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Common interventional procedures for chronic non-cancer spine pain: a systematic review and network meta-analysis of randomised trials

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ABSTRACT

OBJECTIVE

To address the comparative effectiveness of common interventional procedures for chronic non-cancer (axial or radicular) spine pain.

DESIGN

Systematic review and network meta-analysis (NMA) of randomised controlled trials (RCTs).

DATA SOURCES

Medline, Embase, CINAHL, CENTRAL, and Web of Science from inception to 24 January 2023.

STUDY SELECTION

RCTs that enrolled patients with chronic non-cancer spine pain, randomised to receive a commonly used interventional procedure versus sham procedure, usual care, or another interventional procedure.

DATA EXTRACTION AND SYNTHESIS

Pairs of reviewers independently identified eligible studies, extracted data, and assessed risk of bias. We conducted frequentist network meta-analyses to summarise the evidence and used the GRADE approach to rate the certainty of evidence.

RESULTS

Of 132 eligible studies, 81 trials with 7977 patients that explored 13 interventional procedures or combinations of procedures were included in meta-analyses. All subsequent effects refer to comparisons with sham procedures. For chronic axial spine pain, the following probably provide little to no difference in pain relief (moderate certainty evidence): epidural injection of local anaesthetic (weighted mean difference (WMD) 0.28 cm on a 10 cm visual analogue scale (95% CI −1.18 to 1.75)), epidural injection of local anaesthetic and steroids (WMD 0.20 (−1.11 to 1.51)), and joint-targeted steroid injection (WMD 0.83 (−0.26 to 1.93)). Intramuscular injection of local anaesthetic (WMD −0.53 (−1.97 to 0.92)), epidural steroid injection (WMD 0.39 (−0.94 to 1.71)), joint-targeted injection of local anaesthetic (WMD 0.63 (−0.57 to 1.83)), and joint-targeted injection of local anaesthetic with steroids (WMD 0.22 (−0.42 to 0.87)) may provide little to no difference in pain relief (low certainty evidence); intramuscular injection of local anaesthetic with steroids may increase pain (WMD 1.82 (−0.29 to 3.93)) (low certainty evidence). Evidence for joint radiofrequency ablation proved of very low certainty.

For chronic radicular spine pain, epidural injection of local anaesthetic and steroids (WMD −0.49 (−1.54 to 0.55)) and radiofrequency of dorsal root ganglion (WMD 0.15 (−0.98 to 1.28)) probably provide little to no difference in pain relief (moderate certainty evidence). Epidural injection of local anaesthetic (WMD −0.26 (−1.37 to 0.84)) and epidural injection of steroids (WMD −0.56 (−1.30 to 0.17)) may result in little to no difference in pain relief (low certainty evidence).

CONCLUSION

Our NMA of randomised trials provides low to moderate certainty evidence that, compared with sham procedures, commonly performed interventional procedures for axial or radicular chronic non-cancer spine pain may provide little to no pain relief.

REGISTRATION

PROSPERO (CRD42020170667)

WHAT IS ALREADY KNOWN ON THIS TOPIC

Chronic non-cancer spine pain is a major global health challenge associated with considerable socioeconomic burden

Interventional procedures are increasingly provided for chronic spine pain, including epidural steroid injections, nerve blocks, and radiofrequency nerve ablation; however, current guidelines provide conflicting recommendations for their use

WHAT THIS STUDY ADDS

A *BMJ* Rapid Recommendation guideline panel including patients, clinical experts, and methodologists defined the scope of our review, categorised interventions, informed outcome selection and importance, data analyses, and interpretation of findings

For chronic axial spine pain, compared with sham procedures: epidural injection of local anaesthetic with or without steroids, and joint-targeted steroid injection probably result in little to no difference in pain relief (moderate certainty evidence); intramuscular injection of local anaesthetic, epidural steroid injection, and joint-targeted injection of local anaesthetic with or without steroids may provide little to no difference in pain relief (low certainty evidence); and intramuscular injection of local anaesthetic with steroids may increase pain (low certainty evidence). Available evidence for joint radiofrequency ablation proved of very low certainty

For chronic radicular spine pain, compared with sham procedures: epidural injection of local anaesthetic and steroids, and radiofrequency of the dorsal root ganglion probably result in little to no difference in pain relief (moderate certainty evidence); and epidural injection of steroids or local anaesthetic may result in little to no difference in pain relief (low certainty evidence)

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Introduction

Chronic non-cancer spine pain (hereafter termed chronic spine pain) is defined as any painful condition along the spine, or referred from the spine, that persists for ≥3 months and is not associated with a diagnosis of cancer.[1] Chronic spine pain is an important health challenge worldwide, associated with considerable socioeconomic burden.[2] The most recent systematic review found the global prevalence of chronic low back pain was 4.2% among individuals aged 24-39 years, and 19.6% in those between the ages of 20 and 59 years.[3] Observational studies suggest that the 12 month prevalence of chronic neck pain in the general population is between 3.1% and 4.5%.[4]

Particularly in North America, interventional procedures are often provided for the management of chronic spine pain,[5-9] including epidural steroidal injections, facet joint nerve blocks, radiofrequency ablation, and intramuscular trigger point injections.[10 11] Such interventional procedures are not curative, require repeated administration if perceived to be effective, and are costly.[6] Moreover, controversy exists regarding their effectiveness, and a 2021 guideline from the American College of Occupational and Environmental Medicine recommended against the use of interventional procedures for low back disorders.[12] In contrast, a 2022 guideline by the American Society of Pain and Neuroscience recommended in favour of all commonly performed interventional procedures for low back pain.[13]

Several conventional systematic reviews have explored the effectiveness of interventional procedures for chronic spine pain,[14-17] but all have important methodological limitations. Two systematic reviews with network meta-analysis (NMA) have focused on the comparative effectiveness of interventional procedures for spine pain,[18 19] but each considered only a specific type of pain (that is, sciatica and pain due to lumbar disc prolapse), pooled effects across acute and chronic pain, and failed to assess the certainty of the evidence (see supplementary table 1 for details) We therefore conducted a systematic review and NMA of randomised trials to assess the comparative effectiveness of commonly performed interventional procedures for chronic spine pain that address these limitations. This review is part of the *BMJ* Rapid Recommendations project, a collaborative effort from the MAGIC Evidence Ecosystem Foundation (www.magicevidence.org) and the BMJ.[20] This systematic review informed a parallel guideline published in *The BMJ* and MAGICapp (see box 1).

Box 1: Linked articles in this *BMJ* Rapid Recommendations cluster

- Busse JW, Genevay S, Agarwal A, et al. Commonly used interventional procedures for non-cancer chronic spine pain: a clinical practice guideline. *BMJ* 2025;388:e079970, doi:10.1136/bmj-2024-079970

Summary of results from the Rapid Recommendation process

- Wang X, Martin G, Sadeghirad B, et al. Common interventional procedures for chronic non-cancer spine pain: a systematic review and network meta-analysis of randomised trials. *BMJ* 2025;388:e079971, doi:10.1136/bmj-2024-079971
- Malam F, Asif MS, Khalid MF, et al. Adverse events associated with common interventional procedures for chronic spine pain: a systematic review and meta-analysis of non-randomised studies. *BMJ Open* (submitted)
- MAGICapp (https://app.magicapp.org/#/guideline/nBRK8n) multi-layered version of recommendations, rationale, and evidence summaries for use on all electronic devices

Methods

Standardised reporting and registration

We registered our review on PROSPERO (CRD42020170667) and published our study protocol.[21] We reported our review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Network Meta-Analysis Extension checklist.[22] After publication of our protocol, but before analysis, we included three additional subgroup analyses: (1) use of image-guidance versus not, (2) location of procedure/pain source (that is, neck, low back, sacroiliac joint), and (3) clinical condition (that is, facet syndrome, sacroiliac joint syndrome, disc herniation, lumbar stenosis).

The *BMJ* Rapid Recommendations guideline panel provided oversight of our review, including: (1) defining the study question; (2) categorising chronic pain conditions; (3) grouping of interventional procedures, (4) advising on clinically reasonable follow-up times for procedures (that is, the duration in which clinical effects would still be present); (5) defining subgroup analyses; (6) confirming that our list of included trials was complete, and (7) contacting authors of included trials to request additional information when required. The panel included 10 content experts, eight methodologists (five of whom also have general medicine expertise), and four patient partners living with chronic spine pain representing a range of experiences with interventional procedures. All patient partners received personal training and support to optimise contributions throughout the guideline development process.

Patient and public involvement

The four patient partners were full members of the guideline panel. They contributed to our values and preferences assessments, interpretation of findings for the systematic review and the associated *BMJ* Rapid Recommendation and voted on all guideline recommendations.

Data sources

We conducted systematic searches for eligible studies in Medline, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Cochrane Central Register of Controlled Trials (CENTRAL), and Web of Science from inception to 24 January 2023 without language restrictions. An experienced medical librarian (RJC) developed all database-specific search strategies (supplementary appendix 1). In addition, we reviewed the reference lists of included trials and relevant reviews[14-19] and provided our list of eligible

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trials to clinical experts on our guideline panel to ensure we had not omitted any relevant studies.

Eligibility criteria

We included randomised trials that: (1) enrolled at least 80% adult patients (≥18 years old) presenting with chronic axial and/or radicular non-cancer spine pain (≥12 weeks duration, defined by authors as chronic, or adjudicated by our clinical experts as a chronic pain complaint); (2) randomised ≥10 patients to receive an interventional procedure versus an alternate procedure, sham procedure, or usual care (such as physical therapy, exercise, non-steroidal anti-inflammatory drugs); and (3) followed patients for ≥1 month.

Eligible interventional procedures included: (1) joint-targeted injections (that is, injection of local anaesthetic, steroids, or their combination into the cervical or lumbar facet joint or sacroiliac joint); (2) cervical, lumbar, or caudal epidural injections of local anaesthetic, steroids, or their combination; (3) radiofrequency of the dorsal root ganglion; (4) radiofrequency denervation of cervical or lumbar facet joints or the sacroiliac joint; and (5) paravertebral intramuscular injections of local anaesthetic, steroids, or their combination.

Eligible studies that compared similar interventions that our clinical experts advised should be collapsed, did not report patient-important outcomes, only reported outcome data beyond the time point that our clinical experts felt a procedure would be effective, or reported no data for quantitative analysis, were included in our review but did not contribute to meta-analyses.

We excluded studies that enrolled patients with cancer related pain, or those with infection or inflammatory spondylarthritis, which may show systematically different responses to interventional procedures. Furthermore, we excluded trials that evaluated procedures that are not commonly used in practice (that is, rami communicans block or radiofrequency lesioning, intradiscal procedures, chemonucleolysis, injection of methylene blue) or purported regenerative therapies (such as prolotherapy).

Study selection

Using a standardised, pre-tested form, pairs of trained reviewers screened titles and abstracts of identified citations and full texts of all potentially eligible studies independently and in duplicate. Reviewers resolved disagreements through discussion or, when required, independent adjudication by four clinical experts (NB, YRR, CJS, and SG) blinded to trial results. We used DistillerSR (Evidence Partners, Ottawa, Canada; http://systematicreview.net) for literature screening. We contacted authors to clarify eligibility criteria when necessary and excluded studies if we did not receive a response.

Data extraction

Pairs of reviewers extracted data independently and in duplicate using a standardised, pre-tested form with a detailed instruction manual. Reviewers addressed discrepancies through discussion to achieve consensus. For all included studies, we abstracted study characteristics, participant characteristics, details of interventions and comparators, and results for all patient-important outcomes reported as guided by the Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT) recommendations,[23-25] including pain intensity, physical functioning, emotional functioning, role functioning, social functioning, sleep quality, return to work, opioid use, and adverse events. We prioritised least square mean and end of follow-up mean scores adjusted for baseline data when available, change scores if not, and lastly end-of-study scores.

Blinded to study results, six clinical experts on the associated guideline panel independently reviewed all study interventions and grouped them into 15 categories: (1) epidural injection of local anaesthetic; (2) epidural steroid injection; (3) epidural injection of local anaesthetic and steroids; (4) joint-targeted injection of local anaesthetic; (5) joint-targeted steroid injection; (6) joint-targeted injection of local anaesthetic and steroids; (7) intramuscular injection of local anaesthetic; (8) intramuscular injection of local anaesthetic and steroids; (9) dorsal root ganglion radiofrequency; (10) joint radiofrequency nerve ablation; (11) joint radiofrequency nerve ablation with joint-targeted injection of local anaesthetic and steroids; (12) dorsal root ganglion radiofrequency with epidural injection of local anaesthetic; (13) dorsal root ganglion radiofrequency with epidural injection of local anaesthetic with steroids; (14) usual care; and (15) sham procedures (see supplementary table 2).

For adverse events, we collected data at the longest follow-up time reported. For outcomes informing benefits, we collected data at the longest follow-up reported at which an interventional procedure would still be effective. Based on feedback from clinical experts on the guideline panel, we used the following rules to guide our selection of longest follow-up time for data collection when trials reported multiple time points:

a. For joint-targeted injections, epidural injections, and intramuscular injections, we collected outcome data at the follow-up time closest to, but not beyond, three months from the last procedure.
b. For nerve radiofrequency procedures, we collected outcome data at the follow-up time closest to, but not beyond, six months from the last procedure.

Our panel experts advised that they would not anticipate the above procedures to be effective beyond these durations. For trials that provided repeat procedures, we used the last procedure that was provided to ≥80% of patients as our starting point. For trials with multiple follow-ups within the timeframe

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recommended by our experts, we collected outcome data closest to the longest follow-up (3 or 6 months, based on type of procedure) unless there was ≥20% missing data, in which case we used the shorter follow-up if it had <20% missing data. We contacted trial authors to acquire additional information when required.

Risk of bias assessment

Pairs of reviewers independently assessed the risk of bias of eligible studies using a modified Cochrane risk of bias instrument,[26] which considered the following criteria: random sequence generation; allocation concealment; blinding of participants, healthcare providers, data collectors, and outcome assessors/adjudicators; and incomplete outcome data (≥20% missing data was considered high risk of bias). Response options for each item included "definitely yes" and "probably yes" (assigned low risk of bias), and "probably no" and "definitely no" (assigned high risk of bias).[27]

Data synthesis

We transformed all continuous measures to a common scale, on a domain-by-domain basis, by converting the summary statistics from individual trials to natural units of the most frequently reported instrument (supplementary appendix 2)[28]: (1) pain intensity on a 10 cm visual analogue scale (VAS), higher scores are worse; (2) physical functioning to the 100-point Oswestry Disability Index (ODI), higher scores are worse; (3) mental functioning to the 100-point Short Form Survey (SF-36) mental functioning scale, higher scores are better; (4) role functioning to the 100-point SF-36 scale of role limitations due to physical problems, higher scores are better; and (5) social functioning to the 100-point SF-36 social functioning scale, higher scores are better. We used change scores from baseline to the end of follow-up to account for interpatient variability. When authors reported outcome data only at baseline and end of study, we calculated changes scores and the associated standard deviation using the median of correlation coefficients derived from trials that reported a change score.[29] We used methods described in the Cochrane Handbook[29] and by Hozo et al[30] to impute the standard deviation when the standard error or standard deviation for the differences were not reported and we were unable to obtain these details from trial authors.

For all direct comparisons, we conducted meta-analysis with random-effects models [31 32] using the DerSimonian and Laird estimator.[33 34] We pooled all outcomes reported by at least two trials addressing the same comparison. For continuous outcomes, we calculated the weighted mean difference (WMD) and associated 95% confidence interval. For dichotomous outcomes (that is, adverse events), we calculated the relative risk and the associated 95% confidence interval. We summarised study results descriptively when meta-analysis was not possible. When at least 10 trials contributed to a meta-analysis, we assessed small study effects using Harbord's test for binary outcomes[35] and Egger's test for continuous outcomes[36] and visual inspection of contour-enhanced funnel plots.[37]

We constructed networks for all outcomes in which 10 or more trials contributed data.[38] We developed separate networks for axial and radicular spine related pain for all beneficial outcomes, as the aetiology is different and may affect response to treatment. We included evidence for interventional procedures that would not typically be used to target axial or radicular complaints to increase the indirect evidence informing other treatment nodes (that is, dorsal root ganglion radiofrequency for axial pain, joint radiofrequency ablation for radicular pain, joint-targeted injection of steroids for radicular pain).[39] We performed a network meta-analysis using a frequentist random-effects model applying the methodology of multivariate meta-analysis with restricted maximum likelihood estimation for varience.[40 41] Considering the sparse number of adverse events reported in several trials, we used a random effect model (REML method) with continuing T corrections for data arms with zero events. Accordingly, "both-armed zero-event studies" were included in all analyses.[42]

We assessed the coherence for each network with the "design-by-treatment" model (global test)[40] and evaluated the local (loop-specific) incoherence in each closed loop of the network with the side-splitting method.[43 44]

To optimise interpretability of our findings we used the network estimate of treatment effects to calculate the risk difference (RD) for achieving the minimally important difference (MID). We used the median and standard deviation of the control group, with the established MID for the outcome in question to estimate the probability of achieving ≥MID in the control group. We used the pooled mean difference to estimate the mean in the treatment group and calculated the probability of achieving ≥MID in the treatment group. Finally, we used risks in both groups to acquire the RD for achieving ≥MID.[45]

We identified anchor-based MIDs for all continuous outcome measures in our analyses. For pain intensity, we used 1.5 points on a 10 cm scale, with higher score indicating worse pain.[46] For physical functioning, we used 10 points on the 100-point ODI scale, with higher scores indicating worse function.[47 48] For mental health, physical role limitations, and social functioning, which are individual domains of the SF-36, we used 10 points as the MID (all 0-100 scales, with higher scores indicating better functioning).[49]

We pooled non-critical adverse events as the relative risk and 95% confidence interval. When trials reported multiple non-critical adverse events without confirming independence of categories, we used only the most frequent event to avoid clustering. We pooled across both axial and radicular spine-related chronic pain for adverse events, as clinical experts on our guideline panel felt the underlying condition would not affect harms. Only two trials reported

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critical adverse events,[50 51] and we summarised this information descriptively.

Subgroup analysis and meta-regression

We used tau^2 and I^2 to explore statistical heterogeneity for direct meta-analyses. An I^2 of 0-40% was considered as "might not be important," 30-60% as "moderate heterogeneity," 50-90% as "substantial heterogeneity," and 75-100% as "considerable heterogeneity." The Cochrane Collaboration has proposed overlapping categories to convey that there are no strict cut-offs for interpreting heterogeneity, and categorisation depends on the magnitude and direction of effects as well as the strength of evidence for heterogeneity.[29] Tau represents the standard deviation of the true effect, which means that, for continuous outcomes, the true effect in individual studies could vary over the range of the pooled mean difference ±2×tau.

In consultation with the guideline panel, we conducted subgroup analyses for pairwise meta-analyses and meta-regression for network meta-analyses to explain heterogeneity between trials based on: (1) clinical condition (that is, facet syndrome, sacroiliac joint syndrome, disc herniation, lumbar stenosis); (2) higher versus lower risk of bias on a criterion-by-criterion basis; (3) using a positive response on diagnostic block as an entry criterion for participants versus not; (4) receipt of disability benefits or engaged in litigation versus not, (5) use of image guidance versus not, and (6) location of procedure (that is, neck, low back, sacroiliac joint). We hypothesised that trials at higher risk of bias, that required a positive diagnostic block, with no (or fewer) patients receiving disability benefits or engaged in litigation, or used image guidance for interventional procedures would show larger beneficial treatment effects and less harms. We conducted subgroup analyses only if there were two or more studies in each subgroup and used a test of interaction to establish whether the subgroups differed significantly from one another. We assessed the credibility of statistically significant subgroup effects (P value for test of interaction <0.05) using Instrument to assess the Credibility of Effect Modification ANalyse (ICEMAN) criteria.[52]

We used STATA V.16.0 (StataCorp) for all analyses. All comparisons were two-tailed using a P≤0.05 threshold for significance.

Assessing certainty of the evidence

We used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach to assess the certainty of direct, indirect, and network estimates for all pooled outcomes as high, moderate, low or very low. The certainty of evidence from randomised trials starts at high, and direct evidence can be rated down for risk of bias, inconsistency, indirectness, or small study effects.[53] Certainty ratings of indirect estimates start at the lowest GRADE rating of the direct comparison that contributed the most weight to the dominant first order loop, with further rating down for intransitivity when present.[54 55] We assessed for intransitivity considering two fundamental issues: 1) exploring the similarity of patient populations in our networks and confirming with our clinical experts that patients across trials were eligible to receive any of interventions considered in the network; and 2) investigating the distribution of effect modifiers in contributing direct comparisons using NMAstudio (https://www.nmastudioapp.com/).

We assessed all network effect estimates for imprecision using GRADE guidance.[54 56-58] In brief, we rated down effect estimates for imprecision if the associated 95% confidence intervals included half of the MID for continuous outcomes or the null effect for dichotomous outcomes. We did not rate down for imprecision if the confidence interval excluded the decision threshold unless the comparison was statistically significant and informed by fewer than the optimal information size of 300 patients (see supplementary appendix 3 for details). When results suggested that inconsistency in random effect models was responsible for imprecision, we did not rate down the same effect estimate twice. When only a single trial was available to inform the effectiveness of an intervention, and reported a large statistically significant effect, we considered this evidence at high risk of bias due to small study effects.

When significant incoherence in the network was present, we used the result supported by higher certainty of evidence from either the direct comparison or indirect comparison instead of the network estimate. If we observed same certainty of evidence for both the direct and indirect comparisons, we used the network estimate but rated down the certainty of evidence one level because of incoherence. We followed GRADE guidance for communicating our findings.[59]

We did not present the results of dorsal root ganglion radiofrequency with or without epidural local anaesthetic plus steroid for chronic axial spine pain, joint-targeted injection of steroids for chronic radicular spine-related pain, or joint radiofrequency for chronic radicular spine related pain because our panel experts advised that these procedures are typically not administered for these indications.

Categorisation of interventions

We categorised interventions using a minimally contextualised approach.[60] For each effectiveness outcome, we created groups of interventions as follows: (1) evidence failed to support benefits of the intervention over the reference intervention (sham procedure), which we refer to as no more effective than sham procedures; and (2) interventions superior to sham, which we describe as more effective than sham procedures (category 2 interventions). We used the same approach for adverse events with the following groups of interventions: (1) no more harmful than sham procedures; and (2) more harmful than sham procedures. For both benefits and harms, we categorised interventions as those supported by moderate or high certainty evidence, and those

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supported by low or very low certainty evidence relative to sham procedures.[61 62] We choose sham procedures as the reference because they were the most common control, and interventional procedures are associated with large non-specific effects.[63 64]

Results

Of 19 191 unique citations, 152 reports including 132 trials were eligible for review, including 127 English, 2 German, 1 Spanish, 1 Chinese, and 1 Japanese language trial. Of the 132 trials, 51 contributed no data for meta-analysis for the following reasons: (1) 38 trials compared similar interventions that showed no difference in treatment effects and that our clinical experts advised should be collapsed (for example, transforaminal *v* interlaminar epidural steroid injections)[65-68]; (2) six trials reported only surrogate outcomes; (3) five trials provided no data for quantitative analysis; (4) one trial only reported outcome data beyond the time point for which our panel experts advised a clinical effect would likely persist (that is, 6 months for a single intra-articular lumbar facet joint steroid injection)[69]; and (5) one trial was disconnected from all networks (supplementary table 3). Thus, we included 81 trials with 7977 patients in our quantitative analyses (fig 1). Three of the 81 trials contributed data to some, but not all, networks due to excessively long follow-up or internally inconsistent data that we failed to resolve with the authors (supplementary table 4). We calculated change scores and imputed the associated standard deviations for 11 trials.

The median sample size of trials included in our meta-analyses was 64 (interquartile range (IQR) 45-110).

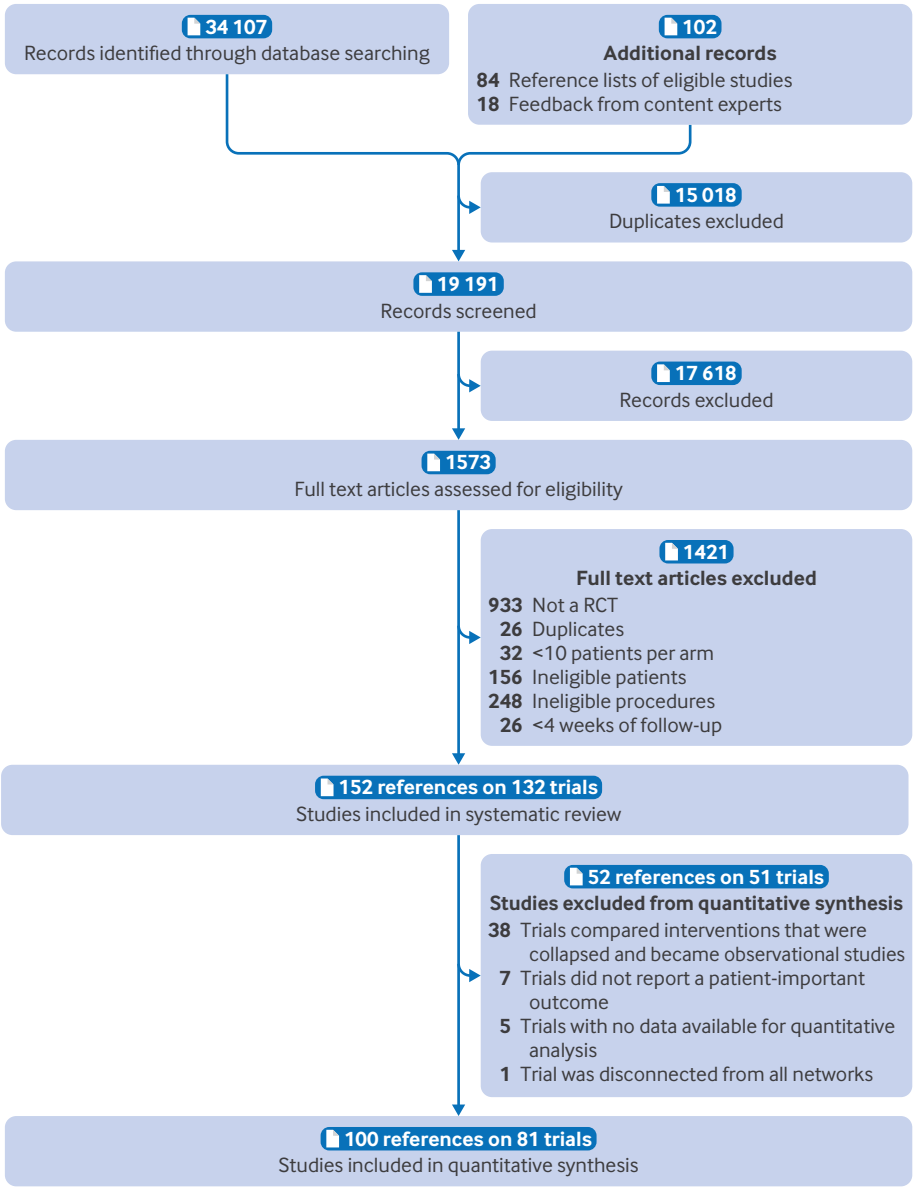


Fig 1 | Study selection for review of interventional procedures for chronic non-cancer spine pain

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The median of the mean age of patients was 48 years (IQR 44-56), and the median average pain duration was 46 months (IQR 17-98). Among the 50 trials that reported baseline pain, the median average score was 6.8 cm (IQR 5.9-7.7) on a 10 cm visual analogue scale, which corresponds to moderate to severe pain.[70] Most trials (63%, 51/81) used diagnostic imaging as an eligibility criterion, and 37% (30/81) required a positive diagnostic block. Approximately half of all trials (53%, 43/81) excluded patients with a history of spine surgery, and 11 (14%) trials enrolled a total of 455 patients with prior spine surgery. Almost all trials either excluded patients receiving disability benefits or involved in litigation or did not report if such patients were represented. One trial (1%) enrolled 14 patients involved in litigation, and eight trials (10%) enrolled a total of 289 patient receiving disability compensation (supplementary table 5). The included trials either excluded patients with comorbid mental illness (58%, 47/81) or did not report if such patients were included (42%, 34/81). Most trials contained no funding statement (41%, 33/81) or declared their study was

Table 1 | Characteristics of 81 randomised controlled trials included in meta-analyses of interventional procedures for relief of chronic non-cancer spine pain

	No (%) of trials unless stated otherwise
Year of publication:	
Up to 2000	10 (12)
2001-05	8 (10)
2006-10	9 (11)
2011-15	27 (33)
2016-20	24 (30)
2021-22	3 (4)
Country area:	
North America	26 (32)
Europe	25 (31)
Asia	23 (28)
Africa	4 (5)
Australia	1 (1)
South America	2 (2)
Median (IQR) age (years)*	48 (44-56)
Median (IQR) percentage female†	59 (50-67)
Diagnostic block criteria for enrolment:	
>50% relief	13 (16)
>75% relief	5 (6)
>80% relief	6 (7)
Unclear threshold	6 (7)
Include patients with negative response on diagnostic block‡	2 (2)
None or not reported	49 (60)
Use of diagnostic imaging for enrolment:	
MRI, CT, or x ray	51 (63)
Not reported	29 (36)
Diagnostic imaging not required for enrolment	1 (1)
Pain duration:	
Specific duration (median 46 months (IQR 17-98))	50 (62)
Range of duration (>3 months)	7 (9)
Range of duration includes <3 months but, for >80%, >3 months	4 (5)
Not specific	20 (25)
History of spine surgery:	
Excluded patients with previous spine surgery	43 (53)
Reported proportion of patients with a history of spine surgery (median 30%)	11 (14)
Not reported	27 (33)
Involved in litigation:	
Excluded patient involved in litigation	9 (11)
Reported proportion of patients involved in litigation (58%)	1 (1)
Not reported	71 (88)
Involved in disability benefits, insurance, compensation:	
Excluded patient involved in disability benefits, insurance, compensation	4 (5)
Reported proportion (median 32%)	8 (10)
Not reported	69 (85)
Funding:	
Unfunded	25(31)
Non-industry funding	22(27)
Industry funding	1(1)
No funding statement	33(41)

*Median of the mean ages reported; 3 studies did not report usable information
†6 studies did not report relevant information
‡2 studies excluded patients with positive response to diagnostic block in order to exclude patients with radicular pain.[77 78]

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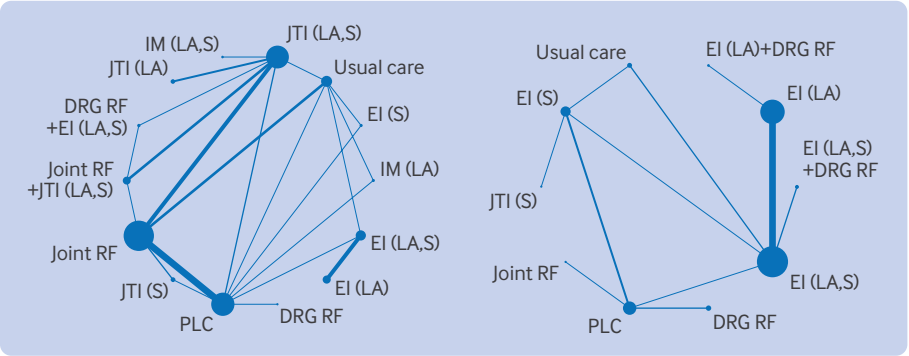


Fig 2 | Network maps of interventional procedures administered for: a. Axial chronic spine pain; b. Radicular chronic spine pain. Abbreviations: DRG RF=Dorsal root ganglion radiofrequency, EI=epidural injection, IM=Intramuscular injection, Joint RF=Joint radiofrequency ablation, JTI=Joint-targeted injection, LA=Local anaesthetic, PLC=Placebo (sham procedure), S=Steroid

unfunded (31%, 25/81); only a single trial reported funding from industry (table 1).

Among the 81 trials included in our meta-analyses, 43 (53%) included patients with axial spine pain: this was attributed to facet joint syndrome in 28 studies (35%), sacroiliac joint syndrome in nine (11%), intervertebral disc syndrome in three (4%), and, in one trial each, spondylolisthesis, chronic post-surgical pain, or mixed complaints. Two trials (2%) did not report details on clinical condition. Thirty six trials (44%) included patients with radicular spine pain: this was attributed to disc herniation/bulge in 24 trials (30%), spinal stenosis in eight (10%), chronic post-surgical pain in one (1%), or mixed complaints in three (4%) (supplementary table 5). Most trials (62%, 50/81) explored the effectiveness of a single interventional procedure, but 31 (38%) explored longer follow-up and allowed for repeated administration. A large majority of trials administered image-guided interventional procedures (85%, 69/81) or did not report whether image guidance was used (6%, 5/81). Only seven trials (9%) reported that image guidance was not used (supplementary table 6).

Risk of bias

Of the 81 trials, 68 (84%) were at risk of bias for at least one domain; 65 (80%) adequately generated their randomisation sequence, 49 (60%) appropriately concealed allocation, 54 (67%) blinded patients and outcome assessors, 34 (42%) blinded care givers, and 52 (64%) blinded outcome collectors. Seven trials (9%) reported ≥20% missing outcome data (supplementary table 7).

Outcomes for chronic axial spine pain

Pain relief

Forty seven trials that enrolled 5290 patients and evaluated 14 interventional procedures reported on pain relief for chronic axial spine pain (fig 2, panel a). Of the 22 direct comparisons, eight were supported by two or more trials for conventional pairwise meta-analysis, and three comparisons showed substantial heterogeneity (I^2 >70%) (supplementary table 8). There was no evidence of intransitivity, global incoherence, or loop-specific incoherence (supplementary table 9; supplementary fig 1, a-c).

For chronic axial spine pain, compared with sham procedures, the following probably result in little to no difference in pain relief (moderate certainty evidence): epidural injection of local anaesthetic (WMD 0.28 cm on 10 cm scale for pain (95% CI −1.18 to 1.75), modelled RD for achieving the MID −4%), epidural injection of local anaesthetic and steroids (WMD 0.20 (−1.11 to 1.51), modelled RD −3%), and joint-targeted steroid injection (WMD 0.83 (−0.26 to 1.93), modelled RD −12%). The following may provide little to no difference in pain relief (low certainty evidence): intramuscular injection of local anaesthetic (WMD −0.53 (−1.97 to 0.92), modelled RD 9%), joint-targeted injection of local anaesthetic (WMD 0.63 (−0.57 to 1.83), modelled RD −9%), joint-targeted injection of local anaesthetic and steroids (WMD 0.22 (−0.42 to 0.87), modelled RD −3%), and epidural steroid injection (WMD 0.39 (−0.94 to 1.71), modelled RD −6%). Intramuscular injection of local anaesthetic and steroids, versus a sham procedure, may increase pain severity (WMD 1.82 (−0.29 to 3.93), modelled RD −24%) (low certainty evidence). Effects for joint radiofrequency nerve ablation, with or without joint-targeted injection of local anaesthetic and steroids, were supported by very low certainty evidence. See figure 3 (table a) and supplementary tables 8 and 10.

Physical function

Twenty four trials that enrolled 3238 patients and evaluated 12 interventions reported physical functioning for chronic axial spine pain (supplementary fig 2a). Of the 16 direct comparisons, five were supported by two or more trials for conventional pairwise meta-analysis, and two showed substantial heterogeneity (I^2>70%) (supplementary table 11). There was no evidence of intransitivity (supplementary figures 3a to 3c). We observed evidence for incoherence for two comparisons: joint radiofrequency ablation versus joint-targeted injection of local anaesthetic and steroids, and joint-targeted injection of local

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3a. Pain relief (VAS 0-10cm, lower scores are better) for chronic axial spine pain

Treatment *v* placebo	MD (NMA)	RD for achieving MID (95% CI)	COE
EI (LA,S)	0.20 (-1.11 to 1.51)	-3 (-21 to 18)	Moderate
EI (LA)	0.28 (-1.18 to 1.75)	-4 (-23 to 19)	Moderate
JTI (S)	0.83 (-0.26 to 1.93)	-12 (-25 to 4)	Moderate
IM (LA)	-0.53 (-1.97 to 0.92)	9 (-14 to 32)	Low
Usual care	0.15 (-0.56 to 0.85)	-2 (-13 to 9)	Low
JTI (LA,S)	0.22 (-0.42 to 0.87)	-3 (-13 to 7)	Low
EI (S)	0.39 (-0.94 to 1.71)	-6 (-23 to 15)	Low
JTI (LA)	0.63 (-0.57 to 1.83)	-9 (-24 to 9)	Low
IM (LA,S)	1.82 (-0.29 to 3.93)	-24 (-36 to 5)	Low
Joint RF	-0.89 (-1.37 to -0.40)	15 (7 to 23)	Very low
Joint RF+JTI (LA,S)	-0.68 (-1.71 to 0.35)	11 (-5 to 28)	Very low

3b. Pain relief (VAS 0-10cm, lower scores are better) for chronic spine related radicular pain

Treatment *v* placebo	MD (NMA)	RD for achieving MID (95% CI)	COE
EI (LA,S)	-0.49 (-1.54 to 0.55)	4 (-4 to 16)	Moderate
DRG RF	0.15 (-0.98 to 1.28)	-1 (-8 to 9)	Moderate
EI (S)	-0.56 (-1.30 to 0.17)	5 (-1 to 13)	Low
EI (LA)	-0.26 (-1.37 to 0.84)	2 (-6 to 14)	Low
EI (LA)+DRG RF	-2.26 (-3.97 to -0.56)	26 (5 to 51)	Very low
EI (LA,S)+DRG RF	-0.94 (-2.52 to 0.65)	9 (-5 to 30)	Very low
Usual care	0.49 (-0.71 to 1.70)	-4 (-9 to 6)	Very low

Certainty	Classifications (the higher level, the better effectiveness)
Moderate to high	Category 2: More effective than sham procedures
	Category 1: No more effective than sham procedure
Low to very low	Category 2: May be more effective than sham procedures
	Category 1: May be no more effective than sham procedures

COE = Certainty of evidence, DRG RF = Dorsal root ganglion radiofrequency ablation, EI = Epidural injection, IM = Intramuscular injection, Joint RF = Joint radiofrequency ablation, JTI = Joint-targeted injection, LA = Local anaesthetic, MD (NMA) = Mean difference (network meta-analysis), MID = Minimally important difference (1.5 cm on 10 cm scale), RD = Risk difference (%), S = steroid, VAS = Visual analogue scale

Fig 3 | Network meta-analysis results, sorted by GRADE certainty of evidence and effect estimate, for the comparisons of interventional procedures versus sham procedures for pain relief of chronic spine pain. Table a. Pain relief scores for axial pain. Table b. Pain relief scores for radicular pain

anaesthetic and steroids versus usual care. We used the network estimate in both cases and rated down the certainty of evidence due to incoherence, because the certainty of evidence for direct and indirect estimates were the same (supplementary table 12).

For chronic axial spine pain patients, moderate certainty evidence shows the following probably result in little to no difference in physical functioning: joint-targeted injection of local anaesthetic and steroids (WMD 2.78 points on the 100 point ODI (95% CI −4.95 to 10.51), modelled RD −7%), joint targeted injection of steroids (WMD 1.60 (−10.45 to 13.65), modelled RD −4%), and intramuscular injection of local anaesthetic with steroids (WMD 9.30 (−6.36 to 24.96), modelled RD −19%). Low certainty evidence suggests that the following may result in little to no difference in physical functioning: joint radiofrequency nerve ablation (WMD −4.56 (−9.97 to 0.85), modelled RD 13%), joint radiofrequency with joint-targeted injection of local anaesthetic plus steroids (WMD −0.77 (−11.88 to 10.33), modelled RD 2%), and joint-targeted injection of local anaesthetic (WMD 0.78 (−10.43 to 11.98), modelled RD −2%). Low certainty evidence suggests that intramuscular injection of local anaesthetic may improve physical functioning slightly (WMD −6.83(−17.18 to 3.51), modelled RD 19%). Effects of epidural injection of local anaesthetic with or without steroids were only supported by very low certainty evidence. See figure 4 (table a) and supplementary tables 11 and 13.

Outcomes for chronic radicular spine-related pain

Pain relief

Thirty-three trials that enrolled 3263 patients and evaluated 10 interventional procedures reported pain relief for chronic radicular spine-related pain

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4a. Physical functioning (ODI 0-100 points, lower scores are better) for chronic axial spine pain

Treatment *v* placebo	MD (NMA)	RD for achieving MID (95 CI%)	COE
JTI (S)	1.60 (-10.45 to 13.65)	-4 (-23 to 30)	Moderate
JTI (LA,S)	2.78 (-4.95 to 10.51)	-7 (-20 to 14)	Moderate
IM (LA,S)	9.30 (-6.36 to 24.96)	-19 (-28 to 18)	Moderate
IM (LA)	-6.83 (-17.18 to 3.51)	19 (-8 to 48)	Low
Joint RF	-4.56 (-9.97 to 0.85)	13 (-2 to 29)	Low
Joint RF+ JTI (LA,S)	-0.77 (-11.88 to 10.33)	2 (-20 to 34)	Low
JTI (LA)	0.78 (-10.43 to 11.98)	-2 (-22 to 30)	Low
Usual care	3.87 (-2.51 to 10.26)	-9 (-20 to 7)	Low
EI (LA,S)	-21.37 (-35.35 to -7.38)	56 (21 to 69)	Very low
EI (LA)	-21.15 (-36.28 to -6.01)	56 (17 to 69)	Very low

4b. Physical functioning (ODI 0-100 points, lower scores are better) for chronic spine related radicular pain

Treatment *v* placebo	MD (NMA)	RD for achieving MID (95 CI%)	COE
EI (LA,S)	-5.97 (-13.07 to 1.13)	17 (-3 to 36)	Moderate
EI (LA)	-4.76 (-12.33 to 2.81)	14 (-8 to 34)	Moderate
DRG RF	-1.35 (-8.50 to 5.80)	4 (-15 to 24)	Moderate
EI (LA,S)+DRG RF	-10.90 (-23.81 to 2.01)	31 (-6 to 53)	Low
EI (S)	-0.89 (-6.20 to 4.41)	3 (-12 to 18)	Low
EI (LA)+DRG RF	-22.72 (-35.04 to -10.41)	52 (29 to 58)	Very low
Usual care	5.97 (-1.81 to 13.75)	-16 (-30 to 5)	Very low

Certainty	Classifications (the higher level, the better effectiveness)
Moderate to high	Category 2: More effective than sham procedures
	Category 1: No more effective than sham procedure
Low to very low	Category 2: May be more effective than sham procedures
	Category 1: May be no more effective than sham procedures

COE = Certainty of evidence, DRG RF = Dorsal root ganglion radiofrequency ablation, EI = Epidural injection, IM = Intramuscular injection, Joint RF = Joint radiofrequency ablation, JTI = Joint-targeted injection, LA = Local anaesthetic, MD (NMA) = Mean difference (network meta-analysis), MID = Minimally important difference (10 points on 100 point scale), ODI = Oswestry Disability Index, RD = Risk difference (%), S = steroid

Fig 4 | Network meta-analysis results, sorted by GRADE certainty of evidence and effect estimate, for the comparisons of interventional procedures versus sham procedures, for physical functioning with chronic spine pain. Table a. Physical functioning scores for axial pain. Table b. Physical functioning scores for radicular pain

(fig 2, panel b). Of the 11 direct comparisons, five were supported by two or more trials for conventional pairwise meta-analysis, of which two showed substantial heterogeneity (I^2>70%) (supplementary table 14). There was no evidence of intransitivity (supplementary figures 4a to 4c) or global or loop-specific incoherence (supplementary table 15).

For chronic radicular spine pain, compared with sham procedures, the following probably result in little to no difference in pain relief (moderate certainty): epidural injection of local anaesthetic and steroids (WMD −0.49 (95% CI −1.54 to 0.55), modelled RD for achieving the MID 4%) and radiofrequency of the dorsal root ganglion (WMD 0.15 (−0.98 to 1.28), modelled RD −1%). The following may result in little to no difference in pain relief (low certainty): epidural injection of local anaesthetic (WMD −0.26 (−1.37 to 0.84), modelled RD 2%) or epidural injection of steroids (WMD −0.56 (−1.30 to 0.17), modelled RD 5%). Effects for dorsal root ganglion radiofrequency with an epidural of local anaesthetic with or without steroids were supported by only very low certainty evidence. See figure 3 (table b) and supplementary tables 14 and 16.

Physical function

Twenty eight trials that enrolled 2857 patients and evaluated nine interventional procedures for chronic radicular spine-related pain for their effects on physical functioning. Of the 10 direct comparisons, four were supported by two or more trials for conventional pairwise meta-analysis, and one pooled effect demonstrated substantial heterogeneity (I^2=98%) (supplementary fig 2b, supplementary table 17). There was no evidence of intransitivity (supplementary figs 5a to 5c). There was no evidence of global incoherence; however, we observed incoherence for the network

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Treatment *v* placebo	Relative risk (95% CI) (NMA)	Certainty of evidence
Joint RF	1.56 (1.08 to 2.24)	Low
JTI (LA,S)	1.61 (0.63 to 4.11)	Low
IM (LA,S)	1.38 (0.30 to 6.38)	Low
JTI (LA)	1.73 (0.15 to 19.78)	Very low
IM (LA)	1.72 (0.55 to 5.38)	Very low
EI (LA,S) + DRG RF	1.70 (0.34 to 8.54)	Very low
EI (S)	1.37 (0.82 to 2.28)	Very low
EI (LA,S)	1.13 (0.37 to 3.47)	Very low
JTI (S)	1.07 (0.39 to 2.96)	Very low
DRG RF	1.03 (0.75 to 1.42)	Very low
Usual care	0.95 (0.37 to 2.45)	Very low
EI (LA) + DRG RF	0.92 (0.02 to 52.74)	Very low
EI (LA)	0.92 (0.29 to 2.93)	Very low

Certainty	Classifications (the higher level, the better effectiveness)
Moderate to high	Category 2: More harmful than sham procedures
	Category 1: No more harmful than sham procedures
Low to very low	Category 2: May be more harmful than sham procedures
	Category 1: May be no more harmful than sham procedures

DRG RF = Dorsal root ganglion radiofrequency ablation, EI = Epidural injection, IM = Intramuscular injection, JTI = Joint-targeted injection, LA = Local anaesthetic, NMA = Network meta-analysis, S = steroid

Fig 5 | Network meta-analysis results, sorted by GRADE certainty of evidence and effect estimate, for the comparisons of interventional procedures versus sham procedures for non-serious adverse events

estimate of epidural steroid injection with or without local anaesthetic versus usual care. In this case, we used the higher certainty of evidence between the direct and indirect estimates instead of the network estimate. Specifically, we used indirect evidence for epidural steroid injection with local anaesthetic versus usual care, and direct evidence for epidural steroid injection versus usual care (supplementary tables 17 and 18).

For chronic radicular spine pain, moderate certainty evidence shows that the following probably result in little to no difference in physical functioning: dorsal root ganglion radiofrequency (WMD −1.35 (95% CI −8.50 to 5.80), modelled RD 4%), epidural injection of local anaesthetic (WMD −4.76 (−12.33 to 2.81), modelled RD 14%), and epidural injection of local anaesthetic with steroids (WMD −5.97 (−13.07 to 1.13), modelled RD 17%). Low certainty evidence suggests that epidural steroid injection may make little to no difference in physical functioning (WMD −0.89 (−6.20 to 4.41), modelled RD 3%), and that dorsal root ganglion radiofrequency with epidural injection of local anaesthetic with steroids may provide a small improvement in physical functioning (WMD −10.90 (−23.81 to 2.01), modelled RD 31%). Effects of dorsal root ganglion radiofrequency with epidural injection of local anaesthetic were supported by only very low certainty evidence. See figure 4 (table b) and supplementary tables 17 and 19.

Adverse events

Seventy two trials (89%) reported information on adverse events. Of these, 52 reported the prevalence of non-serious adverse events, and 20 stated there were no serious adverse events without details about which events were considered. Two trials reported serious adverse events: (1) one case of gastrointestinal bleeding among 31 patients (3%) who received intramuscular injection of local anaesthetic with steroids versus none in the arm receiving joint targeted steroid injections,[51] and (2) hospitalisation, surgery, or both in four of 200 (2%) patients who received epidural injection of local anaesthetic and five of 200 patients (3%) who received epidural injection of local anaesthetic with steroids.[50]

The 52 trials that reported non-serious adverse events enrolled 5124 patients and evaluated 14 interventional procedures. Of the 21 direct comparisons, nine had two or more studies for pairwise meta-analysis; none showed evidence of heterogeneity (supplementary fig 6, supplementary table 20). Further, there was no evidence of global or loop-specific incoherence (supplementary table 21). Low certainty evidence suggests that, compared with sham procedures, the following may increase the risk of non-serious adverse events: joint radiofrequency nerve ablation (relative risk (RR) 1.56 (95% CI 1.08 to 2.24)), joint-targeted injections of local anaesthetics and steroids (RR 1.61 (0.63 to 4.11)), and intramuscular injection of local anaesthetic and steroids (RR 1.38 (0.30 to 6.38)).

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Effects of other interventional procedures on non-serious adverse events were supported only by very low certainty evidence. See figure 5 and supplementary tables 20 and 22)

Additional outcomes

We could not conduct network meta-analysis for mental functioning, role functioning, social functioning, sleep quality, opioid use, or return to work because there were fewer than 10 studies reporting effects of interventional procedures on these outcomes. The results of pairwise meta-analyses are presented in supplementary table 23, and forests plots can be found in supplementary file 2. No intervention compared with a sham procedure showed important improvement in mental function, role function, social function, sleep quality, or return to work (all low certainty evidence).

Subgroup analysis

We were unable to explore subgroup effects based on receipt of disability benefits or engagement in litigation versus not, or use of image-guidance for delivering procedures versus not, because of insufficient variability among eligible trials. We performed subgroup analyses based on location of pain, use of diagnostic blocks versus not, and higher versus lower risk of bias. For pairwise meta-analyses, we observed one credible subgroup effect for the comparison of joint radiofrequency nerve ablation versus sham procedure in which unblinding of treatment providers was associated with larger effects on pain relief for chronic axial spine pain (supplementary table 24). Network meta-regression did not find evidence of important effect modification across outcomes (supplementary tables 25 to 64).

Further, we observed evidence of small study effects for joint radiofrequency nerve ablation versus sham procedure on chronic axial spine pain (Egger's test P=0.002) (supplementary figure 7, supplementary table 65).

Discussion

Main findings

Our network meta-analysis (NMA) of 81 trials that enrolled 7977 patients found moderate certainty evidence that, compared with sham procedures, epidural injection of local anaesthetic with or without steroids, and joint-targeted steroid injection probably result in little to no difference in pain relief for chronic axial spine pain. Moderate certainty evidence also showed that joint-targeted injection of local anaesthetic with or without steroids probably result in little to no difference in physical functioning for chronic axial spine pain patients.

Compared with sham procedures, moderate certainty evidence showed that epidural injection of local anaesthetic and steroids, and radiofrequency of the dorsal root ganglion probably result in little to no difference in pain relief for chronic radicular spine-related pain. Moderate certainty evidence also showed that dorsal root ganglion radiofrequency and epidural injection of local anaesthetic with or without steroids probably result in little to no difference in physical functioning for chronic radicular spine pain compared with sham procedures. The certainty in effects among other interventional procedures for pain and physical functioning was low or very low. All evidence for the effects of interventional procedures on adverse events proved of low or very low certainty.

Relation to other studies

Several observational studies have reported important benefits of interventional procedures for chronic spine pain[71-74]; however, invasive procedures are associated with large non-specific effects.[63 64] As such, rigorously conducted randomised trials, with blinding of patients and outcome assessors and use of a compelling sham intervention for comparison, are essential to inform specific effects. While ours is the first NMA of randomised trials to compare all commonly available interventional procedures for chronic spine pain, other investigators have conducted two prior NMAs exploring procedures for select indications. One review of management options versus placebo for sciatica found no significant effects on leg pain or physical functioning for epidural injections of steroids, local anaesthetics, or their combination.[18] Another NMA explored several non-surgical treatment options for pain associated with lumbar disc prolapse, and found that caudal or epidural steroid injections provided no significant pain relief versus placebo at long term follow-up.[19] Both reviews pooled acute and chronic complaints, and, although neither assessed the certainty of evidence, results consistently failed to show important benefits, or indeed any benefits, for all considered interventional procedures.

Strengths and limitations

Strengths of our review include a comprehensive search strategy for English and non-English trials. Independent coding of clinical conditions and interventional procedures by clinical experts, blinded to study results, provides reassurance regarding the development of our networks. We used the GRADE approach to evaluate the certainty of evidence and anchor-based MIDs to inform the importance of effect estimates.

This review also has several limitations. First, our review found limited direct evidence to inform the effectiveness of several interventions versus sham procedures, and the evidence to inform the effectiveness of some interventional procedures was only low or very low certainty, including all evidence to inform adverse events. Second, we were unable to construct networks for all patient-important outcomes as few trials reported effects of interventional procedures on outcomes aside from pain, physical function, and adverse events. Future trials of interventional procedures should capture effects on all outcomes of importance to patients. Third, due to limited representation, we were unable to explore subgroup effects for all clinical conditions. We did not, however,

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find evidence of statistical variability across treatment effects in our outcome networks or in assessments of between-study variances within the closed loops of evidence. In addition, since all pooled effects supported by low or moderate certainty evidence showed little to no effect on pain relief versus sham procedures, then if an interventional procedure was effective only in certain subtypes of axial or radicular pain it must cause more pain in other subtypes. A more plausible interpretation is that interventional procedures have no specific effect on chronic spine pain. Fourth, although litigation and disability benefits, and prior spine surgery, may influence treatment effects,[75] data in the included trials were insufficient to explore subgroup effects. Finally, a prior systematic review found that randomised controlled trials of epidural steroids for chronic spine pain were three times more likely to report positive results when the primary author was an interventionalist versus a non-interventionalist[76]; however, most trials eligible for our review did not provide sufficient details to explore this issue.

Conclusions

Our NMA of randomised clinical trials found that no commonly performed interventional procedure provided convincing evidence of important pain relief or improvement in physical functioning for axial or radicular chronic spine pain; indeed, in many instances the evidence showed moderate certainty of little to no effect. The accompanying *BMJ* Rapid Recommendation provides contextualised guidance based on this body of evidence (box 1).

Abbreviations

NMA=network meta-analysis; RCT=randomised clinical trials; CENTRAL=Cochrane Central Register of Controlled Trials; CINAHL=Cumulative Index to Nursing and Allied Health Literature; MID=minimally important difference; RD=risk difference; RR=relative risk; SD=standard deviation; SE=standard error; CI=confidence interval; WMD=weighted mean difference; OR=odds ratio; PRISMA=Preferred Reporting Items for Systematic reviews and Meta-Analyses; IMMPACT=Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials; VAS=visual analogue scale; ODI=Oswestry Disability Index; IQR=interquartile range; GRADE=Grading of Recommendations Assessment, Development and Evaluation; ICEMAN=Instrument to assess the Credibility of Effect Modification ANalyse

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Ethical approval: Not required.

Data sharing: Details of the characteristics of the included studies were shared in the supplementary materials. The study specific data included in meta-analyses can be obtained from the first author at wangx431@mcmaster.ca

Transparency: All authors affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Dissemination to participants and related patient and public communities: Our results were used to develop MAGICapp decision aids (available at www.magicapp.org/) to facilitate conversations between healthcare providers and patients. The MAGICapp decision aids were co-created with people living with chronic pain. We also plan to use social media, the websites of our organisations and those of pain-related associations and societies to disseminate our findings.

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Supplementary file 1: Appendices 1-3; supplementary tables 1-65; supplementary figures 1-7
Supplementary file 2: Forests plots of pairwise meta-analyses

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