


## SYSTEMATIC REVIEW OPEN ACCESS

# In Patients With Painful Hip Osteoarthritis, Is It More Beneficial to Offer Them an Ultrasound-Guided or a Fluoroscopic-Guided Intra-Articular Corticosteroid Injection to Relieve Their Symptoms? A Systematic Review and Network Meta-Analysis

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## ABSTRACT

**Purpose:** Hip osteoarthritis (OA) is a common disabling musculoskeletal condition. Clinical guidelines recommend intra-articular corticosteroid injections (IACSI) as a pharmacological adjunct to help manage pain. IACSI are typically image-guided either by ultrasound guidance (USG) or fluoroscopic guidance (FG) with no clear evidence towards the more efficacious guidance technique. This study aims to systematically review the scientific literature to determine the clinical effectiveness of USG compared with FG-IACSI for people with pain-related hip OA.

**Methods:** A systematic review of major bibliographic databases from inception to 24 August 2023 was conducted. Randomised controlled trials of USG- and FG-IACSI for patients with hip OA were included. The primary outcome measure was pain. Hedges' *g* calculated effect size and meta-analysis using the random-effects model-estimated pooled effect sizes.  $\tau^2$ ,  $I^2$  and Cochran's *Q* calculated heterogeneity. Network meta-analysis was completed to indirectly compare effect sizes. Quality was assessed using the Cochrane risk-of-bias tool (RoB2).

**Results:** A total of 1464 citations were identified; eight studies were included in the review. No studies directly compared imaging modalities. Two network meta-analyses indirectly comparing USG- to FG-IACSI via an image-guided comparator hip injection ([any comparator], [local anaesthetic or saline]) established effect sizes (*g*) of 2.61 and 2.46, respectively, both in favour of FG-IACSI. Heterogeneity was low in the USG studies and high in the FG studies.

**Conclusion(s):** Evidence suggests that both USG and FG-IACSI are effective at reducing pain at 1 month in patients with painful hip OA. Although network meta-analyses favoured FG-IACSI, further high-quality trials are needed to determine the preferred guidance technique.

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## 1 | Introduction

Hip osteoarthritis (OA) is a common disabling musculoskeletal condition affecting an estimated 11% of people above the age of 45 in England (NHS England 2023). The high prevalence rate is thought to be linked to an ageing population and the global obesity epidemic (Courties, Berenbaum, and Sellam 2019). Hip OA carries a high individual, societal and economic burden (Sowers 2001), with symptoms commonly including pain, stiffness and loss of function (NICE 2022a).

Clinical guidelines recommend intra-articular corticosteroid injections (IACSI) when other pharmacological treatments are ineffective or unsuitable or to support therapeutic exercise (NICE 2022a). It is estimated that 16%–18% of patients will receive an IACSI in the year preceding their hip arthroplasty (Malik et al. 2020), which may account for 13,600–15,300 hip IACSIs in 2021 (National Joint Registry 2022). Considering that an estimated 2.75 million people in England have hip OA (NHS England 2023; Office of National Statistics 2022), the total number of hip IACSIs is likely to be significant.

IACSI are typically image-guided, historically by fluoroscopic guidance (FG) using continuous X-ray imaging and increasingly by ultrasound guidance (USG) with no clear evidence towards the more efficacious guidance technique. Both techniques are considered to be effective when completing hip joint IACSI, as documented by numerous high-quality reviews (Hoeber et al. 2016; McCabe et al. 2016; Zhong et al. 2020; Rampal et al. 2022).

Gazendam et al. (2021) notes that healthcare interventions are judged not only on their efficacy but also their cost effectiveness, particularly considering the current national economic situation in the United Kingdom (BMA 2023). Corticosteroids are relatively cheap, with the BNF (2023a) listing a 40-mg/1-mL vial of Depo-medrone (methylprednisolone-acetate) at £3.44 per unit and 40 mg/1 mL vial of Kenalog (triamcinolone-acetonide) at £3.63 per unit (BNF 2023b). Image guidance, however, incurs extra costs. USG injections are considered the most cost-effective modality (Byrd et al. 2014; Daniels et al. 2018), on average costing under £200 per procedure in 2019–2020, equivalent to £301 in 2023 (NHS England 2021; Bank of England 2023). This is significantly less than an FG hip IACSI completed in NHS radiology and theatre-based settings, costing between £226 and £810 in 2013–2014 equivalent to £301 and £1080 in 2023 (Subedi et al. 2015; Bank of England 2023). Beside setting, the professional background of the individual delivering the injection can influence cost effectiveness. The extended scope of allied healthcare professionals, such as physiotherapists, allows them to deliver the USG approach, indicating that it is more accessible to patients and less expensive, relative to radiologists delivering the FG approach (Sanders et al. 2017; Smith et al. 2023).

Alongside cost, USG also offers numerous advantages over FG, including convenience, patient satisfaction (Byrd et al. 2014), lack of radiation (Sanders et al. 2017) and workforce opportunities for physiotherapists through ‘point of care ultrasound’ (PoCUS) (Smith et al. 2023; Walter 2022). Conversely, ultrasound is an operator-dependent technology requiring significant

experience and training, whereas FG procedures may be considered ‘relatively straight forward and easy to master’ (Sanders et al. 2017).

NICE (2022a) outlines the following recommendation for research on intra-articular injections in the management of OA: ‘What is the clinical and cost effectiveness of intra-articular corticosteroids for managing osteoarthritis-affected joints other than the knee?’. Exploring the efficacy and economics of guided IACSI is essential as it can reduce costs associated with nonsteroidal anti-inflammatory drugs (NSAIDs) (Chen et al. 2012); delay hip arthroplasty (National Joint Registry 2022); reduce indirect employment-related absence and improve occupational productivity (Harris and Coggon 2015); improve health-related quality of life and mental health status (Salaffi et al. 2005; Boutron et al. 2008) and ultimately if successful, allow patients to engage in physical activity and reduce sedentary behaviour (NICE 2022a). Similarly, increased therapeutic duration of IACSI may lead to less utilisation of healthcare resources, and thus reduced costs (Sibbitt et al. 2011).

The objective of this study was to systematically review the scientific literature to determine the clinical effectiveness of USG compared with FG IACSI for people with pain-related hip OA.

## 2 | Methods

### 2.1 | Study Design

The study design is a systematic review with subsequent meta-analysis on the basis that there will be sufficient literature directly comparing USG with FG IACSI for the outcome of change in pain intensity in patients with painful hip OA. As there were no studies directly comparing these two interventions, a network meta-analysis indirectly compared USG with FG IACSI through a shared control.

This review is reported as per the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al. 2009; Page et al. 2021) and Cochrane Collaboration guidelines for performing and reporting systematic reviews and network meta-analyses (NMA) (J. P. Higgins et al. 2011; Hutton et al. 2015).

### 2.2 | Study Selection

The inclusion and exclusion criteria were defined a priori (Box 1).

### 2.3 | Outcome Measures

The outcome of interest was self-reported pain. Data were extracted for all numerically reported pain measures including (1) visual analogue scale (VAS) pain, a 0–100-mm scale, (2) numeric rating scale (NRS) pain, a 0–10 metric and (3) Western Ontario and McMasters Universities Osteoarthritis Index

**BOX 1 | Eligibility criteria.****Inclusion criteria for studies**

- Published from inception to 24 August 2023
- Randomised controlled trials (RCTs)
- Adult populations (aged > 18 years) with painful hip osteoarthritis (OA)
- Studies comparing at least two different image-guided intra-articular hip injections
  - Delivered by either ultrasound or fluoroscopic guidance
  - Must include corticosteroids in at least one arm of the trial
- Reporting a numerical pain outcome measure pre- and post-injection

**Exclusion criteria**

- Non-randomised studies
- RCTs including other joints which have not analysed hip joint OA data separately
- Palpation, landmark or anatomically guided hip injections

(WOMAC) consisting of five 0–100 mm scales totalling 0–500 mm. During meta-analysis, when outcome data were presented on different scales, data was synthesised using a pooled estimate of effect size using SMD (standardised mean difference). The Cochrane handbook does not recommend the pooling of data, which has been presented in different types when using the SMD (J. P. Higgins et al. 2011; Weweg et al. 2022). Subsequently, for the purpose of this study, pain intensity measures were rescaled to 0–100 to improve interpretability and heterogeneity (Holtz et al. 2020; Weweg et al. 2022). Therefore, (1) VAS pain scales remain unchanged, (2) NRS scales are scaled by a factor of 10 (Weweg et al. 2022) and (3) WOMAC pain scales are scaled by a factor of 0.2 (Holtz et al. 2020).

**2.4 | Time Frame of Outcome Measurement**

The timepoint of outcome measurement chosen was 1 month post-injection or the next closest timepoint if outcomes were not available at 1 month. Various systematic reviews and guidelines exploring the efficacy of IACSI for painful OA hip indicate ‘short term’ pain relief, with optimal relief at 1 month/4 weeks post-injection and diminishing with time, typically up to the 12-week/3-month timepoint (Kruse 2008; McCabe et al. 2016; Zhong et al. 2020; NICE 2022a, 2022b). Therefore, the 1-month time point was used to allow the comparison of imaging modalities.

There is limited evidence supporting the effectiveness of IACSI beyond 3 months (NICE 2022b). However, these injections can play a key role in the holistic management of painful hip OA by providing pain relief in the short term; thus helping patients engage in other management strategies such as physiotherapeutic exercise.

**2.5 | Search Strategy**

AMED, CINAHL, EMBASE, MEDLINE, PubMed, PsycINFO, SPORTDiscus, CENTRAL and PEDro were searched from inception to 24 August 2023 with no language limitations placed on the search. Keywords and MeSH terms included hip, osteoarthritis, arthritis, degenerative, intra-articular, intra-articular, inject\*, steroid, cortico\*, glucocortico\*, fluoro\*, ultrasound and guided. The search strategy is included as Appendix A. The format of the search strategy was adopted and modelled from a similar systematic review and meta-analysis evaluating the efficacy of different injectates for hip OA pain (Gazendam et al. 2021). Eligibility assessment for the inclusion of studies in the review was performed by one reviewer, PB, using a standardised form. PB independently screened all retrieved titles, abstracts and full texts using a standardised form based on the eligibility criteria (Box 1). Retrieved full text articles were reviewed by second author SS to ensure agreement on their inclusion.

**2.6 | Quality Assessment**

The methodological quality of the included RCTs was assessed by authors PB and SS using the Cochrane Collaborations risk of bias tool 2 (RoB2) (J. P. Higgins et al. 2019; Sterne et al. 2019). This tool evaluates various domains of bias to conclude an overall ‘risk of bias’ judgement, including the randomisation process, deviation from intended interventions, missing outcome data, measurement of the outcome and selection of reported results. Any disagreements were discussed and resolved to reach a consensus.

**2.7 | Data Extraction**

Both authors extracted data using a standardised form. Details of data extracted can be found in Table 1.

**2.8 | Data Synthesis**

Meta-analyses were conducted using the statistical computing programming language ‘R’ and associated user interface ‘R Studio’ (R Core Team 2023) by author PB. The following packages were installed using R code: tidyverse, meta, metafor and esc (Balduzzi, Rücker, and Schwarzer 2019; Viechtbauer 2010; Wickham et al. 2019). In instances where ‘mean (change)’ and ‘SD (mean change)’ were not included within the full text of an included article, these figures were calculated on the basis of guidance in the Cochrane handbook (Cochrane 2019; Cumpston et al. 2019; J. P. T. Higgins et al. 2021).

Meta-analyses of within-group SMD were performed in R using either the aforementioned (meta) or (metafor) packages (Viechtbauer 2010; Balduzzi, Rücker, and Schwarzer 2019). When effect sizes are pooled, those with a smaller SE (or higher precision) were allocated a greater weighting using inverse-variance weighting (Harrer et al. 2021). A random-effects model was used to account for the real-world natural

**TABLE 1** | Data extracted.

Participant and paper characteristics	Data required for meta-analysis
– Author and year of publication	– Author and year of publication
– Intervention image guidance	– Mean change (improvement in pain pre/post intervention)
– Intervention injection/injectate (dosage mg)	– Standard deviation (SD) of mean change (improvement in pain pre/post intervention)
– Comparator arms	– Sample size (intervention)
– Comparator injection/injectate (dosage mg)	– Mean change (improvement in pain pre/post comparator intervention)
– Primary pain outcome	– SD of mean change (improvement in pain pre/post comparator intervention)
– Osteoarthritis (OA) diagnostic criteria	– Sample size (control)
– Age of participants (mean)	
– Gender (% of male/% of female)	
– Body Mass Index (BMI)	

heterogeneity that exists among studies within the meta-analysis (Harrer et al. 2021).  $\tau^2$  was calculated to estimate the variance of distribution of effect sizes (Harrer et al. 2021), with a result larger than 0 confirming the appropriateness of a random-effects model. Between-study heterogeneity was calculated using either Cochran's  $Q$  (Cochran 1954) or Higgins and Thompson's  $I^2$  statistic (J. P. Higgins and Thompson 2002). The core result of this meta-analysis is thus a pooled effect size, presented with 95% CI and a  $p$  value of significance. Forest plots were generated within R by author PB and included within the results to provide a visual representation of the meta-analysis. In the event of no studies directly comparing USG with FG IACSI, an indirect comparison was made through network meta-analysis by means of a shared control.

### 3 | Results

#### 3.1 | Search Results

The database search identified 1455 potentially relevant citations. After duplicates and ineligible citations were removed, 103 potentially eligible articles were identified (Figure 1). After title and abstract review, 55 full text articles were screened, with nine meeting the eligibility criteria for inclusion in the review. One of the nine studies was subsequently excluded because the full data set could not be obtained for data analysis despite emailing the authors and the journal directly.

#### 3.2 | Characteristics of Included Studies

Study characteristics of the eight included studies can be found in Tables 2 and 3. All studies included retrievable data for pain scores. The median study sample sizes were 81 (range 52–199) for USG studies, 82 (range 52–312) for FG studies and 81 (range 52–312) for all eight studies. One study had four comparator groups, two had two comparator groups and the remaining five studies had one comparative group each. USG-included studies involved a total of 412 patients with a mean age of 64 ( $\pm 10.5$  years); FG-included studies involved a total of 526 patients with a mean age of 61.5 ( $\pm 9$  years) and the combined group of

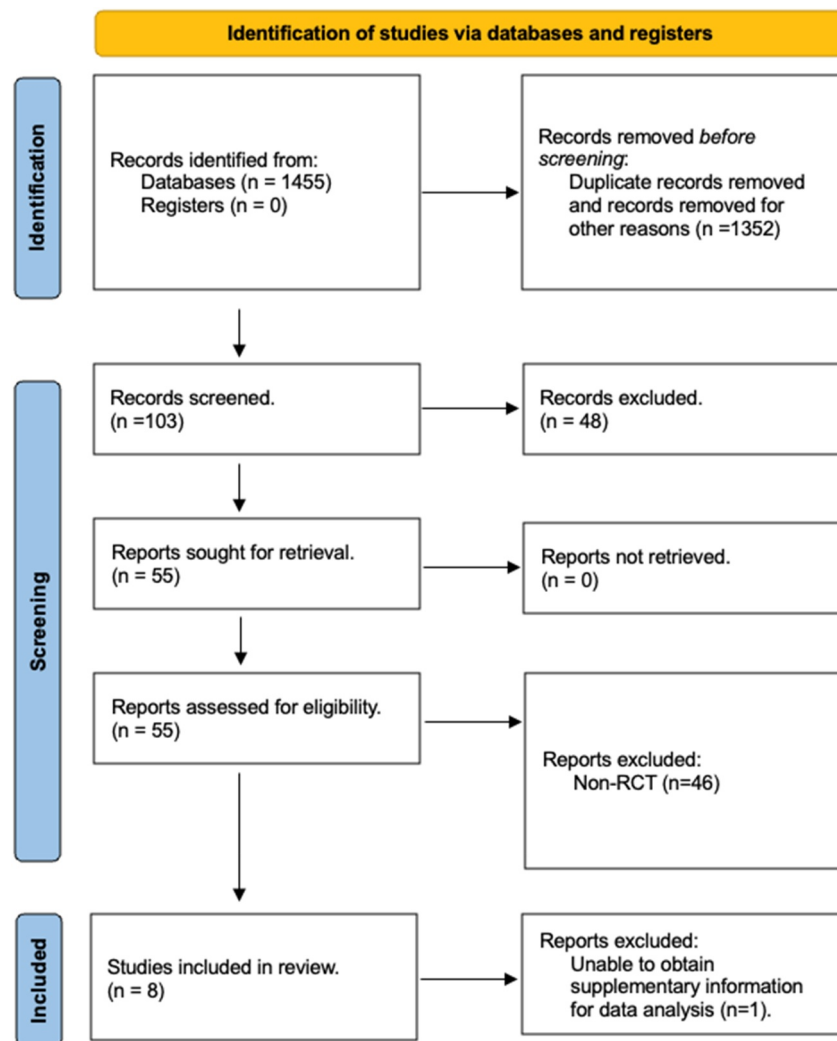
938 patients had a mean age of 62.5 ( $\pm 10$  years). Seven of the eight included studies documented gender with 58.5% of 858 participants being female (range 51.5%–80%). Five studies recorded baseline BMI with a mean score of 29.32 ( $\pm 4.99$ ) across 705 participants.

All included studies recruited patients with OA of the hip joint; however, they used differing diagnostic criteria. Five cited the Kellgren–Lawrence (KL) (1957) radiographic criteria; two in isolation (grade 2+ and grade 2–3), two in combination with the American College of Rheumatology (ACR) diagnostic criteria and one cited KL or ACR. One study mandated ACR diagnostic criteria and symptomology over 6 months. One study listed the Ahlbäck criteria of OA Grade 2 or worse, radiographic evidence of joint space narrowing, cartilage destruction over 50% and on a waiting list for hip. Conversely, one study simply cited ‘moderate to severe pain attributable to hip OA’.

#### 3.3 | Types of Injection

All eight featured studies featured an image-guided corticosteroid injection as at least one arm of the study, shown in Tables 2 and 3. Two studies used triamcinolone–acetone (40 mg; 80 mg), two used triamcinolone–hexatone (20 mg; 40 mg), two used methylprednisolone (40 mg), one used dexamethasone (8 mg) and one used triamcinolone (80 mg, did not specify acetone or hexatone). Comparatively, these individual listed dosages are equivalent to 40–80 mg triamcinolone-acetone (Saunders and Longworth 2018). Four studies combined corticosteroid with LA (two used bupivacaine, one lidocaine and one ropivacaine), two included sham injections at later points, one combined corticosteroid with saline and one injected corticosteroid without an adjunct.

All eight featured studies featured an image-guided comparator injection; however, these varied across studies. Four studies used LA as a comparator: mepivacaine alone, ropivacaine with NSAIDs (ketorolac), lidocaine with ‘standard care’ and bupivacaine with saline. Three studies used hyaluronic acid: Hyalgan with saline, 2 doses of Hylan G-F-20 two weeks apart and Hylan-G-F-20 combined with corticosteroid (methylprednisolone-



**FIGURE 1** | PRISMA flow diagram.

acetate, as per the intervention group). One study used a pericapsular nerve block in the comparator arm.

### 3.4 | Outcome Measures and Timepoints

Six studies used pain as a primary outcome and two used pain as one of three or four patient-reported outcome measures (PROMs). Four studies used VAS pain, two used NRS pain and two used the WOMAC pain subscale. Relative scaling of pain scales for comparability was completed as described in the Methods section. All included studies recorded numerical pain pre- and post-injection in both intervention and comparator arms. Studies were collected between two and six timepoints post-injection ranging from 1 day to 26 weeks/6 months. The timepoints of outcome measurements were at 3 weeks, 4 weeks, 28 days, 1 month and 2 months post-injection as timepoints closest to the 1-month post-injection mark.

After conversion to VAS, all eight included studies reported mean pain improvement scores between 14.6 and 44.0 mm (ultrasound studies pooled mean = 25.21 mm,  $n = 152$ ; fluoroscopy studies pooled mean = 32.43 mm,  $n = 246$ ). An

improvement of 15.3 mm is considered a minimal clinically important improvement (MCII) in patients with hip OA treated with anti-inflammatory medicine (Tubach et al. 2005). Based on this threshold, both USG and FG IACSI provide clinically meaningful improvements in pain, as the reported pain reductions exceed this MCII in most cases.

### 3.5 | Quality Assessment

The risk of bias summary for the included studies can be found in Table 4. Four studies were found to be of moderate risk of bias (some concerns), three studies of high risk and one study of low risk. Overall, the highest risk of bias was due to missing outcome data, the third domain of the RoB-2 tool (J. P. Higgins et al. 2019).

### 3.6 | Meta-Analyses

The extracted and calculated data values used for meta-analysis are presented in Tables 5 and 6. Inverse-variance pooling was used to calculate average effects as is standard practice in meta-analyses, as the inverse of the variance typically indicates higher



TABLE 2 | Participant and paper characteristics (ultrasound-guided hip IACSI).

Author/ year of publication	Intervention image- guidance	Intervention injection/ injection (dosage mg)	Comparator arms	Comparator injection/ injection (dosage mg)	Primary outcome	Time frame <sup>a</sup>	OA diagnostic criteria	Age of participants	Gender (%male/ female)	BMI
Jurgensmeier et al. (2021)	Ultrasound	Triamcinolone (80 mg) and Ropivacaine (0.5%)	1	Ketorolac (30 mg) and 0.5% Ropivacaine	VAS pain	1 week, <b>1 month</b> , 3 months	Kellgren– Lawrence (KL) Grade 2+	65.28 (± 12.6 1SD) <sup>b</sup>	36/64 <sup>b</sup>	31.03 (± 6.4 1SD) <sup>b</sup>
Kose et al. (2023)	Ultrasound	Dexamethasone (2 mL/8 mg) Bupivacaine (11 mL/0.25%)	1	Pericapsular nerve group (PENG block)	NRS pain	1 day, <b>4 weeks</b> , 8 weeks	KL Grade 2–3	62.5 (± 5.62 1SD) (calculated <sup>c</sup> )	45/55	29.18 (± 1.85 1SD) (calculated <sup>c</sup> )
Paskins et al. (2022)	Ultrasound	Standard care plus Triamcinolone acetamide (1 mL/40 mg) and Lidocaine (4 mL/1%)	2	Standard care (noninjection); Standard care plus Lidocaine (5 mL/1%)	NRS pain	2 weeks, <b>2 months</b> , 4 and 6 months	‘Moderate to severe pain attributable to hip OA’	62.8 (± 10.0 1SD)	43/57	29.1 (± 5.8 1SD)
Qvistgaard et al. (2006)	Ultrasound	Methylprednisolone (1 mL/40 mg) and 2 shams	2	3 × hyaluronic acid (2 mL Hyalgan); 3 × saline (2 mL)	VAS pain	14 days, <b>28 days</b> , 90 days	American College of Rheumatology (ACR) and KL Gd1 +	66 (± 12 1SD)	36/64	Not included

Abbreviations: ACR, American College of Rheumatology; BMI, Body Mass Index; IACSI, intra-articular corticosteroid injection; KL, Kellgren–Lawrence; NRS, Numerical Rating Scale; OA, osteoarthritis; SD, standard deviation; VAS, Visual Analogue Scale.

<sup>a</sup>Time frame highlighted in bold used for meta-analysis.

<sup>b</sup>Reported age/gender and BMI by Jurgensmeier et al. (2021) combined hip and knee cohorts.

<sup>c</sup>Pooled means and SD calculated as per formula outlined in the methodology, as per Cochrane Handbook (2019a, 2019b).

**TABLE 3** | Participant and paper characteristics (fluoroscopic-guided hip IACSI).

Author/ year of publication	Intervention image-guidance	Intervention injection/injectate (dosage mg)	Comparator arms	Comparator injection/ injectate (dosage mg)	Primary pain outcome	Time frame <sup>a</sup>	OA diagnostic criteria	Age of participants	Gender (%male/ %female)	BMI
Lambert et al. (2007)	Fluoroscopic	Triamcinolone hexatone 40 mg plus Bupivacaine 10 mg	1	Bupivacaine 10 mg plus saline 2 mL	WOMAC pain	<b>1 month</b> , 2, 3 and 6 months	ACR, symptomatic > 6/12	61.25 (± 8.52 1SD) (calculated <sup>b</sup> )	40/60	Not included
Rezende et al. (2020)	Fluoroscopic	Triamcinolone hexatone (20 mg/ 1 mL) plus saline	4	Intervention plus either 2, 4 or 6 mL of Hylan G-F-20	VAS pain	<b>1 month</b> , 3, 6 and 12 months	ACR and KL 2/3	61.98 (± 8.36 1SD) (calculated <sup>b</sup> )	20/80	28.8 (± 4.16 1SD) (calculated <sup>b</sup> )
Spitzer et al. (2010)	Fluoroscopic	Methylprednisolone acetate (40 mg/ 2 mL) plus sham 2 weeks later	1	Hylan G-F-20 (2 mL) × 2, 2 weeks apart	WOMAC pain	<b>4 weeks</b> , 8, 12, 16, 20 and 26 weeks	ACR or KL 2/3	59 (± 8.96 1SD) (calculated <sup>b</sup> )	48.5/51.5	29.35 (± 4.48 1SD) (calculated <sup>b</sup> )
Kullenberg et al. (2004)	Fluoroscopic	Triamcinolone acetonide (80 mg/2 mL)	1	Mepivacaine (1%/2 mL)	VAS pain	<b>3 and</b> 12 weeks	Waiting list for THR, Ahlbäck criteria of OA 2 or worse, JSN + cartilage destruction > 50%	70 (± 5.59 1SD) (calculated <sup>b</sup> )	Not included	Not included

Abbreviations: ACR, American College of Rheumatology; BMI, Body Mass Index; IACSI, intra-articular corticosteroid injection; JSN, joint space narrowing; KL, Kellgren–Lawrence; OA, osteoarthritis; SD, standard deviation; THR, Total Hip Replacement; VAS, Visual Analogue Scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

<sup>a</sup>Time frame highlighted in bold used for meta-analysis.

<sup>b</sup>Pooled means and SD calculated as per formula outlined in the methodology as per Cochrane Handbook (2019a, 2019b).

**TABLE 4** | Risk of bias assessment using the Cochrane risk of bias 2 (RoB2) tool.

Author	Randomisation process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of reported results	Overall bias (risk of bias judgement)
Jurgensmeier et al. (2021)	L	L	S	S	L	S
Kose et al. (2023)	L	L	L	L	L	L
Paskins et al. (2022)	L	L	S	L	L	S
Qvistgaard et al. (2006)	L	L	S	L	L	S
Kullenberg et al. (2004)	L	H	H	S	H	H
Lambert et al. (2007)	S	L	H	L	L	H
Rezende et al. (2020)	L	S	L	S	L	S
Spitzer et al. (2010)	L	L	H	L	L	H

Key

(L) Low risk of bias	(S) Some concerns	(H) High risk of bias
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precision (Harrer et al. 2021). Effect sizes were expressed in terms of Hedges' *g*, the bias-corrected standardised mean difference accounting for smaller sample sizes.

Network meta-analysis 1: Indirect comparison of USG hip IACSI versus FG hip IACSI using shared comparator (image-guided hip intra-articular injection).

Two meta-analyses were completed: the first comparing USG IACSI against an image-guided comparator injection (Figure 2) and the second comparing FG IACSI against an image-guided comparator injection (Figure 3). Based on the data obtained from these two meta-analyses, an indirect effect size (*g*) between FG hip IACSI and USG hip IACSI for individuals with painful hip OA may be estimated. An estimate for this effect size is 2.61 and may be visualised (Figure 4). This may be interpreted as FG hip IACSI being more efficacious than USG hip IACSI for the treatment of painful hip OA.

Network meta-analysis 2: Indirect comparison of USG IACSI against an FG IACSI using shared comparator (image-guided local anaesthetic [LA] or saline).

Two further meta-analyses were completed: The first comparing USG IACSI against an image-guided comparator injection (LA or saline) (Figure 5) and the second comparing FG IACSI against an image-guided comparator injection (LA or saline) (Figure 6). Based on the data obtained from the meta-analyses (3) and (4), an indirect effect size (*g*) between FG hip joint IACSI and USG hip joint IACSI (for individuals with painful hip OA) was estimated at 2.46 (Figure 7). This may be interpreted as FG hip IACSI being more efficacious than USG hip IACSI for the treatment of painful hip OA.

## 4 | Discussion

### 4.1 | Summary of the Main Findings

The objective of this study was to determine the clinical effectiveness of USG compared with FG IACSI for people with pain related to hip OA. Interestingly, the initial literature search yielded no eligible RCTs comparing the two modalities directly, thereby identifying a gap in the literature and a key finding. This is surprising as both modalities are used in clinical practice without an apparent standardisation or agreement on the 'more optimal' imaging approach (Byrd et al. 2014; Daniels et al. 2018). A modified approach was taken to achieve the study objective by indirectly comparing the two image-guided modalities through network meta-analysis by means of a shared comparator. Both USG and FG IACSI are effective at reducing pain at the 1-month timepoint in patients with painful hip OA when compared to comparator image-guided injections. FG IACSI seems more effective when indirectly compared to USG IACSI; however, this must be interpreted within the context of small sample sizes and large study heterogeneity.

### 4.2 | Comparison to Other Studies

There are no RCTs directly comparing USG with FG IACSI for patients with painful hip OA. A cohort study assessing patient satisfaction of USG hip IACSI for 50 individuals who previously had an FG hip IACSI concluded that USG IACSI was more convenient, less painful and preferential (Byrd et al. 2014). Other peripheral joint injections (such as the shoulder, elbow, wrist and small joints of the hands, knee and ankle) are typically carried out by palpation-guided anatomical markers or



**TABLE 5** | Data required for meta-analysis (ultrasound-guided hip IACSI).

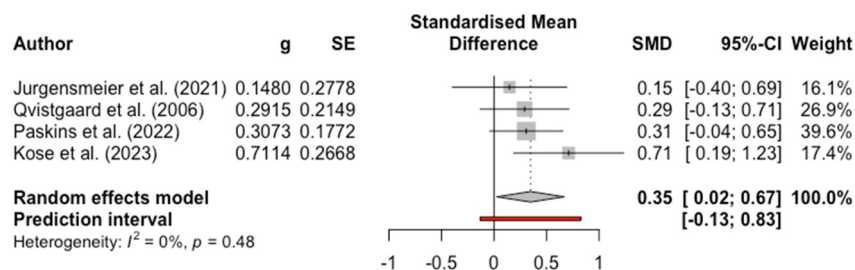
Author/year of publication	Mean change (intervention)	SD mean change (intervention)	Sample size (intervention)	Comparator arm	Mean change (comparator)	SD mean change (comparator)	Sample size (comparator)
Jurgensmeier et al. (2021)	14.60	24.73	26	NSAID	10.80	21.17	26
Kose et al. (2023)	43.60	8.47	30	PENG	36.80	10.31	30
Paskins et al. (2022)	16.00	20.04	64	Standard care + LA	10.00	18.77	65
Paskins et al. (2022)	”	”	”	Standard care (no injection)	1.00	18.19	58
Qvistgaard et al. (2006)	15.00	23.089	32	(G1) Hyaluronic acid	11.00	23.45	33
Qvistgaard et al. (2006)	”	”	”	(G2) Saline	1.00	22.96	36
Qvistgaard et al. (2006)				Total (G1) + (G2)	5.78	34.52	69

Abbreviations: G1, group 1; G2, group 2; IACSI, intra-articular corticosteroid injection; LA, local anaesthetic; NSAID, nonsteroidal anti-inflammatory drug; PENG, Pericapsular Nerve Group Block; SD, standard deviation.

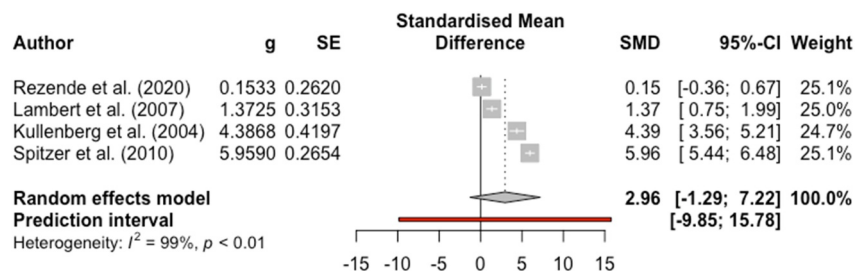
**TABLE 6** | Data required for meta-analysis (fluoroscopic-guided hip IACSI).

Author/year of publication	Mean change (intervention)	SD mean change (intervention)	Sample size (intervention)	Comparator group	Mean change (comparator)	SD mean change (comparator)	Sample size (comparator)
Lambert et al. (2007)	32.1	16.87	31	LA	7.58	18.63	21
Rezende et al. (2020)	32.8	23.93	19	(G1) CSI plus hyaluronic acid	36.3	16.96	19
Rezende et al. (2020)	”	”	”	(G2) CSI plus hyaluronic acid	27.4	23.02	22
Rezende et al. (2020)	”	”	”	(G3) CSI plus hyaluronic acid	25.2	24.69	22
Rezende et al. (2020)	”	”	”	TOTAL (G1) + (G2) + (G3)	29.32	22.06	63
Spitzer et al. (2010)	29.49	1.91	156	Hyaluronic acid	17.90	1.97	156
Kullenberg et al. (2004)	44.00	10.50	40	LA	-3.00	10.72	40

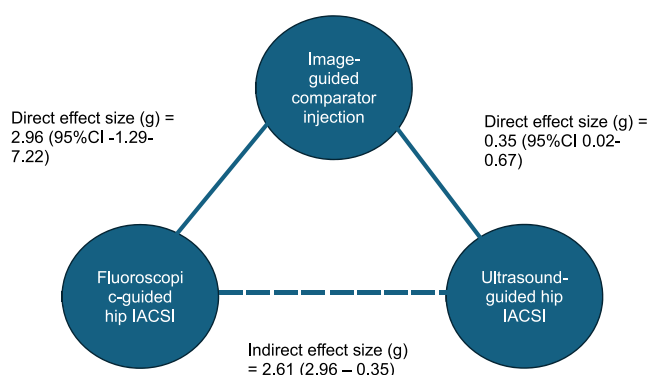
Abbreviations: CSI, corticosteroid injection; G1, group 1; G2, group 2; G3, group 3; IACSI, intra-articular corticosteroid injection; LA, local anaesthetic; SD, standard deviation.



**FIGURE 2** | Forest plot diagram showing the effect size (SMD/g) and standard error (SE) of ultrasound-guided hip intra-articular (IA) steroid injection against an image-guided comparator hip IA injection at the 1-month timepoint. The pooled effect size was 0.35 (small to medium) in favour of ultrasound-guided IA corticosteroid injection. The between-study heterogeneity variance was estimated at  $\tau = 0.0014$  (95% CI 0.00–0.86),  $\tau^2 \leq 0.0001$  (95% CI 0.00–0.74),  $I^2 = 0\%$  (95% CI 0.0%–84.7%), suggesting low heterogeneity between studies.



**FIGURE 3** | Forest plot diagram showing the effect size (SMD/g) and standard error (SE) of fluoroscopic-guided hip intra-articular (IA) steroid injection against an image-guided comparator hip IA injection at the 1-month timepoint. The pooled effect size was 2.96 (large) in favour of fluoroscopic-guided IA corticosteroid injection. The between-study heterogeneity variance was estimated at  $\tau = 2.66$  (95% CI 1.49–9.96),  $\tau^2 = 7.08$  (95% CI 2.21–99.21),  $I^2 = 98.9\%$  (95% CI 98.4%–99.3%) and Cochran's  $Q = 278.5$  ( $p \leq 0.0001$ ), suggesting substantial heterogeneity between studies.



**FIGURE 4** | Network graph illustrating the indirect relationship and effect size (g) between nodes.

USG as opposed to under FG (Hoeber et al. 2016); therefore, there are very few studies comparing USG versus FG for these regions.

Spinal injections are routinely completed under image guidance (ultrasound, fluoroscopy or CT) because of the anatomical complexity associated with the region (Viderman et al. 2023). Systematic reviews of RCTs have evaluated USG versus FG corticosteroid injections for the management of low back pain and spine-related leg pain (Hofmeister et al. 2019; Kimura et al. 2023; Viderman et al. 2023). All three studies were published within the last 4 years, possibly in response to the recommendations for research from NICE (2016) regarding low back pain and sciatica guidelines comparing the clinical and cost effectiveness of injection guidance modalities is an

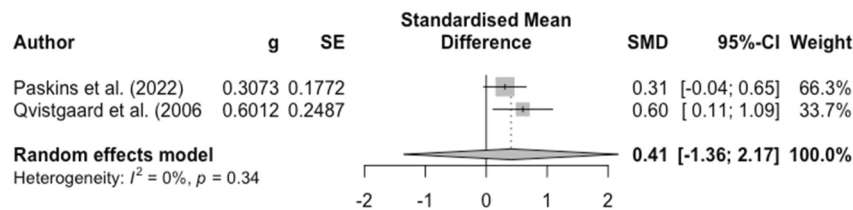
area that needs more research. The studies found no significant difference in terms of post-procedural pain relief between USG and FG modalities at 1-week, 1-month and 3-month timepoints.

### 4.3 | Implications of the Findings and Recommendations for Future Research

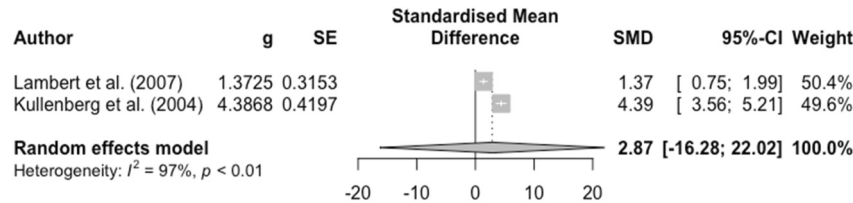
This systematic review reports that both USG and FG IACSI relieve pain at the 1-month timepoint for individuals with painful hip OA. Subsequently, healthcare stakeholders such as patients, providers and policymakers may consider other factors when preferentially choosing a modality. These may include cost effectiveness, convenience, patient experience and radiation exposure.

An RCT directly comparing fluoroscopic-guided hip IACSI with ultrasound-guided hip IACSI in a painful OA hip population would fully evaluate the intended research objective of this review. Future studies may also wish to fully explore the effect of image-guided hip IACSI across multiple timepoints.

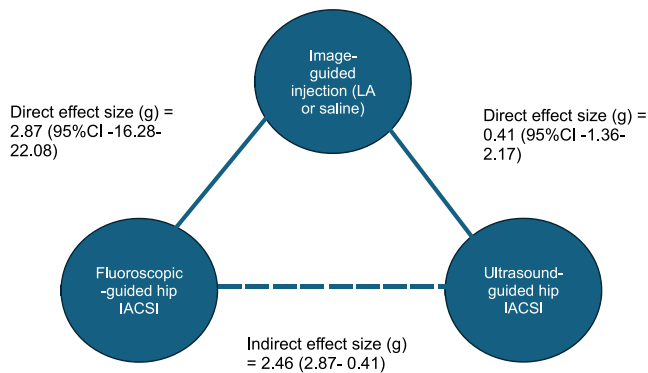
There does not appear to be any estimate of the utilisation rate of each imaging modality relative to one another, in the United Kingdom or worldwide, for individuals with painful hip OA. A scoping questionnaire or review of hospital outpatient appointment data (such as the Hospital Episode Statistics (HES) in the National Health Service (NHS) in the United Kingdom) may help to evaluate current trends in clinical practice.



**FIGURE 5** | Forest plot diagram showing the effect size (SMD/g) and standard error (SE) of ultrasound-guided hip intra-articular (IA) corticosteroid injection against an image-guided comparator hip IA injection (local anaesthetic or saline) at the 1-month timepoint. The pooled effect size was 0.41 (small to medium) in favour of ultrasound-guided IA corticosteroid injection. The between-study heterogeneity variance was estimated at 0 for  $\tau$ ,  $\tau^2$  and  $I^2$ , suggesting no heterogeneity between studies.



**FIGURE 6** | Forest plot diagram showing the effect size (SMD/g) and standard error (SE) of fluoroscopic-guided hip intra-articular (IA) corticosteroid injection against an image-guided comparator hip IA injection (local anaesthetic or saline) at the 1-month timepoint. Pooled effect size of 2.87 (large) in favour of fluoroscopic-guided IA corticosteroid injection. The between-study heterogeneity variance was estimated at  $\tau = 2.10$  (95%CI N/A),  $\tau^2 = 4.41$  (95% CI N/A),  $I^2$  value of 97.0% (95% CI 92.1%–98.9%) and Cochran's  $Q = 32.97$  ( $p \leq 0.0001$ ), suggesting substantial heterogeneity between studies.



**FIGURE 7** | A network graph illustrating the indirect relationship and effect size between nodes.

## 5 | Limitations

The Cochrane risk-of-bias tool for randomised trials (RoB2) (J. P. Higgins et al. 2019) identified varying levels of overall bias across the eight included RCTs, thus naturally impacting the validity of our results. The four studies evaluating the impact of ultrasound-guided intervention had lower risk-of-bias judgement cumulatively compared to the four studies evaluating fluoroscopic-guided intervention.

The study design of network meta-analysis is not without its documented limitations (Trinquart et al. 2016), notably and in the case of this study, the heterogeneous nature of the shared comparator group. Conversely, a strength of network meta-analysis is the ability to make indirect comparisons among treatments, which was essential in this study because of the absence of literature making a direct comparison.

Limitations also include small sample sizes and the time frame of outcome measurement. Although multiple timepoints were reported in the studies included in this review, one arbitrary timepoint was chosen for data extraction and meta-analysis. The timepoint of outcome measurements postinjection, which was closest to the 1-month post injection mark, varied between 3 weeks and 2 months. Eight studies included in this review were from four different continents with participants recruited from varying sources; with varying OA diagnostic criteria; receiving different corticosteroid drugs and dosages and evaluated in relation to varying comparator injection drugs and dosages. These variables are likely to contribute to the significant heterogeneity reported, and thus impact interpretation of the pooled effect sizes.

## 6 | Conclusion

This systematic review found that both ultrasound- and fluoroscopic-guided IACSI are effective at reducing pain at 1-month post-injection in individuals with painful hip OA. Both USG- and FG-IACSI were more effective at reducing pain at 1-month post-injection than image-guided comparator injections. The technique of FG IACSI seems more effective when indirectly compared to USG IACSI; however, this must be interpreted within the context of small sample sizes and large study heterogeneity. A key finding was that no RCTs were identified in our search that directly compared different imaging modalities for IACSI guidance in a hip OA population. Therefore, there is no empirical evidence to gauge their relative contribution in relation to impact, efficacy or pain relief in people with painful hip OA.

The review was not able to determine if it is more beneficial to offer an USG- or an FG-IACSI to relieve symptoms in patients with painful hip OA. No RCTs to date have tested this, making it a logical gap in the literature to address.

## Author Contributions

Conceptualization: P.A.B. and S.S. Data curation: P.A.B. Formal analysis: P.A.B. Investigation: P.A.B. Methodology: P.A.B. and S.S. Project Administration: P.A.B. and S.S. Software: P.A.B. Supervision: S.S. Validation: P.A.B. and S.S. Visualisation: P.A.B. and S.S. Writing—original draft: P.A.B. Writing—review and editing: P.A.B. and S.S. All authors reviewed the results and approved the final version of the manuscript.

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The authors have nothing to report.

## Conflicts of Interest

The authors declare no conflicts of interest.

## Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## References

- Balduzzi, S., G. Rücker, and G. Schwarzer. 2019. “How to Perform a Meta-Analysis With R: A Practical Tutorial.” *BMJ Mental Health* 22, no. 4: 153–160. <https://doi.org/10.1136/ebmental-2019-300117>.
- Bank of England. 2023. Inflation Calculator. August 1. <https://www.bankofengland.co.uk/monetary-policy/inflation/inflation-calculator>.
- BNF. 2023a. British National Formulary. Methylprednisolone, Medicinal Forms. October 12. <https://bnf.nice.org.uk/drugs/methylprednisolone/medicinal-forms/>.
- BNF. 2023b. British National Formulary. Triamcinolone-Acetonide, Medicinal Forms. October 18. <https://bnf.nice.org.uk/drugs/triamcinolone-acetonide/medicinal-forms/>.
- Boutron, I., F. Rannou, M. Jardinaud-Lopez, G. Meric, M. Revel, and S. Poiraudau. 2008. “Disability and Quality of Life of Patients With Knee or Hip Osteoarthritis in the Primary Care Setting and Factors Associated With General Practitioners’ Indication for Prosthetic Replacement Within 1 Year.” *Osteoarthritis and Cartilage* 16, no. 9: 1024–1031. <https://doi.org/10.1016/j.joca.2008.01.001>.
- British Medical Association, BMA. 2023. Health Funding Data Analysis. August 23. <https://www.bma.org.uk/advice-and-support/nhs-delivery-and-workforce/funding/health-funding-data-analysis#:~:text=OECD%20data%20shows%20that%20the,in%20GDP%20of%20the%20G7>.
- Byrd, J. T., E. A. Potts, R. K. Allison, and K. S. Jones. 2014. “Ultrasound-Guided Hip Injections: A Comparative Study With Fluoroscopy-Guided Injections.” *Arthroscopy: The Journal of Arthroscopic & Related Surgery* 30, no. 1: 42–46. <https://doi.org/10.1016/j.arthro.2013.09.083>.
- Chen, A. G. C. M., C. Gupta, K. Akhtar, P. Smith, and J. Cobb. 2012. “The Global Economic Cost of Osteoarthritis: How the UK Compares.” *Arthritis* 2012, no. 1: 698709. <https://doi.org/10.1155/2012/698709>.
- Cochran, W. G. 1954. “Some Methods for Strengthening the Common  $\chi^2$  Tests.” *Biometrics* 10, no. 4: 417–451. <https://doi.org/10.2307/3001616>.
- Cochrane. 2019. (2023, August 23) Cochrane Handbook. Section 16.1.3.2 Inputting Standard Deviations for Changes From Baselines. [http://handbook-5-1.cochrane.org/chapter\\_16/16\\_1\\_3\\_2\\_imputing\\_standard\\_deviations\\_for\\_changes\\_from\\_baseline.htm](http://handbook-5-1.cochrane.org/chapter_16/16_1_3_2_imputing_standard_deviations_for_changes_from_baseline.htm).

Cochrane Handbook. 2019a. (2023, August 25) Section 7.7.3 Data Extraction for Continuous Outcomes, Table 7.7.a Formulae for Combining Groups. [https://handbook-5-1.cochrane.org/chapter\\_7/table\\_7\\_7\\_a\\_formulae\\_for\\_combining\\_groups.htm](https://handbook-5-1.cochrane.org/chapter_7/table_7_7_a_formulae_for_combining_groups.htm).

Cochrane Handbook. 2019b. (2023, August 25) Section 7.7.3.2 Obtaining Standard Deviations From Standard Errors and Confidence Intervals for Group Means. [https://handbook-5-1.cochrane.org/chapter\\_7/7\\_7\\_3\\_2\\_obtaining\\_standard\\_deviations\\_from\\_standard\\_errors\\_and.htm#:~:text=The%20standard%20deviation%20for%20each,should%20be%20replaced%20by%205.15](https://handbook-5-1.cochrane.org/chapter_7/7_7_3_2_obtaining_standard_deviations_from_standard_errors_and.htm#:~:text=The%20standard%20deviation%20for%20each,should%20be%20replaced%20by%205.15).

Courties, A., F. Berenbaum, and J. Sellam. 2019. “The Phenotypic Approach to Osteoarthritis: A Look at Metabolic Syndrome-Associated Osteoarthritis.” *Joint Bone Spine* 86, no. 6: 725–730. <https://doi.org/10.1016/j.jbspin.2018.12.005>.

Cumpston, M., T. Li, M. J. Page, et al. 2019. “Updated Guidance for Trusted Systematic Reviews: A New Edition of the Cochrane Handbook for Systematic Reviews of Interventions.” *Cochrane Database of Systematic Reviews* 2019, no. 10. <https://doi.org/10.1002/14651858.ed000142>.

Daniels, E. W., D. Cole, B. Jacobs, and S. F. Phillips. 2018. “Existing Evidence on Ultrasound-Guided Injections in Sports Medicine.” *Orthopaedic Journal of Sports Medicine* 6, no. 2: 2325967118756576. <https://doi.org/10.1177/2325967118756576>.

Gazendam, A., S. Ekhtiari, A. Bozzo, M. Phillips, and M. Bhandari. 2021. “Intra-Articular Saline Injection Is as Effective as Corticosteroids, Platelet-Rich Plasma and Hyaluronic Acid for Hip Osteoarthritis Pain: A Systematic Review and Network Meta-Analysis of Randomised Controlled Trials.” *British Journal of Sports Medicine* 55, no. 5: 256–261. <https://doi.org/10.1136/bjsports-2020-102179>.

Harrer, M., P. Cuijpers, T. Furukawa, and D. Ebert. 2021. *Doing Meta-Analysis with R: A Hands-On Guide*. New York: Chapman and Hall/CRC. <https://doi.org/10.1201/9781003107347>.

Harris, E. C., and D. Coggon. 2015. “HIP Osteoarthritis and Work.” *Best Practice & Research Clinical Rheumatology* 29, no. 3: 462–482. <https://doi.org/10.1016/j.berh.2015.04.015>.

Higgins, J. P., D. G. Altman, P. C. Gøtzsche, et al. 2011. “The Cochrane Collaboration’s Tool for Assessing Risk of Bias in Randomised Trials.” *BMJ* 343, no. 2: d5928. <https://doi.org/10.1136/bmj.d5928>.

Higgins, J. P., J. Savović, M. J. Page, R. G. Elbers, and J. A. Sterne. 2019. “Assessing Risk of Bias in a Randomized Trial.” *Cochrane Handbook for Systematic Reviews of Interventions*: 205–228. <https://doi.org/10.1002/9781119536604.ch8>.

Higgins, J. P., and S. G. Thompson. 2002. “Quantifying Heterogeneity in a Meta-analysis.” *Statistics in Medicine* 21, no. 11: 1539–1558. <https://doi.org/10.1002/sim.1186>.

Higgins, J. P. T., J. Thomas, J. Chandler, et al. 2021. *Cochrane Handbook for Systematic Reviews of Interventions Version 6.2*. Cochrane. <https://training.cochrane.org/handbook/archive/v6.2>.

Hoerber, S., A. R. Aly, N. Ashworth, and S. Rajasekaran. 2016. “Ultrasound-Guided Hip Joint Injections Are More Accurate Than Landmark-Guided Injections: A Systematic Review and Meta-Analysis.” *British Journal of Sports Medicine* 50, no. 7: 392–396. <https://doi.org/10.1136/bjsports-2014-094570>.

Hofmeister, M., L. E. Dowsett, D. L. Lorenzetti, and F. Clement. 2019. “Ultrasound-Versus Fluoroscopy-Guided Injections in the Lower Back for the Management of Pain: A Systematic Review.” *European Radiology* 29, no. 7: 3401–3409. <https://doi.org/10.1007/s00330-019-06065-3>.

Holtz, N., D. F. Hamilton, J. M. Giesinger, B. Jost, and K. Giesinger. 2020. “Minimal Important Differences for the WOMAC Osteoarthritis Index and the Forgotten Joint Score-12 in Total Knee Arthroplasty Patients.” *BMC Musculoskeletal Disorders* 21: 1–9. <https://doi.org/10.1186/s12891-020-03415-x>.



- Hutton, B., G. Salanti, D. M. Caldwell, et al. 2015. "The PRISMA Extension Statement for Reporting of Systematic Reviews Incorporating Network Meta-Analyses of Health Care Interventions: Checklist and Explanations." *Annals of Internal Medicine* 162, no. 11: 777–784. <https://doi.org/10.7326/m14-2385>.
- Jurgensmeier, K., D. Jurgensmeier, D. E. Kunz, P. G. Fuerst, L. C. Warth, and S. B. Daines. 2021. "Intra-Articular Injections of the Hip and Knee With Triamcinolone vs Ketorolac: A Randomized Controlled Trial." *Journal of Arthroplasty* 36, no. 2: 416–422. <https://doi.org/10.1016/j.arth.2020.08.036>.
- Kellgren, J. H., and J. S. Lawrence. 1957. "Radiological Assessment of Osteo-Arthrosis." *Annals of the Rheumatic Diseases* 16, no. 4: 494–502. <https://doi.org/10.1136/ard.16.4.494>.
- Kimura, R., N. Yamamoto, J. Watanabe, Y. Ono, M. Hongo, and N. Miyakoshi. 2023. "Comparative Efficacy of Ultrasound Guidance and Fluoroscopy or Computed Tomography Guidance in Spinal Nerve Injections: A Systematic Review and Meta-Analysis." *European Spine Journal* 32, no. 12: 4101–4110. <https://doi.org/10.1007/s00586-023-07968-y>.
- Kose, S. G., H. C. Kose, F. Celikel, S. Tulgar, and O. T. Akkaya. 2023. "Ultrasound-Guided PENG Block Versus Intraarticular Corticosteroid Injection in Hip Osteoarthritis: A Randomised Controlled Study." *Korean Journal of Pain* 36, no. 2: 195–207. <https://doi.org/10.3344/kjp.22325>.
- Kruse, D. W. 2008. "Intraarticular Cortisone Injection for Osteoarthritis of the Hip. Is it Effective? Is it Safe?" *Current Reviews in Musculoskeletal Medicine* 1, no. 3: 227–233. <https://doi.org/10.1007/s12178-008-9029-0>.
- Kullenberg, B., R. Runesson, R. Tuvhag, C. Olsson, and S. Resch. 2004. "Intraarticular Corticosteroid Injection: Pain Relief in Osteoarthritis of the Hip?" *Journal of Rheumatology* 31, no. 11: 2265–2268.
- Lambert, R. G., E. J. Hutchings, M. G. Grace, G. S. Jhangri, B. Conner-Spady, and W. P. Maksymowych. 2007. "Steroid Injection for Osteoarthritis of the Hip: A Randomized, Double-Blind, Placebo-Controlled Trial." *Arthritis & Rheumatism: Official Journal of the American College of Rheumatology* 56, no. 7: 2278–2287. <https://doi.org/10.1002/art.22739>.
- Malik, A. T., J. H. Alexander, D. D. Li, M. Li, S. N. Khan, and T. J. Scharschmidt. 2020. "What Are the Costs of Hip Osteoarthritis in the Year Prior to a Total Hip Arthroplasty?" *Journal of Arthroplasty* 35, no. 2: 313–317. <https://doi.org/10.1016/j.arth.2019.09.020>.
- McCabe, P. S., N. Maricar, M. J. Parkes, D. T. Felson, and T. W. O'Neill. 2016. "The Efficacy of Intra-Articular Steroids in Hip Osteoarthritis: A Systematic Review." *Osteoarthritis and Cartilage* 24, no. 9: 1509–1517. <https://doi.org/10.1016/j.joca.2016.04.018>.
- Moher, D., A. Liberati, J. Tetzlaff, D. G. Altman, and T. PRISMA Group\*. 2009. "Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement." *Annals of Internal Medicine* 151, no. 4: 264–269. <https://doi.org/10.7326/0003-4819-151-4-200908180-00135>.
- National Institute for Health and Care Excellence (NICE). 2016. (2024, September 17) Low Back Pain and Sciatica in Over 16s: Assessment and Management. NICE Guideline NG59. <https://www.nice.org.uk/guidance/ng59/chapter/Recommendations-for-research>.
- National Institute for Health and Care Excellence (NICE). 2022a. (2023, August 22) Osteoarthritis in Over 16s: Diagnosis and Management. NICE Guideline NG226. <https://www.nice.org.uk/guidance/ng226/chapter/Recommendations#diagnosis>.
- National Institute for Health and Care Excellence (NICE). 2022b. (2023, September 6) Osteoarthritis in Over 16s: Diagnosis and Management. [J] Evidence Review for the Clinical and Cost-Effectiveness of Intra-Articular Injections for the Management of Osteoarthritis. NICE Guideline NG226. <https://www.nice.org.uk/guidance/ng226/evidence/j-clinical-and-costeffectiveness-of-intraarticular-injections-for-the-management-of-osteoarthritis-pdf-405016302423>.
- National Joint Registry. 2022. (2023, August 22) National Joint Registry: 19th Annual Report 2022. <https://reports.njrcentre.org.uk/Portals/0/PDFdownloads/NJR%2019th%20Annual%20Report%202022.pdf>.
- NHS England. 2021. (2023, October 12) National Schedule of NHS Costs 2019/2020 V2. [https://www.england.nhs.uk/wp-content/uploads/2021/06/2\\_National\\_schedule\\_of\\_NHS\\_costs\\_FY19\\_20\\_V2.xlsx](https://www.england.nhs.uk/wp-content/uploads/2021/06/2_National_schedule_of_NHS_costs_FY19_20_V2.xlsx).
- NHS England. 2023. (2024, August 25). Making a Decision About Hip Osteoarthritis. <https://www.england.nhs.uk/wp-content/uploads/2022/07/Making-a-decision-about-hip-osteoarthritis.pdf>.
- Office of National Statistics. 2022. (2024, August 25). Population of England in 2022, by Age Group. <https://www.statista.com/statistics/281208/population-of-the-england-by-age-group/>.
- Page, M. J., J. E. McKenzie, P. M. Bossuyt, et al. 2021. "The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews." *BMJ* 372: n71. <https://doi.org/10.1136/bmj.n71>.
- Paskins, Z., K. Bromley, M. Lewis, et al. 2022. "Clinical Effectiveness of One Ultrasound Guided Intra-Articular Corticosteroid and Local Anaesthetic Injection in Addition to Advice and Education for Hip Osteoarthritis (HIT Trial): Single Blind, Parallel Group, Three Arm, Randomised Controlled Trial." *BMJ* 377: e068446. <https://doi.org/10.1136/bmj-2021-068446>.
- Qvistgaard, E., R. Christensen, S. Torp-Pedersen, and H. Bliddal. 2006. "Intra-Articular Treatment of Hip Osteoarthritis: A Randomized Trial of Hyaluronic Acid, Corticosteroid, and Isotonic Saline." *Osteoarthritis and Cartilage* 14, no. 2: 163–170. <https://doi.org/10.1016/j.joca.2005.09.007>.
- Rampal, S., A. Jaiman, M. A. Tokgöz, et al. 2022. "A Review of the Efficacy of Intraarticular Hip Injection for Patients With Hip Osteoarthritis: To Inject or Not to Inject in Hip Osteoarthritis?" *Joint Diseases and Related Surgery* 33, no. 1: 255–262. <https://doi.org/10.52312/jdrs.2022.402>.
- R Core Team, R. 2023. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. <https://www.R-project.org/>.
- Rezende, M. U. D., H. M. C. Gurgel, G. P. Ocampos, et al. 2020. "Improvements in Hip Osteoarthritis With Lavage, Triamcinolone and Hylan G-F20." *Acta Ortopédica Brasileira* 28, no. 6: 280–286. <https://doi.org/10.1590/1413-785220202806240075>.
- Salaffi, F., M. Carotti, A. Stancati, and W. Grassi. 2005. "Health-Related Quality of Life in Older Adults With Symptomatic Hip and Knee Osteoarthritis: A Comparison With Matched Healthy Controls." *Aging Clinical and Experimental Research* 17, no. 4: 255–263. <https://doi.org/10.1007/bf03324607>.
- Sanders, B. S., M. D. McInnes, M. L. Sampaio, and K. S. Rakhra. 2017. "Relationship Between Radiologist Training Level and Radiation Exposure for Therapeutic Hip Injections." *European Journal of Radiology* 95: 136–140. <https://doi.org/10.1016/j.ejrad.2017.07.001>.
- Saunders, S., and S. Longworth. 2018. *Injection Techniques in Musculoskeletal Medicine: A Practical Manual for Clinicians in Primary and Secondary Care*. Elsevier Health Sciences. ISBN 978-0-7020-6957-4.
- Sibbitt, W. L., Jr., P. A. Band, L. G. Kettwich, N. R. Chavez-Chiang, S. L. DeLea, and A. D. Bankhurst. 2011. "A Randomized Controlled Trial Evaluating the Cost-Effectiveness of Sonographic Guidance for Intra-Articular Injection of the Osteoarthritic Knee." *Journal of Clinical Rheumatology* 17, no. 8: 409–415. <https://doi.org/10.1097/rhu.0b013e31823a49a4>.
- Smith, M., S. Innes, S. Wildman, and D. Baker. 2023. "A Proposed Framework for Point of Care Musculoskeletal Ultrasound and Ultrasound Image-Guided Interventions by Physiotherapists: Scope of Practice, Education and Governance." *Ultrasound Journal* 15, no. 1: 15. <https://doi.org/10.1186/s13089-023-00311-y>.
- Sowers, M. 2001. "Epidemiology of Risk Factors for Osteoarthritis: Systemic Factors." *Current Opinion in Rheumatology* 13, no. 5: 447–451. <https://doi.org/10.1097/00002281-200109000-00018>.

- Spitzer, A. I., B. I. Bockow, V. A. Brander, et al. 2010. "Hylan GF 20 Improves Hip Osteoarthritis: A Prospective, Randomized Study." *Physician and Sportsmedicine* 38, no. 2: 35–47. <https://doi.org/10.3810/psm.2010.06.1781>.
- Sterne, J. A., J. Savović, M. J. Page, et al. 2019. "RoB 2: A Revised Tool for Assessing Risk of Bias in Randomised Trials." *BMJ* 366: 14898. <https://doi.org/10.1136/bmj.14898>.
- Subedi, N., N. S. Chew, M. Chandramohan, A. J. Scally, and C. Groves. 2015. "Effectiveness of Fluoroscopy-Guided Intra-Articular Steroid Injection for Hip Osteoarthritis." *Clinical Radiology* 70, no. 11: 1276–1280. <https://doi.org/10.1016/j.crad.2015.07.002>.
- Trinquart, L., N. Attiche, A. Bafeta, R. Porcher, and P. Ravaud. 2016. "Uncertainty in Treatment Rankings: Reanalysis of Network Meta-Analyses of Randomized Trials." *Annals of Internal Medicine* 164, no. 10: 666–673. <https://doi.org/10.7326/m15-2521>.
- Tubach, F., P. Ravaud, G. Baron, et al. 2005. "Evaluation of Clinically Relevant Changes in Patient Reported Outcomes in Knee and Hip Osteoarthritis: The Minimal Clinically Important Improvement." *Annals of the Rheumatic Diseases* 64, no. 1: 29–33. <https://doi.org/10.1136/ard.2004.022905>.
- Videman, D., M. Aubakirova, A. Aryngazin, et al. 2023. "Ultrasound-Guided vs. Fluoroscopy-Guided Interventions for Back Pain Management: A Systematic Review and Meta-Analysis of Randomized Controlled Trials." *Diagnostics* 13, no. 22: 3474. <https://doi.org/10.3390/diagnostics13223474>.
- Viechtbauer, W. 2010. "Conducting Meta-Analyses in R With the Metafor Package." *Journal of Statistical Software* 36, no. 3: 1–48. <https://doi.org/10.18637/jss.v036.i03>.
- Walter, U. 2022. "Ultrasound-Guided Medical Procedures: A Growing Field With New Opportunities." *Ultraschall in der Medizin-European Journal of Ultrasound* 43, no. 04: 327–331. <https://doi.org/10.1055/a-1856-8797>.
- Wewege, M. A., M. D. Jones, S. A. Williams, S. J. Kamper, and J. H. McAuley. 2022. "Rescaling Pain Intensity Measures for Meta-Analyses of Analgesic Medicines for Low Back Pain Appears Justified: An Empirical Examination From Randomised Trials." *BMC Medical Research Methodology* 22, no. 1: 285. <https://doi.org/10.1186/s12874-022-01763-x>.
- Wickham, H., M. Averick, J. Bryan, et al. 2019. "Welcome to the Tidyverse." *Journal of Open Source Software* 4, no. 43: 1686. <https://doi.org/10.21105/joss.01686>.
- Zhong, H. M., G. F. Zhao, T. Lin, et al. 2020. "Intra-articular Steroid Injection for Patients With Hip Osteoarthritis: A Systematic Review and Meta-analysis." *BioMed Research International* 2020, no. 1: 6320154. <https://doi.org/10.1155/2020/6320154>.

## Appendix A

Supplementary information: Search strategies

Databases searched:

1. AMED
2. CINAHL
3. EMBASE
4. MEDLINE
5. PUBMED
6. PSYCINFO
7. SPORTDiscus
8. CENTRAL
9. PEDro

Grey literature such as Google Scholar was additionally searched.

Search strategy:

1. Hip
2. Osteoarthritis
3. Arthritis
4. Degenerative
5. 2 or 3 or 4
6. Intra-articular
7. Intra-articular
8. Inject\*
9. 6 or 7 or 8
10. Steroid
11. Cortico\*
12. Glucocortico\*
13. 10 or 11 or 12
14. Fluoro\*
15. Ultrasound
16. Guided
17. 14 or 15 or 16
18. 1 and 5 and 9 and 13 and 17