Supplementary table 4. Outcome details for studies comparing different imaging techniques or imaging vs. palpation guidance in large joints and periarticular structures (PICO1)

AUTHOR, DATE	DISEASE	SITE	OUTCOME CATEGORY	OUTCOME DETAIL	OUTCOME EXPLANATION (UNIT)[1]	TIME POINT	RESULTS[2]	OVERALL ROB[3]
ULTRASOUND vs. PALPATION GUIDANCE								
Raeissadat et al., 2017	adhesive capsulitis	shoulder joint	Accuracy	Accuracy	Intra-target verified by contrast medium in joint according to X-ray exam (%)	Post-procedure	no difference	high
			Safety	Pain	Patient Pain VAS (cm)	BSL, 1w, 4w	no difference	high
			Safety	Adverse events	Complications[4] (%)	4w	no difference	high
			Efficacy	Function	Improvement from BSL in abduction ROM (°)	BSL, 1w, 4w	no difference	high
			Efficacy	Function	Improvement from BSL in flexion ROM (°)	BSL, 1w, 4w	no difference	high
			Efficacy	Function	Improvement from BSL in extension ROM (°)	BSL, 1w, 4w	no difference[5]	high
			Efficacy	Function	Improvement from BSL in internal rotation ROM (°)	BSL, 1w, 4w	no difference	high
			Efficacy	Function	Improvement from BSL in external rotation ROM (°)	BSL, 1w, 4w	1,4w: better for US	high
			Efficacy	Function	Oxford score	BSL, 1w, 4w	no difference	high
Lee et al., 2009	adhesive capsulitis	shoulder joint	Safety	Pain	Daytime patient pain VAS (cm)	BSL, 1w, 2w, 3w, 4w, 5w, 6w	1,2w: better for US	some concern
			Safety	Pain	Before sleep patient pain VAS (cm)	BSL, 1w, 2w, 3w, 4w, 5w, 6w	1,2w: better for US	some concern
			Efficacy	Function	Flexion ROM (°)	BSL, 1w, 2w, 3w, 4w, 5w, 6w	1,2,3w: better for US	some concern
			Efficacy	Function	Abduction ROM (°)	BSL, 1w, 2w, 3w, 4w, 5w, 6w	1,2w: better for US	some concern
			Efficacy	Function	External rotation ROM (°)	BSL, 1w, 2w, 3w, 4w, 5w, 6w	2w: better for US	some concern
			Efficacy	Function	Internal rotation ROM (°)	BSL, 1w, 2w, 3w, 4w, 5w, 6w	1,2,3,4w: better for US	some concern
			Efficacy	Function	general shoulder functions - 10 functions by Cho et al	BSL, 1w, 2w, 3w, 4w, 5w, 6w	1,2,3w: better for US	some concern
Saeed et al., 2014	shoulder impingement	glenohumeral joint, biceps tendon sheath, AC joint	Safety	Pain	Improvement in Patient Pain VAS from BSL (%)	BSL, 6w, 12w	6,12w: better for US	high
			Efficacy	Function	Hawkins Kennedy test and supraspinatus tendon tenderness	BSL, 6w, 12w	6,12w: better for US[6]	high

			Efficacy	Treatment response	Improvement in Physician global assessment from BSL (%)	BSL, 6w, 12w	6,12w: better for US	high
			Efficacy	Treatment failure	Need for reinjection or surgery (%)	up to 12w	no difference	high
Naredo et al., 2004	Periarticular shoulder disorders	SA-SD bursa	Accuracy	Accuracy	Intra-target verified by corticosteroid detection in the SA-SD bursa via US after the intervention (%)	Post-procedure	Post-procedure: better for US[7]	high
			Safety	Pain	Patient Pain VAS (mm)	BSL, 6w	6w: better for US	some concern
			Safety	Adverse events	Complications[8] (n°)	Post-procedure	no difference	some concern
			Efficacy	Function	Shoulder Function Assessment	BSL, 6w	6w: better for US	some concern
Hashiuchi et al., 2011	Anterior shoulder pain	biceps tendon sheath	Accuracy	Accuracy	Intra-target verified by contrast agent detection via CT in tendon sheath (%)	Post-procedure	Post-procedure: better for US	some concern
Zhang et al., 2011	Biceps brachii tendinitis	brachial bicipital groove	Safety	Pain	Patient Pain VAS (cm)	BSL, last FU[9]	last FU: better for US	high
			Safety	Adverse events	Complications[4] (%)	up to the last FU	no difference	high
			Efficacy	Pain Function	Constant Murley Score	BSL, last FU	up to the last FU: better for US	high
			Efficacy	Treatment failure	Need for reinjection (%)	up to the last FU	up to the last FU: better for US	high
			Efficacy	Treatment failure	Need for arthroscopic surgery (%)	up to the last FU	no difference[10]	high
Yiannakopoulos et al., 2020	Tendinosis of the long head of the biceps	long biceps tendon	Accuracy	Accuracy	Intra-target verified by fluid in the tendon sheath according to sonography (%)	post-procedure	post-procedure: better for US[11]	high
			Safety	Pain	Patient Pain VAS (cm)	BSL, during procedure, 4w, 6m	during procedure, 4w, 6m: better for US	high
			Safety	Adverse Events	Complications (%)[12]	up to 6m	no difference	high
			Efficacy	QoL	SANE score[13]	BSL, 4w, 6m	4w, 6m: better for US	high
			Efficacy	Symptom Severity Function	QuickDASH	BSL, 4w, 6m	4w, 6m: better for US	high
			Cost/Time	Time	Duration of procedure[14]	during procedure	during procedure: better for US	high
Chang et al., 2014	Scapular pain	subscapularis muscle	Safety	Pain	Patient Pain VAS (cm)	BSL,1w, 2w, 3w, 3m	no difference	some concern
			Safety	Adverse events	Complications[15] (%)	up to 3m	no difference	some concern

			Efficacy	Treatment response	Rubin scale	1w, 3m	no difference	some concern
Kim et al., 2013	Elbow OA	Elbow joint	Accuracy	Accuracy	Intra-target verified by contrast medium in joint according to X-ray exam (%)	Post-procedure	Post-procedure: better for US	some concern
Luz et al., 2008	RA with wrist synovitis	wrist joint	Accuracy	Accuracy	Intra-target verified by contrast medium in joint according to X-ray exam (%)	Post-procedure	no difference	some concern
			Safety	Pain	Pain VAS at rest (cm)	BSL, 1w, 4w, 8w, 12w	no difference	some concern
			Safety	Symptom severity	VAS for oedema (cm)	BSL, 1w, 4w, 8w, 12w	no difference	some concern
			Efficacy	Function	HAQ	BSL, 1w, 4w, 8w, 12w	no difference	some concern
Mitchell et al., 2018	trochanteric bursitis	Trochanteric bursa	Safety	Pain	Patient Pain VAS (cm)	BSL, during procedure, 2w, 6m	6m: better for US	high
			Safety	Adverse events	Complications[16] (%)	n.a.[4]	no difference	high
			Efficacy	Duration of therapeutic effects	until VAS ≥ 2 cm (months)	up to 6m	no difference	high
			Efficacy	Time to next intervention	Time to the next intervention[17] (months)	up to 12m	no difference	high
			Cost/Time	Costs	Costs per patient per year (US dollars)	n.a.[4]	worse for US	high
Sibbitt Jr et al., 2011	knee OA	knee joint	Safety	Pain	Patient Pain VAS (cm)	BSL, needle introduction, during injection, 2w, 6m	needle introduction, during injections, 2w, 6m: better for US	some concern
			Efficacy	Duration of therapeutic effects	Until VAS≥2 (months)	up to 6m	up to 6m: better for US	some concern
			Efficacy	Time to next intervention	Until reinjection/surgery (months)	up to 12m	no difference	some concern
			Cost/Time	Costs	Cost per year–physician's office (US dollars)	up to 12m	up to 12m: worse for US	some concern
			Cost/Time	Costs	Costs per year–hospital outpatient department (US dollars)	up to 12m	no difference	some concern
Bum Park et al., 2012	knee OA	knee joint	Accuracy	Accuracy	Intra-target verified by contrast medium in joint according to X-ray exam (%)	Post-procedure	Post-procedure: better for US	some concern
Jang et al., 2013	knee OA	knee joint	Accuracy	Accuracy	Intra-target verified by contrast medium in joint according to X-ray exam (%)	Post-procedure	Post-procedure: better for US	some concern
			Safety	Adverse events	Complications[18] (%)	during procedure	during procedure: better for US	some concern
			Cost/Time	Time	time from skin cleansing to injection (min)	during procedure	no difference	some concern

Cankurtaran et al., 2020	chronic knee OA	knee	Safety	Pain	Changes in Patient Pain VAS (mm)	BSL, 1m, 3m[19]	no difference	high
			Safety	Adverse events	Complications (n)[20]	up to 3m	no difference	high
			Efficacy	Treatment response	Changes in WOMAC	BSL, 1m, 3m[19]	no difference	high
			Efficacy	QoL	Changes in Nottingham Health Profile - pain scale	BSL, 1m, 3m[19]	3m-BSL: worse for US	high
			Efficacy	QoL	Changes in Nottingham Health Profile - emotional reaction scale	BSL, 1m, 3m[19]	3m-BSL: worse for US	high
			Efficacy	QoL	Changes in Nottingham Health Profile - sleep scale	BSL, 1m, 3m[19]	no difference	high
			Efficacy	QoL	Changes in Nottingham Health Profile - social isolation scale	BSL, 1m, 3m[19]	1m-BSL: worse for US	high
			Efficacy	QoL	Changes in Nottingham Health Profile - physical mobility scale	BSL, 1m, 3m[19]	no difference	high
			Efficacy	QoL	Changes in Nottingham Health Profile - energy scale	BSL, 1m, 3m[19]	no difference	high
			Efficacy	Treatment response	Changes in Timed Up and Go Test (min)[21]	BSL, 1m, 3m[19]	no difference	high
			Efficacy	Treatment response	Changes in 6 - minute walk test (meters)[22]	BSL, 1m, 3m[19]	1m-BSL: better for US	high
			Efficacy	Treatment response	Changes in 30-second chair stand test (n)[23]	BSL, 1m, 3m[19]	1m-BSL, 3m-1m: better for US	high
			Efficacy	Treatment response	Changes in stair climb test (min)	BSL, 1m, 3m[19]	no difference	high
Sibbitt et al., 2012	knee effusion	knee joint	Accuracy	Tissue/Fluid acquired	Aspirated fluid volume (ml)	Post-procedure	Post-procedure: better for US	some concern
			Accuracy	Tissue/Fluid acquired	Adequate amount for diagnostics: ≥2.5 mL (%)	Post-procedure	Post-procedure: better for US	some concern
			Safety	Pain	Patient Pain VAS (cm)	BSL, during procedure, 2w	during procedure, 2w: better for US	some concern

Im et al., 2009	knee OA	knee joint	Accuracy	Accuracy	Intra-target verified by contrast medium in joint according to X-ray exam (%)	Post-procedure	Post-procedure: better for US	some concern
Lundstrom et al., 2019	Receiving knee injection	knee joint	Efficacy	Treatment failure	received knee arthroplasty (%)	up to 6y	up to 6y: better for US	Serious
			Efficacy	Treatment failure	reinjection with hyaluronic acid (%)	up to 6y	up to 6y: worse for US	Serious
			Efficacy	Treatment failure	reinjection with corticosteroid (%)	up to 6y	up to 6y: better for US	Serious
Sheth et al., 2020	Receiving knee injection	Knee	Safety	Pain	Patient Pain VAS (cm)[24]	BSL, Post-procedure, 4-6w	Post-procedure, 4-6w: better for US	high
			Efficacy	Patient satisfaction	Patient satisfaction on a Likert Scale	Post-procedure, 4-6w	Post-procedure, 4-6w: better for US	high
			Efficacy	Treatment response	Improvement in the KOOS symptoms score	BSL, 4-6w	BSL, 4-6w: better for US	high
			Efficacy	Treatment response	Improvement in KOOS pain score	BSL, 4-6w	BSL, 4-6w: better for US	high
			Efficacy	Treatment response	Improvement in KOOS activity of daily living score	BSL, 4-6w	BSL, 4-6w: better for US	high
			Efficacy	Treatment response	Improvement in KOOS sports and recreation score	BSL, 4-6w	BSL, 4-6w: better for US	high
			Efficacy	Treatment response	Improvement in KOOS quality of life score	BSL, 4-6w	BSL, 4-6w: better for US	high
Lee et al., 2019	Pes anserinus tendinobursitis	Pes anserinus bursa	Accuracy	Accuracy	Intra-target verified by injection material in target structure according to sonography (%)	Postprocedure	post-procedure: better for US[25]	some concern
			Safety	Pain	Patient Pain VAS reduction from BSL[26] (cm)	BSL, 1w, 4w	1,4w: better for US	some concern
			Safety	Adverse Events	Complications (%)	up to 4w	no difference	some concern
ULTRASOUND vs. FLUOROSCOPY								
Petscavage-Thomas and Gustas, 2016	Anterior shoulder pain	biceps tendon sheath	Accuracy	Accuracy	Intra-target verified by contrast medium in tendon sheath according to US or fluoroscopy (%)	Post-procedure	Post-procedure: better for US	serious
			Safety	Pain	Patient Pain VAS change (cm)	n.a.[4]	no difference	serious
			Safety	Adverse events	Complications[4] (%)	1m-3m	no difference	serious
			Cost/Time	Costs	Professional and technical fees[27] (US dollars)	n.a.[27]	n.a.[27]	serious
Fowler et al., 2014	Piriformis syndrome	piriformis muscle	Safety	Pain	Patient Pain NRS (cm)	BSL, post-procedure, 1w-2w, 3m	no difference	high

			Safety	Adverse events	Complications[28] (%)	BSL, 1w-2w, 3m	no difference	high
			Efficacy	Function	Multidimensional Pain Inventory	BSL, 1w-2w, 3m	no differences[29]	high
			Efficacy	Patient satisfaction	Global Impression of Change scale	BSL, 1w-2w, 3m	no difference	high
			Cost/Time	Time	imaging time, needling time, total performance time (min)	BSL, 1w-2w, 3m	no difference	high
Soneji et al., 2016	chronic SIJ arthritis	SIJ	Accuracy	Accuracy	Intra-target verified by contrast medium in the joint via fluoroscopy (%)	During procedure	no difference	some concern
			Safety	Pain	Patient Pain NRS (cm)	BSL, 24h, 72h, 1w, 1m, 3m	no difference	some concern
			Safety	Pain	Procedural discomfort (cm)	During procedure	no difference	some concern
			Efficacy	Function	Oswestry Disability Index	BSL, 1m	no difference	some concern
			Efficacy	Pain medication	Daily opioid consumption (mg)	BSL, 1m	no difference	some concern
			Cost/Time	Time	Time from intervention start to end (sec)[30]	During procedure	During procedure: worse for US	some concern
Jee et al., 2014	Noninflammatory SIJ Dysfunction	SIJ	Accuracy	Accuracy	Intra-target verified by contrast medium in joint according to X-ray exam (%)	Post-procedure	Post-procedure: worse for US	high
			Safety	Pain	Patient Verbal numeric pain scale (cm)	BSL, 2w, 12w	no difference	some concern
			Safety	Adverse events	Complications[31] (%)	Post-procedure, 2w, 12w	no difference	high
			Efficacy	Function	Oswestry Disability Index	BSL, 2w, 12w	no difference	some concern
			Efficacy	Patient satisfaction	5-point patient satisfaction scale	BSL, 2w, 12w	no difference	high
Kim et al., 2019	Chronic knee OA	knee joint	Safety	Pain	11-point pain scale	BSL, 3m, 6m	no difference	some concern
			Safety	Adverse events	Complications[4] (%)	Up to 6m	no difference	some concern
			Efficacy	Treatment response	WOMAC	BSL, 3m, 6m	no difference	some concern
			Efficacy	Treatment response	Composite treatment response score[32]	3m	no difference	some concern
			Efficacy	Patient satisfaction	7-point patient satisfaction scale	3m	no difference	some concern
ULTRASOUND/FLUOROSCOPY vs. PALPATION GUIDANCE								
Bossert et al., 2016	ankle OA	ankle	Safety	Pain	Patient Pain VAS when walking (cm)	time of interview[33]	no difference	14/20

			Efficacy	Function	Patient definition of severe impairment (%)	time of injection	no difference	14/20
			Efficacy	Patient satisfaction	Satisfied/Unsatisfied (%)	time of injection	time of injection: better for US/Fluo	14/20
			Efficacy	Treatment response	Patient definition of treatment efficacy (%)	time of interview[33]	time of interview: better for US/Fluo	14/20
			Efficacy	Pain medication	Patients needing pain medication (%)	time of interview[33]	no difference	14/20
			Efficacy	Patient satisfaction	Patient definition of intervention tolerability (%)	time of interview[33]	no difference	14/20
FLUOROSCOPY vs. PALPATION GUIDANCE								
Cohen et al., 2019	painful SIJ	SIJ	Accuracy	location of the injection	Intra-target verified by contrast medium in the joint according to radiography (%)	Post-procedure	Post-procedure: better for fluoroscopy	low
			Safety	Pain	Average patient pain VAS of back and buttock (cm)	BSL, 1m, 3m	no difference	low
			Safety	Pain	Worst pain VAS of the last week (cm)	BSL, 1m, 3m	no difference	low
			Safety	Adverse Events	Complications (n)[34]	up to 3m	no difference	low
			Safety	Pain	Adjusted average patient pain VAS of back and buttock (cm)[35]	1m, 3m	3m: better for fluoroscopy	low
			Safety	Pain	Adjusted worst pain VAS of the last week (cm)[35]	1m, 3m	3m: better for fluoroscopy	low
			Efficacy	Function	Oswestry Disability Index	BSL, 1m, 3m	no difference	low
			Efficacy	Pain medication	Reduction in analgesic use (%)[36]	1m, 3m	no difference	low
			Efficacy	Patient satisfaction	Patient satisfaction on a Likert Scale	1m, 3m	no difference	low
			Efficacy	Function	Adjusted Oswestry Disability Index[35]	1m, 3m	no difference	low
ULTRASOUND vs. FLUOROSCOPY vs. PALPATION GUIDANCE								
Henne et al., 2020	Hip OA or FAI	hip	Cost/Time	Costs	Costs for OA (U.S. Dollars)[37]	post-procedure	post-procedure: better for palpation guidance/US compared to fluo.	serious
			Cost/Time	Costs	Costs for FIA 27 (U.S. Dollars)[37]	post-procedure	post-procedure: better for US and palpation guidance/US compared to fluo.	serious
FLUOROSCOPY vs. COMPUTED TOMOGRAPHY								
Diffre et al., 2020	pyogenic vertebral osteomyelitis	disco-vertebral tissue	Accuracy	Tissue/Fluid acquired	Positive rate of disco-vertebral biopsy cultures (%)[38]	n.a.[4]	at lumbar level: better for fluo.[39]	serious
			Safety	Adverse Events	Complications (n)[40]	n.a.[4]	no difference	serious

The abbreviation BSL (baseline) refers to the time point before the intervention happened

AC joint, acromioclavicular joint; BSL, baseline; CT, computer tomography; FIA, femoroacetabular impingement: Fluo, fluoroscopy; HAQ, health assessment questionnaire; KOOS, Knee injury and osteoarthritis outcome score; last FU, last follow-up; m, month(s); NRS, numeric rating scale; OA, osteoarthritis; RA, rheumatoid arthritis; ROM, range of motion; Sane, Single Assessment Numeric evaluation; SA-SD bursa, subacromial-subdeltoid bursa; SIJ, sacroiliac joint; US, ultrasound; U.S. Dollars, United States of America Dollars; w, week(s); WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; y, year(s);

[1] The outcomes "Complications" are usually only presented in descriptive manner by the respective authors. Statistical tests were not performed by the authors, unless stated otherwise.

[2] No difference = at none of the give time points a difference was found between the groups. If differences were found, the time point for the differences is depicted.

[3] For details on the RoB assessment see supplementary table 3.

[4] Not specified by authors

[5] Improvement in extension was better at 1 week and 4 weeks in the US group compare to baseline. Extension was however significantly better before the intervention in the palpation guidance group, making the detection of a difference difficult.

[6] At baseline the US group had significantly worse scores (the Hawkins-Kennedy test and supraspinatus tendon tenderness) compared to the palpation guidance group, however significantly greater improvements were noted for 6 and 12 weeks in the US group, with overall better scores at these two time-points in the US group.

[7] In the palpation guidance group corticosteroids were found exclusively in the SA-SD bursa only in 3/20 cases, while in the US group corticosteroids were found exclusively in the SA-SD bursa in 20/21 cases. A statistical test was not performed.

[8] Only reported complication was mild pain.

[9] The last follow up visit was different for each patient. The mean follow-up time was 31 weeks (range, 24 to 53) in the palpation guidance group and 34 weeks (range, 25 to 56) in the US group

[10] For 9/45 patients in the palpation guidance group and 5/53 patients in the US group, who complained of refractory pain after three separate injections, arthroscopic surgery was performed. This outcome was not compared using a statistical test.

[11] Correct fluid placement was found in 100% of the cases in the US group and in 68.12% cases in the palpation guidance group. A statistical comparison was not performed

[12] including tendon rupture, vascular injury, and infection. None of them happened

[13] "How would you rate your affected joint/region of interest today as a percentage of normal (0% to 100% scale with 100% being normal)?"

[14] "The duration of the injection was recorded in all instances" - no more information

[15] No serious complications such as pneumothorax or infection, or symptoms attributable to the side effects of steroid were encountered.

[16] There were no complications in any group, including no infections, patient injuries, nerve injuries, vascular complications, or unintended needle sticks.

[17] Interventions include reinjections, surgery, physical therapy, splint referral, joint imaging, referral to another specialist

[18] Complications were defined as the needle touching the patella cartilage or periosteum. No other complications occurred.

[19] Outcomes were shown as changes between BSL and 1 month, 1 month and 3 months and BSL and 3 months

[20] No complications reported

[21] The TUGT involves the patient getting up from a chair, walking 3 meters, and returning to sit in the same chair. After the patient completed the test we noted the completion time.

[22] performed in a 30-meterlong corridor, and measured the total distance walked in meters over 6 minutes

[23] test that counts the total number of complete chair stands within 30 seconds

[24] the 4-6 w timepoint was either done via clinical exam or via telephone survey

[25] VAS score reduction was measured while constant force was applied to the PA by an examiner with a pressure algometer (FPK-5Wagner Instruments)

[26] Correct injection material placement was found in 25/25 of the cases in the US group and in 2/25 cases in the palpation guidance group. A statistical comparison was not performed

[27] The journal states: "… the total combined ultrasound charges were $105 less than the combined fluoroscopy charges." However, no information is given how these results were calculated, especially for what time frame, and whether they were statistically compared.

[28] No complications including infection, severe bruising or bleeding, allergic reaction, seizure, admission to the hospital, severe or worsening pain lasting more than one day post-procedure, leg weakness occurred.

[29] Parts of the Multidimensional pain index showed significant differences at baseline, making conclusions on superiority of one method at follow-up difficult.

[30] In the fluoroscopy group, procedure timing was defined as time between first fluoroscopic image and completion of injection. In the US group, timing was defined as time from application of the US probe to completion of injection (including fluoroscopic confirmation of needle tip location)

[31] The following complications occurred in the study: Pain in periosteum, leg weakness

[32] Score defined as: ≥50% pain reduction, WOMAC unchanged, ≥4 on patient satisfaction scale OR ≥30% pain reduction, ≥30% WOMAC reduction OR >5 on patient satisfaction scale

[33] The time between the intervention and the interview was different for each patient. The mean (SD) weeks since intervention were 20.5 (11.8), 15.5 (8.9) and 17.1 (8.9) for the fluoroscopy, US and palpation guidance group respectively.

[34] Complications included worsening of back pain and temporary neurological symptoms

[35] In adjusted comparisons, the authors calculated differences in treatment effects and 95%CIs for pain and disability scores with analysis of covariance adjusting for baseline values of pain.

[36] cessation of at least 1 nonopioid analgesic or at least a 20% reduction in opioid use

[37] Costs were determined based on reimbursement data from the insurance company to the payees, which included not only the injection costs, but any other charges that the patient might have incurred on the day of procedure

[38] The Gold Standard was the diagnosis of pyogenic vertebral osteomyelitis, including radiological, clinical and biological data.

[39] No difference between the methods at cervical, thoracical and total spine level

[40] No complications reported, such as hemorrhage, infection, fracture or major pneumothorax

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