–8.
29. Tsung JW, Blaivas M. Emergency department diagnosis of pediatric hip effusion and guided arthrocentesis using point-of-care ultrasound. *J Emerg Med* 2008;35:393–9.
30. Wiler JL, Costantino TG, Filippone L, Satz W. Comparison of ultrasound-guided and standard landmark techniques for knee arthrocentesis. *J Emerg Med* 2010;39:76–82.
31. Parker L, Nazarian LN, Carrino JA, Morrison WB, Grimaldi G, Frangos AJ, et al. Musculoskeletal imaging: medicare use, cost, and potential for cost substitution. *J Am Coll Radiol* 2008;5:182–8.
32. Hall S, Buchbinder R. Do imaging methods that guide needle placement improve outcome? *Ann Rheum Dis* 2004;63:1007–8.
33. Cunningham J, Marshall N, Hide G, Bracewell C, Isaacs J, Platt P, et al. A randomised, controlled, double blinded study of ultrasound guided corticosteroid joint injection in patients with inflammatory arthritis. *Arthritis Rheum* 2010;62:1862–9.
34. Sibbitt WL Jr, Band PA, Chavez-Chiang NR, Delea SL, Norton HE, Bankhurst AD. A randomized controlled trial of the cost-effectiveness of ultrasound-guided intraarticular injection of inflammatory arthritis. *J Rheumatol* 2011;38:252–63.
35. Sander O. Intra-articular corticosteroid injections with the reciprocating procedure device reduced procedural pain and duration more than the conventional syringe. *Evid Based Med* 2007;12:106.
36. Sibbitt WL Jr, Sibbitt RR, Michael AA, Fu DI, Draeger HT, Twining JM, et al. Physician control of needle and syringe during traditional aspiration-injection procedures with the new reciprocating syringe. *J Rheumatol* 2006;33:771–8.
37. Sibbitt RR, Sibbitt WL Jr, Nunez SE, Kettwich LG, Kettwich SC, Bankhurst AD. Control and performance characteristics of eight different suction biopsy devices. *J Vasc Interv Radiol* 2006;17:1657–69.
38. Nunez SE, Draeger HT, Rivero DP, Kettwich LG, Sibbitt WL Jr, Bankhurst AD. Reduced pain of intraarticular hyaluronate injection with the reciprocating procedure device. *J Clin Rheumatol* 2007;13:16–19.
39. Bankhurst AD, Nunez SE, Draeger HT, Kettwich SC, Kettwich LG, Sibbitt WL Jr. A randomized controlled trial of the reciprocating procedure device for intraarticular injection of corticosteroid. *J Rheumatol* 2007;34:187–92.
40. Moorjani GR, Bedrick EJ, Michael AA, Peisajovich A, Sibbitt WL Jr, Bankhurst AD. Integration of safety technologies into rheumatology and orthopedic practice: a randomized controlled trial. *Arthritis Rheum* 2008;58:1907–14.
41. Michael AA, Moorjani GR, Peisajovich A, Park KS, Sibbitt WL Jr, Bankhurst AD. Syringe size: does it matter in physician-performed procedures? *J Clin Rheumatol* 2009;215:56–60.
42. Katz J, Melzack R. Measurement of pain. *Surg Clin North Am* 1999;79:231–52.
43. Bhachu HS, Kay B, Healy TE, Beatty P. Grading of pain and anxiety. Comparison between a linear analogue and a computerised audiovisual analogue scale. *Anaesthesia* 1983;38:875–8.
44. Derendorf H, Mollmann H, Gruner A, Haack D, Gyselby G. Pharmacokinetics and pharmacodynamics of glucocorticoid suspensions after intra-articular administration. *Clin Pharmacol Ther* 1986;39:313–17.
45. Bellamy N, Campbell J, Robinson V, Gee T, Bourne R, Wells G. Intraarticular corticosteroid for treatment of osteoarthritis of the knee. *Cochrane Database Syst Rev* 2006;(2):CD005328.
46. Firestein GS, Paine MM, Littman BH. Gene expression (collagenase, tissue inhibitor of metalloproteinases, complement, and HLA-DR) in rheumatoid arthritis and osteoarthritis synovium. Quantitative analysis and effect of intraarticular corticosteroids. *Arthritis Rheum* 1991;34:1094–105.
47. Furtado RN, Oliveira LM, Natour J. Polyarticular corticosteroid injection versus systemic administration in treatment of rheumatoid arthritis patients: a randomized controlled study. *J Rheumatol* 2005;32:1691–8.
48. Im SH, Lee SC, Park YB, Cho SR, Kim JC. Feasibility of sonography for intraarticular injections in the knee through a medial patellar portal. *J Ultrasound Med* 2009;28:1465–70.
49. Kettwich SC, Sibbitt WL Jr, Brandt JR, Johnson CR, Wong CS, Bankhurst AD. Needle phobia and stress-reducing medical devices in pediatric and adult chemotherapy patients. *J Pediatr Oncol Nurs* 2007;24:20–8.
50. Kettwich SC, Sibbitt WL Jr, Kettwich LG, Palmer CJ, Draeger HT, Bankhurst AD. Patients with needle phobia? Try stress-reducing medical devices: a randomized, controlled trial comparing decorated and plain syringes and butterfly needles. *J Fam Pract* 2006;55:697–700.
51. Kose N, Inan U, Baycu C, Omeroglu H, Seber S. Effects of intraarticular contrast media on synovial membrane and cartilage. An electron microscopic evaluation in rabbit knees. *Saudi Med J* 2007;28:713–16.
52. Hall FM, Rosenthal DI, Goldberg RP, Wyshak G. Morbidity from shoulder arthrography: etiology, incidence, and prevention. *AJR Am J Roentgenol* 1981;136:59–62.
53. Farso Nielsen F, de Carvalho A, Hjøllund Madsen E. Omnipaque and urografin in arthrography of the knee. *Acta Radiol Diagn (Stockh)* 1984;25:151–4.
54. Tallroth K, Vankka E. Comparison of iohexol and meglumine iohalamate in single contrast knee arthrography. A double-blind investigation. *Ann Clin Res* 1986;18:144–7.
55. de Jong BA, Dahmen R, Hogeweg JA, Marti RK. Intra-articular triamcinolone acetonide injection in patients with capsulitis of the shoulder: a comparative study of two dose regimens. *Clin Rehabil* 1998;12:211–15.
56. Haseler LJ, Sibbitt RR, Sibbitt WL Jr, Michael AA, Gasparovic CM, Bankhurst AD. Syringe and needle size, syringe type, vacuum generation, and needle control in aspiration procedures. *Cardiovasc Intervent Radiol* 2011;34:590–600.

Copyright of Scandinavian Journal of Rheumatology is the property of Taylor & Francis Ltd and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.