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What proportion of patients report long-term pain after total hip or knee replacement for osteoarthritis? A systematic review of prospective studies in unselected patients

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ABSTRACT

Background: Total hip or knee replacement is highly successful when judged by prosthesis-related outcomes. However, some people experience long-term pain.

Objectives: To review published studies in representative populations with total hip or knee replacement for the treatment of osteoarthritis reporting proportions of people by pain intensity.

Data sources: MEDLINE and EMBASE databases searched to January 2011 with no language restrictions. Citations of key articles in ISI Web of Science and reference lists were checked.

Study eligibility criteria, participants and interventions: Prospective studies of consecutive, unselected osteoarthritis patients representative of the primary total hip or knee replacement population, with intensities of patient-centred pain measured after 3 months to 5-year follow-up.

Study appraisal and synthesis methods: Two authors screened titles and abstracts. Data extracted by one author were checked independently against original articles by a second. For each study, the authors summarised the proportions of people with different severities of pain in the operated joint.

Results: Searches identified 1308 articles of which 115 reported patient-centred pain outcomes. Fourteen articles describing 17 cohorts (6 with hip and 11 with knee replacement) presented appropriate data on pain intensity. The proportion of people with an unfavourable long-term pain outcome in studies ranged from about 7% to 23% after hip and 10% to 34% after knee replacement. In the best quality studies, an unfavourable pain outcome was reported in 9% or more of patients after hip and about 20% of patients after knee replacement.

Limitations: Other studies reported mean values of pain outcomes. These and routine clinical studies are potential sources of relevant data.

Conclusions and implications of key findings: After hip and knee replacement, a significant proportion of people have painful joints. There is an urgent need to improve general awareness of this possibility and to address determinants of good and bad outcomes.

ARTICLE SUMMARY

Article focus

- Total hip and knee replacement have good clinical outcomes.
- There is a perception that some people experience long-term pain after their joint replacement.
- We aim to establish the proportion of patients experiencing long-term pain after joint replacement.

Key messages

- Well-conducted studies in representative populations of patients with total hip and knee joint replacement suggest that a significant proportion of people continue to have painful joints after surgery.
- The proportion of people with an unfavourable long-term pain outcome in studies ranged from about 7% to 23% after hip and 10% to 34% after knee replacement. In the best quality studies, an unfavourable pain outcome was reported in 9% or more of patients after total hip and about 20% of patients after total knee replacement.
- There is an urgent need to improve general awareness that some patients experience long-term pain after joint replacement and to address the determinants of good and bad outcomes.

Strengths and limitations of this study

- Systematic review conducted according to established methods and guidelines identified 17 studies in representative populations of patients with total hip or knee replacement.
- Pain outcome data are widely recorded as mean values but only a minority of studies reported outcomes as proportions with pain at follow-up.
- The small number of studies and different pain outcome measures precluded meta-analysis, calculation of a summary estimate and exploration of sources of heterogeneity.

INTRODUCTION

Symptoms of osteoarthritis are managed in the community, but if pharmacological and conservative treatments provide inadequate relief, then total joint replacement is commonly performed. In England and Wales during the year ending March 2010, there were 71 021 primary total hip and 79 263 primary total knee replacement operations recorded in the National Joint Registry.[1] In the USA in 2006, the estimated numbers of hospital discharges after total hip or knee replacement procedures were 231 000 and 542 000, respectively,[2] with demand predicted to increase substantially.[3]

Total hip or knee replacement is highly successful when judged by prosthesis-related outcomes, such as the radiographic appearance of the prosthesis,[4] implant survival[5] or surgeon-assessed outcome.[6] Nevertheless, many people continue to experience significant pain and functional problems after total joint replacement. Woolhead and colleagues[7] conducted in-depth interviews with 10 patients 6-months after their total knee replacement. Although patients considered their joint replacement successful, eight of the 10 patients still experienced pain and immobility. In a European collaborative study of 1327 patients with total hip replacement, Judge and colleagues[8] applied three recognised criteria for general symptomatic improvement with symptom severity based on pain, stiffness and physical function according to the WOMAC osteoarthritis index.[9] The different criteria suggested that between 14% and 36% of patients did not improve or were worse 12 months after surgery.

Pain is the most important factor in the decision to recommend total joint replacement.[10] Furthermore, patient-reported pain is now widely assessed using disease-specific outcome measures. In the USA, the importance of patient-reported outcomes in assessing quality of care is recognised,[11] and in England, following the report of Lord Darzi,[12] information is routinely collected after elective surgery.[13]

Reporting of pain outcomes in the orthopaedic literature frequently emphasises improvement in mean scores. An example of this is the study of Bachmeier and colleagues[14] where the improvement of mean WOMAC pain scores at 3, 6, 9 and 12 months after hip or knee replacement is clearly demonstrated. However, at all time points, the mean pain score has an associated SD implying that a proportion of patients still reported pain. To advise both patients and their healthcare professionals, it is important to have a clear understanding of the frequency and extent of pain following total hip or knee replacement.

We have used systematic review methods to identify studies reporting the proportion of people with significant long-term pain after total hip or knee replacement. We aimed to identify studies in populations representative of contemporary clinical practice. Some information on all patients in cohorts is required as patients lost to follow-up may have experienced poorer or at least similar outcomes to those followed up.[15–18]

METHODS

We used systematic review methods in accordance with the MOOSE proposal for reporting systematic reviews and meta-analyses of observational studies.[19] A MOOSE checklist is shown in online appendix 1.

Data sources and searches

MEDLINE and EMBASE databases were searched from inception to 31 January 2011. A general search was performed to identify quantitative research in primary total hip or knee replacement. The MEDLINE search strategy is shown in online appendix 2. Search terms related to hip or knee replacement and studies with an epidemiological design including prospective and longitudinal studies. No language restrictions were applied.

Within titles, abstracts and keywords of articles identified, we searched for text words relating to osteoarthritis and *disease-specific patient-centred pain outcome measures* used in osteoarthritis and joint replacement. Specifically these were Western Ontario and McMaster Universities Arthritis Index (WOMAC), Arthritis Impact (AIMS), Lequesne, Oxford hip or Oxford knee score, Hip Osteoarthritis Outcome Score (HOOS) or Knee Osteoarthritis Outcome Score (KOOS), pain visual analogue scales (VAS) and self-appraisal. Outcomes not considered patient centred were Harris Hip, American Knee Society and Bristol Knee Scores. We did not include generic health measures including the Health Assessment Questionnaire, EuroQol, London Handicap Scale, Medical Outcomes Study Short Form-36 (SF-36), Disease Repercussion Profile, Sickness Impact Profile and WHOQol-BREF.

We also checked citations of key articles in ISI Web of Science and reference lists. Studies reported only as abstracts were excluded. References were managed in an Endnote X3 database.

Study selection

We included prospective studies of consecutive unselected patients representative of the primary total hip or knee replacement population. Studies reporting a specific implant or component were eligible if the population studied was not clearly selected, that is, the group was likely to be representative of the total joint replacement population.

Study designs excluded were cross-sectional and retrospective studies, randomised controlled trials and evaluations of specific technologies. Randomised controlled trials and many evaluations of new technologies comprise selected populations, and furthermore, it is outside the scope of this review to assess whether these reflect best clinical practice.

We made an a priori decision to limit follow-up to between 3 months and 5 years. In evaluating the

effectiveness of primary total hip or knee replacement in reducing pain from osteoarthritis, we are concerned with outcomes when recovery can be considered maximal[14] and not later issues of joint loosening and revision.[20]

Study titles, abstracts and, where necessary, full articles were checked independently for eligibility by two researchers experienced in systematic reviews (ADB) and rheumatology (PD). Disagreements were resolved by discussion. Validity of the database was confirmed by checking against reference lists provided by local experienced researchers in orthopaedic outcomes.

While we recognise that studies may include patients with other joint replacement surgery, we excluded studies specifically describing outcomes of revision operations and partial joint replacements (eg, unicompartmental or patellofemoral knee replacement and hip resurfacing).

Data extraction

The pain measure relating to the operated hip or knee was considered in the review. No attempt was made to contact authors of studies who did not have appropriate data. In the previous reviews we have conducted only a minority of authors contacted have provided additional data for analyses. Although contact with authors is a well-recognised approach in systematic reviews,[21] a survey of review authors indicated that many systematic reviewers do not do so because of poor response rates and variability in the quality of information collected this way.[22] Authors of studies with appropriate data but with specific missing information were contacted.

Data from eligible articles were recorded on an Excel spreadsheet by one reviewer (ADB) and checked against original articles by a second (VW). Data were extracted on indication (all or majority of patients with osteoarthritis), pain outcome, baseline dates, country, study design, how group selected, age, number of patients recruited, number who died and the number lost to follow-up. We recorded the number of people at follow-up with no pain or mild pain, moderate or severe pain (or with little improvement in pain from preoperative), revision or dislocations or deep infection and contralateral or other joint replacement or treatment for fracture.

Data synthesis and analysis

As studies reported different pain measures, we summarised pain outcomes in a way that was applicable to all measures. The proportions of people with different severities of pain were summarised as 'favourable', 'unfavourable' or 'uncertain' outcomes. Favourable outcome includes people with no pain or mild pain at follow-up, while unfavourable outcome includes those with moderate-to-severe pain or for whom surgery had not relieved pain. The uncertain outcome includes all patients for whom we cannot be sure of their pain levels at follow-up. These include patients who died, had revision surgery, contralateral surgery or dislocation and were not followed up with questionnaires and those lost to follow-up. We also included as uncertain those patients with a degree of reported pain, which we could not classify as a favourable or unfavourable outcome.

Quality assessment

Only studies with unselected patients and complete reporting of losses to follow-up were included. To describe the quality of studies, we used the features of the Cochrane risk of bias table applicable to longitudinal studies.[21] Specifically, these were blind outcome assessment (self-completed patient-reported outcome measure), incompleteness of outcome data collection (losses to follow-up low <10%, moderate 10%–20% or high >20%) and other sources of bias (representativeness of study population).

RESULTS

The review process is summarised in figure 1. Searches identified 1308 studies reporting patient-centred outcomes in patients with osteoarthritis. Of these, 115 studies included data on patient-centred pain outcomes in representative population samples studied prospectively for between 3 months and 5 years. Fourteen articles describing 17 cohorts (6 in hip and 11 in knee patients) presented results classifiable as proportions of people with different extents of pain at follow-up. The main reasons for exclusion at this stage were lack of a pain outcome separate from an overall outcome score or the presentation of results as means only.

Patient and study characteristics and outcomes are shown in table 1. The proportions of people with different pain outcomes are summarised in figure 2.

Total hip replacement

Systematic searches identified six studies from Canada, Denmark, Spain, Sweden, UK and USA including a total of 13 031 patients. Pain outcome measures were based on the WOMAC pain scale or authors' own methods. The measures used and the definition of unfavourable pain outcome are summarised for each study in online appendix 3.

Study quality

Issues relating to study quality are summarised in online appendix 4.

Studies described data collected prospectively in consecutive patients with primary total hip replacement. One study was in patients recruited from a national joint registry.[23] Two studies were in multiple centres[24 25] and three were studies in single centres.[26–28] Cohorts were generally similar with regard to patient age (range of means or medians 65.0–73.0 years) and sex (range of percentage female 48.3%–63%), and the indication was osteoarthritis in 87% of patients or more when specified. One national registry study from Denmark included only patients treated with a postero-lateral surgical approach.[23] However, the posterior or lateral approach was used in 99% of patients according to another

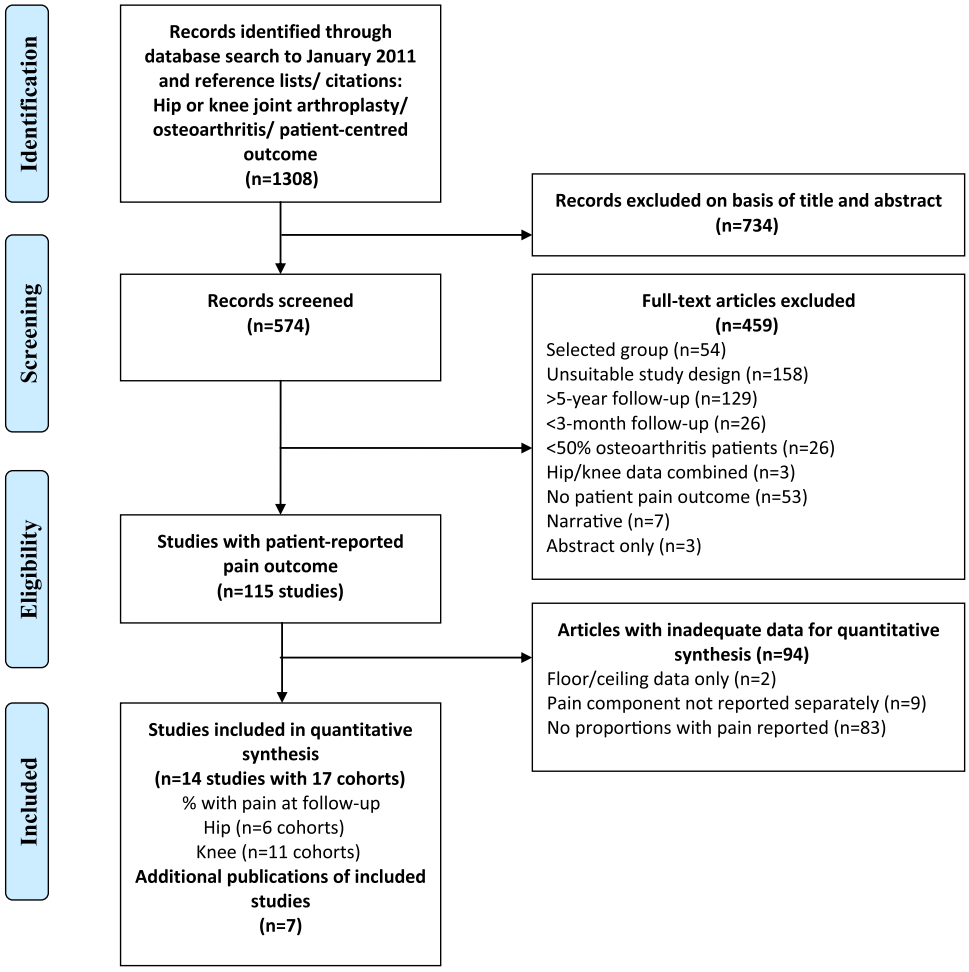

Figure 1 Systematic review flow diagram.

publication from the Danish Hip Registry.[37] Otherwise, no inclusion or exclusion criteria suggested that the patients' studies would not have been representative of the overall total hip replacement population. All studies used self-completed patient reported outcome measures. Losses to follow-up ranged from 5.8% to 47.6%. We considered two markers of better representativeness as indicators of study quality: studies with multiple compared with single centres and by lower losses to follow-up.

WOMAC pain

Jones and colleagues[24] followed up a cohort of 242 consecutive patients receiving total hip replacement in a health region 6 months after total hip replacement. Patients undergoing hemiarthroplasty, revisions and emergency surgery were excluded. Losses to follow-up were low at under 5.8%. Results were presented combined with a total knee replacement cohort, and with the consent of the author, we assumed that equal proportions of hip and knee patients were followed up. The WOMAC outcome used to define a poor pain outcome was an improvement of <10 points on the 100-point pain scale (representing a gain of at least 60% of the baseline SD). We estimate the proportion of patients with no detectable clinical improvement was 8.3% (uncertain 5.8%).

Quintana and colleagues[25] followed up a cohort of 784 patients on waiting lists for total hip replacement at seven teaching hospitals. WOMAC questionnaires were completed 6 months after surgery by 584 patients. Losses to follow-up were high at 25.5%. The authors identified 24.55 points on the 100-point WOMAC pain scale as representing a minimal clinically important difference. No improvement in pain greater than the minimal clinically important difference was observed in 16.3% of patients (uncertain 25.5%). The other two studies reporting WOMAC pain outcomes after total hip replacement were conducted in single centres.

Several reports described the cohort of Nilsdotter and colleagues. The prospective study with 219 consecutive patients with primary unilateral total hip replacement represented the most complete report.[26] Losses to follow-up were low at about 5.9%. Of the 219 patients, only those recruited in the later stages of the study had baseline pain assessed with the WOMAC questionnaire. Thus the detectable clinical improvement outcome of 10 points on the 100-point scale was available on 92 patients. The authors reported that there were no differences between age and sex between these 92

Table 1 Studies of total hip or knee replacement reporting proportion of patients with pain at follow-up

Author, country date of baseline	Indication, population, age	Follow-up, study design, losses to follow-up	Pain outcome measure	Number of patients with		
				Favourable outcome	Uncertain outcome	Unfavourable outcome
Hip replacement						
Nikolajson *et al*,[23] Denmark, 2003	Primary THR, degenerative hip arthritis N=1231 questionnaire follow-up of consecutive patients Mean age 71.6 years (SD 8.7)	12–18-month follow-up Joint registry 5.9% lost to follow-up	Authors' own scale of presence of hip pain and impact on daily life	754 (hip pain not present)	4 died 117 lost to follow-up 62 bilateral or further operation 167 hip pain still present with no/mild impact on daily life	127 (pain with moderate, severe or very severe impact on daily life)
Jones *et al*,[24] Canada, 1995–1997	Primary THR, 94% OA N=242 consecutive patients (includes estimated lost to follow-up based on equal proportions hip/knee lost) Mean age 68.2 years (SD 11.1)	6-month follow-up Prospective 5.8% lost to follow-up or died (Losses to follow-up estimated proportionately as not reported for hip and knee separately)	WOMAC pain Losses to follow-up estimated proportionately as not reported for hip and knee separately	208 (no pain/mild pain defined as more than a 10-point gain on the 100-point WOMAC pain dimension)	14 lost to follow-up (estimated)	20 (moderate/severe pain defined as a gain of <10 points on the 100-point WOMAC pain dimension)
Quintana *et al*,[25] Spain, 1999–2000	THR, OA N=784 consecutive patients willing to participate and with complete presurgical data Mean age 69.1 years	6-month follow-up Prospective 25.5% lost to follow-up	WOMAC pain	456 (patients reporting improvement in pain greater than minimal clinical important difference 24.55/100)	200 lost to follow-up	128 (patients reporting no improvement in pain greater than minimal clinical important difference 24.55/100)
Nilsdotter *et al*,[26] Sweden, 1995–1998	Primary unilateral THR, OA N=219 consecutive patients with two surgical methods. For proportion with pain at follow-up N=92 Mean age 71 years (range 50–92)	Mean 43-month follow-up Prospective 5.9% lost to follow-up	WOMAC pain Favourable/unfavourable estimates based on extrapolation of partial follow-up	153 (Pain improved by more than 10/100 units reflecting detectable clinical improvement)	8 died 13 lost to follow-up	45 (Pain improved by <10/100 units reflecting no detectable clinical improvement)

Continued

Table 1 Continued

Author, country date of baseline	Indication, population, age	Follow-up, study design, losses to follow-up	Pain outcome measure	Number of patients with		
				Favourable outcome	Uncertain outcome	Unfavourable outcome
Singh and Lewallen,[27] USA, 1993–2005	THR, 87% OA N=9154 consecutive patients from joint registry sent postal questionnaire Mean age of patients followed up 65.0 years (SD 13)	24-month follow-up (also 60 month with greater losses to follow-up) Prospective 37.7% lost to follow-up	Single question: How much pain do you have in your operated hip? None, mild, moderate or severe	5272 (None or mild pain)	3447 lost to follow-up	435 (moderate or severe pain)
Wylde *et al*,[28] UK, 2004–2006	THR, majority OA N=1401 consecutive patients Median age 73 years (range 65–78)	Median 41-month follow-up (range 35–48) Prospective with postal follow-up 47.6% lost to follow-up	WOMAC pain	818 (no pain for the past 3 months or mild persistent pain in replaced hip)	71 died 1 revision 667 lost to follow-up	114 (moderate or severe persistent pain for 3 months in replaced hip, WOMAC 0–75/100)
Knee replacement						
Baker *et al*,[29] UK, 2003	Primary TKR, 96% OA N=9417 questionnaire follow-up of random sample of patients in joint registry Mean age 70.7 years (range 25–98)	12-month follow-up or latest available Prospective 14.9% lost to follow-up	Oxford knee score pain dimension	6427 (did not report persistent knee pain)	1407 lost to follow-up or died	1583 (reported persistent knee pain)
Jones *et al*,[24] Canada, 1995–1997	Primary TKR, 94% OA N=292 consecutive patients (includes estimated lost to follow-up based on equal proportions hip/knee lost) Mean age 69.2 years (SD 9.2)	6-month follow-up Prospective 5.5% lost to follow-up or died (estimated proportionately as not reported for hip and knee separately)	WOMAC pain Losses to follow-up estimated proportionately as not reported for hip and knee separately	222 (no pain/mild pain defined as more than a 10-point gain on the WOMAC pain dimension)	16 lost to follow-up or died (estimated)	54 (moderate / severe pain defined as a gain of <10 points on the WOMAC pain dimension)
Quintana *et al*,[25] Spain, 1999–2000	TKR, OA N=792 consecutive patients willing to participate and with complete presurgical data Mean age 71.9 years	6-month follow-up Prospective 24.1% lost to follow-up	WOMAC pain	402 (patients reporting improvement in pain greater than minimal clinical important difference 22.6/100)	191 lost to follow-up	199 (patients reporting no improvement in pain greater than minimal clinical important difference 22.6/100)

Continued

Table 1 Continued

Author, country date of baseline	Indication, population, age	Follow-up, study design, losses to follow-up	Pain outcome measure	Number of patients with		
				Favourable outcome	Uncertain outcome	Unfavourable outcome
Núñez *et al*,[30] Spain, 2000–2001	Primary TKR, OA N=88 consecutive patients Mean age 74.8 years (SD 5.6)	36-month follow-up Prospective 8.0% lost to follow-up	WOMAC pain	60 (improvement in postoperative pain scores)	1 died 7 lost to follow-up 13 contralateral or other surgery	7 (no improvement in postoperative pain scores)
Stephens *et al*,[31] USA	TKR, OA N=68 patients referred for knee replacement aged 50 years or older Mean age 67.4 years	6-month follow-up Prospective 7.4% lost to follow-up	WOMAC	52 (decrease in pain)	5 lost to follow-up	11 (no change or increase in pain)
Lundblad *et al*,[32] Sweden	TKR, OA N=69 patients scheduled for knee replacement Mean age 68 years (range 40–80)	18-month follow-up Prospective 10.1% lost to follow-up (including deaths)	VAS pain	21 (no pain at rest or with movement)	7 lost to follow-up or died 26 pain with movement	15 (pain at rest and movement)
Nilsdotter *et al*,[33] Sweden, 1999–2001	Primary TKR, OA N=102 responders to postal survey on waiting list for knee replacement Mean age 71 years (SD 8, range 51–86)	60-month follow-up Prospective 12.7% lost to follow-up	KOOS pain compared with preoperatively	47 (much less or less pain than preoperatively)	9 died 13 lost to follow-up 6 operated bilaterally	27 (similar or more pain than preoperatively)
Vuorenmaa *et al*,[34] Finland	TKR, OA N=51 patients referred for knee replacement Mean age 70 (SD 5)	3-month follow-up Prospective 11.8% lost to follow-up	VAS pain Pain calculated from 20% followed up had moderate or severe pain (defined as score of >30 on a 100-mm pain VAS)	34 (none or mild pain)	1 died 6 lost to follow-up 1 infection	9 (moderate or severe pain)
Czurda *et al*,[35] Austria, 2003–2005	Primary TKR, OA N=411 consecutive patients with computer-assisted or conventional surgery with at least 18-month follow-up Mean age 75–76 years (range 45–96)	Mean 26-month follow-up (range 18–42) 13.4% lost to follow-up	WOMAC pain	273 (no report of painful knees—no moderate or worse response in any WOMAC pain dimension)	2 died 55 lost to follow-up 24 infection, trauma, reoperation, poor general condition	57 (painful knees—moderate or worse response in any WOMAC pain dimension)

Continued

Table 1 Continued

Author, country date of baseline	Indication, population, age	Follow-up, study design, losses to follow-up	Pain outcome measure	Number of patients with		
				Favourable outcome	Uncertain outcome	Unfavourable outcome
Wylde *et al*,[28] UK, 2004–2006	TKR, majority OA N=1394 consecutive patients Median age 73 (range 28–96)	Median 41-month follow-up (range 34–49) Prospective with postal follow-up 45.3% lost to follow-up	WOMAC pain	433 (no pain for the past 3 months or mild persistent pain in replaced hip)	62 died 4 revision 696 lost to follow-up	199 (moderate or severe persistent pain for 3 months in replaced hip, WOMAC 0–75/100)
Brander *et al*,[36] USA, 1998–2000	Primary TKR, 94% OA N=116 consecutive patients (1 surgeon) Mean age 66 years (SD 10.5, range 36–85)	12-month follow-up Prospective 0% lost to follow-up	VAS pain	98 (no significant pain, VAS score ≤40)	1 died 2 revision or dislocation	15 (significant pain, VAS score >40)

Studies ordered within hip and knee replacement groups by decreasing representativeness (multiple compared with single centre) and by increasing losses to follow-up.
KOOS, Knee Osteoarthritis Outcome Score; THR, total hip replacement; TKR, total knee replacement; OA, osteoarthritis; VAS, visual analogue scales; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

patients and those without WOMAC data. We estimated overall numbers of patients with favourable and unfavourable outcomes on the basis of these 92 patients. Approximately 20.5% of patients had no detectable clinical improvement after a mean of 43 months (uncertain 9.6%).

In the study of Wylde and colleagues,[28] 1401 consecutive patients with total hip replacement were followed prospectively for a median of 41 months. In a postal survey losses to follow-up were high at 47.6%. Moderate or severe persistent pain, indicated by a WOMAC score of 0–75 points on the 100-point scale, lasting 3 months or more, was reported by 8.1% of patients (uncertain 52.7%).

Authors own pain measure

In the study of Nikolajson and colleagues,[23] 1231 patients with primary total hip replacement recorded in a national joint registry were followed up by postal questionnaire at 12–18 months. Losses to follow-up were low at 5.9%. Pain from the operated hip (validated by pain drawings) with moderate to very severe impact on daily life was reported by 10.3% of patients (uncertain 28.4%).

Singh and Lewallen[27] followed up a single centre population with a postal questionnaire. Of 9154 patients with total hip replacement, 5707 provided information at 24 months with high loss to follow-up of 37.7%. Moderate or severe pain in the operated hip was reported by 4.8% of patients (uncertain 37.7%).

Total knee replacement

Searches identified eleven studies conducted in Canada, Finland, Spain, Sweden, UK and USA reporting appropriate pain outcomes after total knee replacement. Studies included a total of 12 800 patients. Pain outcome measures were based on the WOMAC and KOOS pain scales, the Oxford knee score pain dimension or VAS pain scales. The measures used and the definition of unfavourable pain outcome are summarised for each study in online appendix 3.

Study quality

Issues relating to study quality are summarised in online appendix 4.

Studies described data collected prospectively in patients with primary total knee replacement. One study was in patients recruited from a national joint registry.[29] Two studies were in patients from multiple centres,[24 25] six studies were in patients treated at a single centre,[30–35] and one study reported all patients operated on by one surgeon.[36] Cohorts were generally similar with regard to patient age (range of means or medians 66–76 years) and sex (range of percentage female 54–86%), and the indication was osteoarthritis in 94% of patients or more when specified. In one study patients were identified before surgery but no other further details of recruitment centre were reported.[31] Although one study limited inclusion of patients to those aged

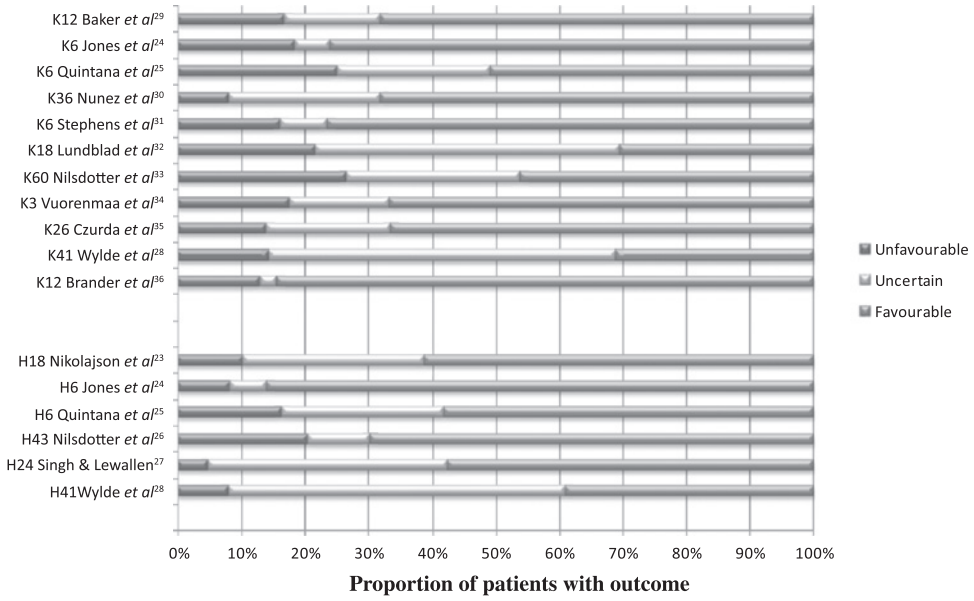

Figure 2 Studies of hip or knee replacement reporting proportion of patients with pain at follow-up. Preceding study author: H (hip), K (knee) and months (follow-up). Studies ordered within hip and knee replacement groups by decreasing representativeness (multiple compared with single centre) and by increasing losses to follow-up.

50 years and older[31] and another followed up patients operated on by experienced surgeons only, study inclusion and exclusion criteria suggested that all studies were likely to be representative of the general total knee replacement population. With the exception of one study which used exclusively telephone interview, all studies assessed pain at follow-up using self-completed questionnaires. All assessed pain using patient reported outcome measures. Losses to follow-up ranged from 0% to 43.5%.

WOMAC pain

In addition to their study in hip replacement patients, Jones and colleagues[24] followed up a cohort of 292 consecutive patients 6 months after total knee replacement. Patients receiving hemiarthroplasty, revisions and emergency surgery were excluded. Losses to follow-up were low at 5.8%. As previously described, assuming equal proportions followed up we estimate that a detectable clinical improvement of <10/100 points on the WOMAC pain scale (representing a gain of at least 60% of the baseline SD) was reported by 18.5% (uncertain 5.5%).

Quintana and colleagues[25] followed up 792 consecutive patients from seven hospitals who received total knee replacement. At 6-month follow-up, WOMAC questionnaires were completed by 601 patients. Losses to follow-up were high at 24.1%. No improvement in pain greater than the minimal clinically important difference (22.6/100) was observed in 25.1% of patients (uncertain 24.1%).

Núñez and colleagues[30] followed up a group of 88 consecutive primary total knee replacement patients. Only 5.0% of patients were lost to follow-up. At 36 months, 8.0% of patients (uncertain 23.9%) had no improvement in WOMAC pain scores.

After total knee replacement surgery, a cohort of 68 patients was followed up prospectively by Stephens and colleagues.[31] Losses to follow-up were low at 7.4%. At 6 months, 16.2% of patients (uncertain 7.4%) had no change or increased WOMAC pain compared with before surgery.

Czurda and colleagues[35] followed up 411 consecutive patients after computer-assisted or conventional primary knee replacement at a mean of 26 months. Painful knees, defined as moderate pain or worse in any of the WOMAC pain questions, were reported by 13.9% of patients (uncertain 19.7%). Losses to follow-up were moderate at 13.4%.

A cohort of 1394 consecutive total knee replacement patients were followed up prospectively by Wylde and colleagues[28] for a median of 41 months. In a postal survey, moderate or severe persistent pain, indicated by a WOMAC pain score of 0–75 points on the 100-point scale, lasting 3 months or more was reported by 14.3% of patients (uncertain 54.7%). However, losses to follow-up were high at 45.3%.

KOOS pain

From a postal survey of patients waiting for primary total knee replacement, Nilsdotter and colleagues[33] followed 102 patients prospectively. Losses to follow-up were moderate at 12.7%. At 60 months, 26.5% of patients (uncertain 27.5%) experienced similar or more pain than before surgery.

Oxford knee score pain dimension

Baker and colleagues[29] followed up 9417 patients with primary total knee replacement from a joint registry by postal questionnaire at least 12 months after surgery. Losses to follow-up were moderate at 14.9%. Persistent knee pain was reported by 16.8% of patients (uncertain 14.9%).

VAS pain

Lundblad and colleagues[32] followed up 69 total knee replacement patients for 18 months. Losses to follow-up were moderate at 10.1%. Interpreting VAS responses,

the authors reported pain at rest and on movement in 21.7% of patients (uncertain 47.8%).

Vuorenmaa and colleagues[34] followed up 51 total knee replacement patients prospectively at 3 months. Losses to follow-up were moderate at 11.8%. Moderate or severe pain, defined as >30 on a 100-mm VAS pain scale, was reported in 17.6% of patients (uncertain 15.7%).

In the study of Brander and colleagues,[36] 116 consecutive patients treated with primary total knee replacement by a single surgeon were followed prospectively for up to 12 months. Using a VAS scale, the authors identified significant knee pain (defined as a VAS score of >40) in 12.9% of patients (uncertain 2.6%). No patients were lost to follow-up.

OVERVIEW

Total hip replacement

Overall, an unfavourable pain outcome was seen in at least 4.8% and up to 20.5% of patients after hip replacement (figure 2). However, these are likely to be underestimates as we do not have information on the outcomes in between 5.8% and 52.7% of patients.

As indicators of studies with more representative populations, the three studies in multiple centres reported an unfavourable pain outcome relating to the operated hip in 8.3%, 10.3% and 16.3% of patients followed up. Studies with low losses to follow-up reported an unfavourable pain outcome in 8.3%, 10.3% and 20.5% of patients. Even considering studies with some degree of outcome consistency involving minimal clinically important differences, the range of unfavourable pain outcome was wide with at least 8.1% and up to 20.5% of patients affected.

Applying the conservative assumption that an equal proportion of patients with missing data had an unfavourable pain outcome, we estimate that at least 7%–23% of patients experienced long-term pain after hip replacement. In three higher quality studies as judged by representativeness, this would reflect an unfavourable pain outcome in 9%, 13% and 20% of patients, and in three studies with low losses to follow-up in 9%, 13% and 23% of patients. Two studies with both indicators of best study quality suggested that 9%–13% of patients had an unfavourable pain outcome after total hip replacement.

Total knee replacement

After knee replacement, an unfavourable pain outcome was seen in at least 8.0% and up to 26.5% of patients (figure 2). Three studies followed up populations from multiple centres and unfavourable pain outcomes relating to the operated knee were reported in 16.8%, 18.5% and 25.1% of patients. In four studies with low losses to follow-up, an unfavourable pain outcome was reported in 8.0%, 12.9%, 16.2% and 18.5% of patients. Considering studies with some degree of outcome consistency, the range of unfavourable pain outcome was wide with at least 14.3% and up to 25.1% of patients affected.

These are likely to be underestimates as we do not have outcome information on between 2.6% and 54.7% of patients. Assuming conservatively that the patients with missing data had similar pain outcomes, studies suggested that at least 10%–34% of patients experience long-term pain after knee replacement. Applying this assumption in the higher quality studies with potentially more representative populations, at least 19%, 20% and 31% of patients had an unfavourable pain outcome after total knee replacement. In four studies with low losses to follow-up, 10%, 13%, 17% and 20% of patients reported an unfavourable pain outcome at follow-up. In one study conducted in multiple centres with low losses to follow-up, 20% of patients reported an unfavourable pain outcome at follow-up.

DISCUSSION

These data show that many people with a total hip or knee replacement complain of pain in the operated joint in the early years after surgery. This was particularly evident after total knee replacement.

Although we have interpreted pain outcomes as favourable, unfavourable or uncertain, we do not believe that the data justify combination to provide summary values. In the studies identified in our review, several different outcome measures were reported, and in studies with similar outcomes, different methods of analysis were used. Without specific information on responsiveness and correlation between methods, an important additional source of heterogeneity may be introduced.[38]

Previous reviews have looked at functional and health-related quality of life after joint replacement. Kane and colleagues[39] reported functional outcomes after total knee replacement in a literature review of 62 studies published between 1995 and 2003. They concluded that knee replacement leads to improved function as shown by large effect sizes in studies but that larger benefits were perceived by physicians than experienced by patients. Ethgen and colleagues[40] identified 74 prospective cohort studies published between 1980 and 2003 that included quality of life outcomes. The authors highlighted the value of health-related quality of life data in improving management of patients undergoing hip or knee replacement. They concluded that total hip and knee arthroplasties were 'quite effective' in improving health-related quality of life dimensions. In a large European cohort, Judge and colleagues[8] concluded that 14%–36% of patients had no symptomatic improvement 12 months after total hip replacement.

The results we present are consistent with those reporting satisfaction as an outcome. For example, Bourne and colleagues[41] reported satisfaction with pain relief in a study in knee replacement patients. Satisfaction with pain relief ranged from 72% for going up or downstairs to 85% for walking on a flat surface.

In systematic reviews, publication bias is important in assessing the validity of the results. In this review, we identified 95 studies where the proportion of people with

pain at follow-up could have been estimated by authors with access to original data. In previous reviews that we have conducted, replies to requests for additional data have been patchy and we chose not to pursue this approach. Nevertheless, we encourage study authors to perform and publish appropriate analyses of their data. Similarly, a wealth of patient-centred outcome data is now collected routinely and merits wide dissemination.

The majority of studies included in our review reported outcomes of patients after total joint replacement. A few studies followed up patients listed for total joint replacement, and it is possible that these studies included patients who subsequently received other surgical treatments including unicompartmental knee replacement or hip resurfacing.

In this review, we were unable to apply a standard definition of pain severity at follow-up and the need to improve assessment and measurement of musculoskeletal pain in the clinical setting is recognised.[42] In the articles we included there were several interpretations of pain as an unfavourable outcome. These included lack of improvement in postoperative pain scores, pain at rest, persistent pain, night pain and lack of detectable clinical improvement.

Although having a standard outcome has advantages, our more encompassing approach allows us to include studies from wide time periods and different countries with different favoured methods for outcome assessment. However, the different outcome measures and small number of studies precluded exploration of sources of heterogeneity relating to patient characteristics, surgical method, peri-operative care and rehabilitation.

In the studies included in this review, the measures may not fully describe chronic postsurgical pain. Measures that focus on pain during specific activities may not reflect the intermittent and intense pain that has the greatest impact on quality of life.[43] Another issue in considering pain as an outcome after replacement is that no account is made for the effect of analgesics and assistive aids on the reporting of pain. Self-reported analgesic use is high with 40% of men and 58% of women taking pain medications after knee replacement[44] and 30% of patients taking analgesics daily after hip replacement because of pain in their replaced joint.[23] We used disease-specific instruments focusing on the operated joint rather than generic measures of pain. In the replacement population, there are likely to be high levels of morbidity due to osteoarthritis and other conditions common in old age.

Our data suggest that many hip and knee replacement patients are likely to be in pain at the time when recovery from surgery should be optimal. In a cohort of 194 patients following hip or knee replacement surgery, pain was seen to achieve its lowest level by 3 months after surgery.[14]

While acknowledging probable underestimates of the extent of pain after surgery reported in the literature, we should recognise the effectiveness of replacement for many. However, a significant proportion of people have painful joints despite surgery and strategies to improve outcomes merit research.

Many determinants of long-term outcome after hip and knee replacement are described and interventions evaluated. Better general health, physical, emotional and social function, motivation and self-efficacy and lower levels of pain before surgery and during the rehabilitation period are associated with improved short- and medium-term outcomes.[26 45–47] However, the evidence for benefit of presurgical and rehabilitation interventions is limited, particularly as few studies have been adequately powered or of sufficient duration.[48–52]

Another approach is the identification of patients before surgery who are at risk of a poor pain outcome. Kalkman and colleagues[53] developed a multivariable model to predict short-term pain after surgical procedures. Use of a predictive model based on presurgical or postsurgical factors might allow targeting of additional pain management and rehabilitation to patients likely to benefit.

In conclusion, persistent pain in a hip or knee joint that has been replaced is not uncommon. For patients to participate in decisions about their care, it is important that they are informed and aware of both the likely benefits of surgery and the possibility of a less favourable outcome. With this knowledge, they may contribute more fully to the replacement process including preparatory strategies and long-term rehabilitation. It is clear that the current move to a greater interest in patient-centred outcomes after replacement is necessary and that there is an urgent need to address the determinants of good and bad outcomes.

Contributors PD conceived the review. All authors contributed to the design of the review. ADB identified and acquired reports of studies. ADB and PD checked studies for eligibility. ADB and VW extracted and checked data. ADB analysed and interpreted the data. ADB drafted the manuscript. All authors contributed to the final version of the manuscript. All authors contributed to revision of the manuscript. All authors approved the final version of the manuscript.

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Patient consent We only used grouped patient data reported in published studies.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement Data extracted from articles included in the review are available from author ADB.

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Appendix 1. MOOSE Checklist

Reporting of background should include	
Problem definition	Introduction
Hypothesis statement	Introduction paragraph 4. "Reporting of pain outcomes in the orthopaedic literature frequently emphasises improvement in mean scores. To advise both patients and their healthcare professionals, it is important to have a clear understanding of the frequency and extent of pain following total hip or knee replacement. In the absence of appropriate clinical trials, the best way to explore this is the prospective study of unselected patients"
Description of study outcome(s)	Background paragraph 4 Methods/ Data sources and searches: disease specific patient reported outcome measures described Data synthesis and analysis
Type of exposure or intervention used	Background. Total hip or knee replacement
Type of study designs used	Methods/ Study selection. Prospective studies in consecutive/ unselected populations
Study population	Methods/ Study selection. Prospective studies in consecutive/ unselected populations
Reporting of search strategy should include	
Qualifications of searchers (eg, librarians and investigators)	Methods/ Study selection. Researchers experienced in systematic reviews and rheumatology
Search strategy, including time period included in the synthesis and keywords	Methods/ Data sources and searches, and Appendix 2
Effort to include all available studies, including contact with authors	Methods/ Data extraction and Quality assessment. We did not contact authors. Potentially, data is available not just from published studies with mean pain outcome scores. It is also available as routinely collected data. We included only published studies in representative populations with appropriate outcome data. Also considered in Discussion Methods/ Study selection.
Databases and registries searched	Methods/ Data sources and searches
Search software used, name and version, including special features used (eg, explosion)	Methods/ Data sources and searches.
Use of hand searching (eg, reference lists of obtained articles)	Methods/ Data sources and searches.
List of citations located and those excluded,	PRISMA style flow diagram shown in

including justification	Figure 1
Method of addressing articles published in languages other than English	Methods/ Data sources and searches. No exclusions on basis of language. No studies were identified that were not published in English
Method of handling abstracts and unpublished studies	Methods/ Data sources and searches. We did not include studies only published as abstracts
Description of any contact with authors	Methods/ Data extraction and Quality assessment/Discussion. We did not approach authors of studies with pain measured at follow up but not reported as proportions with degrees of pain. In recent reviews (Beswick et al. Lancet 2008, Beswick et al. Reviews in Clinical Gerontology 2010) we had additional data provided by under half of authors. Recent review by Mullan et al. 2009 suggests this is a common issue in reviews. This is considered in Discussion. Authors of studies with appropriate data but with specific missing information were contacted by email.
Reporting of methods should include	
Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	Results
Rationale for the selection and coding of data (eg, sound clinical principles or convenience)	Results/ Data synthesis and analysis
Documentation of how data were classified and coded (eg, multiple raters, blinding, and interrater reliability)	Results/ Study selection/ Data extraction/ and Quality assessment
Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	We identified only studies where populations were representative of the population receiving joint replacement
Assessment of study quality, including blinding of quality assessors; stratification or regression on possible predictors of study results	To assess whether -studies were representative of the joint replacement population we assessed quality of studies based on: blind outcome assessment, incompleteness of outcome data collection, and other sources of bias (representativeness of study population). These are describe in Methods/ Study quality, Appendix 3, and throughout the Results section
Assessment of heterogeneity	In Results/ Overview we have considered quality of studies as a source of heterogeneity. In Discussion paragraph 7

	we explain why the dataset is limited with regard to heterogeneity analyses.
Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	No analysis with combination was possible as described in Discussion paragraph 2.
Provision of appropriate tables and graphics	Results summarised in Figure 2 and Table 1. Also Study flow diagram in Figure1, Search strategy in Appendix 2, Quality assessments in Appendix 3 and Pain outcomes in Appendix 4.
Reporting of results should include	
Graphic summarizing individual study estimates and overall estimate	Figure 2 and Results section
Table giving descriptive information for each study included	Table 1
Results of sensitivity testing (eg, subgroup analysis)	Not possible due to range of outcome measures.
Indication of statistical uncertainty of findings	Discussed in detail in Results section and Discussion
Reporting of discussion should include	
Quantitative assessment of bias (eg, publication bias)	Risk of bias table showing quality/ representativeness of studies included as Appendix 3. Considered extensively in Results sections: we used number of study centres and losses to follow up as markers of representativeness.
Justification for exclusion (eg, exclusion of non–English-language citations)	No exclusions on the basis of language of publication.
Assessment of quality of included studies	As described in Methods/ Quality assessment we used relevant issues from te Cochrane risk of bias table. Specifically these were: blind outcome assessment, incompleteness of outcome data collection, and representativeness of the study cohort. These are then applied in detail in the Results section.
Reporting of conclusions should include	
Consideration of alternative explanations for observed results	In the Introduction paragraph 5 and Discussion paragraph 11 we consider the possibility that patients lost to follow up have different pain outcomes than those followed up.
Generalisation of the conclusions (ie, appropriate for the data presented and within the domain of the literature review)	We think that reporting the proportion of people with a poor pain outcome across the studies is the best approach. A measured speculation on outcomes of

	those lost to follow up seems appropriate in Results/ Overview.
Guidelines for future research	Discussion paragraph 12 and 13 discuss possible interventions based on determinants of good and bad outcomes.
Disclosure of funding source	Funding described

Appendix 2. MEDLINE search strategy

1. Arthroplasty, Replacement, Knee/ or Arthroplasty, Replacement, Hip/
2. exp Arthroplasty, Replacement, Hip/ or exp Hip Prosthesis/ or hip replacement.mp.
3. 1 or 2
4. exp Arthroplasty, Replacement, Knee/ or exp Knee Prosthesis/ or knee replacement.mp.
5. knee prosthesis.mp. or exp Knee Prosthesis/
6. 4 or 5
7. 6 or 3
8. hip prosthesis.mp. or exp Hip Prosthesis/
9. 8 or 7
10. total hip.tw.
11. total knee.tw.
12. 11 or 10 or 9
13. Orthopedic Procedures/ or orthopaedic surgery.mp.
14. 12 or 13
15. survey.mp. or exp Data Collection/
16. randomized controlled trial.mp. or exp Randomized Controlled Trials/
17. prospective study.mp. or exp Prospective Studies/
18. observational study.mp.
19. Comparative Study/
20. exp EPIDEMIOLOGY/ or epidemiology.mp.
21. longitudinal study.mp. or exp Longitudinal Studies/
22. case control study.mp. or exp Case-Control Studies/
23. evaluation study.mp. or exp Evaluation Studies/
24. follow up study.mp. or exp Follow-Up Studies/
25. 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24
26. 25 and 14
27. osteoarthriti$.mp. or Osteoarthritis, Hip/ or Osteoarthritis/ or Osteoarthritis, Knee/
28. 26 and 27
29. WOMAC.mp.
30. western ontario.mp.
31. american knee.mp.
32. aks.mp.
33. arthritis impact.mp.
34. oxford hip.mp.
35. oxford knee.mp.
36. hoos.mp.
37. koos.mp.
38. lequesne.mp.
39. self appraisal.mp.
40. vas.mp.
41. visual analogue.mp.
42. osteoarthritis outcome score.mp.
43. 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42
44. 28 and 43

Appendix 43. Unfavourable pain outcome reported in included studies

Hip replacement		
Nikolajson et al. 2006[23]	Authors' own scale of presence of hip pain and impact on daily life	Pain with moderate, severe or very severe impact on daily life
Jones et al. 2000[24]	WOMAC pain	Moderate/ severe pain defined as a gain of less than 10 points on the 100 point WOMAC pain dimension (representing a gain of at least 60% of the baseline standard deviation)
Quintana et al. 2006[30]	WOMAC pain	Patients reporting no improvement in pain greater than minimal clinical important difference 24.55/100
Nilsdotter et al. 2003[26]	WOMAC pain	Pain improved by less than 10/ 100 units reflecting no detectable clinical improvement
Singh & Lewallen 2010[27]	Single question: How much pain do you have in your operated hip? None, mild, moderate or severe.	Moderate or severe pain
Wylde et al. 2011[28]	WOMAC pain	Moderate or severe persistent pain for 3 months in replaced hip, WOMAC 0–75/100
Knee replacement		
Baker et al. 2007[31]	Oxford knee score pain dimension	Persistent knee pain
Jones et al. 2000[24]	WOMAC pain	Moderate/ severe pain defined as an improvement of less than 10 points on the WOMAC pain dimension
Quintana et al. 2006[30]	WOMAC pain	Patients reporting no improvement in pain greater than minimal clinical important diff[illegible] 22.6/100

		difference 22.6/100
Núñez et al. 2007[35]	WOMAC pain	No improvement in postoperative pain scores
Stephens 2002[34]	WOMAC	No change or increase in pain
Lundblad et al. 2008[37]	VAS pain	Pain at rest and movement
Nilsdotter et al. 2009[36]	KOOS pain compared with pre-operatively	Similar or more pain than pre-operatively
Vuorenmaa 2008[38]	VAS pain	Moderate or severe pain
Czurda et al. 2010[32]	WOMAC pain	Painful knees – moderate or worse response in any WOMAC pain dimension
Wylde et al. 2011[28]	WOMAC pain	Moderate or severe persistent pain for 3 months in replaced hip, WOMAC 0–75/100
Brander et al. 2003[33]	VAS pain	Significant pain, VAS score >40

Appendix ~~3~~4. Risk of bias (Quality of studies: representativeness)

Study	Cohort representativeness	Exclusions	Comparability of cohort Age (SD), % female, indication	Outcome assessment Follow up
Hip replacement				
Registry				
Nikolajson et al. 2006[23]	Consecutive patients identified in a national joint registry with 94% of hip replacements recorded. 93.6% response rate to postal questionnaire	Not degenerative hip arthritis Not age 18-90 years Not postero-lateral surgical approach No pre-operative registration of pain Previous or subsequent ipsilateral or contralateral hip operations	71.6 (8.7) % female not reported 100% degenerative hip arthritis, operation through a posterolateral surgical approach	Self-completed 5.9% lost to follow up
Multiple centres				
Jones et al. 2000[24]	Approximately 81% of consecutive patients listed for and who subsequently received joint replacement in health region.	On health region waiting list for less than 7 days Non-elective Hemiarthroplasties, revisions and emergency surgery Not resident in health region Age <40 years Non-English speaking Living in long-term care	68.2 (11.1) 60% 94% OA	Self-completed 5.8% lost to follow up or died
Quintana et al. 2006[30]	Consecutive patients scheduled to undergo total hip replacement in 7 teaching hospitals. 82.4% response	Not on waiting list for THR Severe comorbidities, such as cancer, terminal disease, or psychiatric conditions Main diagnosis not hip OA	69.1 48.3% 100% OA	Self-completed (postal) 25.5% lost to follow up
Single centre				
Nilsdotter et al. 2003[26]	Consecutive patients at single department of orthopaedics	Not primary unilateral THR Not primary OA	71 (range 50-92) 55% 100% OA	Self-completed 5.9% lost to follow up

Singh & Lewallen 2010[27]	Consecutive patients from single centre joint registry sent postal questionnaire or completed at outpatient clinic or telephone	Not alive at follow up Not primary THA	65.0 (13.3) 51% 87% OA	Self-completed (postal or in clinic) or administered on telephone by experienced registry staff 37.7% lost to follow up
Wylde et al. 2011[28]	Consecutive patients on an orthopaedic centre database	Not primary THR	Median 73 range 65-78) 63% Majority OA	Self-completed postal questionnaire 47.6% lost to follow up
Knee replacement				
Registry				
Baker et al. 2007[31]	Random sample of patients in national joint registry	Not primary unilateral TKR No contact details recorded Known to have died	70.7 (range 25-98) 57% (estimate) 96% OA	Self-completed postal questionnaire 14.9% lost to follow up
Multiple centres				
Jones et al. 2000[24]	Approximately 81% of consecutive patients listed for and who subsequently received joint replacement in health region.	On health region waiting list for less than 7 days Non-elective Hemiarthroplasties, revisions and emergency surgery Not resident in health region Age <40 years Non-English speaking Living in long-term care	69.2 (9.2) 59% 94% OA	Self-completed 5.8% lost to follow up or died
Quintana et al. 2006[30]	Consecutive patients scheduled to undergo total knee replacement in 7 teaching hospitals. 83.4% response	Not on waiting list for TKR Severe comorbidities, such as cancer, terminal disease, or psychiatric conditions Main diagnosis not knee OA	71.9 73% 100% OA	Self-completed (postal) 24.1% lost to follow up
Single centre				

Núñez et al. 2007[35]	Consecutive patients at a single tertiary care centre	Not OA grade IV Kellgren and Lawrence criteria grade 4 Did not agree to participate and give informed consent (2 out of 90) Functional illiteracy or severe psychopathology	74.8 (5.6) 81% 100% OA	Self-completed at clinic 5.0% lost to follow up
Stephens 2002[34]	Patients referred for and receiving TKR	Age <50 years Significant cognitive impairment (Telephone Interview for Cognitive Status)	67.4 (8.1) followed up 54% followed up 100% OA	Self-completed (postal) 7.4% lost to follow up
Lundblad et al. 2008[37]	Patients scheduled for TKR at a single hospital	No consent Not Caucasian Not scheduled for TKR for OA	68 (range 40-80) 50.7% 100% OA	Self-completed postal 10.1% lost to follow up
Nilsdotter et al. 2009[36]	Patients on waiting list for knee replacement at a single hospital department of orthopaedics	Not primary TKR Not knee OA	71 (8) 61.8% 100% OA	Self-completed postal 12.7% lost to follow up
Vuorenmaa 2008[38]	Patients referred for and receiving TKR at a single hospital	Age >80 years Knee OA rating not 3–4 by Ahlbäck classification Inflammatory joint disease Early TKR Medical diagnosis of serious disease	70 (5) 86% 100% OA	Self completed VAS pain score at clinic 11.8% lost to follow up
Czurda et al. 2010[32]	Consecutive patients at single centre	Not primary TKR Not degenerative OA Rheumatoid arthritis, post-operative infection and/or if the pain they suffered from at the time of follow-up appeared after falling or another traumatic experience Not performed by experienced surgeon <18 months follow up	75-76 (range 45-96) 76% 100% OA	Telephone interview with patient-reported outcome measure 13.4% lost to follow up
Wylde et al. 2011[28]	Consecutive patients on an orthopaedic centre	Not primary TKR	Median 73 (range 28-96)	Self-completed postal questionnaire

	database		59% Majority OA	45.3% lost to follow up
Single surgeon				
Brander et al. 2003[33]	Consecutive patients treated by single surgeon at single centre	Not degenerative arthritis Not intact cognitive abilities Younger than 18 years Depression or treatment with antidepressant or anxiolytic Concurrent musculoskeletal diagnosis (fibromyalgia, spinal stenosis, significant ipsilateral hip OA) No signed consent form.	66 (10.5) 55.2% 94% OA	Self-completed questionnaire 0% lost to follow up

THR total hip replacement, TKR total knee replacement, OA osteoarthritis, WOMAC Western Ontario and McMaster Universities Arthritis Index, VAS visual analogue scale, KOOS Knee Osteoarthritis Outcome Score