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INTERVENTIONAL

Ultrasound- versus fluoroscopy-guided injections in the lower back for the management of pain: a systematic review

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Abstract

Purpose Ultrasound-guided spinal injections are less common than fluoroscopy-guided injections. Although unable to penetrate bones, ultrasound guidance has a number of advantages including convenience and reduced exposure to ionizing radiation. However, it is not known how ultrasound-guided injections compare to fluoroscopy-guided injections in the management of lower back pain. Our objective is to systematically review the literature comparing ultrasound-guided injections to fluoroscopy-guided injections for the management of lower back pain.

Methods Medline, Cochrane CENTRAL Register of Controlled Trials, Embase, and NHSEED were searched from 2007 to September 26, 2017. Inclusion criteria included (1) randomized controlled trial design, (2) compared ultrasound-guided and fluoroscopy-guided injections for lower back pain, (3) dose and volume of medications injected were identical between trial arms, and (4) reported original data.

Results One hundred one unique records were identified, and 21 studies were considered for full-text inclusion. Nine studies formed the final data set. Studies comparing ultrasound- and fluoroscopy-guided injections for lower back pain management reported no difference in pain relief, procedure time, number of needle passes, changes in disability indices, complications or adverse events, post-procedure opioid consumption, or patient satisfaction.

Conclusion Fluoroscopic guidance of injections for the management of lower back pain is similar in efficacy to ultrasound guidance. The exact role of ultrasound guidance needs to be further studied, especially for nerve root injections, where safety is the major concern.

Key Points

- *There were no differences in pain relief, procedure time, number of needle passes, changes in disability indices, complications or adverse events, post-procedure opioid consumption, or patient satisfaction between ultrasound- and fluoroscopy-guided injections for the management of lower back pain.*
- *Given the lack of evidence to demonstrate superior efficacy and the added harms with fluoroscopic guidance, ultrasound guidance may be the preferred method of guidance for injections to manage lower back pain in appropriate patients. Further study is required to understand the exact role of ultrasound in image-guided injections.*

Keywords Fluoroscopy · Ultrasonography · Low back pain

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Abbreviations

$\mu Gy \cdot m^2$	Microgray-meters squared
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Introduction

Back pain will affect up to 80% of people throughout their lifetime and is the most frequent cause of activity limitation in those less than 45 years old [1]. In the 2010 Global Burden of Disease Study, lower back pain was ranked highest in years lived with disability, and sixth in terms of overall disease burden (measured in disability-adjusted life years) [2]. In the USA, costs associated with lower back pain are greater than $100 billion annually, in the form of reduced work productivity and lost wages, and direct medical costs for healthcare provision [3]. Conventional management for lower back pain includes physical therapy and functional rehabilitation, oral and topical analgesics, psychologic interventions, acupuncture and chiropractic treatments, and surgery, as well as other therapeutic options. In addition, for patients who do not respond to more conservative management, spinal injections might be considered [4].

Image-guided spinal injections reduce the rate of neurovascular complications and increase the likelihood that medications reach the intended target [4]. Most commonly, fluoroscopic guidance is used for spinal injections [4]. However, ultrasound guidance may represent an alternative guidance approach that does not expose the patient to radiation [5]. Currently, no complete synthesis comparing ultrasound-guided injections to fluoroscopy-guided injections in the management of lower back pain exists. The objective of this systematic review was to compare ultrasound-guided and fluoroscopy-guided injections in the management of lower back pain. The findings of this work may inform physicians, patients, and healthcare systems about which guidance approach leads to improved clinical outcomes.

Materials and methods

A systematic review was completed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [6]. To limit results to recent imaging and injection techniques, the following databases were searched from 2007 to September 26, 2017: Medline, Cochrane CENTRAL Register of Controlled Trials, Embase, and NHSEED. Search terms for fluoroscopy such as "fluoroscopy," "fluorescene radiation," or "radiofluoroscopy" were combined using the Boolean Operator "and" with terms describing ultrasound, such as "ultrasonography," "sonography," "ultrasound," and "sonograph." These terms were all combined using the Boolean Operator "and" with terms for the lower back, such as "sciatica," "low back pain," or "lumbar." Results were limited to English or French language studies with human participants. A filter for randomized controlled trials was used [7]. Details of the search strategy can be found in the Appendix.

All abstracts were screened independently in duplicate. Abstracts proceeded to full-text review if ultrasound and fluoroscopic guided injections for the management of lower back pain were compared in a randomized controlled trial. Abstracts selected for inclusion by either reviewer proceeded to full-text review. The full text of included abstracts was reviewed in duplicate. Inclusion criteria were (1) randomized controlled trial design, (2) compared ultrasound-guided and fluoroscopy-guided injections, (3) injections were in the lower back, (4) dose and volume of medications injected were identical between trial arms, and (5) reported original data. Conference proceedings, abstracts, animal studies, and studies published in languages other than English or French were excluded. Any discrepancy between reviewers was resolved through discussion and consensus. Reference lists of included randomized controlled trials were hand-searched to identify additional studies of relevance to this review.

Year of publication, country, comparators, patient selection, and outcomes were extracted in duplicate using standardized data extraction forms. Discrepancies between reviewers during data extraction were resolved through consensus. Study quality was assessed using the Cochrane Risk of Bias checklist, which examines the potential for bias in seven domains: random assignment generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and any additional potential sources of bias [8]. A narrative synthesis was completed of all included studies.

Results

Searches of electronic databases returned 103 records. Following removal of duplicates, 100 records remained for title/abstract screening. Eighty-one articles were excluded at the title/abstract screen state (Fig. 1). All references from included studies were also assessed for inclusion and returned one additional study that met inclusion criteria. The full text of 21 articles was assessed for inclusion, and nine articles were included in the final data set for the narrative synthesis.

Characteristics of included studies can be found in Table 1. Four studies were conducted in the Republic of Korea [9, 10, 13, 17] and the remaining studies were conducted in Canada [16], China [11], Turkey [12], Latvia [14], and India [15]. Five studies involved injections into the epidural space between L2 and S3 [11, 14–17], two studies involved injections into the lumbar facet joints [9, 10], and two studies involved injections into the sacroiliac joint [12, 13]. Lidocaine or bupivacaine was included in the injection in all included studies. In all studies, a glucocorticoid such as methylprednisolone or dexamethasone was included in the injection.

In study quality assessment using the Cochrane "Risk of Bias" tool, study quality varied [8]. Of included studies, nearly 60% were deemed to be of high risk of bias in the domain of blinding of participants and personnel [11–13, 15, 16], and the remainder were deemed to be of unclear risk of bias [9, 10, 14, 17]. High risk of bias was also identified in the domain of selective reporting for the study by Ha et al [9]. There were

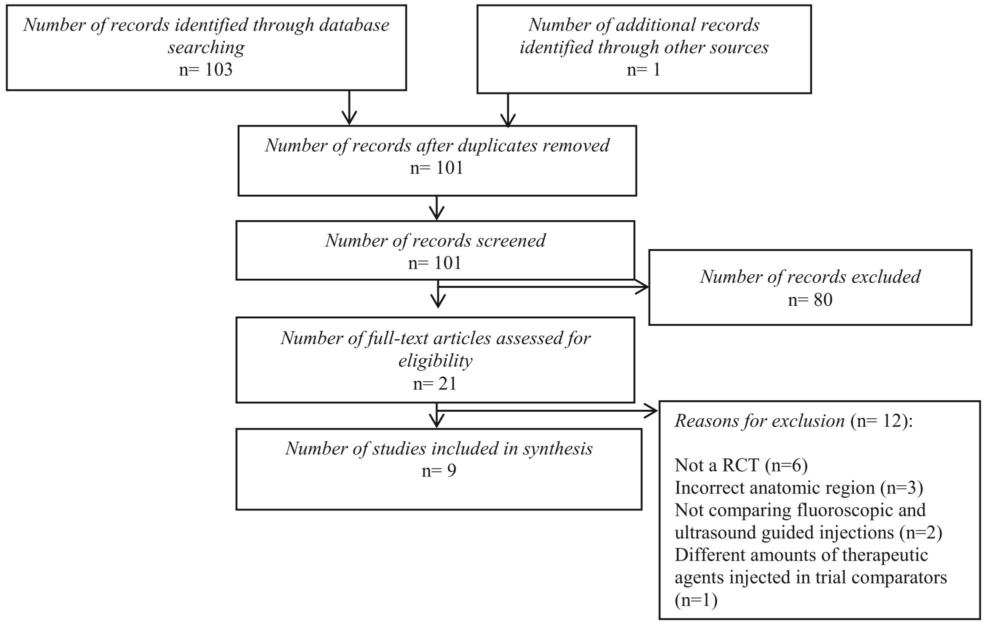

Fig. 1 PRISMA flow chart

no domains in which all included studies were judged to be a low risk of bias (Fig. 2).

In all studies, there was no difference in pain relief between ultrasound- and fluoroscopy-guided injections (Table 2). Three studies found a lower procedure time for the ultrasound-guided injections [14, 15, 17], and three studies found a lower procedure time for the fluoroscopy-guided injections [9, 10, 13]. There was no difference reported in the number of needle passes, disability, complications and adverse events, daily opioid consumption, or patient satisfaction. In one study examining radiation dosage, the dose of radiation was lower in the ultrasound group (2640 ± 906 micrograymeters squared (μGy·m^2)) compared to the fluoroscopy group (8992 ± 2132 μGy·m^2) ($p < 0.05$) [11]. In this study, any radiation experienced in the ultrasound group was due to fluoroscopic confirmation of needle placement to determine success [11].

Discussion

Nine randomized controlled trials comparing ultrasound and fluoroscopic guidance for the management of lower back pain were identified. Included studies were of low to unclear risk of bias in all domains. Few significant differences were found across outcomes; there was no difference in pain relief, number of needle passes, disability, complications and adverse events, daily opioid consumption, or patient satisfaction. Given the lower cost of ultrasound and the risk of radiation exposure with fluoroscopy, ultrasound may be the preferred guidance technique for physicians, patients, and healthcare systems.

In five studies, medications were injected into the epidural space; in two studies, medications were injected into the facet joints; and in the remaining two studies, medications were injected into the sacroiliac joint. In the US Medicare population in 2006, the most prevalent interventional procedures for the management of pain were epidural interventions and facet joint interventions, which match the intervention targets in the included studies [18]. Despite differences in injection site, findings of this review are likely generalizable to the broader population.

Performing physicians are also subject to scattered radiation during fluoroscopically guided procedures. This may have substantial cumulative effects over a career [19]. In one study in which radiation dosimeters were placed over the collar of physicians performing fluoroscopic pain interventions, the predicted annual radiation dose was 20.32 millisievert; this is roughly equivalent to the radiation associated with a full body computed tomography scan [20]. Kim and Miller note that physician position relative to the patient during fluoroscopically guided procedures was associated with a 40-fold variation in radiation dose and fixed factors such as physician body size, height, experience, and workload also affected radiation exposure [21]. The evidence connecting radiation exposure in physicians to cancer reflects this variation in exposure. The relative risk of malignant neoplasms in 45,634 physicians performing fluoroscopy-guided interventions compared to 64,401 psychiatrists, all of whom graduated medical school after 1980, is 1.04 (95% CI, 0.71 to 1.52) [22]. Increasing the proportion of spinal injections in the lower back for the management of pain conducted with ultrasound guidance rather than fluoroscopic guidance would reduce radiation exposure for physicians and patients.

Table 1 Summary and characteristics of included studies

Anatomic region	First author, country, year	Comparators	Patient selection	Results	High risk of bias features
Lumbar facet joints	Ha et al [9], Korea, 2016	Ultrasound- or fluoroscopy-guided injection of 0.5 mL dexamethasone and 2% lidocaine between L2 and S1	105 patients with lumbar pain or referred pain, diagnosed with spinal stenosis	• Ultrasound-guided injections required approximately 20 s more than fluoroscopy-guided injections. • Significant improvements in the Oswestry Disability Index and pain in both groups. • No significant differences in complication rates between groups.	Selective reporting
	Yun et al [10], Korea, 2012	Ultrasound- or fluoroscopy-guided injection of 10 mg triamcinolone and 2 mL of 1% lidocaine between L4 and S1	57 subjects with facet syndrome of the lumbar spine	• No significant differences in pain, physician's or patient's global assessment, and modified Oswestry Disability Index between groups at 1 week, 1 month, and 3 months. • Ultrasound-guided injection had a longer procedure time (FS 248.7 ± 6.5 s; US 263.4 ± 5.9 s; $p = 0.023$)	None
Lumbar epidural space	Yang et al [11], China, 2016	Ultrasound- or fluoroscopy-guided injection of 4 mL of 0.5% lidocaine and 1 mL diprospan between L3 and L5	80 patients with low back pain and radicular pain	• In both groups, pain decreased over time, and there was no significant difference in pain between groups during the 1-month observation phase. • Procedure time in the ultrasound group (518 ± 103 s) was shorter than in the fluoroscopy group (929 ± 228 s) ($p < 0.05$). • Radiation dosage in the ultrasound group (2640 ± 906 $\mu Gy \cdot m^2$) was lower than in the fluoroscopy group (8992 ± 2132 $\mu Gy \cdot m^2$) ($p < 0.05$).	None
Lumbosacral epidural space	Akkaya et al [12], Turkey, 2016	Ultrasound- or fluoroscopy-guided injection of 2.5% bupivacaine and dexamethasone 8 mg between L4 and S1	30 patients who had undergone L4–5 or L5–S1 hemilaminectomy in the last year	• Both groups had similar improvements in $p = 0.455$ and function. • Time to block was shorter in ultrasound-guided injections (6.06 ± 0.88 min versus 11.2 ± 1.14 min; $p = 0.0001$)	Blinding of participant and personnel
	Park et al [13], Republic of Korea, 2013	Ultrasound- or fluoroscopy-guided injection of 5 mL nonionic contrast medium, 13 mL of 0.5% lidocaine, and 2 mL dexamethasone (10 mg) between L4 and S1	120 patients suspected of lumbar radicular pain	• Two weeks after the procedure, both methods resulted in similar improvements in symptoms (3.14 vs 3.18), and disability scores (33.25 versus 30.83). • Number of needle passes did not differ between groups.	Blinding of participants and personnel
	Evansa et al [14], Latvia, 2015	Ultrasound- or fluoroscopy-guided injection of methylprednisolone acetate 80 mg and 4 mL of 1% lidocaine between L4 and S1	112 patients with axial chronic lower back pain and extremity pain diagnosed with degenerative diseases of the spine	• Mean procedure time (fluoroscopy 370 s, ultrasound 323 s), number of needle insertion attempts (fluoroscopy 5, ultrasound 5), mean pain intensity and degree of disability scores at 1 (fluoroscopy 3.5, ultrasound 3.4) and 3 months (fluoroscopy 4.0, ultrasound 4.1) after the procedure did not significantly differ between groups. • Neither group had serious complications.	Blinding of participants and personnel
Sacral epidural space	Hazra et al [15], India, 2016	Ultrasound- or fluoroscopy-guided injection of 2 mL of 1%	50 patients with chronic low back pain and radiculopathy not		None

Table 1 (continued)

Anatomic region	First author, country, year	Comparators	Patient selection	Results	High risk of bias features
		lignocaine and 40 mg methylprednisolone at S3	responding to conventional medical management	• Needle placement time was shorter using ultrasound compared to fluoroscopy (119 versus 222 s, $p < 0.001$). • Pain and clinical improvement were comparable between both groups at all time points.	
Sacroiliac joint	Soneji et al [16], Canada, 2015	Ultrasound- or fluoroscopy-guided injection of 40 mg methylprednisolone acetate; diluted in 3 mL of bipuvacaine 0.25% with epinephrine 1:200,000	40 patients with chronic moderate-to-severe lower back pain secondary to sacroiliac joint arthritis	• No significant difference between pain scores $p = 0.785$), Oswestry Disability Index ($p = 0.716$), daily morphine consumption post procedure ($p = 0.285$), or overall patient satisfaction ($p = 0.375$) at 1 month. • No significant differences in rates of intra-articular versus peri-articular injection ($p = 0.52$), or patient discomfort during the procedure. • Significantly lower procedure in the fluoroscopy-guided group compared to the ultrasound group (323.10 ± 132.32 s and 560.75 ± 251.82 s, respectively; $p < 0.01$).	Blinding of participants and personnel
	Jee et al [17], Republic of Korea, 2014	Ultrasound- or fluoroscopy-guided injection of 0.5 mL nonionic contrast media, 1 mL of 0.5% lidocaine, and 1 mL dexamethasone (10 mg)	120 patients with noninflammatory sacroiliac arthritis	• Pain and disability were improved in both groups, with no significant differences between groups. • The fluoroscopy-guided approach was more accurate (98.2%) than the ultrasound-guided approach (87.3%). • Three cases of intravascular injections occurred in the fluoroscopy group.	Blinding of participants and personnel

Table 2 Included study outcomes, all US vs FL

	Lumbosacral epidural space			Sacral epidural space	Lumbar epidural space	Sacroiliac joint		Lumbar facet joints	
	Akkaya et al [12]	Park et al [13]	Evansa et al [14]	Hazra et al [15]	Yang et al [11]	Soneji et al [16]	Jee et al [17]	Ha et al [9]	Yun et al [10]
Post-procedure pain (visual analogue/-numeric scale)	4.4 vs 4.5 (at 3 months)	2.5 vs 2.6 (at 12 weeks)	4.1 vs 4.0 (at 3 months)	3.0 vs 2.8 (at 2 months)	2.6 vs 2.5 (at 1 month)	5.5 vs 6.2 (at 3 months)	2.6 vs 2.6 (at 12 weeks)	2.8 vs 2.7 (mean f/u 9 months)	3.0 vs 3.0 (at 3 months)
Procedure time (minutes)	6.1 vs 11.2 (time of block)	16.7 vs 18.7 (duration of procedure)	5.4 vs 6.2 (duration of procedure)	2.0 vs 3.7 (time to needle placement)	8.6 vs 15.5 (duration of procedure)	9.3 vs 5.4 (duration of procedure)		Lower for FL	=
Needle passes (repositioning required)		9 vs 8	10 vs 15						
Radiation dose					2640 vs 8992 µGy·m2	38.5 mGy in Fl group			
Disability (ODI)	33.8 vs 35.1 (at 3 months)	28.8 vs 28.9 (at 12 weeks)	32.2 vs 33.0 (at 3 months)	32.2 vs 30.9 (at 2 months)		54.5 vs 52.3 (at 3 months)	21.3 vs 20.5 (at 12 weeks)	23.5 vs 24.8 (mean f/u 9 months)	16.2 vs 14.6 (modified ODI at 3 months)
Complications/a-dverse events		2 vs 1 (headache)	7 vs 8 (dizziness, pain, flushing)	0 vs 0	0 vs 0	0 vs 0		5 vs 3 (pain, headache, allergy, infection)	
Daily opioid consumption (oral morphine equivalent (mg))						1.1 vs 30.0 (at 3 months)			
Patient Satisfaction	14 vs 13 (at 3 months, number ≥ 3 out of 4)	=				11 vs 14 (number satisfied or most satisfied)			

All outcomes presented as ultrasound versus fluoroscopy

ODI Oswestry Disability Index

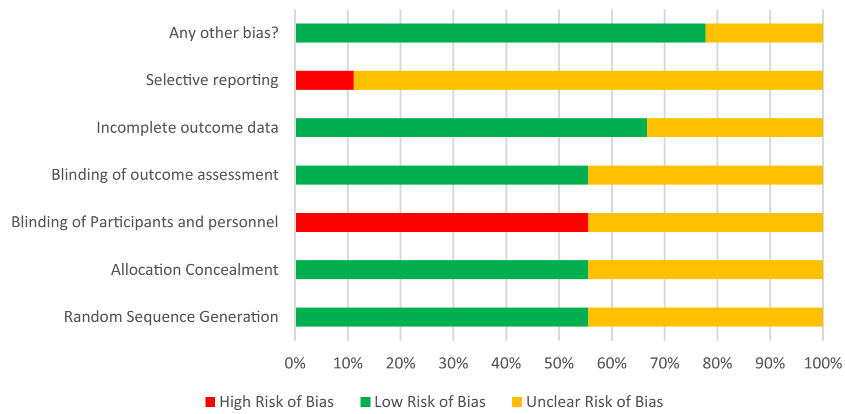

Fig. 2 Included risk of bias assessment. High risk of bias (red), low risk of bias (green), and unclear risk of bias (yellow)

Although ultrasound guidance will reduce radiation exposure and may improve the ability to visualize soft tissues and vascular structures, there are a number of drawbacks [5]. Patient morphology and injection location affect image quality and therefore technique. In the visualization of axial or spine structures where an acoustic shadow is produced by bone, quality of images is likely to be poor [23]. Accuracy of fluoroscopy-guided injections is established, and fluoroscopy has been recommended to confirm needle placement while the performing physician is developing proficiency [24]. In the included studies by Yang et al [11] and Park et al [13], fluoroscopy was used to confirm needle placement prior to injection in participants randomized to ultrasound guidance. Thus, until physicians are experienced in ultrasound guidance, some radiation exposure is still required.

Gharries [25] suggests that ultrasound-guided scanning will not show intravascular injection, but the first injection of the test dose will show no distribution of drug around the target. Spinal infarction and paraplegia can result from intraarterial penetration and injection of particulate steroids via the artery of Adamkiewicz [26]. When real-time contrast dye injection with fluoroscopy is not also used and the risk of intravascular injection is unavoidable, insoluble corticosteroids should not be used [27]. Additionally, in obese patients, ultrasound guidance may not be sufficient to correctly visualize the target [25]. Clearly, ultrasound-guided injections will only be appropriate for a subset of the candidates for image-guided injections in the lower back.

Findings in this review are similar to a systematic review by Wu et al [28] which included randomized and non-randomized trials, but were limited to guided lumbar facet joint injections. No significant differences in pain or functional improvement were found in this review, although high heterogeneity limited the utility of pooled outcomes [28]. Similar to Wu et al [28], we conclude that ultrasound-guided injections reduce exposure to radiation. This review extends the findings of Wu et al [28] from the facet joints to the lumbosacral epidural space, sacral epidural space, lumbar epidural space, and the sacroiliac joint and compares ultrasound guidance to fluoroscopic guidance for injection across a number of additional outcomes.

This study has limitations. There is the possibility that relevant studies may have been missed. Although not many studies met inclusion/exclusion criteria, the search strategy was designed to be comprehensive, robust, and broad to ensure that studies were captured. In addition, references of included studies were also assessed for inclusion; thus, the likelihood that relevant studies were missed is low. No two studies examined the same set of outcomes. Due to poor reporting of inconsistently measured outcomes, it was not possible to pool outcomes. This limited our synthesis approach. However, included studies consistently identified the lack of difference in patient-reported outcomes, with the only noteworthy difference identified in radiation exposure.

Clinical heterogeneity also limits our ability to draw strong conclusions from this body of literature. Underlying diagnoses for patients with lower back pain, location of injection and approach for the injection varied in included studies. Although a corticosteroid and a local anesthetic were injected in most studies, the medications were not identical between studies. This variation and heterogeneity in outcome reporting in studies prevented meaningful pooling of results. Standardization of measurement, outcomes, and reporting in this area may increase the ability to compare results across studies.

This is the first systematic review comparing ultrasound- and fluoroscopy-guided injections for the management of lower back pain. Despite heterogeneity that prevented the meaningful pooling of results, this study provides a useful contribution to the literature. Differences in patient populations, injection sites, approach, and medications injected do not detract from the conclusion that there were no differences in pain, procedure time, needle passes, disability indices, complications or adverse events, post-procedure opioid consumption, or patient satisfaction between the two image-guidance techniques. In non-obese patients that do not require the injection of an insoluble medication, ultrasound-guided injection will reduce radiation exposure for patients and practitioners, but limited evidence was available to quantify the radiation exposure that would be avoided. However, not all patients will be appropriate for the use of ultrasound-guided injections. Sacroiliac and facet joint injections are more likely to be performed with ultrasound guidance than foraminal or epidural injection for safety purposes. For nerve root injection (epidural, foraminal), ultrasound guidance cannot be recommended as the first option. Fusion imaging, which couples ultrasound with the corresponding computed tomography or magnetic resonance image obtained from the diagnostic exam and reformatted in real time according to the ultrasound scanning plane, may reduce some of the risks associated with ultrasound guidance [29]. The exact role of ultrasound in terms of guidance requires further study in the setting of lumbar pain. Future studies powered to assess the non-superiority of ultrasound and an exploration of the effect modifiers that make ultrasound guidance most likely to succeed would further the understanding of optimal guidance approaches.

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Compliance with ethical standards

Guarantor The scientific guarantor of this publication is Dr. F. Clement.

Conflict of interest The authors of this manuscript declare no relationships with any companies, whose products or services may be related to the subject matter of the article.

Statistics and biometry No complex statistical methods were necessary for this paper.

Informed consent Written informed consent was not required for this study because this study uses previously published data; therefore, no subjects were included in this study.

Ethical approval Institutional Review Board approval was not required because this is a systematic review of previously published randomized controlled trials.

Methodology
• Multicenter study

Appendix

Search Strategy: MEDLINE (OVID)
Cochrane CENTRAL Register of Controlled Trials (OVD)

1. Fluoroscopy/
2. (fluoroscop* or fluroscop*).tw.
3. (fluorescence radiation or fluorescence scanning or fluorescent scanning or fluorophotography or photofluoroscopy or radiofluoroscopy or roentgenfluoroscopy or xray guided or x-ray guided).tw.
4. 1 or 2 or 3
5. exp Ultrasonography/
6. (computer echotomography or echography or echogram* or echoscopy or echosound or echotomography or sonography or sonogram* or ultrasonic diagnos* or ultrasonic scanning or ultrasonic tomography or ultrasonography or ultrasound*).tw.
7. 5 or 6
8. Low Back Pain/
9. Lumbar Vertebrae/
10. hip/
11. exp. Sciatica/
12. Intervertebral Disc Displacement/
13. exp Intervertebral Disc Degeneration/
14. exp Spondylolisthesis/
15. exp Spinal Stenosis/
16. exp Zygapophyseal Joint/
17. (degenerative disc* or degenerative disk* or disc* hernia* or disk hernia* or disk prolapse or disc prolapse or facet joint* or herniated disc* or herniated disk* or herniated intervertebral disk* or herniated intervertebral disc* or hip or hips or intervertebral disc perforation* or intervertebral disk perforation* or low back or lower back or low backache or low backpain or (lumbar adj2 herniated adj2 disc*) or lumbal pain or lumbar pain or lumbar or lumbosacral or lumbosacroiliac or sciatica or sciatic neuralgia* or slipped disc* or slipped disk* or spondylisthes* or spondylolisthes* or spinal canal stenosis or spinal stenosis or zygapophysial joint* or Z-joint*).tw.
18. 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17
19. 4 and 7 and 18
20. limit 19 to english language
21. limit 20 to yr="2007 -Current"

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