Cochrane Library

Cochrane Database of Systematic Reviews

Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis (Review)

Verra WC, van den Boom LGH, Jacobs W, Clement DJ, Wymenga AAB, Nelissen RGHH

Verra WC, van den Boom LGH, Jacobs W, Clement DJ, Wymenga AAB, Nelissen RGHH.
Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis.
Cochrane Database of Systematic Reviews 2013, Issue 10. Art. No.: CD004803.
DOI: 10.1002/14651858.CD004803.pub3.

www.cochranelibrary.com

WILEY

TABLE OF CONTENTS

[Intervention Review]

Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Wiebe C Verra[1], Lennard GH van den Boom[2], Wilco Jacobs[3], Darren J Clement[4], Ate AB Wymenga[5], Rob GHH Nelissen[1]

[1]Department of Orthopedics, Leiden University Medical Center, Leiden, Netherlands. [2]Department of Orthopedics, University Medical Center Groningen, Groningen, Netherlands. [3]Department of Neurosurgery, Leiden University Medical Center, Leiden, Netherlands. [4]Medical Research Unit, School of Medicine, University Hospital of North Straffordshire, Hartshill, UK. [5]Department of Orthopedics, Sint Maartenskliniek, Nijmegen, Netherlands

Contact address: Wiebe C Verra, Department of Orthopedics, Leiden University Medical Center, Albinusdreef 2, Leiden, Zuid Holland, 2333 ZA, Netherlands. w.c.verra@lumc.nl.

Editorial group: Cochrane Musculoskeletal Group.
Publication status and date: New search for studies and content updated (no change to conclusions), published in Issue 10, 2013.

Citation: Verra WC, van den Boom LGH, Jacobs W, Clement DJ, Wymenga AAB, Nelissen RGHH. Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis. *Cochrane Database of Systematic Reviews* 2013, Issue 10. Art. No.: CD004803. DOI: 10.1002/14651858.CD004803.pub3.

ABSTRACT

Background

The functional and clinical basis on which to choose whether or not to retain the posterior cruciate ligament during total knee arthroplasty surgery remained unclear after a Cochrane systematic review and meta-analysis in 2005, which contained eight clinical trials. Several new trials have been conducted since then. Hence, an update of the review was performed.

Objectives

Our aim was to assess the benefits and harms of retention compared to sacrifice of the posterior cruciate ligament in total knee arthroplasty in patients with osteoarthritis of the knee.

Search methods

An extensive search was conducted in CENTRAL, MEDLINE (PubMed), EMBASE, Web of Science, CINAHL, Academic Search Premier, Current Contents Connect and Science Direct. All databases were searched, without any limitations, up to 6 December 2012. References of the articles were checked and citation tracking was performed.

Selection criteria

Randomised and quasi-randomised controlled trials comparing retention with sacrifice of the posterior cruciate ligament in primary total knee arthroplasty in patients with osteoarthritis of the knee.

Data collection and analysis

Data were collected with a pre-developed form. Risk of bias was assessed independently by two authors (WV, LB). The level of evidence was graded using the GRADE approach. Meta-analysis was performed by pooling the results of the selected studies, when possible. Subgroup analyses were performed for posterior cruciate ligament retention versus sacrifice using the same total knee arthroplasty design, and for studies using a posterior cruciate ligament retaining or posterior stabilised design, and when sufficient studies were available subgroup analyses were performed for the same brand.

Main results

Seventeen randomised controlled trials (with 1810 patients and 2206 knees) were found, described in 18 articles. Ten of these were new studies compared to the previous Cochrane Review. One study from the original Cochrane review was excluded. Most new studies compared a posterior cruciate ligament retaining design with a posterior stabilised design, in which the posterior cruciate ligament is sacrificed (a posterior stabilised design has an insert with a central post which can engage on a femoral cam during flexion).

The quality of evidence (graded with the GRADE approach) and the risk of bias were highly variable, ranging from moderate to low quality evidence and with unclear or low risk of bias for most domains, respectively.

The performance outcome 'range of motion' was 2.4 ° higher in favour of posterior cruciate ligament sacrifice (118.3 ° versus 115.9 °; 95% confidence interval (CI) of the difference 0.13 to 4.67; P = 0.04), however the results were heterogeneous. On the item 'knee pain' as experienced by patients, meta-analysis could be performed on the Knee Society knee pain score; this score was 48.3 in both groups, yielding no difference between the groups. Implant survival rate could not be meta-analysed adequately since randomised controlled trials lack the longer term follow-up in order to evaluate implant survival. A total of four revisions in the cruciate-retention and four revisions in the cruciate-sacrifice group were found. The well-validated Western Ontario and McMaster Universities osteoarthritis index (WOMAC) total score was not statistically significantly different between the groups (16.6 points for cruciate-retention versus 15.0 points for cruciate-sacrifice). One study reported a patient satisfaction grade (7.7 points for cruciate-retention versus 7.9 points for cruciate-sacrifice on a scale from 0 to 10, 10 being completely satisfied) which did not differ statistically significantly. Complications were distributed equally between both groups. Only one study reported several re-operations other than revision surgery; that is patella luxations, surgical manipulation because of impaired flexion.

The mean functional Knee Society Score was 2.3 points higher (81.2 versus 79.0 points; 95% CI of the difference 0.37 to 4.26; P = 0.02) in the posterior cruciate ligament sacrificing group. Results from the outcome Knee Society functional score were homogeneous. All other outcome measures (extension angle, knee pain, adverse effects, clinical questionnaire scores, Knee Society clinical scores, radiological rollback, radiolucencies, femorotibial angle and tibial slope) showed no statistically significant differences between the groups. In the subgroup analyses that allowed pooling of the results of the different studies, no homogeneous statistically significant differences were identified.

Authors' conclusions

The methodological quality and the quality of reporting of the studies were highly variable. With respect to range of motion, pain, clinical, and radiological outcomes, no clinically relevant differences were found between total knee arthroplasty with retention or sacrifice of the posterior cruciate ligament. Two statistically significant differences were found; range of motion was 2.4 ° higher in the posterior cruciate ligament sacrificing group, however results were heterogeneous; and the mean functional Knee Society Score was 2.3 points higher in the posterior cruciate ligament sacrificing group. These differences are clinically not relevant.

PLAIN LANGUAGE SUMMARY

Retention versus sacrifice of the posterior cruciate ligament in total knee replacement for the treatment of osteoarthritis

Researchers in The Cochrane Collaboration have conducted a review of two types of knee replacement surgery for people with knee osteoarthritis. In one type, the posterior cruciate ligament is kept and in the other, it is removed. After searching for all relevant studies, they found 17 studies with up to 1810 patients.

The review shows that in people with osteoarthritis who have the posterior cruciate ligament preserved during total knee replacement surgery:

- this may not improve their range of motion, pain, function and patient satisfaction compared with removing the ligament.

We do not have precise information about side effects and complications, especially rare but serious side effects. Possible side effects may include infection, pain, and the need to have further surgery.

What is osteoarthritis and what is the posterior cruciate ligament?

Osteoarthritis (OA) is a disease of the joints, such as your knee or hip. When the joint loses cartilage, the bone may grow abnormally to try and repair the damage and make things worse. For example, it can make the joint painful and unstable. This can affect your physical function or ability to use your knee.

In some people, damage and pain in the knee from arthritis may be severe enough to require surgery. In total knee replacement surgery, a surgeon removes the damaged joint surface and replaces it with a metal and plastic implant.

The posterior cruciate ligament provides support and stable movement of the knee. In total knee replacement surgery, the posterior cruciate ligament can be kept in place or removed. This choice depends on the condition of the ligament, the type of total knee replacement selected or preference of the surgeon. When the ligament is removed, a special peg is used to provide stability and give your knee forward and backward movement with the tibia stabilised in relation to the femur.

What happens to people who have the posterior cruciate ligament preserved or removed during total knee replacement surgery

Range of motion (range of motion is the distance your knee can move from being bent to being fully extended. A lower range of motion is worse; you can't bend or stretch your knee fully)

- People who had their posterior cruciate ligament preserved had 2 ° less range of motion compared to those who had it removed. This may be a result of chance

- People who had their posterior cruciate ligament removed had a range of motion of 118 ° of a possible 0 ° to 140 °

- People who had their posterior cruciate ligament preserved had a range of motion of 116 ° of a possible 0 ° to 140 °

Knee pain (lower score means worse pain)

- People who had their posterior cruciate ligament preserved rated their pain to be the same as those who had it removed. This may be a result of chance

- People who had their posterior cruciate ligament preserved or removed rated their pain to be 48 on a scale of 0 to 50

Health related quality of life and functional measures (higher means worse)

- People who had their posterior cruciate ligament preserved rated their quality of life to be 1 point worse than those who had it removed. This may be a result of chance

- People who had their posterior cruciate ligament preserved rated their quality of life to be 16 on a scale of 0 to 100

- People who had their posterior cruciate ligament removed rated their quality of life to be 15 on a scale of 0 to 100

Patient satisfaction (lower means worse)

- People who had their posterior cruciate ligament preserved rated their satisfaction the same as those who had it removed. This may be a result of chance

- People who had their posterior cruciate ligament preserved or removed rated their satisfaction to be 8 on a scale of 0 to 10

Complications and the need to have further surgery

- There were no differences in the number of revision surgeries, complications, or other further surgeries in people who had their posterior cruciate ligament preserved or removed.

SUMMARY OF FINDINGS FOR THE MAIN COMPARISON [Explanation]

Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

Patient or population: Patients receiving total knee arthroplasty with or without posterior stabilised design for the treatment of osteoarthritis
Settings: Hospital
Intervention: Posterior cruciate ligament retention
Comparison: Posterior cruciate ligament sacrifice

Outcomes	Comparative risks		Relative effect	No. of patients (% of total)	No. of studies (% of total)	Quality of the evidence (GRADE)	Comments
	Cruciate-sacrifice	Cruciate-retention					
Performance based measures - Range of motion (possible range 0 (worst) to 140 (maximal) degrees) Follow-up: 12-78 months[1]	The mean range of motion in the cruciate-sacrifice group was **118.3** degrees (± SE 0.53)	The mean range of motion in the cruciate-retaining group **2.40 lower** (4.61 lower to 0.13 higher)		Total No. of patients: 1,119 (62%) Total No. of knees: 1,440 (65%)	11 studies (65%)	⊕⊕◯◯ **low**[2,3,4,5]	Absolute difference 2.40 lower (4.61 lower to 0.13 higher) Relative percent change: -2.0% (3.9% lower to 0.1% higher) Not statistically significant.
Knee pain Knee Society Score, sub score pain (possible range of points 0 (severe pain) - 50 (no pain)) Follow-up: 24-87 months years	The mean knee pain score in the cruciate-sacrifice group was **48.3** points (± SE 0.54)	The mean knee pain score in the cruciate-retention group was **0.01 higher** (1.40 lower to 1.43 higher)		Total No. of patients: 656 (36%) Total No. of knees: 1,004 (46%)	4 studies (24%)	⊕⊕⊕◯ **moderate**[2,5,6]	Absolute difference: 0.01 higher (1.40 lower to 1.43 higher) Relative percent change: 0.0% (2.9% lower to 3.0% higher) Not statistically significant.

Survival rate of the implant (Revision surgery reported) Follow-up: 17-87 months	See comment	See comment	Not estimable	Total No. of patients: 926 (51%) Total No. of knees: 1, 229 (56%)	7 studies (41%)	See comment	Insufficient data provided. Incidental remarks on implant survival could be derived from 7 studies One study Misra 2003 reported 2 revisions in de cruciate-retention group, Chaudhary 2008 1 in the cruciate-retention group, Harato 2008 1 in the cruciate-retention group and 3 in the sacrifice group. Aglietti 2005 1 revision in the cruciate-sacrifice group due to septic loosening Kim 2009, Yagishita 2012 and Tanzer 2002 specifically reported no revision surgery had occurred during follow-up
Health related quality of life measures and functional measures with validated instruments (WOMAC, range 0-100, higher scores indicate worse pain, stiffness and functional limitations)	The mean WOMAC total score in the cruciate-sacrifice group was **15.0** points (± SE 1.2)	The mean WOMAC total score in the cruciate-retention group was **0.78 higher** (1.51 lower to 3.07 higher)		Total No. of patients: 501 (28%) Total No. of knees: 531 (24%)	4 studies (24%)	⊕⊕◯◯ **low**[2,3,4,5]	Absolute difference: 0.78 higher (1.51 lower to 3.07 higher) Relative percent change: 5.2% (10.0% lower to 20.5% higher) Not statistically sig-

Follow-up: 24-87 months							nificant.
Global assessment (patient) Patient satisfaction on scale 0 (not at all satisfied) to 10 (completely satisfied) Follow-up: 12-83 months	The mean satisfaction score in the cruciate-sacrifice group was **7.9** [10]	The mean satisfaction score in the cruciate-retention group was **0.2 lower** [10]		Total No. of patients: 103 (6%) Total No. of knees: 105 (5%)	1 study (6%)	⊕⊕◯◯ **low**[2,5]	Absolute difference: 0.2 lower [10] Relative percent change: -2.5% [10] Not statistically significant.
Complications Follow-up: 8-87 months[7]	See comment	See comment	Not estimable	Total No. of patients: 1,252 (69%) Total No. of knees: 1, 635 (74%)	11 studies (65%)	See comment	Due to the very diverse way of reporting and defining complications combining data for quantitative analysis was not possible[8,9]
Re-operation rate (not involving implant change, short and long term) Follow-up: 24 months	See comment	See comment	Not estimable	Total No. of patients: 40 (2%)	1 study (6%)	See comment	Catani 2004 reported 4 re-operations; 3 patella luxations (2 in cruciate-sacrificing, 1 in cruciate-retention group) and 1 surgical manipulation due to lack of range of motion (in the cruciate-retention group)

CI: Confidence interval; KSS: Knee Society Score, WOMAC: Western Ontario and McMasters Universities Osteoarthritis Index. NA: not applicable

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1] Median follow-up: 2 years
[2] Risk of bias individual studies, see risk of bias tables
[3] Some studies have high risk of bias. Relatively too many unclear risks
[4] Results of Catani 2004 inconsistent with the rest
[5] More than 400 arthroplasties
[6] Relatively too many unclear risks of bias
[7] Some studies reported complications after several months. Mean follow-up of other endpoints was > 1 year
[8] Complications reported in the cruciate-sacrifice group: 4 anterior knee pain, 4 limited range of motion, 1 deep venous thrombosis, 3 instability, 3 femoral notching, 3 aseptic loosening, 3 (deep) infection
[9] Complications reported in the cruciate-retention group: 6 anterior knee pain, 10 limited range of motion, 0 deep venous thrombosis, 3 instability, 2 femoral notching, 2 aseptic loosening, 3 (deep) infection, 2 ligament laxity, 1 ligament tightness
[10] Not sufficient data reported to calculate standard error, range or confidence interval

BACKGROUND

Description of the condition

Osteoarthritis is a degenerative joint disease leading to degradation of articular cartilage and subchondral bone. Clinically, patients with knee osteoarthritis present in general with disabling knee pain and impaired knee function. At some point during the disease the only remaining treatment is surgery with a total knee arthroplasty.

Description of the intervention

A total knee arthroplasty is the resurfacing of the joint articulating surfaces. During total knee arthroplasty surgery several structures involved in the knee joint are either retained (for example the posterior cruciate ligament), replaced by artificial structures (for example patella resurfacing), or discarded (for example the anterior cruciate ligament and possibly the posterior cruciate ligament). The distal femur and proximal tibia are cut and replaced by a femoral and a tibial component. Between these components a polyethylene insert is placed. See Figure total knee arthroplasty components (Figure 1).

Figure 1. Bicondylar ligament cruciate retaining balancing total knee arthroplasty with rotating platform (balanSys®, Mathys Ltd., Bettlach, Switzerland) Hirschmann et al. BMC Musculoskeletal Disorders 2010 11:167 doi:10.1186/1471-2474-11-167

Download authors' original image

For total knee arthroplasty it is desirable to reproduce the natural movements of the knee while maintaining stability from extension to flexion. In patients in whom the posterior cruciate ligament can be retained, this ligament can provide these requirements (Lombardi 2001; Mihalko 1999). Moreover, the posterior cruciate ligament is supposed to have different types of mechanoreceptors detecting joint position (proprioception) and joint motion (kinaesthesia) (Hogervorst 1998; Nelissen 2001; Swanik 2004). However, the structural integrity of the posterior cruciate ligament of an osteoarthritic knee may be lost due to mucoid degeneration (Nelissen 2001). When the posterior cruciate ligament is retained in total knee arthroplasty, some studies have shown a lack of posterior femoro-tibial translation (for example the naturally occurring movement of the distal femur on the tibia, also known as rollback) with knee flexion (Dennis 1998; Mahoney 1994). This is thought to be attributable to inadequate balancing of the posterior cruciate ligament in flexion during surgery (Emodi 1999; Most 2003; Nozaki 2002). Balancing of the posterior cruciate ligament consists of choosing the insert thickness and component sizes in a way that the posterior cruciate ligament is adequately tensioned in flexion but relaxed in extension. When posterior cruciate ligament balancing has not been performed adequately, the patient might have a suboptimal total knee arthroplasty, which often produces pain (Pagnano 1998). If the posterior cruciate ligament is too loose, the patient might present with instability (Pagnano 1998; Waslewski 1998). If the posterior cruciate ligament is too tight, the patient suffers from limited flexion and the polyethylene insert is subjected to high stresses and wear (Migaud 2003; Pagnano 1998). A release of the posterior cruciate ligament can be used in cases with a tight ligament and difficulty to perform knee flexion during the procedure.

In many instances, however, the posterior cruciate ligament is sacrificed in the surgical procedure and another arthroplasty design is used. Sacrifice of the posterior cruciate ligament results in an increase in the flexion gap (the flexion gap is the gap between the cut posterior parts of the distal femur and the cut proximal tibia when the knee is flexed) (Baldini 2004; Mihalko 1999). This increase is generally compensated for with thicker polyethylene inserts or larger femoral components. Sacrificing the posterior cruciate ligament leads to an increase in the extension gap as well (the extension gap is the gap between the cut distal femur and the cut proximal tibia when the knee is in extension) (Baldini 2004). The size of these gaps has to be in such a way that the ligaments in and around the knee joint are balanced in order to achieve stability after placement of the arthroplasty. Several adjustments in total knee arthroplasty design exist to compensate for the absence of the posterior cruciate ligament. The posterior stabilised design is most commonly used. This design has a cam post mechanism to substitute for the function of the posterior cruciate ligament and permits rollback of the femoral component on the tibial component during flexion. Other knee systems use deep dish inserts with a high anterior rim as a brake against posterior subluxation of the tibia.

Factors influencing the choice of sacrifice or retention of the posterior cruciate ligament are the degenerative status of the ligament, knee deformities, the type of implant used, or the personal preference of the surgeon. Lombardi 2001 proposed a decision tree based upon the patient's history, the clinical examination, and the intraoperative findings (Lombardi 2001).

Why it is important to do this review

Randomised studies comparing posterior cruciate ligament retention with sacrifice have been conducted from the early 90s up to now (Seon 2011; Shoji 1994). In 2005, when the original Cochrane systematic review on this topic was published, these studies combined in a meta-analysis could not find a clear difference between the two treatments. It was impossible to give clear advice on whether to retain or to sacrifice the posterior cruciate ligament (Jacobs 2005). In this extensive update the question remains whether the study results allow for pooling and whether the pooled results favour retention or sacrifice of the posterior cruciate ligament.

OBJECTIVES

To assess the range of motion, pain, clinical and radiological outcomes in patients with retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for the treatment of osteoarthritis.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised and quasi-randomised controlled trials were included. Quasi-randomised studies use alternating sequences for randomisation (that is odd or even chart numbers, date of hospital admission, etc.) Non-randomised clinical trials and historically controlled studies were excluded.

Types of participants

Studies were included when dealing with patients with osteoarthritis. Studies which included a wider range of indications were excluded if the proportion of patients with osteoarthritis was lower

than 95% of the total group or when the subgroups were poorly described with separate results.

Types of interventions

Studies were included if total knee arthroplasty with retention of the posterior cruciate ligament was compared to sacrifice of the posterior cruciate ligament. Procedures with sacrifice of the posterior cruciate ligament were considered when the same arthroplasty design or when a posterior cruciate ligament substituting design was used.

Types of outcome measures

Major outcomes

- Performance outcome: range of motion (flexion, extension)
- Knee pain (i.e. as measured by a Visual Analogue Scale (VAS), Knee Society Score pain subscale, etc.)
- Implant survival rate (revision surgery)
- Validated clinical and functional questionnaire scores (i.e. Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC))
- Patient satisfaction
- Complications
- Re-operations other than revision surgery (e.g. manipulation because of impaired knee function)

Minor outcomes

- Specific evaluation of daily tasks (i.e. walking or stair climbing ability, rising from a chair)
- Less validated clinical and functional questionnaire scores (i.e. Knee Society score)
- Radiological outcomes (i.e. Radio Stereotactic Analysis (RSA)
- Gait analysis parameters

Search methods for identification of studies

Electronic searches

We conducted a sensitive search in order to retrieve all available literature. In consultation with an experienced librarian of the medical scientific library of the Leiden University Medical Center, we searched the following databases: the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE (PubMed), EMBASE, Web of Science, CINAHL, Academic Search Premier, Current Contents Connect and Science Direct. All databases were searched up to 6 December 2012 using an adopted syntax for every single database. The search syntax for the different databases is presented in Appendix 1. No restrictions or limits were formulated.

Searching other resources

A final check that no relevant articles were missed was carried out by screening the references from the articles and by performing citation tracking on the articles that were selected. To identify ongoing trials comparing retention with sacrifice of the posterior cruciate ligament we checked the online trial registries via the portal of the World Health Organization (www.who.int/trialsearch).

Data collection and analysis

Selection of studies

Articles were selected in two steps. Studies were excluded when it was apparent from the title or the abstract that the study did not meet all of the following criteria.

- The intervention evaluated in the trials had to be primary total knee arthroplasty (excluding post-patellectomy and post-osteotomy studies), comparing one treatment in which the posterior cruciate ligament was retained against one in which it was sacrificed. Procedures with sacrifice of the posterior cruciate ligament were considered when the same prosthesis design was used as for the retention group, or when a posterior cruciate ligament substituting design was used (e.g. posterior stabilised or a deep dish insert).
- The indication for total knee arthroplasty had to be osteoarthritis. Studies which included a wider range of indications were excluded if the proportion of patients with osteoarthritis was lower than 95% of the group.
- Minimal follow-up had to be 12 months.
- Studies had to be randomised or quasi-randomised controlled trials.

In the first step only the titles and abstracts were screened. In the second step, articles which passed the first step were retrieved in full and evaluated against the inclusion and exclusion criteria.

Data extraction and management

One review author (WV) conducted the literature search and retrieved the references to be evaluated. Two review authors (WV, LB) independently selected the trials to be included in the review. Disagreements were resolved by consensus. When no consensus could be reached, a third review author (WJ) was available for the decisive vote. A pre-developed and tested data extraction form was used to extract data from the selected studies. Items collected

were: study design features, population data, statistical analysis techniques, intervention characteristics, and all reported outcome parameters including results. All data was entered into Review Manager 5.1 (Review Manager 2011). When a selected article was written in a foreign language, the data extraction form was sent to a translator via the Cochrane Musculoskeletal group. A second form was used to assess the risk of bias (see below) and the clinical relevance of the selected studies.

Assessment of risk of bias in included studies

Selected studies were closely examined by two review authors working independently (WV, LB). Risk of bias was assessed according to the recommendations of The Cochrane Collaboration in risk of bias tables (Higgins 2011). To detect selection bias, performance bias and attrition bias, several items were evaluated in all selected studies. The risk of selection bias was judged by assessing how the randomisation sequence was generated and by assessing the way the allocation of treatment was concealed. Risk of performance and detection bias was judged by evaluating the blinding (of personnel, patients and outcome assessors) in the studies. The risk of attrition bias was assessed by judging the completeness of the data, including the follow-up rates. Finally, the risk of reporting bias was assessed by judging if all (relevant) outcome measurements were reported. The possible judgments that could be made were low risk of bias, high risk of bias and unclear risk of bias.

Measures of treatment effect

Continuous data were entered as means and standard deviations, dichotomous outcomes as number of events. In the absence of significant heterogeneity, and given sufficient included trials, results were combined using mean differences for continuous data and risk ratios for dichotomous data.

Unit of analysis issues

Special issues in the analysis of studies with non-standard (randomised controlled trial) designs (for example cluster-randomised trials) were identified. A specific issue for studies on knee replacement surgery is the possibility to perform surgery bilaterally: allocating one knee to posterior cruciate ligament retention automatically allocates ligament sacrifice to the other contralateral knee.

Dealing with missing data

Standard deviations were used when available. When not provided, standard deviations were imputed from comparable studies or from the original scores (for example confidence intervals) when calculating change scores (Higgins 2011).

Assessment of heterogeneity

Heterogeneity was first assessed by visual inspection of the forest plots. Furthermore, it was investigated with the I^2 statistic and if significant ($P < 0.10$ using the Chi^2 statistic) the source of heterogeneity was investigated by doing a sensitivity analysis and considering clinical reasons for potential clinical heterogeneity. I^2 values of 30% to 50% were considered to represent moderate heterogeneity; from 50% to 80% were considered to represent substantial heterogeneity and above 80% considerable heterogeneity (Higgins 2011).

Assessment of reporting biases

In order to evaluate the risk of publication bias we checked the online trial registries via the portal of the World Health Organization (www.who.int/trialsearch). When studies were tagged as 'stopped' (for example not ongoing) and were not published in an article, the investigator of the study was contacted and the reason why the study was not published was identified, when possible.

Data synthesis

Statistical analyses were conducted using RevMan 5.1. The outcomes specified in the protocol were included in the analysis. A random-effects model was used for all analyses in this review (Fleiss 1993).

Subgroup analysis and investigation of heterogeneity

Besides the general comparison of total knee arthroplasties with and without sacrifice of the posterior cruciate ligament, several subgroup analyses were performed. First, as in the original Cochrane review, studies evaluating the effect of posterior cruciate ligament retention and sacrifice using the same design total knee arthroplasty (the posterior cruciate ligament retaining design) were considered in a subgroup analysis. Secondly, the studies evaluating the effect of posterior cruciate ligament retention and sacrifice comparing a posterior cruciate ligament retaining arthroplasty design with a posterior stabilised posterior ligament sacrificing design were considered in a subgroup analysis. When other design modifications than posterior stabilisation were studied, these were considered in separate subgroup analyses.

Sensitivity analysis

When it was unclear if findings in the meta-analysis were robust to the decisions made in the process of obtaining them, this was tested in a sensitivity analysis. For example, when data for a specific outcome measure were not adequately reported the analysis was performed with and without inputed outcome values. Findings were considered 'robust' when they did not change significantly. Moreover, outcomes of the meta-analyses were compared with the pooled outcomes from the studies with the lowest risk of bias.

Quality of evidence and summary of findings tables

For the outcome measures range of motion, flexion angle and knee pain, the primary outcome measures, beneficial effects were evaluated. To evaluate harmful effect differences between the two treatment groups we evaluated the occurrence of complications. Results were presented in 'summary of findings' tables. As prescribed by The Cochrane Collaboration, a quality of evidence assessment was performed using the GRADE approach (with GRADEpro software (version 3.6)).

The different grades of evidence according to the GRADE working group are as follows.

- High quality: further research is very unlikely to change confidence in the estimate of effect.
- Moderate quality: further research is likely to have an important impact on confidence in the estimate of the effect, and may change the effect.
- Low quality: further research is very likely to have an important impact on confidence in the estimate of the effect, and is likely to change the effect.
- Very low quality: the effect estimate is very uncertain.

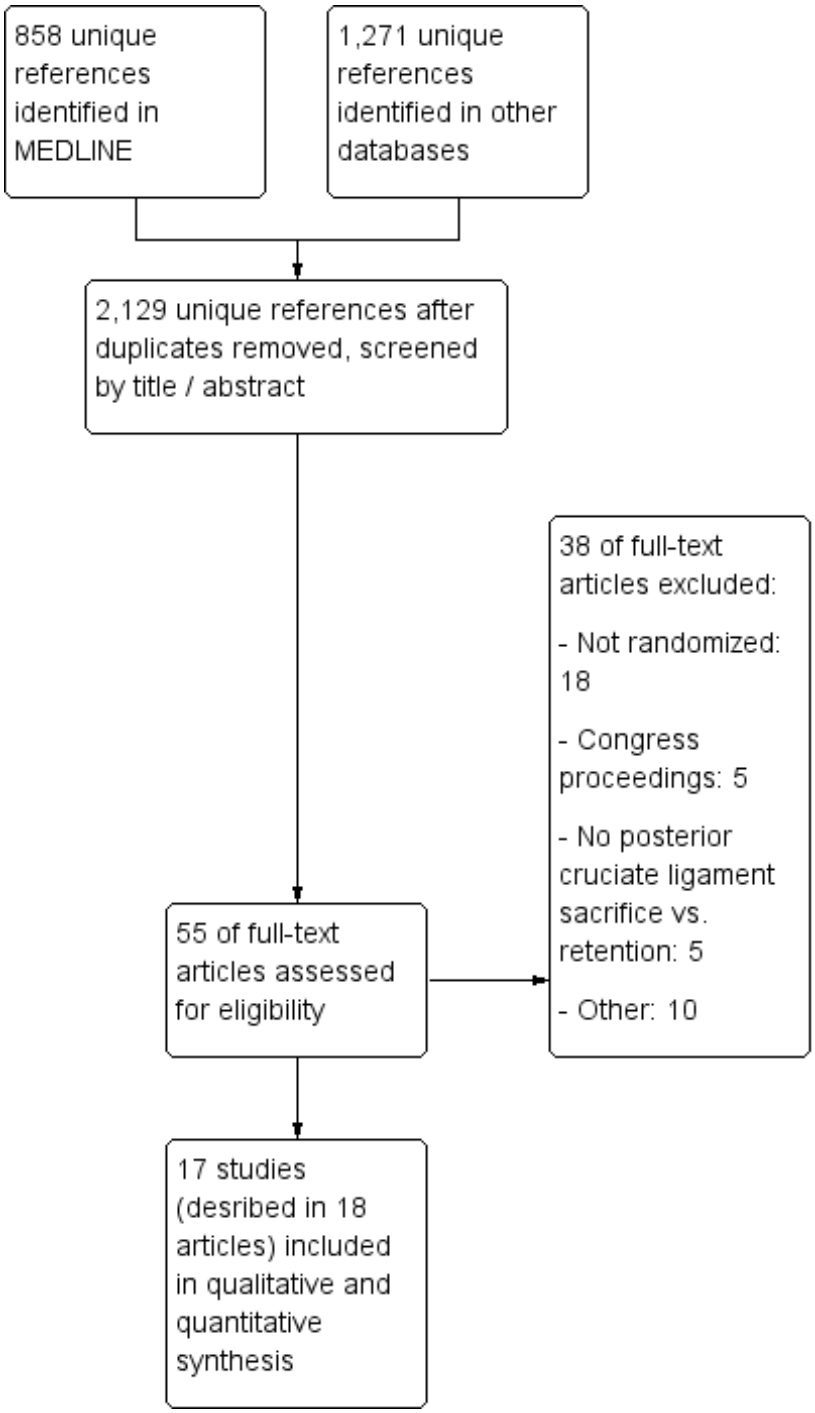
RESULTS

Description of studies

Results of the search

For this update, a total of 2129 unique references were identified (Figure 2, PRISMA flowchart). The search in MEDLINE (PubMed) resulted in 858 references. Furthermore, EMBASE yielded 543 unique references, Web of Science 299, Current Contents Connect 19, CENTRAL 72, CINAHL 215, Academic Search Premier 26 and Science Direct 97 unique references. After the first step of selection, 55 articles were selected for the second step. After applying the inclusion and exclusion criteria to the full text 18 papers remained. Citation tracking did not result in any extra references.

Figure 2. Study flow diagram (PRISMA).



The article of Victor 2005 described a population that was also part of the study population of Harato 2008. The data from both articles were used only once.

Included studies

Ultimately 17 studies (with 1810 patients and 2206 knees), described in 18 articles, were considered for analysis (Aglietti 2005; Catani 2004; Chaudhary 2008; Clark 2001; de Andrade 2009; Harato 2008; Kim 2009; Maruyama 2004; Matsumoto 2012; Misra 2003; Roh 2012; Seon 2011; Shoji 1994; Straw 2003; Tanzer 2002; Victor 2005; Wang 2004; Yagishita 2012). Ten studies were new compared to the original Cochrane review. The article of de Andrade et al (de Andrade 2009) was written in Portuguese and data were extracted by a translator from the Cochrane Musculoskeletal Group.

Interventions

In 12 studies the comparison between the two treatment arms was posterior cruciate retention with a cruciate retaining design versus sacrifice using a posterior stabilised design (Aglietti 2005: LPS/MBK; Catani 2004: Optetrak; Chaudhary 2008: SCORPIO; Clark 2001: AMK; de Andrade 2009: NexGen; Harato 2008: Genesis II; Kim 2009: NexGen; Maruyama 2004: PFC; Matsumoto 2012: NexGen; Seon 2011: NexGen; Tanzer 2002: NexGen; Yagishita 2012: NexGen). In three studies the same (cruciate-retaining) arthroplasty design was used for both groups (Misra 2003: PFC; Roh 2012: E-motion; Shoji 1994: Total Condylar Modifier). One study used all three treatments (that is cruciate-retaining design with ligament retention and with ligament sacrifice and a posterior stabilised design (Straw 2003: Genesis I). Finally, one study did not clearly report the design of the arthroplasty (Wang 2004).

Duration of follow-up in the included studies

Aglietti 2005 had a mean follow-up of 36 months (range 30 to 48 months). Catani 2004 had a 24 months follow-up; no range was reported. Chaudhary 2008 had a mean follow-up of 22.7 months (± 5.2 months). Follow-up in the study from Clark 2001 ranged from 12 to 36 months; no mean follow-up was reported. de Andrade 2009 had a mean follow-up of 15.8 months (± 3.8 months). Harato 2008 had a mean follow-up of 64.8 months (range 60 to 87.6 months) for the cruciate-retention group and a mean follow-up of 67.2 months (range 60 to 87.6 months) for the cruciate-sacrificing group. Kim 2009 had a mean follow-up of 27.6 months (range 24 to 36 months). Maruyama 2004 had a mean follow-up of 31.7 months (range 24 to 53 months) for the cruciate-retention group and a mean follow-up of 30.6 (range 24 to 38 months) for the cruciate-sacrificing group. Matsumoto 2012 had a mean follow-up of 71.9 months (range 61 to 83 months) for the cruciate-retention group and a mean follow-up of 70.2 months (range 63 to 87 months) for the cruciate-sacrificing group. Misra 2003 had a mean follow-up of 57 months; no range was reported. Roh 2012 had a mean follow-up of 27.3 months (range 24 to 28 months) for the cruciate-retention group and a mean follow-up of 32.2 months (range 24 to 37 months) for the cruciate-sacrificing group. Seon 2011 had a mean follow-up of 26.1 months (± 1.7) for the cruciate-retention group and a mean follow-up of 28.4 months (± 2.1) for the cruciate-sacrificing group. Shoji 1994 had a mean follow-up of 38.4 months (range 30 to 54 months). Straw 2003 had a mean follow-up of 42 months (range 12 to 78 months). Tanzer 2002 had a mean follow-up of 24 months; no range was reported. Wang 2004 had a mean follow-up of 42 months (range 24 to 66 months). Yagishita 2012 had a mean follow-up of 60 months (range 36 to 73 months). See Characteristics of included studies.

Sex and age (patient characteristics)

The mean age in Aglietti 2005 et al was 71 years in the cruciate-retention group (86% female patients) and 69.5 years in the cruciate-sacrificing group (81% female patients). The mean age in Catani 2004 et al was 70 ± 6.0 years in the cruciate-retention group (65% female patients) and 71 ± 7.0 years in the cruciate-sacrificing group (75% female patients). The mean age in Chaudhary 2008 et al was 69.2 ± 9.1 years in the cruciate-retention group (53% female patients) and 70.2 ± 8.4 years in the cruciate-sacrificing group (45% female patients). The mean age in Clark 2001 et al was 71.8 ± 12.2 years in the cruciate-retention group (sex of the patients not reported) and 71.2 ± 13.6 years in the cruciate-sacrificing group. The mean age in de Andrade 2009 et al was 66.3 years (range 41 to 78 years) overall; 74% pf the patients were female. The mean age in Harato 2008 et al was 68.3 years (range 49 to 89 years) in the cruciate-retention group (34% female patients) and 66.0 years (range 44 to 83 years) in the cruciate-sacrificing group (34% female patients). The mean age in Kim 2009 et al was 71.6 ± 6.0 years overall; in the cruciate-retention group (86% female patients) and 69.5 years in the cruciate-sacrificing group (81% female patients). The mean age in Maruyama 2004 et al was 74.3 years (range 65 to 84 years) overall; 60% of the patients were female. The mean age in Matsumoto 2012 et al was 73.5 ± 1.3 years in the cruciate-retention group (100% female patients) and 74.4 ± 0.9 years in the cruciate-sacrificing group (100% female patients). The mean age in Misra 2003 et al was 66.8 years (range 55 to 83 years) in the cruciate-retention group (67% female patients) and 67.2 years (range 59 to 82 years) in the cruciate-sacrificing group (59% female patients). The mean age in Roh 2012 et al was 69.8 ± 4.7 years in the cruciate-retention group (95% fe-

male patients) and 71 ± 4.9 years in the cruciate-sacrificing group (93% female patients). The mean age in Seon 2011 et al was 68.2 ± 7.0 years in the cruciate-retention group (91% female patients overall in the study) and 69.1 ± 6.7 years in the cruciate-sacrificing group. The mean age in Shoji 1994 et al was not reported nor was the sex distribution of the patients. The mean age in Straw 2003 et al was 72.6 years in the cruciate-retention group, 72.6 years in the posterior stabilised group and 74.1 years in the cruciate-sacrificing group. The mean age in Tanzer 2002 et al was 68 years (range 51 to 86 years) in the cruciate-retention group (75% female patients) and 66 years (range 52 to 77 years) in the cruciate-sacrificing group (80% female patients). The mean age in Wang 2004 et al was 54.5 years (range 31 to 69 years) in the cruciate-retention group (80% female patients) and 55 years (range 20 to 83 years) in the cruciate-sacrificing group (80% female patients). The mean age in Yagishita 2012 et al was 74.3 ± 7.2 years overall; 86% of the patients were female. See Characteristics of included studies.

Categorisation

The comparisons made in the trials could be divided into several distinct comparisons based on the outcome of range of motion. One was posterior cruciate ligament retention versus sacrifice with a posterior stabilised total knee arthroplasty design. Another comparison was made between posterior cruciate ligament retention versus sacrifice using the same arthroplasty design (see analysis section).

Two studies (Misra 2003; Shoji 1994), identified in the original review, and one new study (Roh 2012) compared posterior cruciate ligament retention and sacrifice using the same arthroplasty design (for example a posterior cruciate retaining design without a substitution of the resected ligament). When a specific posterior cruciate ligament substituting design was used, a posterior cruciate ligament retaining design was compared with a posterior stabilised design in all selected studies.

For details of the included studies see the Characteristics of included studies table.

Outcomes

All studies used a clinical rating scale, either well validated (that is WOMAC) or less well validated (that is Knee Society score or Hospital for Special Surgery score), and reported range of motion or flexion measurements.

Sample size

Eight studies (Aglietti 2005; Clark 2001; Harato 2008; Kim 2009; Misra 2003; Seon 2011; Straw 2003; Wang 2004) had group sizes of more than 50. Chaudhary et al compared 51 patients in which the posterior cruciate ligament was retained to 49 patients in which it was sacrificed (Chaudhary 2008).

Excluded studies

One study from the original Cochrane review (Jacobs 2005) was excluded from this update (Swanik 2004). This study reported results with a mean follow-up of 7.6 months. The protocol stated that follow-up had to be at least 12 months.

Most excluded studies were classified as non-randomised studies after reading the full text articles. Proceeding communications and abstracts of studies presented at international congresses were evaluated (Husain 1998; Matsuda 2003; MacDonald 2005; Surace 1997; Yamamoto 2003). Since methodological issues (for example randomisation technique) and outcome measures (for example mean with standard deviation) were not reported extensively enough, these studies were not included in the analyses. No additional publications were found for these studies. Ten studies were excluded for other different reasons.

For an overview of the excluded studies see the Characteristics of excluded studies table.

Risk of bias in included studies

Overall, the more recent publications had a lower risk of bias. Based on study characteristics and the risks of bias as described before, the studies of highest quality from the current selection of articles were Chaudhary (Chaudhary 2008), Kim (Kim 2009), Misra (Misra 2003) and Seon (Seon 2011).

Allocation

Four of the selected studies (24%) described how the randomisation sequence was generated (Chaudhary 2008: computer generated randomisation blocks; Harato 2008: randomisation blocks, stratified per centre; Misra 2003: random numbers table; Roh 2012: permuted block randomisation). The other 13 studies (76%) did not describe randomisation sequence generation (see Figure 3 and Figure 4). Concealment of allocation was performed using sealed or opaque envelopes, or both, as reported in five studies (29%) (Chaudhary 2008; Harato 2008; Kim 2009; Matsumoto 2012; Seon 2011). The other 12 studies (71%) did not mention concealment of allocation (see Figure 3 and Figure 4). Three studies used 'quasi-randomisation': Aglietti 2005 based treatment choice on odd or even patient numbers; Maruyama 2004 used alternating sequences; and Wang 2004 used hospital admission moment to base treatment on (see Figure 3 and Figure 4).

Figure 3. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

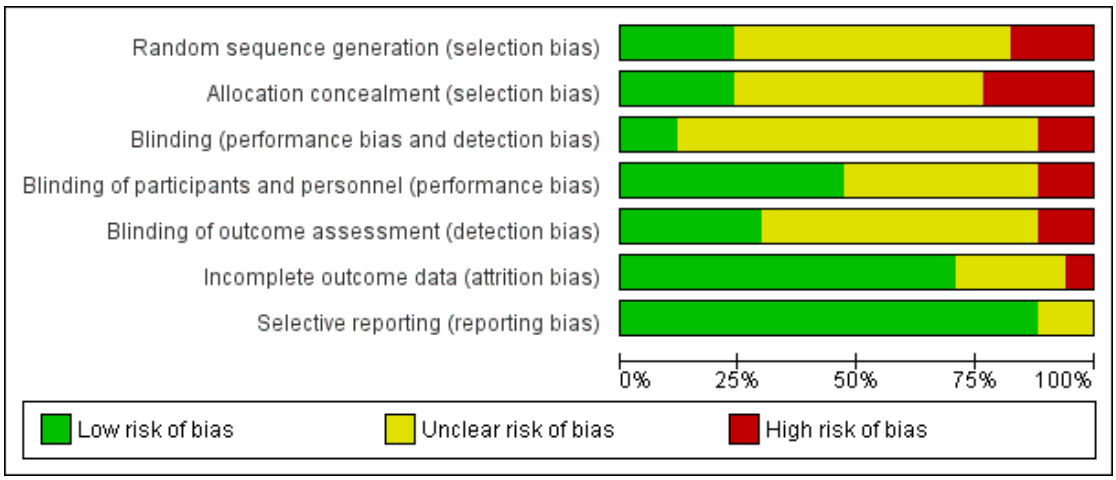
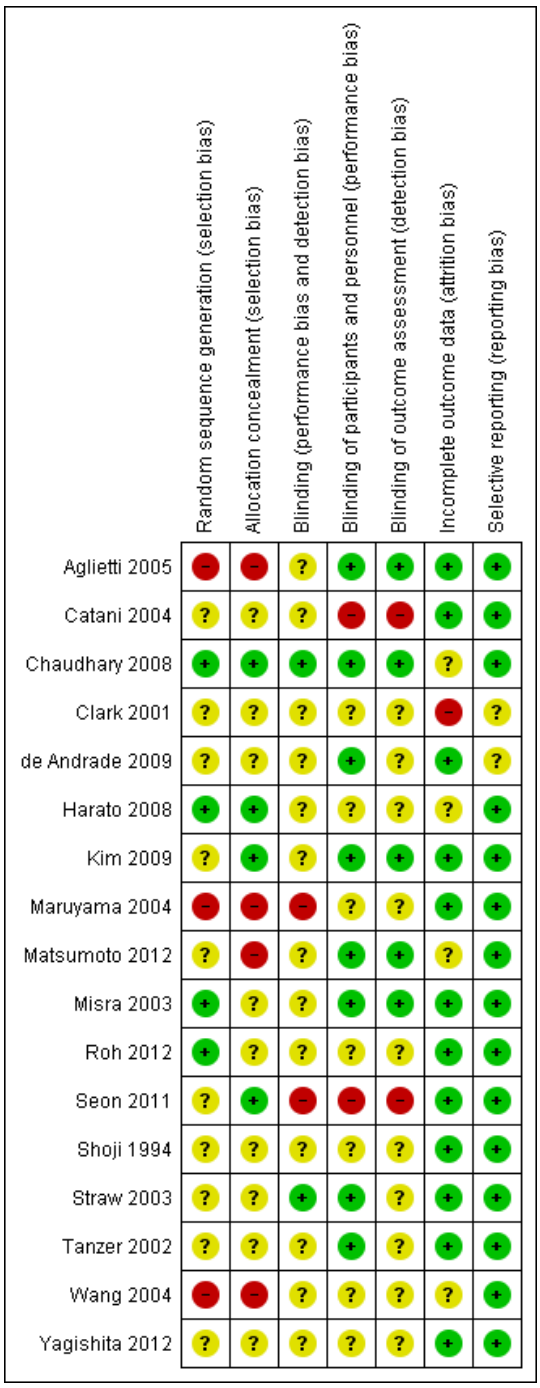


Figure 4. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.



Blinding

Blinding of participants and personnel was not described in eight studies (47%) (Catani 2004; Clark 2001; Harato 2008; Maruyama 2004; Roh 2012; Shoji 1994; Wang 2004; Yagishita 2012). Seon et al mentioned explicitly that no blinding was applied (Seon 2011). The other eight studies (47%) described only blinding of the outcome assessor (see Figure 3 and Figure 4).

Incomplete outcome data

The follow-up rate was described by all studies, ranging from 0% lost to follow-up (Catani 2004; de Andrade 2009; Maruyama 2004; Shoji 1994; Tanzer 2002; Yagishita 2012) to 22% lost to follow-up (Chaudhary 2008) (see Figure 3 and Figure 4).

Selective reporting

It seemed that 15 studies (88%) reported all outcome measures that were studied. Of these, Kim 2009 reported some outcomes (WOMAC and radiological results) in a digital appendix. Clark 2001 and de Andrade 2009 reported only the total Knee Society Score. It is more usual to report the clinical and functional score separately because this gives more insight into the nature of the possible differences between groups.

No studies were identified from the trial registries that were not still ongoing.

Clinical relevance

Clinical relevance is assessed in the table 'Assessment of clinical relevance' (Table 1). Most notable is that effect sizes of both the posterior cruciate ligament retaining and posterior cruciate ligament sacrificing groups reported in the studies were clinically not relevant in almost all of the studies.

Effects of interventions

See: **Summary of findings for the main comparison** Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs); **Summary of findings 2** Posterior cruciate ligament retention versus sacrifice (using the same arthroplasty design); **Summary of findings 3** Posterior cruciate ligament retention versus posterior stabilised sacrifice

Forest plots are displayed in the 'Data collection and analysis' section. Furthermore, an overview is given in Summary of findings for the main comparison, Summary of findings 2 and Summary of findings 3.

Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

These analyses included posterior cruciate retaining implant designs (sometimes used where the posterior cruciate ligament was sacrificed as well) and posterior stabilised posterior cruciate sacrificing designs. These were all studied implants included in this review.

Performance based outcome: range of motion, flexion and extension angle

Range of motion (reported in 65% of the studies, analysed on 62% of all potential patients and 65% of all potential knees) showed a mean difference of 2.4 ° (95% CI 0.13 to 4.61; P = 0.04) favouring posterior cruciate ligament sacrifice (118.3 ° versus 115.9 °). The results were heterogeneous (I^2 = 60%, P = 0.006). In particular, the results of Catani 2004 were very different compared to the other studies; these results indicated a large 17 ° higher flexion angle in favour of sacrifice of the posterior cruciate ligament.

The flexion angle showed a mean difference of 1.5 ° (119.8 ° versus 118.3 °) in favour of posterior cruciate ligament sacrifice (95% CI 0.24 to 3.15; P = 0.09). The results were homogeneous (I^2 = 6%, P = 0.39).

Result for the extension angle were heterogeneous (I^2 = 88%, P < 0.001) and showed a statistically non-significant difference of 0.36 ° (95% CI -0.63 to 1.36).

Knee pain

Two studies reported outcomes on the VAS for pain (Aglietti 2005; Yagishita 2012). The mean difference was 1.50 points (95% CI -1.84 to 4.84; P = 0.38) in favour of ligament retention. This result was homogeneous (I^2 = 0%, P = 0.58). There was also no difference between knee pain, as measured with the Knee Society pain score (zero is no pain, 50 is maximal pain). The mean difference was 0.02 points (95% CI -1.43 to 1.38; P = 0.97). However, this result was considered heterogeneous (I^2 = 71%, P = 0.02). This result was based on 36% of all patients, 46% of all knees, and data were reported in 24% of all included studies.

Implant survival rate

Several studies reported the survival rate of the arthroplasties. Aglietti 2005 reported one case of revision due to septic loosening in the cruciate-sacrificing group. Chaudhary 2008 reported one revision in the cruciate-retention group, Harato 2008 reported one revision in the cruciate-retention group and three in the sacrifice group. Misra 2003 reported two revisions in the cruciate-retention group. Kim 2009, Yagishita 2012 and Tanzer 2002 specifically

reported that no revision surgery had occurred during their follow-up.

Validated clinical scoring systems

A validated scoring system, the WOMAC total score, was used in four studies (24% of included studies with data on 28% of all patients and 24% of all knees) (Clark 2001; Harato 2008; Roh 2012; Seon 2011). There was a 0.78 (95% CI -1.51 to 3.07; P = 0.50) points difference between posterior cruciate ligament retention and sacrifice in favour of the posterior cruciate sacrifice (sacrifice versus retention: 15.7 versus 16.4 points). This difference was not statistically significant (P = 0.57) and was homogeneous (I^2 = 0, P = 0.69). No other validated scoring systems (that is Knee injury and Osteoarthritis Outcome Score (KOOS), Oxford Knee Score) were available for pooling.

Patient satisfaction

Only Misra 2003 (one study, 6% of all included studies) asked patients to grade their satisfaction, on a scale from 0 to 10 with 10 being completely satisfied: cruciate-sacrifice scored 7.9 and cruciate-retention 7.7. This difference was not statistically significant.

Complications

Complications were reported in 11 studies (65% of all included studies, reporting on 69% of all patients and 74% of all knees). Complications are listed in Table 2. Complications occurred with equal frequency in the two treatment groups. Reported complications ranged from anterior knee pain (10 patients) and limited range of motion (14 patients) a few weeks after surgery to septic or aseptic loosening (4 and 5 patients respectively). The latter is a serious complication, also occurring equally often in the two treatment groups.

Other endpoints

The Knee Society functional score showed a statistically significant 2.3 points higher score (81.3 versus 79.0 points) in the posterior cruciate ligament sacrificed groups (95% CI of the difference 0.37 to 4.26; P = 0.02). Results were homogeneous (I^2= 0%, P = 0.43). This result was clinically not relevant. This score ranges from 0 to 100, 100 being optimal function.

Meta-analyses on the other outcomes, as displayed in the Data and analyses section, showed no statistically significant differences. These outcomes were: Knee Society clinical score, Hospital for Special Surgery score, Short Form (SF)-12 mental score, radiological radiolucencies, radiological femorotibial angle, radiological rollback, and radiological tibial slope.

Posterior cruciate ligament retention versus sacrifice (using the same arthroplasty design)

Posterior cruciate ligament sacrifice versus retention with the same arthroplasty design (a posterior cruciate retaining design) did not show a statistically significant difference in range of motion (mean difference 2.7 °; 95% CI -8.7 to 3.32; P = 0.38). Data were heterogeneous (I^2 = 88%, P < 0.001). Range of motion was the only endpoint available for meta-analysis.

Posterior cruciate ligament retention versus posterior stabilised sacrifice

Posterior cruciate ligament sacrifice versus retention with a posterior stabilised design showed a statistically significant difference in range of motion of 3.47 ° (116.5 ° versus 120.0 °) in favour of the posterior stabilised design (95% CI 0.56 to 6.38; P = 0.02). However, data were heterogeneous (I^2 = 60%, P = 0.01).

The flexion angle was 2.10 ° higher (95% CI -0.04 to 4.24; P = 0.05) in favour of the posterior stabilised design. This was a homogeneous result (I^2 = 1%, P = 0.42).

The outcomes VAS pain, Knee Society pain score, WOMAC total score, Knee Society clinical and functional score, Hospital for Special Surgery score, Knee Society total score, the number of radiolucent lines, the femorotibial angles and tibial slope showed no statistically significant differences and these results were homogeneous.

The outcomes extension angle, SF-12 mental score and radiological rollback showed no statistically significant differences and these results were heterogeneous.

ADDITIONAL SUMMARY OF FINDINGS *[Explanation]*

Posterior cruciate ligament retention versus sacrifice (using the same arthroplasty design)

Patient or population: Patients receiving total knee arthroplasty with or without resection of the posterior cruciate ligament for the treatment of osteoarthritis
Settings: Hospital
Intervention: Posterior cruciate ligament retention
Comparison: Posterior cruciate ligament sacrifice

Outcomes	Comparative risks		Relative effect	No. of patients (% of total)	No of studies (% of total)	Quality of the evidence (GRADE)	Comments
	Cruciate-sacrifice	Cruciate-retention					
Performance based measures - Range of motion (possible range 0 (worst) to 140 (maximal) degrees) Follow-up: 12-78 months	The mean range of motion in the cruciate-sacrifice group was **114.1** degrees (± SE 0.82)	The mean range of motion in the cruciate-retention group was **2.7** degrees **lower** (8.71 lower to 3.32 higher)		Total No. of patients: 405 (22%) Total No. of knees: 414 (19%)	4 studies (24%)	⊕◯◯◯ **very low**[1,2,3,4]	Absolute difference: 2.7 degrees lower (8.71 lower to 3.32 higher) Relative percent change: -2.4% (7.6% lower to 2.9% higher) Not statistically significant.
Knee pain Knee Society Score, sub score pain (possible range 0 (severe pain) - 50 (no pain) points)	See comment	See comment	Not estimable	-	-	See comment	No data in studies comparing ligament resection and sacrifice using similar arthroplasty designs
Survival rate of the implant (Revision surgery reported) Follow-up: 56-60 months	See comment	See comment	Not estimable	Total No. of patients: 103 (6%) Total No. of knees: 105 (5%)	1 study (6%)	See comment	Insufficient data provided. One study (Misra 2003) reported 2 revisions in the cruciate-retention group.

Health related quality of life measures and functional measures with validated instruments (WOMAC, range 0-100, higher scores indicate worse pain, stiffness and functional limitations) Follow-up: 24-37 months	The mean WOMAC total score in the cruciate-sacrifice group was **17.0** points (± SE 1.1)	The mean WOMAC total score in the cruciate-retention group was **1.10 lower** (-5.19 lower to 2.99 higher)		Total No. of patients: 86 (5%) Total No. of knees: 86 (4%)	1 study (6%)	See comment	One study reported this outcome: Roh 2012 Absolute difference: 1.10 lower (-5.19 lower to 2.99 higher) Relative percent change: -6.5% (30.5% lower to 17.6% higher) Not statisitically significant
Global assessment (patient) Patient satisfaction on scale 0 (not at all satisfied) to 10 (completely satisfied)) Follow-up: 12-83 months	The mean satisfaction score in the cruciate-sacrifice group was **7.9** [7]	The mean satisfaction score in the cruciate-retention group was **0.2 lower** [7]		Total No. of patients: 103 (6%) Total No. of knees: 105 (5%)	1 study (6%)	⊕⊕◯◯ **low**[2,4]	Absolute difference: 0.2 lower [7] Relative percent change: -2.5% [7] Not statistically significant.
Complications Follow-up: 12-78 months	See comment	See comment	Not estimable	Total No. of patients: 405 (22%) Total No. of knees: 414 (19%)	4 studies (24%)	See comment	Due to the very diverse way of reporting and defining complications combining data for quantitative analysis was not possible[5,6]
Re-operation rate (not involving implant change, short and long term)	See comment	See comment	Not estimable	-	-	See comment	No data in studies comparing ligament resection and sacrifice using similar arthroplasty designs

CI: Confidence interval. KSS: Knee Society Score, WOMAC: Western Ontaria and McMasters Universities Osteoarthritis Index. NA: not applicable

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1] Risk of bias individual studies, see risk of bias tables
[2] Relatively too much unclear risks of bias
[3] Inconsistent results from the studies
[4] < 400 arthroplasties in analysis
[5] Complications reported in the cruciate-sacrifice group: 3 instability, 3 aseptic loosening, 2 stiffness
[6] Complications reported in the cruciate-retention group: 3 instability, 1 infection (deep), 2 aseptic loosening, 2 stiffness, 2 ligament laxity, 1 ligament tightness
[7] Not sufficient data reported to calculate standard error, range or confidence interval

Posterior cruciate ligament retention versus posterior stabilised sacrifice

Patient or population: Patients receiving total knee arthroplasty with or without posterior stabilised design for the treatment of osteoarthritis
Settings: Hospital
Intervention: Posterior cruciate ligament retention
Comparison: Posterior cruciate ligament sacrifice with posterior stabilised design

Outcomes	Mean differences (95% CI)		Relative effect	No. of patients (% of total)	No. of studies (% of total)	Quality of the evidence (GRADE)	Comments
	Cruciate-sacrifice (posterior stabilised)	Cruciate-retention					
Performance based measures - Range of motion (possible range 0 (worst) to 140 (maximal) degrees) Follow-up: 1-6.5 years[1]	The mean range of motion in the cruciate-sacrifice group was **119.8** degrees (± SE 0.66)	The mean range of motion in the cruciate-retention group was **3.4** degrees **lower** (6.32 to 0.54 lower)		Total No. of patients: 899 (50%) Total No. of knees: 1,193 (54%)	8 studies (47%)	⊕⊕⊕○ **moderate**[1]	Absolute difference: -3.4 degrees (6.32 to 0.54 lower) Relative percent change: -2.8% (5.3% lower to 0.45% higher) Statistically significant (P = 0.02) NNTB: 9 (5 to 51)
Knee pain Knee Society Score, subscore pain (possible range 0 (severe pain) - 50 (no pain) points) Follow-up: 2-7.3 years	The mean knee pain score in the cruciate-sacrifice group was **48.3** points (± SE 0.68)	The mean knee pain score in the cruciate-retention group was **0.60 higher** (0.39 lower to 1.60 higher)		Total No. of patients: 471 (26%) Total No. of knees: 780 (35%)	3 studies (18%)	⊕⊕⊕○ **moderate**[1,2]	Absolute difference: 0.60 (0.39 lower to 1.60 higher) Relative percent change: 1.2% (0.81% lower to 3.3% higher) Not statistically significant.

Survival rate of the implant (Revision surgery reported)	See comment	See comment	Not estimable	Total No. of patients: 802 (44%) Total No. of knees: 1, 100 (50%)	6 studies (35%)	See comment	Insufficient data provided. Incidental remarks on implant survival could be derived from 6 studies Chaudhary 2008 1 in the cruciate-retention group, Harato 2008 1 in the cruciate-retention group and 3 in the sacrifice group. Aglietti 2005 1 revision in the cruciate-sacrifice group due to septic loosening Kim 2009, Yagishita 2012 and Tanzer 2002 specifically reported no revision surgery had occurred during follow-up
Health related quality of life measures and functional measures with validated instruments (WOMAC, range 0-100, higher scores indicate worse pain, stiffness and functional limitations) Follow-up: 24-87 months	The mean WOMAC total score in the cruciate-sacrifice group was **18.2** points(± SE 1.5)	The mean WOMAC total score in the cruciate-retention group was **1.60 lower** (1.32 lower to 4.50 higher)		Total No. of patients: 415 (23%) Total No. of knees: 445 (20%)	3 studies (18%)	⊕⊕◯◯ **low** [1,2]	Absolute difference: 1.60 lower (1.32 lower to 4.50 higher) Relative percent change: -8.8% (7.3% lower to 24.7% higher) Not statistically significant.

Global assessment (patient)	See comment	See comment	Not estimable	-	-	See comment	No data in studies comparing ligament resection and sacrifice using similar arthroplasty designs
Complications Follow-up: 8-87 months[5]	See comment	See comment	Not estimable	Total No. of patients: 878 (49%) Total No. of knees: 1, 220 (55%)	8 studies (47%)	See comment	Due to the very diverse way of reporting and defining complications combining data for quantitative analysis was not possible[3,4]
Re-operation rate (not involving implant change, short- and long-term) Follow-up: 24 months	See comment	See comment	Not estimable	Total No. of patients: 40 (2%)	1 study (6%)	See comment	Catani 2004 reported 4 re-operations; 3 patella luxations (2 in cruciate-sacrificing, 1 in cruciate-retention group) and 1 surgical manipulation due to lack of range of motion (in the cruciate-retention group)

CI: Confidence interval. KSS: Knee Society Score, WOMAC: Western Ontaria and McMasters Universities Osteoarthritis Index. ROM range of motion NA: not applicable

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1] Relatively many studies with 'unclear' risk of bias
[2] < 400 arthroplasties in analysis
[3] Complications reported in the cruciate-sacrifice group: 2 anterior knee pain, 3 femoral notching, 1 superficial wound infection, 2 deep venous thrombosis, 1 septic loosening

[4] Complications reported in the cruciate-retention group: 1 anterior knee pain, 1 limited ROM, 2 femoral notching, 1 superficial wound infection

[5] Some studies reported complications after several months. Mean follow-up of other endpoints was > 1 year

DISCUSSION

Summary of main results

By thoroughly updating the original review (Jacobs 2005) we were able to add 10 studies, described in 11 articles, to the analyses (Aglietti 2005; Chaudhary 2008; de Andrade 2009; Harato 2008; Kim 2009; Matsumoto 2012; Roh 2012; Seon 2011; Victor 2005; Wang 2004; Yagishita 2012). Only two outcomes differed statistically when all selected studies reporting similar outcomes were pooled. The range of motion was 2.4 ° higher and the functional Knee Society score was 2.3 points higher in the group with sacrifice of the posterior cruciate ligament. Complications were reported in 11 studies (Aglietti 2005; Catani 2004; Chaudhary 2008; Harato 2008; Kim 2009; Maruyama 2004; Matsumoto 2012; Misra 2003; Roh 2012; Wang 2004; Yagishita 2012). Complications varied from anterior knee pain and femoral notching to deep infection. Most complications occurred equally frequently in the posterior cruciate ligament sacrificing and retaining groups (Table 2). A remarkable finding in Harato 2008 was that the posterior cruciate ligament retaining group showed seven cases (6.3%) of a stiff knee, defined as < 90 ° of flexion, compared to one case (0.9%) in the posterior cruciate ligament sacrificing group.

The meta-analyses showed statistically significant differences in range of motion and in the Knee Society functional score. Although the evidence originates from a meta-analysis of more than one randomised controlled trial, one should be aware that the effect is still unstable and sensitive to the inclusion of new studies. Moreover, the mean difference in range of motion of 2.4 ° and in mean Knee Society functional score of 2.3 points are considered clinically not relevant (Pijls 2011). The table 'Assessment of clinical relevance' (Table 1) shows that most reported outcomes are not clinically relevant. The original review also showed a statistically significant mean difference in the Hospital for Special Surgery score of 1.6 points (P = 0.03) (Jacobs 2005) in favour of posterior cruciate ligament sacrifice arthroplasty. This difference, small and clinically not relevant, has disappeared in this review.

In order to have an impression of the difference in pain experienced between both groups we extracted data on pain from all studies. Four studies reported data on pain (Harato 2008; Kim 2009; Wang 2004; Yagishita 2012). All four presented the pain score as derived from the Knee Society Knee score. No study showed different scores per answer of the Knee score so it is not entirely clear how these pain scores were derived. Two studies used the VAS to evaluate the pain experienced by patients yielding no differences between retention or sacrifice of the posterior cruciate ligament (Aglietti 2005; Yagishita 2012).

The quality of the evidence, graded with the GRADE approach, ranged from moderate to low (Summary of findings for the main comparison; Summary of findings 2; Summary of findings 3). No harmful outcomes were presented in the summary of findings tables in this review due to the absence of reporting of sufficient data.

Overall completeness and applicability of evidence

Because of our broad and thorough search we were able to find 10 additional studies to the previous review, increasing completeness of the evidence. Overall, outcome measures studied in the selected studies give solid indications on the clinical, functional and radiological features one might be interested in after total knee arthroplasty. Unfortunately, patient-oriented outcomes such as patient satisfaction were hardly ever studied. An exception is Misra 2003, who asked patients to grade their satisfaction on a scale from one to 10.

Despite the fact that randomised controlled trials are described as providing the least biased evidence, the mean survival rate of total knee arthroplasty cannot be easily investigated by randomised controlled trials. Long term follow-up evaluations in observational cohort studies are valuable alternatives. A survivorship analysis report on a large cohort of 11,606 total knee arthroplasties showed a mean survival rate at 10 years after surgery of 91% (95% CI 90 to 92) in the posterior cruciate ligament retention group and 76% (95% CI 62 to 86) in the posterior cruciate ligament sacrificing posterior stabilised group (Rand 2003). Abdel et al found similar results (Abdel 2011).

In the more recent years, the high demands in performance of total knee arthroplasty in certain ethnic (for example squatting position) and religious (for example prayer position) groups as well as in younger patients who require greater magnitudes of knee flexion has led to the development of newer implants. Together with the continuing process of optimising stability and kinematics in total knee arthroplasty, high flex posterior stabilised and bicruciate stabilising designs were introduced. Long term follow-up studies have yet to prove whether those implants indeed show improved results compared to the more established design types. In this review, Kim 2009, Seon 2011 and Yagishita 2012 studied high flexion total knee arthroplasties.

Quality of the evidence

In the original Cochrane review, the quality of the included studies was assessed using the van Tulder and Jadad checklist (Jacobs 2005). Catani (Catani 2004), Misra (Misra 2003) and Tanzer (Tanzer 2002) were regarded as high quality studies. However, The Cochrane Collaboration nowadays discourages the use of scales assessing the quality (Higgins 2011). To assess quality and risk of bias, risk of bias tables were used as advocated by The Cochrane Collaboration. Several items were evaluated, first the method of generation of randomisation sequence. This should be based on chance and should be reported clearly to avoid doubt about bias.

Together with the method of concealment of treatment allocation these items indicate the risk of selection bias. Treatment allocation has to be completely at random; knowledge of the next allocation by the care provider could result in an 'awkward' patient either being at risk of being illegally excluded from the trial or of being assigned to the other treatment group. This will lead to an overestimation of the treatment effect (Wood 2008). A valid randomisation technique is applied just before the treatments are given, thus ensuring unpredictable allocation. There are several techniques to keep the allocation unpredictable, such as sealed envelopes or a telephone call to a research centre for the treatment allocations. It was chosen to include quasi-randomised trials in the review as well. Quasi-randomisation is randomisation based on odd or even chart numbers, dates of birth, alternating sequences, day of hospital admission etc. The risk of selection bias in this kind of randomisation is higher compared to pure randomisation. Another item is blinding. In most surgical trials blinding of the surgeon is impossible. However, the patients and the observers measuring the endpoints can be blinded for the studied intervention. Well-blinded studies reduce risk of performance and detection bias. Furthermore, incomplete outcome data raise the possibility that the outcome is biased. When almost all anticipated outcome data are available the risk of attrition bias is low. Additionally, selection-by-indication bias was taken into account. This can only be corrected for if the degree of preoperative flexion contracture, valgus or varus deformity, is mentioned in the articles. Unfortunately the selected studies did not report these factors, except for one study that stated that a valgus or varus deformity in excess of 15 ° was an exclusion criterion (Chaudhary 2008).

The Cochrane Collaboration encourages the use of the GRADE approach (Atkins 2004). This GRADE approach defines "the quality of a body of evidence as the extent to which one can be confident that an estimate of effect or association is close to the quantity of specific interest" (Higgins 2011). Randomised controlled trials are considered as yielding high quality evidence. However, this grade can be downgraded to moderate, low or very low quality due to limitations in the design suggesting the likelihood of bias, indirectness of evidence, unexplained heterogeneity or inconsistency in the results, imprecision of the results, and a high probability of publication bias (Higgins 2011). Results were presented in the summary of findings tables. The Cochrane Collaboration encourages review authors to present the most important outcomes in these tables, including both beneficial and harmful outcomes. In this review serious adverse effects (for example serious complications) would be a harmful outcome, however the amount of data from the selected studies were not sufficient.

The quality of the evidence, graded with the GRADE approach, was low for range of motion, and moderate for the outcomes flexion angle and knee pain. In the subgroup analysis of posterior cruciate ligament retention and sacrifice with the same (cruciate-retaining) arthroplasty design the evidence was graded 'very low' for the outcome range of motion. In the other subgroup analyses (cruciate-retaining versus posterior stabilised) the evidence was moderate for the outcome range of motion (Summary of findings for the main comparison; Summary of findings 2; Summary of findings 3).

The risk of bias estimations are displayed for all selected studies in the 'Characteristics of included studies' risk of bias tables. The studies regarded as having the least risk of bias from the current selection of articles are Chaudhary (Chaudhary 2008), Kim (Kim 2009), and Misra (Misra 2003). Except for Misra 2003 these are newly added studies. There seems to be a positive trend towards better methodologically performed and reported studies in the more recent years. However, because of the incomplete description of the methodology of the trials it was difficult to assess whether the methodology was inaccurate or the description of the methodology was just lacking information. None of the selected studies could be judged on all four items described above. Selection bias items were not described in 53% of the articles (9/17), performance bias in 41% (7/17), and attrition bias in 24% (4/17) of the studies. The summary of findings tables show the results of the quality appraisal by the GRADE approach. All outcomes were downgraded from high quality to moderate or even low quality.

Reporting of external funding could influence the likelihood of publication of the study. From the selected studies only one industry funded study was found (Chaudhary 2008). One study reported a non-commercial grant from the National Council of Science (Wang 2004). Eight studies did not describe external funding (Aglietti 2005; Clark 2001; de Andrade 2009; Harato 2008; Maruyama 2004; Matsumoto 2012; Roh 2012; Shoji 1994). From the same study population described by Harato et al (Harato 2008) the report of Victor (Victor 2005) reported no external funding. The rest of the selected studies explicitly reported no external funding.

Potential biases in the review process

This review has several strengths and limitations. As mentioned before, randomised controlled trials are not the best studies to evaluate implant survival (for example 10 or 15 year survival) because follow-up is usually too short in trials. Since implant survival is an important outcome after total knee arthroplasty this is a limitation. Furthermore, we could not present information on patient experience and satisfaction after total knee arthroplasty because these data were not presented in the selected studies. Even in a systematic review, publication bias can never be ruled out with certainty. We applied a relatively broad search strategy in multiple databases. Nevertheless, some references could not be indexed in the databases; therefore we also used citation tracking and we checked the reference lists of the included articles. Screening the international trials registers via the portal of the World Health Organization (www.who.int/trialsearch), four trials, tagged with an ongoing status, were found (ACTRN12609000960257; ISRCTN05635855;

ISRCTN82612978; van den Boom 2009). For one of these studies, the study protocol was published ahead of starting the trial (van den Boom 2009). No clinically relevant differences and only two statistically significant differences were found comparing the two groups in our meta-analyses, this might be due to a power problem. In the next update of the review these four studies can possibly overcome this problem.

This systematic review with meta-analysis was composed in accordance with the criteria of the PRISMA statement (Preferred Reporting Items for Systematic reviews and Meta-Analyses) (Liberati 2009). This is a revision and expansion of the QUORUM statement (QUality Of Reporting Of Meta-analyses). Another strength is that we applied a broad and extensive search strategy.

Agreements and disagreements with other studies or reviews

Similar to the randomised and quasi-randomised controlled trials selected in this review, other orthopaedic literature on this topic shows inconclusive results. Range of motion, for example, is the parameter most often measured. Only two randomised controlled trials (Catani 2004; Straw 2003) found a statistically significant difference, favouring posterior cruciate ligament sacrifice. One study (Stiehl 1997) found a superior range of motion for a posterior cruciate ligament retaining total knee arthroplasty and another study (Maloney 1992) for a posterior stabilised design. However, both studies showed a higher preoperative range of motion for the group with the superior results. Hirsch (Hirsch 1994) found a superior range of motion for a posterior stabilised design over posterior cruciate ligament sacrifice in a total knee arthroplasty without posterior stabilisation. Preoperative range of motion is believed to have a large influence on the postoperative results. Therefore, improvement of range of motion should be calculated and reported as well. The method of assessment of range of motion was not described in all reports. The measurement of range of motion is notoriously inaccurate if performed clinically (Kafer 2005).

Clinical rating scales are considered not very sensitive tools to evaluate the difference between two implant designs when only total scores are reported. WOMAC and KOOS scales are better validated and hence are preferred instruments for use in clinical trials. The studies in this review did not find any difference. Other non-randomised studies show the same results; several studies found no difference on the Hospital for Special Surgery score between a posterior cruciate ligament retaining and a posterior stabilised design (Becker 1991; Pereira 1998; Vinciguerra 1994).

Technically relevant outcome measures are the outcomes anterior-posterior stability and contact position. These measurements were not addressed in any of the studies. One laboratory study concludes that proper balancing is imperative to achieve proper roll-back (Most 2003). De Jong et al found an average contact point between the femur and tibia at the posterior two-thirds of the anteroposterior distance of the tibia and assumed that this is also the correct contact point for a replaced cruciate retaining knee implant and a correctly balanced posterior cruciate ligament (de Jong 2010). Balancing of the posterior cruciate ligament is technically more difficult due to the oblique orientation of the posterior cruciate ligament in flexion and a strong 3 to 5 mm anterior translation of the tibia with a 2 mm increase of the insert thickness (Christen 2007; Heesterbeek 2010).

Several studies using fluoroscopy suggest that participants having a posterior stabilised total knee arthroplasty have less abnormal knee kinematics in deeper flexion and greater flexion than participants having a posterior cruciate ligament retaining total knee arthroplasty (Dennis 1998; Garling 2005; Udomkiat 2000; Victor 2005; Wolterbeek 2009; Wolterbeek 2011). As mentioned before, the posterior cruciate ligament is reported to have proprioceptive properties (Hogervorst 1998; Nelissen 2001; Swanik 2004). Another study found no difference in proprioception between a posterior cruciate ligament retaining and a posterior stabilised design (Cash 1996). Simmons 1996 found no difference in proprioception in moderate grades of osteoarthritis, but in higher osteoarthritis grades the posterior cruciate ligament retaining group performed better than the sacrificing group.

Gait analysis could provide additional but generally unvalidated results. In this review we did not find any randomised controlled trials evaluating gait analysis. Dennis et al found in two (fluoroscopic) studies that posterior cruciate ligament retaining and posterior stabilised arthroplasties have similar kinematic patterns in early flexion activities such as gait (Dennis 2003; Dennis 2004). Bolanos et al performed gait analysis on posterior cruciate ligament retaining and posterior stabilised arthroplasties and found no statistically significant differences in range of motion or knee flexion moments during a level gait (Bolanos 1998). A recent study showed no differences in gait analysis parameters between posterior cruciate ligament retention and posterior stabilised total knee arthroplasty with the ligament resected in both treatment arms (Joglekar 2012). Ishii 1998 found increased abduction and adduction and increased proximal and distal translation during gait analysis for the posterior stabilised design, which may indicate decreased stability; however the results did not differ significantly.

There are other issues to be considered in total knee replacement surgery like the choice of what kind of bearing system is to be used. Jacobs 2004(2) performed a Cochrane systematic review to answer this question, this review is currently in update phase. Another question is whether or not to use cement on the implants, and Nakama 2012 has performed a Cochrane systematic review to answer this question. We refer to these reviews for more in-depth information on these issues.

AUTHORS' CONCLUSIONS

Implications for practice

Based on this update of a Cochrane systematic review and meta-analysis, no clear and relevant differences were identified between either retention or sacrifice of the posterior cruciate ligament, or between retention and sacrifice accompanied by a posterior stabilised design. The studies found to support any conclusions on this comparison are still of limited quality. The technique of posterior cruciate ligament balancing is very demanding and complicated, and was not carefully described in the identified trials. Furthermore, the preoperative deformity of the knee might necessitate certain soft tissue releases for correct alignment, thus making it impossible to retain the posterior cruciate ligament (that is severe flexion contracture, valgus contracture). Techniques to improve balancing of the posterior cruciate ligament during total knee arthroplasty are still ongoing as this is a specific focus within total knee arthroplasty surgery. When these techniques are developed and described in sufficient detail renewed scientific experiments in patient series should be undertaken.

Implications for research

Total knee arthroplasty is a successful procedure. To improve an already successful procedure we need to look at small details. We believe that the treatment of the posterior cruciate ligament during surgery remains one of those details. Therefore, choices regarding retention or sacrifice of the posterior cruciate ligament should be thoroughly investigated in adequately and well-developed trials. The inability to apply surgeon blinding in these trials increases the need for independent and blinded outcome assessments. Also, after the surgical procedure, the patient cannot be changed to the other group and any revision implies that the treatment has been discontinued, so the quality criteria 'intention to treat' and 'compliance' should be used for cost effectiveness analysis but cannot be used for an analysis of the performance of the study. This should be taken into account. The quality of reporting of the trials is still poor; 33% to 66% of the risk of bias items were marked as 'unclear risk'. Sufficient information about the patient population was lacking in the majority of the studies. The degree of preoperative deformity was not mentioned. The selection criteria used should be given as well as the result of this selection procedure. This is essential for other clinicians to decide if the results of the trial are applicable to their own patient populations. In the field of knee surgery, the use of well-validated clinical rating scales such as the KOOS or WOMAC scale is important and they should be used more frequently, in the correct form.

Equally important is the description of the treatments applied. In the field of knee arthroplasty a few specific characteristics should be mentioned. These are the mobility of the insert (for example fixed, mobile), the status of the posterior cruciate ligament, whether either the tibial or femoral component has been cemented, the coating of the implant, the posterior tibial slope, and whether the patella has been resurfaced. The choice of the outcome parameter in a randomised trial is often of specific interest for a specific study. In studies evaluating the posterior cruciate ligament in total knee arthroplasty this should be range of motion (flexion), stability, and contact position. When more generally accepted outcome parameters are also used, the trials can be grouped together in future systematic reviews. Trials should be set up to assess the outcome parameters at uniform time intervals for all patients, before and at more than one time after the surgery. This increases the chance that identical follow-up times can be constructed from different trials. At the least, the short term outcome should be assessed at one and two years and the long term outcome at five and 10 years. It is equally important that the assessed variables are presented for the follow-up times as well for all subgroups. Besides these more technical outcome measures of total knee arthroplasty, more attention should be given to outcomes such as patient experience, quality of life and satisfaction after total knee arthroplasty.

ACKNOWLEDGEMENTS

We would like to thank JW Schoones, librarian (Walaeus Library, Leiden University Medical Center, Leiden, the Netherlands) for assisting in the searches and arranging reprints, as well as the Cochrane Musculoskeletal Group, especially Ms E Ghogomu for her help in the development of the review.

REFERENCES

References to studies included in this review

Aglietti 2005 ***{published data only}***

Aglietti P, Baldini A, Buzzi R, Lup D, Luca L. Comparison of mobile-bearing and fixed bearing total knee arthroplasty. A prospective randomized study. *The Journal of Arthroplasty* 2005;**20(2)**:145–53.

Catani 2004 ***{published data only}***

Catani F, Leardini A, Ensini A, Cucca G, Bragonzoni L, Toksvig-Larsen S, et al. The stability of the cemented tibial component of total knee arthroplasty: posterior cruciate-retaining versus posterior-stabilized design. *The Journal of Arthroplasty* 2004;**19**(6):775–82.

Chaudhary 2008 ***{published data only}***

Chaudhary R, Beaupre LA, Johnston DWC. Knee range of motion during the first two years after use of posterior cruciate-stabilizing or posterior cruciate retaining total knee prostheses. A randomized clinical trial. *Journal of Bone and Joint Surgery. American Volume* 2008;**90**:2579–86.

Clark 2001 *{published data only}*
Clark CR, Rorabeck CH, MacDonald S, MacDonald D, Swafford J, Cleland D. Posterior-stabilized and cruciate-retaining total knee replacement: a randomized study. *Clinical Orthopaedics and Related Research* 2001;**392**(11): 208–12.

de Andrade 2009 *{published data only}*
de Andrade MAP, Honorio de Carvalho Junior L, Goncalves MBJ, de Castro CAC, Fontes BPC. Clinical evaluation of total knee arthroplasties with posterior cruciate ligament retain and sacrifice [Avaliacao clinica de artroplastias totais de joelho com preservacao e sacrificio do ligamento cruzado posterior]. *Revista Brasileira de Medicina* 2009;**66**:48–51.

Harato 2008 *{published data only}*
* Harato K, Bourne RB, Victor J, Snyder M, Hart J, Ries MD. Midterm comparison of posterior cruciate-retaining versus -substituting total knee arthroplasty using the Genesis II prosthesis. A multicenter prospective randomized clinical trial. *The Knee* 2008;**15**:217–21.
Victor J, Banks S, Bellemans J. Kinematics of posterior cruciate ligament- retaining and -substituting total knee arthroplasty. A prospective randomised outcome study. *Journal of Bone and Joint Surgery. British Volume* 2005;**87**: 646–55.

Kim 2009 *{published data only}*
Kim YH, Choi Y, Kwon OR, Kim JS. Functional outcome and range of motion of high-flexion posterior cruciate-retaining and high-flexion posterior cruciate-substituting total knee prostheses. A prospective, randomized study. *Journal of Bone and Joint Surgery. American Volume* 2009; **91**:753–60.

Maruyama 2004 *{published data only}*
Maruyama S, Yoshiya S, Matsui N, Kuroda R, Kurosaka M. Functional comparison of posterior cruciate-retaining versus posterior stabilized total knee arthroplasty. *The Journal of Arthroplasty* 2004;**19(3)**:349–53.

Matsumoto 2012 *{published data only}*
Matsumoto T, Muratsu H, Kubo S, Matsushita T, Kurosaka M, Kuroda R. Intraoperative soft tissue balance reflects minimum 5-year midterm outcomes in cruciate-retaining and posterior stabilized total knee arthroplasty. *The Journal of Arthroplasty* 2012;**27(9)**:1723–30.

Misra 2003 *{published data only}*
Misra AN, Hussain MR, Fiddian NJ, Newton G. The role of the posterior cruciate ligament in total knee replacement. *Journal of Bone and Joint Surgery. British Volume* 2003;**85** (3):389–92.

Roh 2012 *{published data only}*
Roh YW, Jang J, Choi WC, Lee JK, Chun SH, Lee S, et al. Preservation of the posterior cruciate ligament is not helpful in highly conforming mobile-bearing total knee arthroplasty: a randomized controlled study. *Knee Surgery, Sports Traumatology, Arthroscopy* 2012 Nov 1 [Epub ahead of print].

Seon 2011 *{published data only}*
Seon JK, Park JK, Shin YJ, Seo HY, Lee KB, Song EK. Comparisons of kinematics and range of motion in high-flexion total knee arthroplasty: cruciate retaining vs. substituting designs. *Knee Surgery, Sports Traumatology, Arthroscopy* 2011;**19**(12):2016–22.

Shoji 1994 *{published data only}*
Shoji H, Wolf A, Packard S, Yoshino S. Cruciate retained and excised total knee arthroplasty. A comparative study in patients with bilateral total knee arthroplasty. *Clinical Orthopaedics and Related Research* 1994;**305**(8):218–22.

Straw 2003 *{published data only}*
Straw R, Kulkarni S, Attfield S, Wilton TJ. Posterior cruciate ligament at total knee replacement. Essential, beneficial or a hindrance?. *Journal of Bone and Joint Surgery. British Volume* 2003;**85**(5):671–4.

Tanzer 2002 *{published data only}*
Tanzer M, Smith K, Burnett S. Posterior-stabilized versus cruciate-retaining total knee arthroplasty: balancing the gap. *The Journal of Arthroplasty* 2002;**17**(7):813–9.

Wang 2004 *{published data only}*
Wang CJ, Wang JW, Chen HS. Comparing cruciate-retaining total knee arthroplasty and cruciate-substituting total knee arthroplasty: a prospective clinical study. *Chang Gung Medical Journal* 2004;**27(8)**:578–85.

Yagishita 2012 *{published data only}*
Yagishita K, Muneta T, Ju Y-J, Morito T, Yamazaki J, Sekiya I. High-flex posterior cruciate-retaining versus posterior cruciate-substituting designs in simultaneous bilateral total knee arthroplasty. *The Journal of Arthroplasty* 2012;**27**(3): 368–74.

References to studies excluded from this review

Aigner 2004 *{published data only}*
Aigner C, Windhager R, Pechmann M, Rehak P, Engeleke K. The influence of an anterior-posterior gliding mobile bearing on range of motion after total knee arthroplasty. A prospective randomized, double blinded study. *Journal of Bone and Joint Surgery. American Volume* 2004;**86**:2257–62.

Cope 2002 *{published data only}*
Cope MR, O'Brien BS, Nanu AM. The influence of the posterior cruciate ligament in the maintenance of joint line in primary total knee arthroplasty: a radiologic study. *The Journal of Arthroplasty* 2002;**17 (2)**:206–8.

Husain 1998 *{published data only}*
Hussain MRA, Fiddian NJ, Blakeway C, Kumar A, Kulkami S. The role of the posterior cruciate ligament in total knee replacement, a randomised comparison of posterior cruciate ligament preservation and sacrifice in a cruciate retaining prosthesis. *Journal of Bone and Joint Surgery. British Volume* 1998;**80 Suppl II**:209.

Ishii 2008 *{published data only}*
Ishii Y, Noguchi H, Matsuda Y, Takeda M, Kiga H, Toyabe S. Range of motion during the peri-operative period in

total knee arthroplasty. *Archives of Orthopaedic and Trauma Surgery* 2008;**128**:795–9.

Lee 2005 ***{published data only}***
Lee SY, Matsui N, Kurosaka M, Komistek RD, Mahfouz M, Dennis DA, et al. A posterior-stabilized total knee arthroplasty shows condylar lift-off during deep bends. *Clinical Orthopaedics and Related Research* 2005;**435**:181–4.

MacDonald 2005 ***{published data only}***
MacDonald SJ, Rorabeck CH, Marr JT, Clark CR, Swafford J, MacDonals DA. A multi-centred randomised controlled trial to compare posterior cruciate sparing versus posterior cruciate substitution in total knee arthroplasty. *Journal of Bone and Joint Surgery. British Volume* 2005;**87 Suppl III**: 339.

Matsuda 2003 ***{published data only}***
Matsuda Y, Ishii, Ishii R. In vivo laxity of LCS mobile bearing prostheses: a randomised prospective study of posterior cruciate ligament retaining versus sacrificing total knee arthroplasty. *The Journal of Arthroscopy and Related Surgery* 2003;**19**(6):96–7.

Matsuda 2005 ***{published data only}***
Matsuda Y, Ishii Y, Noguchi H, Ishii R. Varus-valgus balance and range of movement after total knee arthroplasty. *Journal of Bone and Joint Surgery. British Volume* 2005;**87**:804–8.

Surace 1997 ***{published data only}***
Surace FM, McNab ISH, Bentley G. "The PCL - to sacrifice or to preserve?" Prospective comparison of the Kinemax and PFC total knee systems. *Journal of Bone and Joint Surgery. British Volume* 1997;**79 Suppl II**:268.

Swanik 2004 ***{published data only}***
Swanik CB, Lephart SM, Rubasch HE. Proprioception, kinesthesia, and balance after total knee arthroplasty with cruciate-retaining and posterior stabilized prostheses. *Journal of Bone and Joint Surgery. American Volume* 2004; **86**:328–34.

Yamamoto 2003 ***{published data only}***
Yamamoto K, Ohkoshi Y, Nagasaki S, Hashimoto T, Yamane S. Comparion of posterior cruciate-retained and posterior stabilized total knee arthroplasty. *The Journal of Arthroscopy and Related Surgery* 2003;**19**(6 Suppl):96.

References to ongoing studies

ACTRN12609000960257 ***{unpublished data only}***
Cruciate retaining versus posterior stabilised total knee replacement: a randomised controlled trial. Ongoing study 01/11/2009.

ISRCTN05635855 ***{unpublished data only}***
Functional outcome in two different designs of knee replacements. Ongoing study 01/09/2007.

ISRCTN82612978 ***{unpublished data only}***
Posterior cruciate ligament and total knee arthroplasty: retain, sacrifice or substitute? A prospective, randomised clinical trial. Ongoing study 20/04/2006.

van den Boom 2009 ***{published data only}***
van den Boom LGH, Brouwer RW, van den Akker-Scheek I, Bulstra SK, van Raaij JAM. Retention of the posterior cruciate ligament versus the posterior stabilized design in total knee arthroplasty: a prospective randomized controlled clinical trial. *BMC Musculoskeletal Disorders* 2009;**10**:119. [NTR 1673]

Additional references

Abdel 2011
Abdel MP, Morrey ME, Jensen MR, Morrey BF. Increased long-term survival of posterior cruciate-retaining versus posterior cruciate-stabilizing total knee replacements. *Journal of Bone and Joint Surgery. American Volume* 2011; **93**:2072–8.

Atkins 2004
Atkins D, Best D, Briss PA, Eccles M, Falck-Ytter Y, Flottorp S, et al. Grading quality of evidence and strength of recommendations. *BMJ* 2004;**328**(7454):1490.

Baldini 2004
Baldini A, Scuderi GR, Aglietti P, Chalnick D, Insall JN. Flexion-extension gap changes during total knee arthroplasty: effect of posterior cruciate ligament and posterior osteophytes removal. *The Journal of Knee Surgery* 2004;**17**(2):69–72.

Becker 1991
Becker MW, Insall JN, Faris PM. Bilateral total knee arthroplasty. One cruciate retaining and one cruciate substituting. *Clinical Orthopaedics and Related Research* 1991;**271**:122–4.

Bolanos 1998
Bolanos AA, Colizza WA, McCann PD, Gotlin RS, Wootten ME, Kahn BA, et al. A comparison of isokinetic strength testing and gait analysis in patients with posterior cruciate retaining and substituting knee arthroplasties. *The Journal of Arthroplasty* 1998;**13**(8):906–15.

Cash 1996
Cash RM, Gonzalez MH, Garst J. Proprioception after arthroplasty: role of the posterior cruciate ligament. *Clinical Orthopaedics and Related Research* 1996;**331**:172–8.

Christen 2007
Christen B, Heesterbeek PJ, Wymenga AB, Wehrli U. Posterior cruciate ligament balancing in total knee replacement: the quantitative relationship between tightness of the flexion gap and tibial translation. *Journal of Bone and Joint Surgery. British Volume* 2007;**89**(8):1046–50.

de Jong 2010
de Jong RJ, Heesterbeek PJ, Wymenga AB. A new measurement technique for the tibiofemoral contact point in normal knees and knees with TKR. *Knee Surgery, Sports Traumatology, Arthroscopy* 2010;**18**(3):388–93.

Dennis 1998
Dennis DA, Komistek RD, Colwell CE Jr, Ranawat CS, Scott RD, Thornhill TS, et al. In vivo anteroposterior femorotibial translation of total knee arthroplasty: a

multicenter analysis. *Clinical Orthopaedics and Related Research* 1998;**356**:47–57.

Dennis 2003
Dennis DA, Komistek RD, Mahfouz MR, Haas BD, Stiehl JB. Multicenter determination of in vivo kinematics after total knee arthroplasty. *Clinical Orthopaedics and Related Research* 2003;**416**:37–57.

Dennis 2004
Dennis DA, Komistek RD, Mahfouz MR, Walker SA, Tucker A. A multicenter analysis of axial femorotibial rotation after total knee arthroplasty. *Clinical Orthopaedics and Relatated Research* 2004;**428**(11):180–9.

Emodi 1999
Emodi GJ, Callaghan JJ, Pedersen DR, Brown TD. Posterior cruciate ligament function following total knee arthroplasty: the effect of joint line elevation. *The Iowa Orthopaedic Journal* 1999;**19**:82–92.

Fleiss 1993
Fleiss JL. The statistical basis of meta-analysis. *Statistical Methods in Medical Research* 1993;**2**(2):121–45.

Garling 2005
Garling EH, Valstar ER, Nelissen GH. Comparison of micormotion in mobile bearing and posterior stabilized total knee protheses: a randomized RSA study of 40 knees followed for 2 years. *Acta Orthopaedica* 2005;**76**(3):353–61.

Heesterbeek 2010
Heesterbeek PJ, Wymenga AB. Correction of axial and rotational alignment after medial and lateral releases during balanced gap TKA. A clinical study in 54 patients. *Acta Orthopaedica* 2010;**81**(3):347–53.

Higgins 2011
Higgins JPT, Green S (editors). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. The Cochrane Collaboration, 2011. Available from www.cochrane-handbook.org.

Hirsch 1994
Hirsch HS, Lotke PA, Morrison LD. The posterior cruciate ligament in total knee surgery. Save, sacrifice, or substitute?. *Clinical Orthopaedics and Related Research* 1994;**309**:64–8.

Hogervorst 1998
Hogervorst T, Brand RA. Mechanoreceptors in joint function. *Journal of Bone and Joint Surgery. American Volume* 1998;**80**(9):1365–78.

Ishii 1998
Ishii Y, Terajima K, Koga Y. Gait analysis after total knee arthroplasty: comparison of posterior cruciate ligament retention and substitution. *The Journal of Orthopaedic Science* 1998;**3**(6):310–7.

Jacobs 2004
Jacobs WCH. Methodology and reporting of randomised controlled trials. *The Knee* 2004;**11**(6):423–5.

Jacobs 2004(2)
Jacobs W, Anderson P, Limbeek J, Wymenga A. Mobile bearing vs fixed bearing prostheses for posterior cruciate retaining total knee arthroplasty for post-operative functional status in patients with osteoarthritis and rheumatoid arthritis. *Cochrane Database of Systematic Reviews* 2004;**2**:CD003130.

Joglekar 2012
Joglekar S, Gioe TJ, Yoon P, Schwartz MH. Gait analysis comparison of cruciate retaining and substituting TKA following PCL sacrifice. *The Knee* 2012;**19**:279–85.

Kafer 2005
Kafer W, Fraitzl CR, Kinkel S, Clessienne CB, Puhl W, Kessler S. Outcome assessment in total knee arthroplasty: is the clinical measurement of range of motion a reliable measurable outcome variable? [Outcome–Messung in der Knieendoprothetik: Ist die klinische Bestimmung der Gelenkbeweglichkeit eine zuverlassig messbare Ergebnisgrosse?]. *Zeitschrift fur Orthopadie und Ihre Grenzgebiete* 2005;**143**(1):25–9.

Liberati 2009
Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotschze PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ* 2009;**339**:2700.

Lombardi 2001
Lombardi AV Jr, Mallory TH, Fada RA, Hartman JF, Capps SG, Kefauver CA, et al. An algorithm for the posterior cruciate ligament in total knee arthroplasty. *Clinical Orthopaedics and Related Research* 2001;**392**:75–87.

Mahoney 1994
Mahoney OM, Noble PC, Rhoads DD, Alexander JW, Tullos HS. Posterior cruciate function following total knee arthroplasty. A biomechanical study. *The Journal of Arthroplasty* 1994;**9**(6):569–78.

Maloney 1992
Maloney WJ, Schurman DJ. The effects of implant design on range of motion after total knee arthroplasty. Total condylar versus posterior stabilized total condylar designs. *Clinical Orthopaedics and Related Research* 1992;**278**: 147–52.

Migaud 2003
Migaud H, Tirveilliot F. Preservation, resection or substitution of the posterior cruciate ligament in total knee replacement. *Proceedings of the EFORT Congress. European Instructional Course Lectures* 2003;**6**:176–84.

Mihalko 1999
Mihalko WM, Krackow KA. Posterior cruciate ligament effects on the flexion space in total knee arthroplasty. *Clinical Orthopaedics and Related Research* 1999;**360**: 243–50.

Most 2003
Most E, Zayontz S, Li G, Otterberg E, Sabbag K, Rubash HE. Femoral rollback after cruciate-retaining and stabilizing total knee arthroplasty. *Clinical Orthopaedics and Related Research* 2003;**410**:101–13.

Nakama 2012
Nakama GY, Peccin MS, Almeida GJ, Lira Neto Ode A, Queiroz AA, Navarro RD. Cemented, cementless or hybrid fixation options in total knee arthroplasty for osteoarthritis and other non-traumatic diseases. *Cochrane Database of Systematic Reviews* 2012;**10**(17):CD006193.

Nelissen 2001
Nelissen RG, Hogendoorn PC. Retain or sacrifice the posterior cruciate ligament in total knee arthroplasty? A histopathological study of the cruciate ligament in osteoarthritic and rheumatoid disease. *Journal of Clinical Pathology* 2001;**54**(4):381–4.

Nozaki 2002
Nozaki H, Banks SA, Suguro T, Hodge WA. Observations of femoral rollback in cruciate-retaining knee arthroplasty. *Clinical Orthopaedics and Related Research* 2002;**404**: 308–14.

Pagnano 1998
Pagnano MW, Hanssen AD, Lewallen DG, Stuart MJ. Flexion instability after primary posterior cruciate retaining total knee arthroplasty. *Clinical Orthopaedics and Related Research* 1998;**356**(11):39–46.

Pereira 1998
Pereira DS, Jaffe FF, Ortiguera C. Posterior cruciate ligament-sparing versus posterior cruciate ligament-sacrificing arthroplasty. Functional results using the same prosthesis. *The Journal of Arthroplasty* 1998;**13**(2):138–44.

Pijls 2011
Pijls BG, Dekkers OM, Middeldorp S, Valstar ER, vd Heide HJ, vd Linden-vd Zwaag HM, et al. AQUILA: assessment of quality in lower lim arthroplasty. An expert Delphi consensus for total knee and hip arthroplasty. *BMC Musculoskeletal Disorders* 2011;**221**(12):173.

Rand 2003
Rand JA, Trousdale RT, Ilstrup DM, Harmsen WS. Factors affecting the durability of primary total knee prostheses. *Journal of Bone and Joint Surgery. American Volume* 2003; **85**:259–65.

Review Manager 2011 [Computer program]
The Nordic Cochrane Centre, The Cochrane Collaboration. Review Manager (RevMan). Version 5.0. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2008.

Simmons 1996
Simmons S, Lephart S, Rubash H, Borsa P, Barrack RL. Proprioception following total knee arthroplasty with and without the posterior cruciate ligament. *The Journal of Arthroplasty* 1996;**11**(7):763–8.

Stiehl 1997
Stiehl JB, Voorhorst PE, Keblish P. Comparisons of range of motion after posterior cruciate ligament retention of sacrifice with a mobile bearing total knee arthroplasty. *The American Journal of Knee Surgery* 1997;**10**(4):216–20.

Udomkiat 2000
Udomkiat P, Meng BJ, Dorr LD, Wan Z. Functional comparison of posterior cruciate retention and substitution knee replacement. *Clinical Orthopaedics and Related Research* 2000;**378**(9):192–201.

Victor 2005
Victor J, Banks S, Bellemans J. Kinematics of posterior cruciate ligament-retaining and -substituting total knee arthroplasty. A prospective randomised outcome study. *Journal of Bone and Joint Surgery. British Volume* 2005;**87**: 646–55.

Vinciguerra 1994
Vinciguerra B, Pascarel X, Honton JL. Results of total knee prostheses with or without preservation of the posterior cruciate ligament. *Revue de Chirurgie Orthopedique et Reparatrice de l'Appareil Moteur* 1994;**80**(4):620–5.

Waslewski 1998
Waslewski GL, Marson BM, Benjamin JB. Early, incapacitating instability of posterior cruciate ligament-retaining total knee arthroplasty. *The Journal of Arthroplasty* 1998;**13**(7):763–7.

Wolterbeek 2009
Wolterbeek N, Garling EH, Mertens B, Valstar ER, Nelissen RG. Mobile bearing knee kinematics change over time. A fluoroscopic study in rheumatoid arthritis patients. *Clinical Biomechanics* 2009;**24**(5):441–5.

Wolterbeek 2011
Wolterbeek N, Nelissen RG, Valstar ER. No differences in in vivo kinematics between six different types of knee prostheses. *Knee Surgery, Sports Traumatology, Arthroscopy* 2012;**20**(3):559–64.

Wood 2008
Wood L, Egger M, Gluud LL, Schulz KF, Juni P, Altman DG, et al. Empirical evidence of bias in treatment effect estimates in controlled trials with different interventions and outcomes: meta-epidemiological study. *BMJ* 2008;**336** (7644):601–5.

References to other published versions of this review

Jacobs 2005
Jacobs WCH, Clement DJ, Wymenga AAB. Retention versus sacrifice of the posterior cruciate ligament in total knee replacement for treatment of osteoarthritis and rheumatoid arthritis. *Cochrane Database of Systematic Reviews* 2005, Issue 4. DOI: 10.1002/14651858.CD004803.pub2

Jacobs 2005b
Jacobs WCH, Clement DJ, Wymenga AB. Retention versus removal of the posterior cruciate ligament in total knee replacement. *Acta Orthopaedica* 2005;**76**:757–68.

* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Aglietti 2005

Methods	Randomised controlled trial. Method of randomisation: quasi-randomisation by odd/even numbers
Participants	Group A: 103 knees (98 patients) Group B: 107 knees (99 patients) Inclusion: Not described (all osteoarthritic patients between Jan 1999 and Dec 2000) Exclusion: Not described Age: Group A 71 years, Group B 69.5 years Gender: Group A 86% female, Group B 81% female
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection + posterior stabilised Brand: LPS/MBK, Zimmer, Warsaw, Ind, USA Patella: resurfaced in all cases Bearing: Group A mobile bearing (MBK), Group B fixed bearing (LPS) Cement: Yes
Outcomes	VAS pain Patellar scoring system Knee Society roentgenographic evaluation system Radiolucencies Mechanical axis Knee Society score (functional and clinical) ROM
Notes	Mean duration of follow-up: 36 months (30-48) Funding source: not described

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Quasi-randomisation based on odd/even patient numbers
Allocation concealment (selection bias)	High risk	Quasi-randomisation based on odd/even patient numbers
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Due to the randomisation method blinding of treatment arm is not possible

Aglietti 2005 (*Continued*)

Blinding of participants and personnel (performance bias) All outcomes	Low risk	Authors state that evaluation during follow-up visit was blinded for type of arthroplasty
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Authors state that evaluation during follow-up visit was blinded for type of arthroplasty
Incomplete outcome data (attrition bias) All outcomes	Low risk	3 patients lost to follow-up at the final follow-up moment
Selective reporting (reporting bias)	Low risk	All outcome measures seem reported

Catani 2004

Methods	Randomised controlled trial. Method of randomisation, allocation concealment or blinding not described	
Participants	Group A: 20 knees/patients Group B: 20 knees/patients Inclusion: Not described (osteoarthritis selected) Exclusion: Not described Age: Group A 70 ± 6.0 (60 to 82), Group B 71 ± 7.0 (48 to 80) Gender: (M:F) Group A 7:13 (65% female), Group B 5:15 (75% female)	
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection + posterior stabilised Brand: Optetrak, Exactech, Gainesville, Fl, US Patella: Not described Bearing: Not described Cement: Yes	
Outcomes	Radiological: RSA Knee Society Score Hospital Special Surgery Score Range of motion	
Notes	Duration of follow-up: 2 years Follow-up rate: 100% Funding source: no external funding	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**

Catani 2004 (*Continued*)

Random sequence generation (selection bias)	Unclear risk	Not described
Allocation concealment (selection bias)	Unclear risk	Not described
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Not described
Blinding of participants and personnel (performance bias) All outcomes	High risk	For radiological outcomes (e.g. RSA), personnel (e.g. physicians) can see on the images what arthroplasty design was implanted
Blinding of outcome assessment (detection bias) All outcomes	High risk	For radiological outcomes (e.g. RSA), personnel (e.g. physicians) can see on the images what arthroplasty design was implanted
Incomplete outcome data (attrition bias) All outcomes	Low risk	Follow-up rate 100%
Selective reporting (reporting bias)	Low risk	All outcome measurements are reported

Chaudhary 2008

Methods	Randomised controlled trial. Method of randomisation: computer generated block randomisation; concealment of allocation: opaque envelopes; blinding: patients are blinded, physiotherapists measuring primary outcome were blinded
Participants	Group A: 51 knees/patients Group B: 49 knees/patients Inclusion: Osteoarthritis (primary total knee arthroplasty) Intact posterior cruciate ligament at surgery Exclusion: Inflammatory arthritis Bonegrafting required Varus/valgus deformity >15 degrees Previous high tibial osteotomy Unable to understand study requirements Age: Group A 69.2 ± 9.1, Group B 70.2 ± 8.4 Gender: Group A 53% female, Group B 45% female
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection + posterior stabilised Brand: SCORPIO total knee system, Stryker Orthopaedics, Mahwah, New Jersey, US

Chaudhary 2008 (*Continued*)

	Patella: Free to surgeon's indication Bearing: Not described Cement: Free to surgeon's indication	
Outcomes	ROM (flexion and extension) RAND-36 WOMAC total	
Notes	Duration of follow-up: 2 years. Follow-up rate: lost to follow-up n = 22 (22%) Funding source: industry funding is reported	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Block randomisation performed by computer
Allocation concealment (selection bias)	Low risk	Opaque envelopes
Blinding (performance bias and detection bias) All outcomes	Low risk	Blinding was performed
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Participants and physiotherapists measuring primary outcome were blinded for the randomisation outcome
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Physiotherapists measuring primary outcome were blinded for the randomisation outcome, radiologically the difference between posterior cruciate retaining and sacrificing implant designs is clear
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	22% lost to follow-up
Selective reporting (reporting bias)	Low risk	All outcome measures seem reported

Clark 2001

Methods	Randomised controlled trial. Multicentre, stratified by surgeon, method of randomisation, allocation concealment or blinding not described
Participants	Group A: 59 knees/patients Group B: 69 knees/patients Inclusion: Speaking English

Clark 2001 (*Continued*)

	57 to 89 years of age Osteoarthritis, osteoarthritis plus psoriasis, or fracture osteoarthritis Intact posterior cruciate ligament Exclusion: Previous total knee arthroplasty Patellectomy High tibial osteotomy Cruciate ligament reconstruction Knee sepsis Flexion <90 degrees Flexion contracture >15 degrees Willing to comply with the assessments Varus >20 and Valgus >15 degrees Age: Group A: 71.8 ±12.2, Group B 71.2 ±13.6 Gender: Not described
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection + posterior stabilised Brand: AMK, DePuy / Johnson & Johnson, Warsaw Indiana, US Patella: Yes Bearing: Not described Cement: Yes
Outcomes	Knee Society Score Range of motion SF-12 WOMAC total
Notes	Duration of follow-up: 6 weeks, 3 and 6 months and yearly thereafter Follow-up rate: 90% 1 year, 76% 2 years, 51% 3 years Post-traumatic OA N = 4 (is exclusion criterion for analysis in the review) Funding source: not described

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Not described
Allocation concealment (selection bias)	Unclear risk	Not described
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not described

Clark 2001 (*Continued*)

Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not described, radiologically the difference between posterior cruciate retaining and sacrificing implant designs is clear
Incomplete outcome data (attrition bias) All outcomes	High risk	Losses to follow-up augment with large steps each following year
Selective reporting (reporting bias)	Unclear risk	Only the total Knee Society Score was reported. It is more usual to report the clinical and functional score separately giving more insight in the nature of the possible differences between groups

de Andrade 2009

Methods	Randomised controlled trial. Method of randomisation and concealment of allocation not described. Blinding: evaluators were blinded for treatment allocation, surgeon was blind for clinical parameters. Statistician did not have contact with patients and/or surgical team
Participants	Group A: 36 knees/patients Group B: 49 knees/patients Inclusion: Not described Exclusion: Not described Age: 66.3 (41 to 78) Gender: (M:F) 22:63 (74% female)
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection Brand: Nexgen, Zimmer, Warsaw, Indiana, US Patella: Not described Bearing: Not described Cement: Not described
Outcomes	KSS (overall)
Notes	Original article in Portuguese, translated and data extracted by translator of Cochrane Musculoskeletal group, Canada Duration of follow-up: up to 15.8 months (6wk, 3 m, 6 m, final) Funding source: not described

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

de Andrade 2009 (*Continued*)

Random sequence generation (selection bias)	Unclear risk	Not described
Allocation concealment (selection bias)	Unclear risk	Not described
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Not described
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Observers blinded
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not described, radiologically the difference between posterior cruciate retaining and sacrificing implant designs is clear
Incomplete outcome data (attrition bias) All outcomes	Low risk	100% follow-up
Selective reporting (reporting bias)	Unclear risk	Only the total Knee Society Score was reported. It is more usual to report the clinical and functional score separately giving more insight in the nature of the possible differences between groups

Harato 2008

Methods	Randomised controlled trial. Method of randomisation: centralized, permuted blocks, concealment of allocation: closed envelopes, blinding: unclear
Participants	Group A: 111 knees (99 patients) Group B: 111 knees (93 patients) Inclusion: Degenerative osteoarthritis Macroscopically intact posterior cruciate ligament at surgery Exclusion: Reumatoid arthritis Osteonecrosis Previous high tibial osteotomy Previous patellectomy Previous cruciate ligament reconstruction Previous arthroscopic surgery Age: Group A 68.3 (49 to 89), Group B 66.0 (44 to 83) Gender: (M:F) Group A 65:34 (34% female), Group B 61:32 (34% female)

Harato 2008 (*Continued*)

Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection + posterior stabilised Brand: Genesis II, Smith & Nephew, Memphis, Tennessee, US Patella: Resurfaced Bearing: Not described Cement: Yes
Outcomes	Knee Society Score WOMAC total SF-12 Radiographic assessment (lucency at follow-up) Kinematics (in subset of patients published separately Victor et al 2005)
Notes	Duration of follow-up 5.0-7.3 years. Follow-up rate: lost to follow-up group A N=12 (10.8%), group B N=18 (16.2%) Data of a subset of patients from the study (the Belgian group) is published in another paper as well; Victor et al 2005 "Kinematics of posterior cruciate ligament retaining and -substituting total knee arthroplasty" Funding source: not described (not described in Victor et al 2005 as well)

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Centralized randomisation, using permutated randomisation blocks, randomisation per centre
Allocation concealment (selection bias)	Low risk	Closed envelopes
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Blinding unclear
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Blinding unclear
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Blinding unclear, radiologically the difference between posterior cruciate retaining and sacrificing implant designs is clear
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	13.5% lost to follow-up (N = 30), from this 16 participants deceased during follow-up
Selective reporting (reporting bias)	Low risk	It seems all outcomes are reported

Kim 2009

Methods	Randomised controlled trial. Method of randomisation: random distribution of envelopes, concealment of allocation and blinding: sealed envelope, however, all procedures were bilateral, the first knee received the treatment according to the envelope, the other knee the other treatment. Hence, the second allocation was not concealed. Clinical outcome measured by blinded evaluator
Participants	Group A: 250 knees Group B: 250 knees Inclusion: Bilateral osteoarthritis Exclusion: Inflammatory arthritis OA of the hip restricting mobility Foot or ankle disorder limiting mobility Dementia Neurological disorder: e.g. stroke, affecting mobility Age: 71.6 ± 6.0 (40 to 84) Gender: (M:F) 10:240 in total study population (96% female)
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection + posterior stabilised Brand: Nexgen, Zimmer, Warsaw, Indiana, US (CR-flex versus Legacy PS-flex) Patella: Yes Bearing: Fixed Cement: Yes
Outcomes	Range of motion Knee Society Score Hospital Special Surgery Score WOMAC pain score Radiological
Notes	Duration of follow-up: 2.3 years (2 to 3 years). Lost to follow-up: N = 6 (2.3%) All participants received continuous passive motion postoperatively Funding source: no external funding

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Randimisation via sealed envelopes, however unclear if these were shuffled
Allocation concealment (selection bias)	Low risk	Sealed envelopes. Note that treatment allocation of the contra-lateral knee was not concealed, however, investigator could not influence the allocation of treatment of the

Kim 2009 (*Continued*)

		first knee. There were no violations of the randomisation reported
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Since the treatment was bilateral, knowledge on the allocated intervention was available for the contralateral knee directly after first randomisation
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Clinical data obtained by researcher unfamiliar with randomisation outcome
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Clinical data obtained by researcher unfamiliar with randomisation outcome, however radiologically the difference between posterior cruciate retaining and sacrificing implant designs is clear
Incomplete outcome data (attrition bias) All outcomes	Low risk	Relatively little lost to follow-up: 2.3%
Selective reporting (reporting bias)	Low risk	Part of the data was reported in an appendix. It seems all data are reported

Maruyama 2004

Methods	Randomised controlled trial: quasi-randomisation: alternating sequences, bilateral procedures
Participants	Group A: 20 knees (10 patients) Group B: 20 knees (10 patients) Inclusion: bilateral procedure within 2 years Osteoarthritis Correction of alignment can be achieved with retention of the posterior cruciate ligament Exclusion: significant fixed deformity Age: 74.3 years (65-84) Gender: 12 female, 8 male (60% female)
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection + posterior stabilised Brand: PFC from DePuy / Johnson & Johnson, Warsaw, Indiana, US Patella: Not described Bearing: Not described Cement: Yes
Outcomes	Knee Society score Extension angle Flexion angle

Maruyama 2004 (*Continued*)

	Range of motion Joint line
Notes	Average follow-up: group A: 31.7 months (24-53), Group B: 30.6 (24-38) Follow-up rate: 100% Funding source: not described

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Quasi-randomisation based on alternating sequence
Allocation concealment (selection bias)	High risk	Quasi-randomisation based on alternating sequence
Blinding (performance bias and detection bias) All outcomes	High risk	Due to the method of randomisation adequate blinding is not possible
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not described
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not described
Incomplete outcome data (attrition bias) All outcomes	Low risk	100% follow-up
Selective reporting (reporting bias)	Low risk	All data seems reported

Matsumoto 2012

Methods	Randomised controlled trial. Randomisation according to the envelope technique. Opaqueness of envelopes not described
Participants	Group A: 25 knees/patients Group B: 25 knees/patients Inclusion: Pain and loss of function due to osteoarthritis Exclusion: Valgus deformity Sever bony defect needing augmentation or bone grafting Revision total knee arthroplasty Active joint infection Bilateral procedures Age: Group A: 73.5 ± 1.3 years, Group B: 74.4 ± 0.9 years

Matsumoto 2012 (*Continued*)

	Gender: 100% females in both groups
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection + posterior stabilised Brand: NexGen CR/LPS flex, Zimmer, Warsaw, Ind, USA Patella: Yes Bearing: Not described Cement: Not described
Outcomes	Range of motion Knee Society clinical/functional score Coronal laxity
Notes	Mean follow-up: Group A: 71.9 (61-83) months, Group B: 70.2 (63-87) months After 5 years lost to follow-up: Group A: 6 patients, Group B: 3 patients Funding source: not described

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Not described how the order of envelopes was generated
Allocation concealment (selection bias)	High risk	The envelope technique is known to be prone to errors
Blinding (performance bias and detection bias) All outcomes	Unclear risk	The envelope technique does not guarantee blindness
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Outcome measurements were performed by blinded observers
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Outcome measurements were performed by blinded observers
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Group A had 24% loss to follow-up and Group B 12% after 5 years
Selective reporting (reporting bias)	Low risk	All data seem reported

Misra 2003

Methods	Randomised controlled trial. Table generated randomisation sequence, observer blinded. Method of allocation concealment not described
Participants	Group A: 51 knees (50 patients) Group B: 54 knees (53 patients) Inclusion: Not described (osteoarthritis/rheumatoid arthritis selected) Exclusion: Not described Age: Group A 66.8 (55 to 83), Group B 67.2 (59 to 82) Gender: (M:F) Group A 17:34 (67% female), Group B 22:32 (59% female)
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection Brand: Press Fit Condylar (PFC), DePuy, Warsaw Indina, US. Both groups same design Patella: Criteria for resurfacing (resurfaced in 48 knees) Bearing: Not described Cement: Yes
Outcomes	Hospital Special Surgery Score Range of motion Satisfaction (score 1 to 10) Radiological: rollback and loosening
Notes	Duration of follow-up: 57 months Follow-up rate: 81% Funding source: no external funding

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Random numbers table used
Allocation concealment (selection bias)	Unclear risk	Not described
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Not clearly described
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Clinical measurements performed by blinded personnel
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Clinical measurements performed by blinded personnel, however radiologically the difference between posterior cruciate retaining and sacrificing implant designs is

Misra 2003 (*Continued*)

		clear
Incomplete outcome data (attrition bias) All outcomes	Low risk	81% follow-up rate, random losses to follow-up, analysed and described in paper
Selective reporting (reporting bias)	Low risk	It seems all outcome measures were reported

Roh 2012

Methods	Randomised controlled trial. Permuted block randomisation. Same arthroplasty design was applied in both treatment arms (deep dish), intention-to-treat analysis
Participants	Group A: 42 knees knees/patients Group B: 44 knees knees/patients Inclusion: Primary osteoarthritis Exclusion: Previous surgery to the affected knee Age: Group A: 69.8 ± 4.7, Group B: 71.0 ± 4.9 Gender: Group A: M:F 2:40 (95% female), Group B: M:F 3:41 (93% female)
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection Brand: E-motion TKA system, B. Braun Aesculap, Tuttlingen, Germany Patella: Some (Group A: 8, Group B: 6) Bearing: Mobile bearing, rotating Cement: Yes
Outcomes	Range of motion Flexion angle Tibiofemoral angle Knee Society clinical/functional score Hospital for Special Surgery score WOMAC total
Notes	Mean follow-up: Group A: 27.3 ± 3.7 months. Group B: 32.2 ± 4.8 months Group A 3 patients lost (6.7%), Group B 1 patient lost (2.2%) Funding source: not described

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Using permutated blocks
Allocation concealment (selection bias)	Unclear risk	Not described

Roh 2012 (*Continued*)

Blinding (performance bias and detection bias) All outcomes	Unclear risk	Not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not described
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not described
Incomplete outcome data (attrition bias) All outcomes	Low risk	Few patients lost to follow-up
Selective reporting (reporting bias)	Low risk	All data seem reported

Seon 2011

Methods	Randomised controlled trial. Randomisation and concealment of allocation: sealed envelopes, blinding: clinical data acquired by unblinded evaluators, radiological measurements performed by evaluators unaware of clinical status of participants
Participants	Group A: 48 knees/patients Group B: 47 knees/patients Inclusion: Osteoarthritis Minimal range of motion >90 degrees or 90 degrees Excusion: Previous open surgery with placement of metallic implants History of revision total knee arthroplasty Other than osteoarthritis as indication diagnosis Restricted mobility Severe pain after contralateral total knee arthroplasty Age: Group A 68.2 ± 7.0 (54 to 85), Group B 69.1 ± 6.7 (56 to 81) Gender: (M:F) 9:86 in total study population
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection + posterior stabilised Brand: Nexgen, Zimmer, Warsaw Indiana, US Patella: Not resurfaced Bearing: Not described Cement: Yes
Outcomes	Range of motion (incl weight-bearing and non-weight-bearing maximal flexion) Hospital Special Surgery Score WOMAC total Femorotibial angles

Seon 2011 (*Continued*)

	Tibiofemoral kinematics: femoral rollback and tibial rotation
Notes	Duration of follow-up: 2 years, loss to follow-up group A N = 3 (5.9%), group B N = 4 (7.8%) Funding source: no external funding

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Pile of sealed envelopes, unclear if and how they were shuffled
Allocation concealment (selection bias)	Low risk	Sealed envelopes
Blinding (performance bias and detection bias) All outcomes	High risk	Blinding is not performed ("all range of motion and clinical data obtained were evaluated and recorded by two independent evaluators who were part of the surgical team")
Blinding of participants and personnel (performance bias) All outcomes	High risk	Blinding is not performed
Blinding of outcome assessment (detection bias) All outcomes	High risk	Blinding is not performed, radiologically the difference between posterior cruciate retaining and sacrificing implant designs is clear
Incomplete outcome data (attrition bias) All outcomes	Low risk	6.9% (N=7) participants lost to follow-up: reasonable
Selective reporting (reporting bias)	Low risk	All outcome measures seem reported

Shoji 1994

Methods	Randomised controlled trial. Bilateral procedures, method of randomisation, allocation concealment or blinding not described
Participants	Group A: 28 knees/patients Group B: 28 knees/patients Inclusion: Not described (osteoarthritis/rheumatoid arthritis selected) Exclusion: Not described Age: Not described Gender: Not described

Shoji 1994 (*Continued*)

Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection Brand: Total Condylar Modifier, Biomed, Warsaw Indiana, US, both groups similar design Patella: Not described Bearing: Not described Cement: Not described
Outcomes	Hospital Special Surgery Score HSS pain subscore HSS muscle power subscore Range of motion
Notes	Duration of follow-up: 2.5 to 4.5 years (3.2 years average) Follow-up rate: 100% Funding source: not described

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Not described
Allocation concealment (selection bias)	Unclear risk	Not described
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not described
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not described, radiologically the difference between posterior cruciate retaining and sacrificing implant designs is clear
Incomplete outcome data (attrition bias) All outcomes	Low risk	100% follow-up rate
Selective reporting (reporting bias)	Low risk	It seems all outcome measures are reported

Straw 2003

Methods	Randomised controlled trial. Observer blinded, method of randomisation or allocation concealment not described
Participants	Group A: 66 Group B: 101 Total 188 patients participating Inclusion: Not described (osteoarthritis/rheumatoid arthritis selected) Exclusion: Not described Age: Group cruciate-retaining: 72.6, Group PS: 72.6, Group ligament resection: 74.1 Gender: (M:F) Group A: 37:29, Group PS: 32:27, Group B: 20:22
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection: further randomised to posterior stabilised or standard total knee arthroplasty design Brand: Genesis I, Smith & Nephew, Memphis, Tennessee, US Patella: Yes Bearing: Not described Cement: Not described
Outcomes	Knee Society Score Range of motion Pain score Antero-posterior / medio-lateral stability
Notes	Duration of follow-up: 1 to 6.5 years (3.5 years average) Follow-up rate: 89% Funding source: no external funding

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Not described
Allocation concealment (selection bias)	Unclear risk	Not described
Blinding (performance bias and detection bias) All outcomes	Low risk	Observer is blinded
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Observer is blinded

Straw 2003 (*Continued*)

Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Radiologically the difference between posterior cruciate retaining and sacrificing implant designs is clear
Incomplete outcome data (attrition bias) All outcomes	Low risk	Reasonable follow-up rate
Selective reporting (reporting bias)	Low risk	It seems all outcome measures are reported

Tanzer 2002

Methods	Randomised controlled trial. Patient and observer blinded, method of randomisation or allocation concealment not described
Participants	Group A: 20 knees Group B: 20 knees A total of 37 patients participated in the study Inclusion: Not described (osteoarthritis, rheumatoid arthritis, avascular necrosis selected) Exclusion: Not described Age: Group A: 68 (51 to 86), Group B: 66 (52 to 77) Gender: (M:F) Group A 5:15 (75% female), Group B 4:16 (80% female)
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection + posterior stabilised Brand: Retention: Nexgen; Posterior stabilised: Legacy Zimmer, Warsaw Indiana, US Patella: Partly (Group A n = 18, Group B n = 17) Bearing: Not described Cement: Yes
Outcomes	Knee Society Score clinical Knee Society Score functional Flexion
Notes	Duration of follow-up: (6 weeks, 3 and 6 months, and 1 and) 2 years Follow-up rate: 100% Funding source: no external funding

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Not described
Allocation concealment (selection bias)	Unclear risk	Not described

Tanzer 2002 (*Continued*)

Blinding (performance bias and detection bias) All outcomes	Unclear risk	Patient and observer blinded
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Patient and observer blinded
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Patient and observer blinded, radiologically the difference between posterior cruciate retaining and sacrificing implant designs is clear
Incomplete outcome data (attrition bias) All outcomes	Low risk	100% follow-up
Selective reporting (reporting bias)	Low risk	It seems all outcome measures are reported

Wang 2004

Methods	Randomised controlled trial. Quasi-randomisation; randomisation based on hospital admission Due to an inventory shortage of cruciate substituting arthroplasties more patient received a cruciate retaining arthroplasty. No intention-to-treat analysis is reported
Participants	Group A: 157 knees (137 patients) Group B: 110 knees (91 patients) Inclusion: osteoarthrtitis and rheumatoid arthritis (rheumatoid: Group A: 20 knees, Group B: 3) Exclusion: Not described Age: Group A: 54.5 (31-69), Group B: 55 (20-83) Gender: Group A: M:F 45:183 (80% female), Group B: M:F 27:110 (80% female)
Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection Brand: PFC, Johnson & Johnson, Ryndum, Mass, USA Patella: No Bearing: Not described Cement: Yes
Outcomes	Knee Society clinical/functional/pain score Tibiofemoral angle Flexion/extension angle Radiolucencies (%) SF-12 functional score Ligament laxity

Wang 2004 (*Continued*)

Notes	Lost to follow-up: 42 patients (43 knees) 16% at 2 years follow-up Average follow-up: 42 ± 18 months (range 24 to 66 months) Funding source: non-commercial grant from National Science Council reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Quasi-randomisation based on hospital admission
Allocation concealment (selection bias)	High risk	Quasi-randomisation based on hospital admission
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Due to the quasi-randomisation method treatment arms cannot be adequately blinded
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not described
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not described
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	16% loss to follow-up at 2 years
Selective reporting (reporting bias)	Low risk	All data seem reported

Yagishita 2012

Methods	Randomised controlled trial. Method of randomisation, concealment of allocation and blinding not described
Participants	Group A: 29 knees Group B: 29 knees 29 patients participated; bilateral procedures were studied Inclusion: Osteoarthritis bilateral (with the same K&L grade in both knees) Exclusion: Osteoarthritis of hip or ankle resulting in restricted walking Neurological deficits resulting in restricted walking If an augmentation procedure was necessary Age: 74.3 ± 7.2 (58 to 91) Gender (M:F): 4:25 (86% female)

Yagishita 2012 (*Continued*)

Interventions	Posterior cruciate ligament: Group A: Retention Group B: Resection + posterior stabilised Brand: NexGen (Zimmer, Warsaw, Ind) Patella: Not described Bearing: Not described Cement: Not described
Outcomes	Knee Society Score Clinical Knee Society Score Functional Pain (including VAS) Range of motion Radiological: radiolucency
Notes	Mean follow-up: 5.0 ± 0.7 (3y to 6y) Follow-up rate: 90% (at three years after operation) Ligament balancing in extension and flexion was performed Funding source: no external funding

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Sequence generation is not described
Allocation concealment (selection bias)	Unclear risk	There is no method described how allocation was concealed, furthermore since surgery was bilateral the allocation of the contralateral knee was never concealed
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not described
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not described, radiologically the difference between posterior cruciate retaining and sacrificing implant designs is clear
Incomplete outcome data (attrition bias) All outcomes	Low risk	10% (N = 3) lost to follow-up after 3 years including 1 (N = 3.5%) deceased during follow-up
Selective reporting (reporting bias)	Low risk	It seems all outcome measures are reported

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Aigner 2004	Intervention is not focused on retention versus removal of the posterior cruciate ligament. Information could not be extracted adequately
Cope 2002	< 12 months follow-up
Husain 1998	Conference proceedings
Ishii 2008	< 12 months follow-up; latest outcome measure at discharge
Lee 2005	Unclear if the study is a randomised trial
MacDonald 2005	Conference proceedings
Matsuda 2003	Conference proceedings
Matsuda 2005	Unclear if the study is a randomised trial
Surace 1997	Conference proceedings
Swanik 2004	< 12 months follow-up
Yamamoto 2003	Conference proceedings

Characteristics of ongoing studies *[ordered by study ID]*

ACTRN12609000960257

Trial name or title	Cruciate retaining versus posterior stabilised total knee replacement: a randomised controlled trial
Methods	Randomised controlled trial
Participants	Target N = 60 Including both osteoarthritis and rheumatoid arthritis Exclusion criteria: Tibial deformity (including past fracture or high tibial osteotomy) Valgus deformity < 40 years old and > 90 years old
Interventions	Group A: total knee arthroplasty cruciate-retaining Group B: total knee arthroplasty posterior stabilised

ACTRN12609000960257 (*Continued*)

Outcomes	Primary outcome: Active range of motion measured with goniometer Oxford Knee Score (knee function) Secondary outcome: 6 minute walking test
Starting date	01/11/2009
Contact information	tibialalignment@gmail.com (Riaz Kahn)
Notes	

ISRCTN05635855

Trial name or title	Functional outcome in two different designs of knee replacements
Methods	Randomised controlled trial
Participants	Target N = 90 Inclusion criteria: Osteoarthritis able to flex the knee 90 degrees or more Exclusion criteria: Inflammatory poly-arthritis Disorders of feet, ankles, hips or spine causing abnormal gait or significant pain Dementia Severe visual impairment Neurological conditions affecting movement Inability to give informed consent Any other disorders of the contralateral knee causing abnormal gait or significant pain
Interventions	Group A: PFC Sigma (DePuy Int, UK) fixed bearing posterior cruciate ligament preserving arthroplasty Group B: PFC Sigma (DePuy Int, UK) posterior stabilised mobile bearing arthroplasty
Outcomes	Primary outcome: Knee excursion during functional activities as measured using electrogoniometry Secondary outcomes: Passive knee range of motion Flexor and extensor strength as measured using a MIE myometer Knee Society Score WOMAC total SF-36 quality of life survey Pain (visual analogue scale) Walking speed Physical activity measured with activity monitor Canadian Occupational Performance Measure
Starting date	01/09/2007

ISRCTN05635855 (*Continued*)

Contact information	mvanderlinden@gmu.ac.uk
Notes	Funded by DePuy Int Ltd (UK)

ISRCTN82612978

Trial name or title	Posterior cruciate ligament and total knee arthroplasty: retain, sacrifice or substitute? A prospective, randomised clinical trial
Methods	Randomised controlled trial
Participants	Target N = 285 Inclusion criteria: Primary osteoarthritis planned for total knee arthroplasty Operation can be performed using total condylar knee Collateral (ligaments) are intact Axis at least one degree varus Age 18 to 80 years old Patient speaks Finnish Exclusion criteria: Secondary osteoarthritis Arthroplasty of other knee or of the ankle preceding 12 months Simultaneous one-stage total knee arthroplasty Patient has undergone surgery of the other hip, knee or ankle with unsatisfactory outcome Malignancy Cortisone or immunosuppressive medication use Impaired co-operation Impairment of mobility due to systemic disease BMI > 40 Fertile women who are planning to give birth during the study Previous knee surgery (either open or arthroscopic) Permanent patellar dislocation Extra-articular deformity Mechanical axis >15 degrees varus or valgus
Interventions	Group A: Posterior cruciate ligament retaining total knee arthroplasty Group B: Posterior cruciate ligament excised, but not replaced Group C: Posterior cruciate ligament excised, and posterior stabilised design
Outcomes	Primary outcome: Total knee function questionnaire Visual Analogue Scale for satisfaction (2, 5 and 10 years after surgery) Secondary outcome: WOMAC total 20 metre walking test 3 metre up and go test Quality of life Oxford Knee Score

ISRCTN82612978 (*Continued*)

Starting date	20/04/2006
Contact information	ville.remes@hus.fi
Notes	

van den Boom 2009

Trial name or title	Retention of the posterior cruciate ligament versus the posterior stabilised design in total knee arthroplasty: a prospective randomised controlled clinical trial
Methods	Randomised controlled trial. Group A: Retention of the posterior cruciate ligament Group B: Resection of the posterior cruciate ligament + posterior stabilised design
Participants	Target N = 120
Interventions	Group A: posterior cruciate ligament retaining Group B: posterior cruciate ligament sacrificing, posterior stabilised
Outcomes	Perceived outcome measures, range of motion, Knee Score, quality of life, gait parameters and femoral rollback
Starting date	01-01-2008
Contact information	l.vandenboom@home.nl
Notes	NTR (Dutch Trial Registry) 1673

DATA AND ANALYSES

Comparison 1. Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Range of motion	11	1440	Mean Difference (IV, Random, 95% CI)	-2.37 [-4.61, -0.13]
2 Flexion angle	9	915	Mean Difference (IV, Random, 95% CI)	-1.47 [-3.15, 0.21]
3 Extension angle	7	734	Mean Difference (IV, Random, 95% CI)	0.36 [-0.61, 1.32]
4 VAS pain	2	268	Mean Difference (IV, Random, 95% CI)	1.50 [-1.84, 4.84]
5 Knee pain (KSS pain)	4	1004	Mean Difference (IV, Random, 95% CI)	0.01 [-1.40, 1.43]
6 WOMAC total	4	531	Mean Difference (IV, Random, 95% CI)	0.78 [-1.51, 3.07]
7 Knee Society Clinical score	11	1637	Mean Difference (IV, Random, 95% CI)	-0.08 [-0.93, 0.77]
8 Knee Society Function Score	9	1539	Mean Difference (IV, Random, 95% CI)	-2.32 [-4.26, -0.37]
9 Hospital Special Surgery Score	6	882	Mean Difference (IV, Random, 95% CI)	-0.51 [-1.55, 0.54]
10 Knee Society Score overall	2	213	Mean Difference (IV, Random, 95% CI)	-0.39 [-10.80, 10.03]
11 SF-12 mental	2	350	Mean Difference (IV, Random, 95% CI)	0.41 [-5.08, 5.89]
12 Radiological: Radiolucent lines	5	754	Risk Ratio (M-H, Random, 95% CI)	0.86 [0.68, 1.07]
13 Radiological: Femorotibial angle	7	1170	Mean Difference (IV, Random, 95% CI)	0.36 [-0.08, 0.79]
14 Radiological: Rollback (in mm)	2	110	Mean Difference (IV, Random, 95% CI)	2.78 [-9.57, 15.13]
15 Radiological: Tibial slope	2	98	Mean Difference (IV, Random, 95% CI)	-0.37 [-1.21, 0.48]

Comparison 2. Posterior cruciate ligament retention versus sacrifice (using the same arthroplasty design)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Range of motion	4	372	Mean Difference (IV, Random, 95% CI)	-2.70 [-8.71, 3.32]
2 Improvement of range of motion	2	161	Mean Difference (IV, Random, 95% CI)	1.92 [-6.25, 10.08]

Comparison 3. Posterior cruciate ligament retention versus posterior stabilised sacrifice

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Range of motion	8	1193	Mean Difference (IV, Random, 95% CI)	-3.43 [-6.32, -0.54]
2 Flexion angle	7	605	Mean Difference (IV, Random, 95% CI)	-2.07 [-4.17, 0.04]
3 Extension angle	6	438	Mean Difference (IV, Random, 95% CI)	0.03 [-0.66, 0.73]
4 VAS pain	2	268	Mean Difference (IV, Random, 95% CI)	1.50 [-1.84, 4.84]
5 Knee pain (KSS pain)	3	750	Mean Difference (IV, Random, 95% CI)	0.60 [-0.39, 1.60]
6 WOMAC total	3	395	Mean Difference (IV, Random, 95% CI)	1.59 [-1.32, 4.50]
7 Knee Society Clinical score	8	1110	Mean Difference (IV, Random, 95% CI)	0.16 [-1.11, 1.43]

8 Knee Society Functional score	6	1012	Mean Difference (IV, Random, 95% CI)	-1.42 [-4.66, 1.82]
9 Hospital Special Surgery score	3	635	Mean Difference (IV, Random, 95% CI)	-0.55 [-2.11, 1.01]
10 Knee Society total score	2	193	Mean Difference (IV, Random, 95% CI)	-0.38 [-11.23, 10.47]
11 SF-12 mental	2	300	Mean Difference (IV, Random, 95% CI)	0.39 [-5.10, 5.87]
12 Radiological: Radiolucent lines	4	500	Odds Ratio (M-H, Random, 95% CI)	0.80 [0.47, 1.35]
13 Radiological: Femorotibial angle	4	693	Mean Difference (IV, Random, 95% CI)	0.09 [-0.29, 0.47]
14 Radiological: Rollback	2	110	Mean Difference (IV, Random, 95% CI)	2.78 [-9.57, 15.13]
15 Radiological: Tibial slope	2	98	Mean Difference (IV, Random, 95% CI)	-0.37 [-1.21, 0.48]

Analysis 1.1. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 1 Range of motion.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

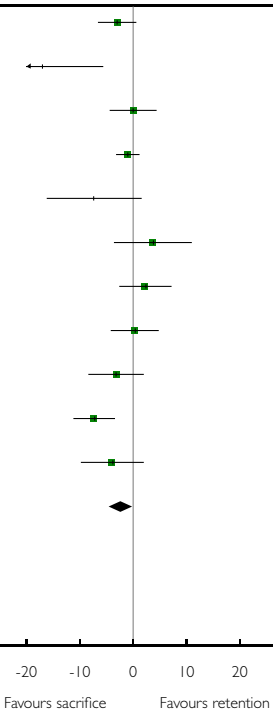
Outcome: 1 Range of motion

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Aglietti 2005	103	110 (11.6)	107	113 (14.3)		12.3 %	-3.00 [-6.52, 0.52]
Catani 2004	20	97 (15)	20	114 (21)		3.2 %	-17.00 [-28.31, -5.69]
Clark 2001 (1)	59	108.5 (11.6)	69	108.5 (14.3)		10.3 %	0.0 [-4.49, 4.49]
Kim 2009 (2)	250	132 (11.6)	250	133 (14.3)		14.9 %	-1.00 [-3.28, 1.28]
Maruyama 2004	20	122.2 (14.8)	20	129.6 (13.9)		4.7 %	-7.40 [-16.30, 1.50]
Matsumoto 2012	25	125.3 (11.6)	25	121.6 (14.3)		6.2 %	3.70 [-3.52, 10.92]
Misra 2003 (3)	51	107.5 (11.6)	54	105.2 (14.3)		9.4 %	2.30 [-2.67, 7.27]
Roh 2012	42	124.3 (9.1)	44	124 (11.9)		10.4 %	0.30 [-4.17, 4.77]
Shoji 1994	28	114.2 (9.5)	28	117.4 (10.3)		9.1 %	-3.20 [-8.39, 1.99]
Straw 2003 (4)	66	102.7 (11.6)	101	110 (14.3)		11.4 %	-7.30 [-11.25, -3.35]
Yagishita 2012	29	125.4 (10.9)	29	129.3 (11.7)		8.1 %	-3.90 [-9.72, 1.92]
Total (95% CI)	**693**		**747**			**100.0 %**	**-2.37 [-4.61, -0.13]**

Heterogeneity: Tau² = 7.39; Chi² = 23.80, df = 10 (P = 0.01); I² =58%

Test for overall effect: Z = 2.07 (P = 0.038)

Test for subgroup differences: Not applicable



(1) at three years follow-up, weighted average sd from reported sd's in studies (Catani Yagishita Shoji)

(2) Weighted average sd from reported sd's in studies (Catani Yagishita Shoji)

(3) Weighted average sd from reported sd's in studies (Catani Yagishita Shoji)

(4) Weighted average sd from reported sd's in studies (Catani Yagishita Shoji)

Analysis 1.2. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 2 Flexion angle.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

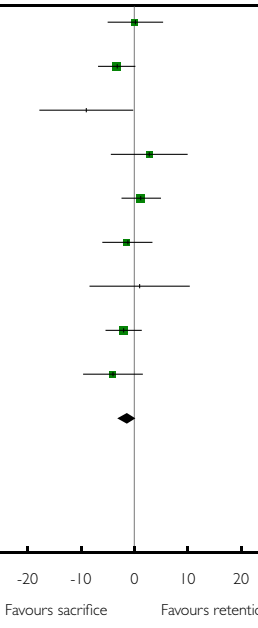
Outcome: 2 Flexion angle

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Chaudhary 2008 (1)	51	105.9 (13)	49	105.8 (13.5)		9.7 %	0.10 [-5.10, 5.30]
Harato 2008 (2)	111	113.7 (12.8)	111	117 (13.5)		20.1 %	-3.30 [-6.76, 0.16]
Maruyama 2004	20	122.3 (15)	20	131.3 (13.4)		3.5 %	-9.00 [-17.82, -0.18]
Matsumoto 2012	25	126.1 (12.6)	25	123.3 (13.3)		5.3 %	2.80 [-4.38, 9.98]
Roh 2012	42	126.7 (7.1)	44	125.5 (10.2)		17.9 %	1.20 [-2.50, 4.90]
Seon 2011 (3)	48	128.2 (12.2)	47	129.5 (10.9)		11.9 %	-1.30 [-5.95, 3.35]
Tanzer 2002 (4)	20	112 (13)	20	111 (17)		3.1 %	1.00 [-8.38, 10.38]
Wang 2004	128	110 (12.6)	96	112 (13.3)		20.2 %	-2.00 [-5.44, 1.44]
Yagishita 2012	29	125.7 (10.7)	29	129.7 (11.3)		8.3 %	-4.00 [-9.66, 1.66]
Total (95% CI)	**474**		**441**			**100.0 %**	**-1.47 [-3.15, 0.21]**

Heterogeneity: $Tau^2 = 0.55$; $Chi^2 = 8.71$, df = 8 (P = 0.37); $I^2 = 8\%$

Test for overall effect: Z = 1.71 (P = 0.087)

Test for subgroup differences: Not applicable



(1) 2y postop

(2) min. 5y postop

(3) min. 2y postop

(4) 2y postop

Analysis 1.3. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 3 Extension angle.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

Outcome: 3 Extension angle

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Chaudhary 2008 (1)	51	-1.2 (2.5)	49	-2.2 (3.5)		13.3 %	1.00 [-0.20, 2.20]
Harato 2008 (2)	111	0.8 (2.1)	111	1.6 (1.5)		16.1 %	-0.80 [-1.28, -0.32]
Maruyama 2004	20	0.3 (1.3)	20	0.9 (2)		14.0 %	-0.60 [-1.65, 0.45]
Matsumoto 2012	25	-0.8 (2.1)	25	-1.7 (2)		13.6 %	0.90 [-0.24, 2.04]
Tanzer 2002 (3)	20	1 (2.2)	20	1 (1.8)		13.1 %	0.0 [-1.25, 1.25]
Wang 2004	128	-1 (2.1)	96	-2.8 (2)		15.9 %	1.80 [1.26, 2.34]
Yagishita 2012	29	-0.1 (2)	29	-0.3 (2)		14.1 %	0.20 [-0.83, 1.23]
Total (95% CI)	**384**		**350**			**100.0 %**	**0.36 [-0.61, 1.32]**

Heterogeneity: $Tau^2 = 1.45$; $Chi^2 = 55.20$, df = 6 ($P<0.00001$); $I^2 = 89\%$

Test for overall effect: Z = 0.73 (P = 0.47)

Test for subgroup differences: Not applicable

(1) 2y postop

(2) min 5y postop

(3) 2y postop

Analysis 1.4. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 4 VAS pain.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

Outcome: 4 VAS pain

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Aglietti 2005	103	10 (13.9)	107	8 (14)		78.4 %	2.00 [-1.77, 5.77]
Yagishita 2012	29	4.7 (13.9)	29	5 (14)		21.6 %	-0.30 [-7.48, 6.88]
Total (95% CI)	**132**		**136**			**100.0 %**	**1.50 [-1.84, 4.84]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.31$, df = 1 (P = 0.58); $I^2 = 0.0\%$

Test for overall effect: Z = 0.88 (P = 0.38)

Test for subgroup differences: Not applicable

Analysis 1.5. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 5 Knee pain (KSS pain).

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

Outcome: 5 Knee pain (KSS pain)

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Harato 2008	111	44.5 (9.7)	111	42.3 (14.6)		12.7 %	2.20 [-1.06, 5.46]
Kim 2009 (1)	250	48.2 (8.6)	250	48.3 (12.9)		22.6 %	-0.10 [-2.02, 1.82]
Yagishita 2012	29	49.7 (1.9)	29	49 (2.8)		29.9 %	0.70 [-0.53, 1.93]
Wang 2004	128	48.3 (4)	96	49.6 (1.4)		34.9 %	-1.30 [-2.05, -0.55]
Total (95% CI)	**518**		**486**			**100.0 %**	**0.01 [-1.40, 1.43]**

Heterogeneity: $Tau^2 = 1.35$; $Chi^2 = 10.74$, df = 3 (P = 0.01); $I^2 = 72\%$

Test for overall effect: Z = 0.02 (P = 0.99)

Test for subgroup differences: Not applicable

(1) Weighted average sd from reported sd's in studies

Analysis 1.6. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 6 WOMAC total.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

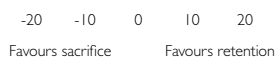
Outcome: 6 WOMAC total

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Clark 2001	59	22.8 (35.4)	69	18.5 (32.9)		3.7 %	4.30 [-7.61, 16.21]
Harato 2008	111	10.4 (13.4)	111	8.5 (12.3)		45.8 %	1.90 [-1.48, 5.28]
Roh 2012	42	15.9 (8.6)	44	17 (10.7)		31.3 %	-1.10 [-5.19, 2.99]
Seon 2011	48	28.4 (13.8)	47	27.9 (12.2)		19.1 %	0.50 [-4.74, 5.74]
Total (95% CI)	**260**		**271**			**100.0 %**	**0.78 [-1.51, 3.07]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.58$, df = 3 (P = 0.66); $I^2 = 0.0\%$

Test for overall effect: Z = 0.67 (P = 0.50)

Test for subgroup differences: Not applicable



Analysis 1.7. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 7 Knee Society Clinical score.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

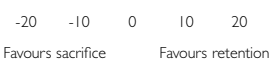
Outcome: 7 Knee Society Clinical score

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Aglietti 2005	103	91 (11.5)	107	91 (13.3)		6.4 %	0.0 [-3.36, 3.36]
Catani 2004	20	89 (10)	20	90 (9)		2.1 %	-1.00 [-6.90, 4.90]
Harato 2008	111	90.8 (13)	111	90.4 (15.7)		5.0 %	0.40 [-3.39, 4.19]
Kim 2009 (1)	250	94 (11.5)	250	95 (13.3)		15.1 %	-1.00 [-3.18, 1.18]
Maruyama 2004	20	89.8 (7.2)	20	89.5 (8.9)		2.9 %	0.30 [-4.72, 5.32]
Matsumoto 2012	25	95.7 (11.5)	25	92.9 (13.3)		1.5 %	2.80 [-4.09, 9.69]
Roh 2012	42	95.7 (6.4)	44	94.6 (7.5)		8.3 %	1.10 [-1.84, 4.04]
Straw 2003 (2)	66	89 (11.5)	101	91.1 (13.3)		5.0 %	-2.10 [-5.90, 1.70]
Tanzer 2002	20	90 (12)	20	93 (11)		1.4 %	-3.00 [-10.13, 4.13]
Wang 2004	128	90.7 (5.3)	96	91 (4.8)		40.8 %	-0.30 [-1.63, 1.03]
Yagishita 2012	29	95.4 (4.1)	29	93.7 (5.5)		11.5 %	1.70 [-0.80, 4.20]
Total (95% CI)	**814**		**823**			**100.0 %**	**-0.08 [-0.93, 0.77]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 5.94$, df = 10 (P = 0.82); $I^2 = 0.0\%$

Test for overall effect: Z = 0.19 (P = 0.85)

Test for subgroup differences: Not applicable



(1) Weighted average sd from reported sd's in studies

(2) Weighted average sd from reported sd's in studies

Analysis 1.8. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 8 Knee Society Function Score.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

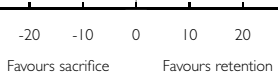
Outcome: 8 Knee Society Function Score

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Aglietti 2005	103	84 (19.7)	107	82 (19.6)		13.3 %	2.00 [-3.32, 7.32]
Catani 2004	20	81 (17)	20	76 (19)		3.0 %	5.00 [-6.17, 16.17]
Harato 2008	111	69.6 (19.7)	111	74.9 (18.7)		14.8 %	-5.30 [-10.35, -0.25]
Kim 2009 (1)	250	80.2 (19.7)	250	83.7 (19.6)		31.6 %	-3.50 [-6.94, -0.06]
Matsumoto 2012	25	88.6 (19.7)	25	84.8 (19.6)		3.2 %	3.80 [-7.09, 14.69]
Roh 2012	42	83.8 (16.6)	44	84.6 (13.6)		9.1 %	-0.80 [-7.23, 5.63]
Straw 2003 (2)	66	69 (19.7)	101	73.7 (19.6)		10.1 %	-4.70 [-10.80, 1.40]
Tanzer 2002	20	73 (24)	20	76 (28)		1.4 %	-3.00 [-19.16, 13.16]
Wang 2004	128	84.2 (20.8)	96	87 (19.6)		13.3 %	-2.80 [-8.13, 2.53]
Total (95% CI)	**765**		**774**			**100.0 %**	**-2.32 [-4.26, -0.37]**

Heterogeneity: $Tau^2 = 0.03$; $Chi^2 = 8.02$, df = 8 (P = 0.43); $I^2 = 0\%$

Test for overall effect: Z = 2.33 (P = 0.020)

Test for subgroup differences: Not applicable



(1) Weighted average sd from reported sd's in studies

(2) Weighted average sd from reported sd's in studies

Analysis 1.9. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 9 Hospital Special Surgery Score.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

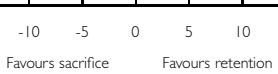
Outcome: 9 Hospital Special Surgery Score

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Catani 2004	20	86 (8)	20	89 (7)		4.6 %	-3.00 [-7.66, 1.66]
Kim 2009 (1)	250	90 (5.8)	250	91 (5.2)		33.2 %	-1.00 [-1.97, -0.03]
Misra 2003 (2)	51	81.4 (5.8)	54	83.6 (5.2)		16.1 %	-2.20 [-4.31, -0.09]
Roh 2012	42	91 (4.5)	44	90.5 (7.4)		12.2 %	0.50 [-2.08, 3.08]
Seon 2011	48	94.7 (4.3)	47	93.9 (4.7)		19.4 %	0.80 [-1.01, 2.61]
Shoji 1994	28	88.2 (4.2)	28	87.5 (4.5)		14.5 %	0.70 [-1.58, 2.98]
Total (95% CI)	**439**		**443**			**100.0 %**	**-0.51 [-1.55, 0.54]**

Heterogeneity: $Tau^2 = 0.62$; $Chi^2 = 8.12$, df = 5 (P = 0.15); $I^2 = 38\%$

Test for overall effect: Z = 0.94 (P = 0.35)

Test for subgroup differences: Not applicable



(1) Weighted average sd from reported sd's in studies

(2) Weighted average sd from reported sd's in studies

Analysis 1.10. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 10 Knee Society Score overall.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

Outcome: 10 Knee Society Score overall

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Clark 2001 (1)	59	156.5 (53.2)	69	157.1 (57.8)		29.3 %	-0.60 [-19.84, 18.64]
de Andrade 2009	36	157.1 (26.7)	49	157.4 (31.4)		70.7 %	-0.30 [-12.68, 12.08]
Total (95% CI)	**95**		**118**			**100.0 %**	**-0.39 [-10.80, 10.03]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.00$, df = 1 (P = 0.98); $I^2 = 0.0\%$

Test for overall effect: Z = 0.07 (P = 0.94)

Test for subgroup differences: Not applicable

(1) 2y postop

Analysis 1.11. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 11 SF-12 mental.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

Outcome: 11 SF-12 mental

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Clark 2001 (1)	59	57.5 (9.1)	69	54.2 (8.5)		48.3 %	3.30 [0.23, 6.37]
Harato 2008	111	53 (9.1)	111	55.3 (8.5)		51.7 %	-2.30 [-4.62, 0.02]
Total (95% CI)	**170**		**180**			**100.0 %**	**0.41 [-5.08, 5.89]**

Heterogeneity: $Tau^2 = 13.76$; $Chi^2 = 8.15$, df = 1 (P = 0.004); $I^2 = 88\%$

Test for overall effect: Z = 0.15 (P = 0.88)

Test for subgroup differences: Not applicable

(1) SD from Harato et al.

Analysis 1.12. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 12 Radiological: Radiolucent lines.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

Outcome: 12 Radiological: Radiolucent lines

Study or subgroup	Retention n/N	Sacrifice n/N	Risk Ratio M-H,Random,95% CI	Weight	Risk Ratio M-H,Random,95% CI
Aglietti 2005	28/103	31/107		27.0 %	0.94 [0.61, 1.45]
Harato 2008	1/111	1/111		0.7 %	1.00 [0.06, 15.79]
Tanzer 2002	5/20	8/20		5.9 %	0.63 [0.25, 1.58]
Wang 2004	56/128	49/96		65.9 %	0.86 [0.65, 1.13]
Yagishita 2012	0/29	2/29		0.6 %	0.20 [0.01, 3.99]
Total (95% CI)	**391**	**363**		**100.0 %**	**0.86 [0.68, 1.07]**

Total events: 90 (Retention), 91 (Sacrifice)

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.54$, df = 4 (P = 0.82); $I^2 = 0.0\%$

Test for overall effect: Z = 1.35 (P = 0.18)

Test for subgroup differences: Not applicable

Analysis 1.13. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 13 Radiological: Femorotibial angle.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

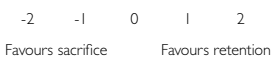
Outcome: 13 Radiological: Femorotibial angle

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Kim 2009	250	6.5 (2.4)	250	6.5 (2.6)		24.6 %	0.0 [-0.44, 0.44]
Roh 2012	42	5.1 (2.2)	44	5.2 (2.4)		12.4 %	-0.10 [-1.07, 0.87]
Seon 2011	48	5.8 (2.8)	47	5.7 (2.8)		10.3 %	0.10 [-1.03, 1.23]
Straw 2003 (1)	66	6.6 (2.5)	101	6.4 (2.7)		15.5 %	0.20 [-0.60, 1.00]
Tanzer 2002 (2)	20	6.6 (2.5)	20	5.8 (2.7)		6.0 %	0.80 [-0.81, 2.41]
Wang 2004	128	7.3 (1.6)	96	6.3 (1.7)		24.6 %	1.00 [0.56, 1.44]
Yagishita 2012	29	5.2 (2.8)	29	4.7 (3)		6.7 %	0.50 [-0.99, 1.99]
Total (95% CI)	**583**		**587**			**100.0 %**	**0.36 [-0.08, 0.79]**

Heterogeneity: $Tau^2 = 0.15$; $Chi^2 = 12.15$, df = 6 (P = 0.06); $I^2 = 51\%$

Test for overall effect: Z = 1.60 (P = 0.11)

Test for subgroup differences: Not applicable



(1) Weighted average sd from reported sd's in studies

(2) Weighted average sd from reported sd's in studies

Analysis 1.14. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 14 Radiological: Rollback (in mm).

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

Outcome: 14 Radiological: Rollback (in mm)

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Harato 2008 (1)	8	-2.7 (3.9)	7	-11.8 (2.5)		49.9 %	9.10 [5.82, 12.38]
Seon 2011	48	6.1 (8.6)	47	9.6 (6.2)		50.1 %	-3.50 [-6.51, -0.49]
Total (95% CI)	**56**		**54**			**100.0 %**	**2.78 [-9.57, 15.13]**

Heterogeneity: $Tau^2 = 76.80$; $Chi^2 = 30.81$, df = 1 ($P<0.00001$); $I^2 = 97\%$

Test for overall effect: Z = 0.44 (P = 0.66)

Test for subgroup differences: Not applicable

(1) Results from Victor 2005 N=15

Analysis 1.15. Comparison 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs), Outcome 15 Radiological: Tibial slope.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 1 Posterior cruciate ligament retention versus sacrifice (all types of arthroplasty designs)

Outcome: 15 Radiological: Tibial slope

Study or subgroup	Retention N	Mean(SD)	Sacrifice N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Catani 2004	20	6 (3)	20	7 (3)		20.8 %	-1.00 [-2.86, 0.86]
Yagishita 2012	29	3 (1.9)	29	3.2 (1.8)		79.2 %	-0.20 [-1.15, 0.75]
Total (95% CI)	**49**		**49**			**100.0 %**	**-0.37 [-1.21, 0.48]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.56$, df = 1 ($P = 0.45$); $I^2 = 0.0\%$

Test for overall effect: Z = 0.85 (P = 0.40)

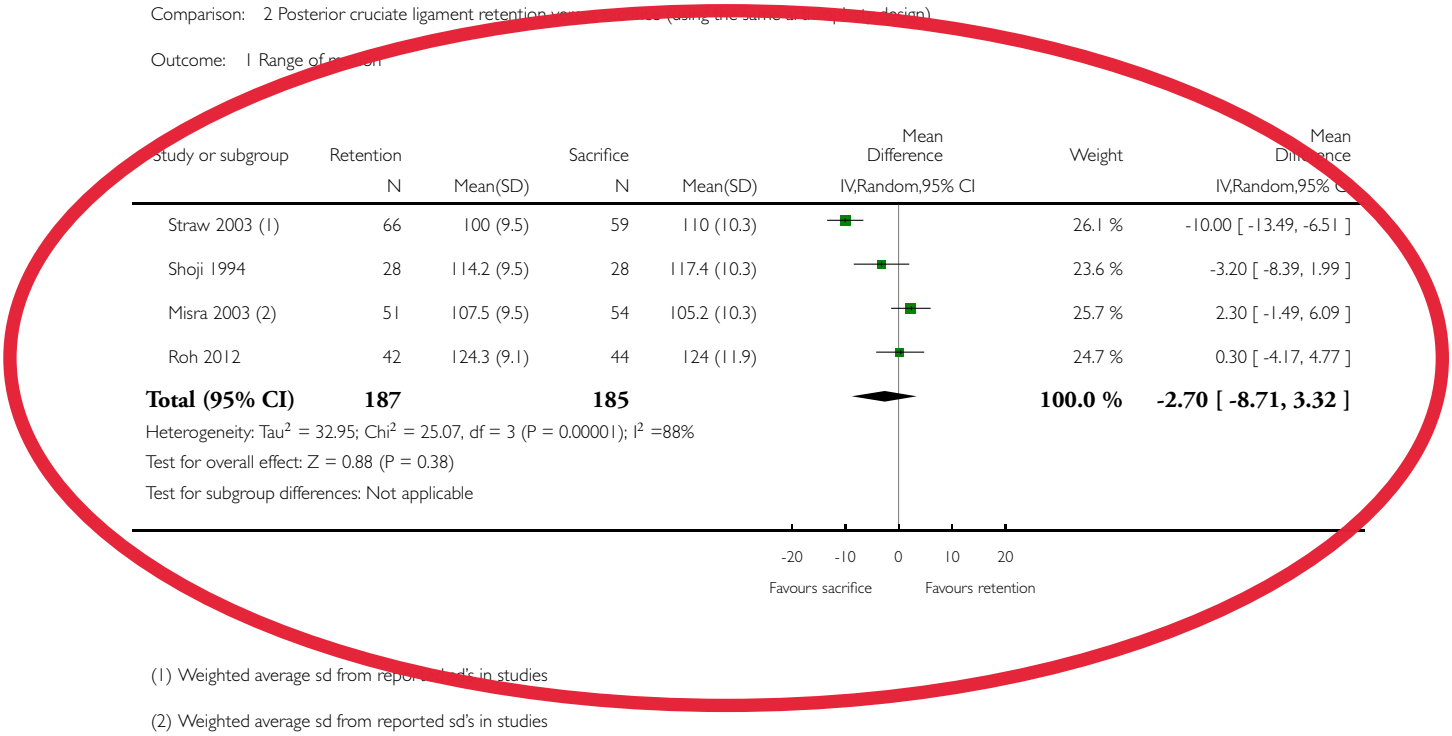
Test for subgroup differences: Not applicable

Analysis 2.1. Comparison 2 Posterior cruciate ligament retention versus sacrifice (using the same arthroplasty design), Outcome 1 Range of motion.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 2 Posterior cruciate ligament retention versus sacrifice (using the same arthroplasty design)

Outcome: 1 Range of motion



(1) Weighted average sd from reported sd's in studies

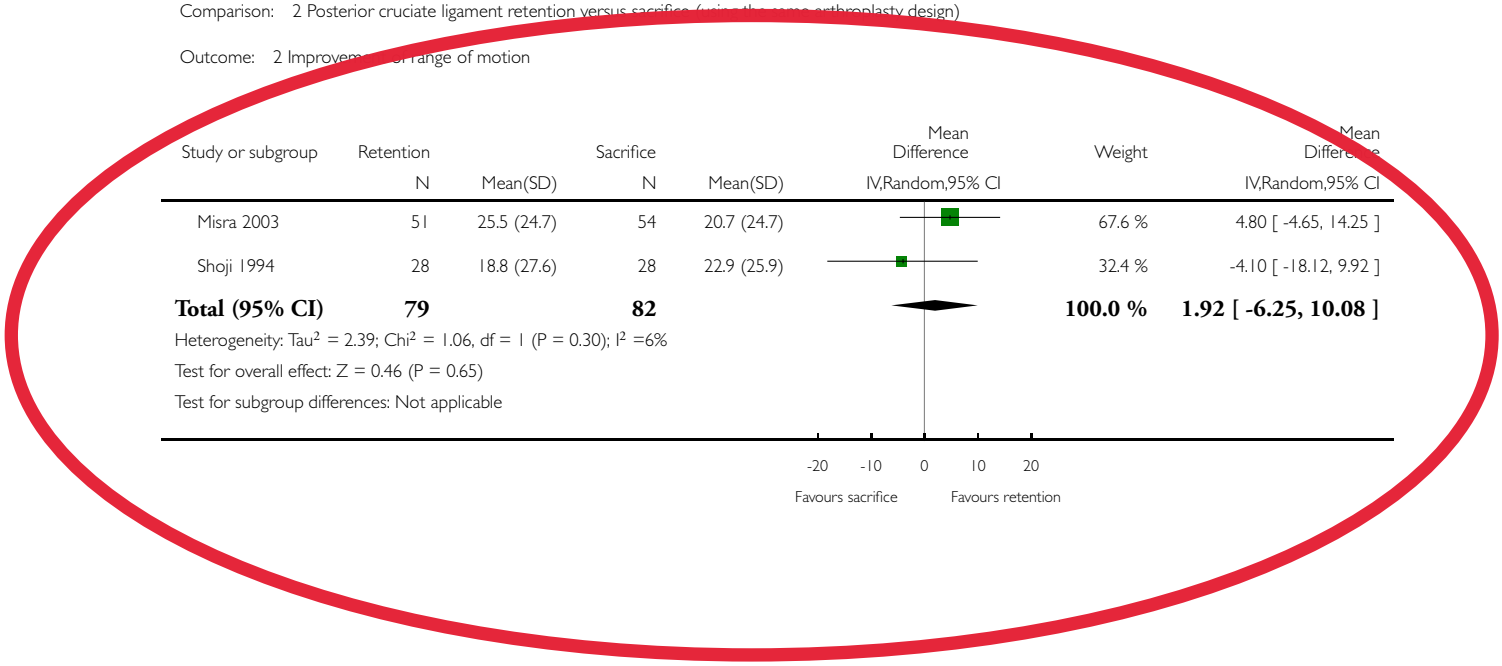
(2) Weighted average sd from reported sd's in studies

Analysis 2.2. Comparison 2 Posterior cruciate ligament retention versus sacrifice (using the same arthroplasty design), Outcome 2 Improvement of range of motion.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 2 Posterior cruciate ligament retention versus sacrifice (using the same arthroplasty design)

Outcome: 2 Improvement of range of motion



Analysis 3.1. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 1 Range of motion.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

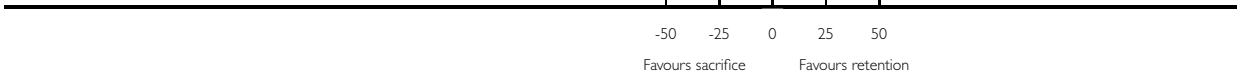
Outcome: 1 Range of motion

Study or subgroup	Retention N	Mean(SD)	Substitution N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Aglietti 2005	103	110 (12.7)	107	113 (16.1)		16.8 %	-3.00 [-6.91, 0.91]
Catani 2004	20	97 (15)	20	114 (21)		5.1 %	-17.00 [-28.31, -5.69]
Clark 2001 (1)	59	108.5 (12.7)	69	108.5 (16.1)		14.1 %	0.0 [-4.99, 4.99]
Kim 2009 (2)	250	132 (12.7)	250	133 (16.1)		20.4 %	-1.00 [-3.54, 1.54]
Maruyama 2004	20	122.2 (14.8)	20	129.6 (13.9)		7.3 %	-7.40 [-16.30, 1.50]
Matsumoto 2012	25	125.3 (12.7)	25	121.6 (16.1)		8.4 %	3.70 [-4.34, 11.74]
Straw 2003 (3)	66	102.7 (12.7)	101	110 (16.1)		15.6 %	-7.30 [-11.69, -2.91]
Yagishita 2012	29	125.4 (10.9)	29	129.3 (11.7)		12.2 %	-3.90 [-9.72, 1.92]
Total (95% CI)	**572**		**621**			**100.0 %**	**-3.43 [-6.32, -0.54]**

Heterogeneity: $Tau^2 = 8.95$; $Chi^2 = 16.90$, df = 7 (P = 0.02); $I^2 = 59\%$

Test for overall effect: Z = 2.32 (P = 0.020)

Test for subgroup differences: Not applicable



(1) Weighted average sd from reported sd's in studies

(2) Weighted average sd from reported sd's in studies

(3) Weighted average sd from reported sd's in studies

Analysis 3.2. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 2 Flexion angle.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

Outcome: 2 Flexion angle

Study or subgroup	Retention N	Mean(SD)	Substitution N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Chaudhary 2008	51	105.9 (13)	49	105.8 (13.5)		15.6 %	0.10 [-5.10, 5.30]
Harato 2008	111	113.7 (12.8)	111	117 (13.5)		32.9 %	-3.30 [-6.76, 0.16]
Maruyama 2004	20	122.3 (15)	20	131.3 (13.4)		5.6 %	-9.00 [-17.82, -0.18]
Matsumoto 2012	25	126.1 (12.7)	25	123.3 (13)		8.5 %	2.80 [-4.32, 9.92]
Seon 2011	48	128.2 (12.2)	47	129.5 (10.9)		19.2 %	-1.30 [-5.95, 3.35]
Tanzer 2002	20	112 (13)	20	111 (17)		5.0 %	1.00 [-8.38, 10.38]
Yagishita 2012	29	125.7 (10.7)	29	129.7 (11.3)		13.2 %	-4.00 [-9.66, 1.66]
Total (95% CI)	**304**		**301**			**100.0 %**	**-2.07 [-4.17, 0.04]**

Heterogeneity: $Tau^2 = 0.39$; $Chi^2 = 6.29$, df = 6 (P = 0.39); $I^2 = 5\%$

Test for overall effect: Z = 1.92 (P = 0.054)

Test for subgroup differences: Not applicable

Analysis 3.3. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 3 Extension angle.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

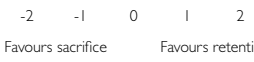
Outcome: 3 Extension angle

Study or subgroup	Retention N	Mean(SD)	Substitution N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Chaudhary 2008	40	-1.2 (2.5)	38	-2.2 (3.5)		13.6 %	1.00 [-0.36, 2.36]
Harato 2008	99	0.8 (2.1)	93	1.6 (1.5)		24.2 %	-0.80 [-1.31, -0.29]
Maruyama 2004	20	0.3 (1.3)	20	0.9 (2)		17.1 %	-0.60 [-1.65, 0.45]
Matsumoto 2012	25	-0.8 (1.8)	25	-1.7 (1.8)		17.7 %	0.90 [-0.10, 1.90]
Tanzer 2002	10	1 (2.2)	10	1 (1.8)		10.0 %	0.0 [-1.76, 1.76]
Yagishita 2012	29	-0.1 (2)	29	-0.3 (2)		17.3 %	0.20 [-0.83, 1.23]
Total (95% CI)	**223**		**215**			**100.0 %**	**0.03 [-0.66, 0.73]**

Heterogeneity: $Tau^2 = 0.45$; $Chi^2 = 14.01$, df = 5 (P = 0.02); $I^2 = 64\%$

Test for overall effect: Z = 0.09 (P = 0.93)

Test for subgroup differences: Not applicable



Analysis 3.4. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 4 VAS pain.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

Outcome: 4 VAS pain

Study or subgroup	Retention N	Mean(SD)	Substitution N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Aglietti 2005	103	10 (13.9)	107	8 (14)		78.4 %	2.00 [-1.77, 5.77]
Yagishita 2012	29	4.7 (13.9)	29	5 (14)		21.6 %	-0.30 [-7.48, 6.88]
Total (95% CI)	**132**		**136**			**100.0 %**	**1.50 [-1.84, 4.84]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.31$, df = 1 (P = 0.58); $I^2 = 0.0\%$

Test for overall effect: Z = 0.88 (P = 0.38)

Test for subgroup differences: Not applicable

Analysis 3.5. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 5 Knee pain (KSS pain).

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

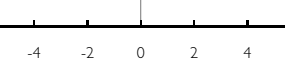
Outcome: 5 Knee pain (KSS pain)

Study or subgroup	Retention N	Mean(SD)	Substitution N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Harato 2008	99	44.5 (9.7)	93	42.3 (14.6)		7.9 %	2.20 [-1.33, 5.73]
Kim 2009	250	48.2 (8.6)	250	48.3 (12.9)		26.8 %	-0.10 [-2.02, 1.82]
Yagishita 2012	29	49.7 (1.9)	29	49 (2.8)		65.3 %	0.70 [-0.53, 1.93]
Total (95% CI)	**378**		**372**			**100.0 %**	**0.60 [-0.39, 1.60]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.32$, df = 2 (P = 0.52); $I^2 = 0.0\%$

Test for overall effect: Z = 1.19 (P = 0.23)

Test for subgroup differences: Not applicable



Analysis 3.6. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 6 WOMAC total.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

Outcome: 6 WOMAC total

Study or subgroup	Retention N	Mean(SD)	Substitution N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Clark 2001	51	22.8 (35.4)	57	18.5 (32.9)		5.1 %	4.30 [-8.64, 17.24]
Harato 2008	99	10.4 (13.4)	93	8.5 (12.3)		64.1 %	1.90 [-1.74, 5.54]
Seon 2011	48	28.4 (13.8)	47	27.9 (12.2)		30.9 %	0.50 [-4.74, 5.74]
Total (95% CI)	**198**		**197**			**100.0 %**	**1.59 [-1.32, 4.50]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.36$, df = 2 (P = 0.83); $I^2 = 0.0\%$

Test for overall effect: Z = 1.07 (P = 0.28)

Test for subgroup differences: Not applicable

Analysis 3.7. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 7 Knee Society Clinical score.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

Outcome: 7 Knee Society Clinical score

Study or subgroup	Retention N	Mean(SD)	Substitution N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Aglietti 2005	103	91 (11.4)	107	91 (13.2)		14.5 %	0.0 [-3.33, 3.33]
Catani 2004	20	89 (10)	20	90 (9)		4.6 %	-1.00 [-6.90, 4.90]
Harato 2008	99	90.8 (13)	93	90.4 (15.7)		9.6 %	0.40 [-3.69, 4.49]
Kim 2009	250	94 (11.5)	250	95 (13.3)		33.9 %	-1.00 [-3.18, 1.18]
Maruyama 2004	20	89.8 (7.2)	20	89.5 (8.9)		6.4 %	0.30 [-4.72, 5.32]
Matsumoto 2012	25	95.7 (11.4)	25	92.9 (13.2)		3.4 %	2.80 [-4.04, 9.64]
Tanzer 2002	10	90 (12)	10	93 (11)		1.6 %	-3.00 [-13.09, 7.09]
Yagishita 2012	29	95.4 (4.1)	29	93.7 (5.5)		25.9 %	1.70 [-0.80, 4.20]
Total (95% CI)	**556**		**554**			**100.0 %**	**0.16 [-1.11, 1.43]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 3.67$, df = 7 (P = 0.82); $I^2 = 0.0\%$

Test for overall effect: Z = 0.25 (P = 0.80)

Test for subgroup differences: Not applicable

Analysis 3.8. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 8 Knee Society Functional score.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

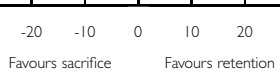
Outcome: 8 Knee Society Functional score

Study or subgroup	Retention N	Mean(SD)	Substitution N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Aglietti 2005	103	84 (19.7)	107	82 (19.6)		23.4 %	2.00 [-3.32, 7.32]
Catani 2004	20	81 (17)	20	76 (19)		7.4 %	5.00 [-6.17, 16.17]
Harato 2008	99	69.6 (19.7)	93	74.9 (18.7)		22.7 %	-5.30 [-10.73, 0.13]
Kim 2009	250	80.2 (19.7)	250	83.7 (19.6)		36.8 %	-3.50 [-6.94, -0.06]
Matsumoto 2012	25	88.6 (19.7)	25	84.8 (19.6)		7.7 %	3.80 [-7.09, 14.69]
Tanzer 2002	10	73 (24)	10	76 (28)		1.9 %	-3.00 [-25.86, 19.86]
Total (95% CI)	**507**		**505**			**100.0 %**	**-1.42 [-4.66, 1.82]**

Heterogeneity: $Tau^2 = 4.32$; $Chi^2 = 6.92$, df = 5 (P = 0.23); $I^2 = 28\%$

Test for overall effect: Z = 0.86 (P = 0.39)

Test for subgroup differences: Not applicable

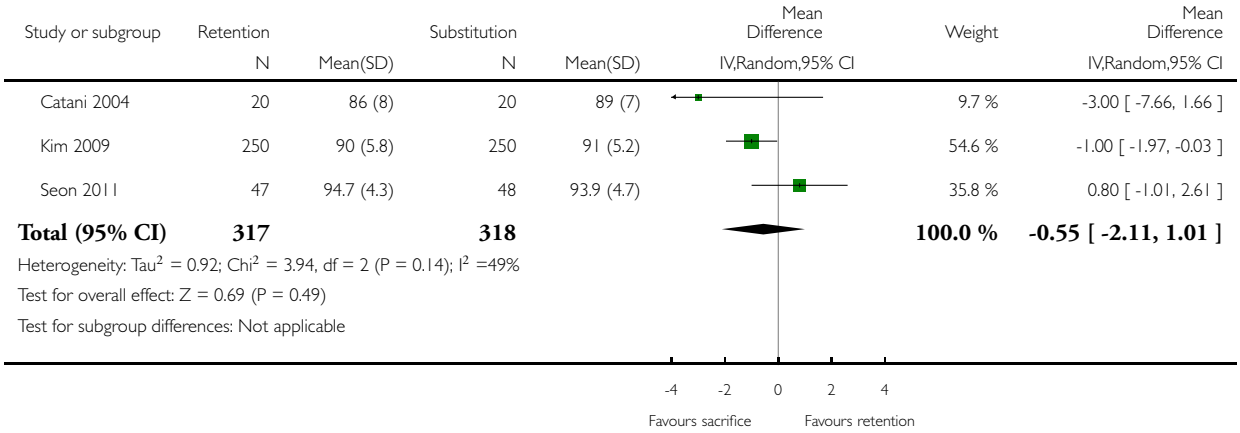


Analysis 3.9. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 9 Hospital Special Surgery score.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

Outcome: 9 Hospital Special Surgery score

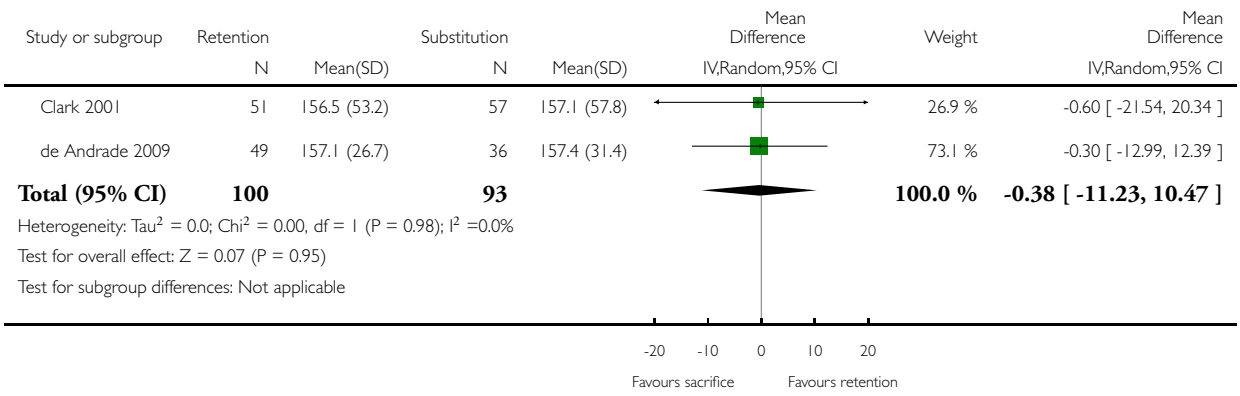


Analysis 3.10. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 10 Knee Society total score.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

Outcome: 10 Knee Society total score



Analysis 3.11. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 11 SF-12 mental.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

Outcome: 11 SF-12 mental

Study or subgroup	Retention N	Mean(SD)	Substitution N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Clark 2001	51	57.5 (9.1)	57	54.2 (8.5)		48.0 %	3.30 [-0.03, 6.63]
Harato 2008	99	53 (9.1)	93	55.3 (8.5)		52.0 %	-2.30 [-4.79, 0.19]
Total (95% CI)	**150**		**150**			**100.0 %**	**0.39 [-5.10, 5.87]**

Heterogeneity: $Tau^2 = 13.43$; $Chi^2 = 6.96$, df = 1 (P = 0.01); $I^2 = 86\%$

Test for overall effect: Z = 0.14 (P = 0.89)

Test for subgroup differences: Not applicable

Analysis 3.12. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 12 Radiological: Radiolucent lines.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

Outcome: 12 Radiological: Radiolucent lines

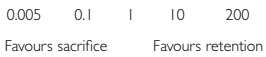
Study or subgroup	Retention n/N	Substitution n/N	Odds Ratio M-H,Random,95% CI	Weight	Odds Ratio M-H,Random,95% CI
Aglietti 2005	28/103	31/107		77.9 %	0.92 [0.50, 1.67]
Harato 2008	1/99	1/93		3.6 %	0.94 [0.06, 15.23]
Tanzer 2002	5/20	8/20		15.5 %	0.50 [0.13, 1.93]
Yagishita 2012	0/29	2/29		3.0 %	0.19 [0.01, 4.06]
Total (95% CI)	**251**	**249**		**100.0 %**	**0.80 [0.47, 1.35]**

Total events: 34 (Retention), 42 (Substitution)

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.53$, df = 3 (P = 0.67); $I^2 = 0.0\%$

Test for overall effect: Z = 0.84 (P = 0.40)

Test for subgroup differences: Not applicable



Analysis 3.13. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 13 Radiological: Femorotibial angle.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

Outcome: 13 Radiological: Femorotibial angle

Study or subgroup	Retention N	Mean(SD)	Substitution N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Kim 2009	250	6.5 (2.4)	250	6.5 (2.6)		76.2 %	0.0 [-0.44, 0.44]
Seon 2011	48	5.8 (2.8)	47	5.7 (2.8)		11.6 %	0.10 [-1.03, 1.23]
Tanzer 2002	20	6.6 (2.5)	20	5.8 (2.7)		5.6 %	0.80 [-0.81, 2.41]
Yagishita 2012	29	5.2 (2.8)	29	4.7 (3)		6.6 %	0.50 [-0.99, 1.99]
Total (95% CI)	**347**		**346**			**100.0 %**	**0.09 [-0.29, 0.47]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.20$, df = 3 (P = 0.75); $I^2 = 0.0\%$

Test for overall effect: Z = 0.46 (P = 0.65)

Test for subgroup differences: Not applicable

Analysis 3.14. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 14 Radiological: Rollback.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

Outcome: 14 Radiological: Rollback

Study or subgroup	Retention N	Mean(SD)	Substitution N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Harato 2008	8	-2.7 (3.9)	7	-11.8 (2.5)		49.9 %	9.10 [5.82, 12.38]
Seon 2011	48	6.1 (8.6)	47	9.6 (6.2)		50.1 %	-3.50 [-6.51, -0.49]
Total (95% CI)	**56**		**54**			**100.0 %**	**2.78 [-9.57, 15.13]**

Heterogeneity: $Tau^2 = 76.80$; $Chi^2 = 30.81$, df = 1 (P<0.00001); I^2 =97%

Test for overall effect: Z = 0.44 (P = 0.66)

Test for subgroup differences: Not applicable

Analysis 3.15. Comparison 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice, Outcome 15 Radiological: Tibial slope.

Review: Retention versus sacrifice of the posterior cruciate ligament in total knee arthroplasty for treating osteoarthritis

Comparison: 3 Posterior cruciate ligament retention versus posterior stabilised sacrifice

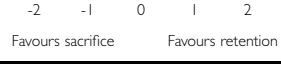
Outcome: 15 Radiological: Tibial slope

Study or subgroup	Retention N	Mean(SD)	Substitution N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Catani 2004	20	6 (3)	20	7 (3)		20.8 %	-1.00 [-2.86, 0.86]
Yagishita 2012	29	3 (1.9)	29	3.2 (1.8)		79.2 %	-0.20 [-1.15, 0.75]
Total (95% CI)	**49**		**49**			**100.0 %**	**-0.37 [-1.21, 0.48]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.56$, df = 1 (P = 0.45); I^2 =0.0%

Test for overall effect: Z = 0.85 (P = 0.40)

Test for subgroup differences: Not applicable



ADDITIONAL TABLES

Table 1. Assessment of clinical relevance

Study	Description patients	Intervention described	Outcome measures	Effect size
	Are the patients described in detail so that you can decide whether they are comparable to those that you see in your practice?	Are the interventions and treatment settings described well enough so that you can provide the same for your patients?	Were all clinically relevant outcomes measured and reported?	Is the size of the effect clinically important?
Aglietti 2004	No	Yes	Yes	No
Catani 2004	No	No	No	Yes
Chaudhary 2008	Yes	Yes	Yes	No
Clark 2001	Unsure	Yes	No	No
de Andrade 2009	Unsure	Unsure	No	No
Harato 2008	Unsure	Yes	Yes	No
Kim 2009	Yes	Yes	Yes	No
Maruyama 2004	Yes	Yes	Yes	No
Matsumoto 2012	Yes	Unsure	Yes	No
Misra 2003	No	No	No	No
Roh 2012	Yes	Yes	Yes	No
Seon 2011	Yes	Unsure	Yes	Yes

Table 1. Assessment of clinical relevance (*Continued*)

Shoji 1994	No	No	No	No
Straw 2003	No	Unsure	No	No
Tanzer 2002	Yes	Yes	No	No
Wang 2004	Yes	No	Yes	No
Yagishita 2011	Yes	Yes	Yes	No

Table 2. Complications

Study	Complications posterior cruciate ligament retention	Complications posterior cruciate ligament sacrifice
Aglietti 2004	None	1 Septic loosening after 2 years requiring 2-stage revision surgery
Catani 2004	1 Anterior knee pain; treated: lateral release and patella resurfacing, 1 Limited range of motion; treated: surgical manipulation	2 Anterior knee pain; treated: lateral release and patella resurfacing
Chaudhary 2008	1 Deep infection	1 Limited range of motion (poor flexion); treated: surgical manipulation
Clark 2001	Not reported	Not reported
de Andrade 2009	Not reported	Not reported
Harato 2008	7 Stiff knee (<90 degrees flexion), 5 severe/moderate knee pain, 1 infection 2 Hemoarthrosis	1 Deep venous thrombosis, 3 infection, 1 stiff knee (<90 degrees flexion) 2 Severe/moderate knee pain
Kim 2009	2 Femoral notching, 1 superficial wound infection	3 Femoral notching, 1 superficial wound infection
Maruyama 2004	None	None
Matsumoto 2012	None	1 Deep venous thrombosis

Table 2. Complications (*Continued*)

Misra 2003	3 Instability, 1 infection, 2 aseptic loosening, 2 stiffness (<30 degrees flexion)	3 Instability, 3 aseptic loosening, 2 stiffness (<30 degrees flexion), 1 Reflex sympathetic dystrophy
Roh 2012	2 posterior cruciate laxity 1 posterior cruciate tightness	None
Seon 2011	Not reported	Not reported
Shoji 1994	Not reported	Not reported
Straw 2003	Not reported	Not reported
Tanzer 2002	Not reported	Not reported
Wang 2004	Not specified per treatment group: 3 deaths unrelated to the knee surgery, 3 deep wound infections, 1 above the knee amputation due to diabetic gangrene, 1 cerebral vascular accident, 1 Parkinsons disease, 1 colon cancer	
Yagishita 2011	None	1 Deep venous thrombosis

APPENDICES

Appendix 1. Search strategy (syntax) for all databases

PubMed

1. "Arthroplasty, Replacement, Knee"[Mesh]
2. "Knee Prosthesis"[Mesh]
3. "knee replacement arthroplasty"[tw]
4. "total knee arthroplasty"[tw]
5. "total knee"[tw]
6. tka[tw]
7. "total knee replacement"[tw]
8. "knee prosthesis"[tw]
9. "knee implantation"[tw]
10. "knee implant"[tw]
11. "knee implants"[tw]
12. "knee prosthesis"[tw]
13. "knee joint replacement"[tw]
14. "knee joint arthroplasty"[tw]

15. tkr[tw]
16. "Knee Replacement Arthroplasties"[tw]
17. "Total Knee Replacements"[tw]
18. "Knee Prostheses"[tw]
19. "Knee endoprosthesis"[tw]
20. "Knee endoprostheses"[tw]
21. "Knee joint arthroplasty"[tw]
22. "Knee joint arthroplasties"[tw]
23. "knee joint prosthesis"[tw]
24. "knee joint prostheses"[tw]
25. "knee prosthetic"[tw]
26. "Knee endoprosthetic"[tw]
27. "knee joint prosthetic"[tw]
28. "Knee joint endoprosthetic"[tw]
29. "knee prosthetics"[tw]
30. "Knee endoprosthetics"[tw]
31. "knee joint prosthetics"[tw]
32. "Knee joint endoprosthetics"[tw]
33. "Knee replacement"[tw]
34. "Knee replacements"[tw]
35. "knee arthroplasty"[tw]
36. "knee arthroplasties"[tw]
37. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36
38. "osteoarthritis"[Mesh]
39. "arthritis"[Mesh]
40. "posterior cruciate ligament"[Mesh]
41. Osteoarthrosis[tw]
42. Osteoarthroses[tw]
43. Osteoarthritides[tw]
44. Osteoarthritis[tw]
45. Osteoartrosis[tw]
46. Osteoartroses[tw]
47. Osteoartritides[tw]
48. Osteoartritis[tw]
49. Degenerative Arthritis[tw]
50. Degenerative Arthritides[tw]
51. Degenerative Artritis[tw]
52. Degenerative Artritides[tw]
53. Arthrosis[tw]
54. Arthroses[tw]
55. Arthritides[tw]
56. Arthritis[tw]
57. arthritic[tw]
58. RA[tw]
59. rheumatoid[tw]
60. rheumatic[tw]
61. Artrosis[tw]
62. Artroses[tw]
63. Artritides[tw]
64. Artritis[tw]
65. Osteoarthrosis Deformans[tw]
66. Osteoartrosis Deformans[tw]

67. Posterior Cruciate Ligament[tw]
68. Posterior Cruciate Ligaments[tw]
69. Cruciate[tw]
70. PCL[tw]
71. 38 or 29 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70
72. "randomized controlled trial"[Publication Type]
73. randomized controlled trials as topic"[Mesh]
74. "random allocation"[Mesh]
75. "double-blind method"[Mesh]
76. "single-blind method"[Mesh]
77. "placebos"[Mesh]
78. random*[tw]
79. ramdom*[tw]
80. ramdon*[tw]
81. randon*[tw]
82. rct[tw]
83. rct's[tw]
84. rcts[tw]
85. placebo*[tw]
86. random*[tw]
87. compare*[ti]
88. versus[ti]
89. vs[ti]
90. single[tw]
91. double[tw]
92. treble[tw]
93. triple[tw]
94. mask*[tw]
95. blind*[tw]
96. 90 or 91 or 92 or 93
97. 94 or 95
98. 96 and 97
99. 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86 or 87 or 88 or 89 or 98
100. 37 and 71 and 99

EMBASE

1. exp knee arthroplasty/
2. "knee replacement arthroplasty"
3. "total knee arthroplasty".mp
4. "total knee".mp
5. tka.mp
6. "total knee replacement".mp
7. "knee prosthesis".mp
8. "knee implantation".mp
9. "knee implant".mp
10. "knee implants".mp
11. "knee prosthesis".mp
12. "knee joint replacement".mp
13. "knee joint arthroplasty".mp
14. tkr.mp
15. "Knee Replacement Arthroplasties".mp
16. "Total Knee Replacements".mp
17. "Knee Prostheses".mp

18. "Knee endoprosthesis".mp
19. "Knee endoprostheses".mp
20. "Knee joint arthroplasty".mp
21. "Knee joint arthroplasties".mp
22. "knee joint prosthesis".mp
23. "knee joint prostheses".mp
24. "knee prosthetic".mp
25. "Knee endoprosthetic".mp
26. "knee joint prosthetic".mp
27. "Knee joint endoprosthetic".mp
28. "knee prosthetics".mp
29. "Knee endoprosthetics".mp
30. "knee joint prosthetics".mp
31. "Knee joint endoprosthetics".mp
32. "Knee replacement".mp
33. "Knee replacements".mp
34. "knee arthroplasty".mp
35. "knee arthroplasties".mp
37. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36
38. exp osteoarthritis/
39. exp Arthritis/
40. exp knee ligament/
41. Osteoarthrosis.mp
42. Osteoarthroses.mp
43. Osteoarthritides.mp
44. Osteoarthritis.mp
45. Osteoartrosis.mp
46. Osteoartroses.mp
47. Osteoartritides.mp
48. Osteoartritis.mp
49. Degenerative Arthritis.mp
50. Degenerative Arthritides.mp
51. Degenerative Artritis.mp
52. Degenerative Artritides.mp
53. Arthrosis.mp
54. Arthroses.mp
55. Arthritides.mp
56. Arthritis.mp
57. arthritic.mp
58. RA.mp
59. rheumatoid.mp
60. rheumatic.mp
61. Artrosis.mp
62. Artroses.mp
63. Artritides.mp
64. Artritis.mp
65. Osteoarthrosis Deformans.mp
66. Osteoartrosis Deformans.mp
67. Posterior Cruciate Ligament.mp
68. Posterior Cruciate Ligaments.mp
69. Cruciate.mp
70. PCL.mp

71. 38 or 29 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70
72. randomized controlled trial/
73. randomization/
74. triple blind procedure/
75. double blind procedure/
76. single blind procedure/
77. placebo/
78. "random allocation".mp
79. "double-blind*".mp
80. "single-blind*".mp
81. placebo.mp
82. placebos.mp
83. random*.mp
84. ramdom*.mp
85. ramdon*.mp
86. randon*.mp
87. rct.mp
88. rct's.mp
89.rcts
90. single.mp
91. double.mp
92. treble.mp
93. triple.mp
94. 90 or 91 or 92 or 93
95. mask*.mp
96. blind*.mp
97. 95 or 96
98. 94 and 97
99. placebo*.mp
100. random*.mp
101 compare*.ti
102 versus.ti
103. vs.ti
104. 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86 or 87 or 88 or 89 or 98 or 99 or 100 or 101 or 102 or 103
105. 37 and 71 and 104

Web of Science

1. TS="knee arthroplasty"
2. TS="knee replacement arthroplasty"
3. TS="total knee arthroplasty"
4. TS="total knee"
5. TS=tka
6. TS="total knee replacement"
7. TS="knee prosthesis"
8. TS="knee implantation"
9. TS="knee implant"
10. TS="knee implants"
11. TS="knee prosthesis"
12. TS="knee joint replacement"
13. TS="knee joint arthroplasty"
14. TS=tkr
15. TS="Knee Replacement Arthroplasties"

16. TS="Total Knee Replacements"
17. TS="Knee Prostheses"
18. TS="Knee endoprosthesis"
19. TS="Knee endoprostheses"
20. TS="Knee joint arthroplasty"
21. TS="Knee joint arthroplasties"
22. TS="knee joint prosthesis"
23. TS="knee joint prostheses"
24. TS="knee prosthetic"
25. TS="Knee endoprosthetic"
26. TS="knee joint prosthetic"
27. TS="Knee joint endoprosthetic"
28. TS="knee prosthetics"
29. TS="Knee endoprosthetics"
30. TS="knee joint prosthetics"
31. TS="Knee joint endoprosthetics"
32. TS="Knee replacement"
34. TS="Knee replacements"
35. TS="knee arthroplasty"
36. TS="knee arthroplasties"
37. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36
38 TS=osteoarthriti*
39. TS=arthriti*
40. TS=Osteoarthrosis
41. TS=Osteoarthroses
42. TS=Osteoarthritides
43. TS=Osteoarthritis
44. TS=Osteoartrosis
45. TS=Osteoartroses
46. TS=Osteoartritides
47. TS=Osteoartritis
48. TS=Degenerative Arthritis
49. TS=Degenerative Arthritides
50. TS=Degenerative Artritis
51. TS=Degenerative Artritides
52. TS=Arthrosis
53. TS=Arthroses
54. TS=Arthritides
55. TS=Arthritis
56. TS=arthritic
57. TS=RA
58. TS=rheumatoid
59. TS=rheumatic
60. TS=Artrosis
61. TS=Artroses
62. TS=Artritides
63. TS=Artritis
64. TS=Osteoarthrosis Deformans
65. TS=Osteoartrosis Deformans
66. TS=Posterior Cruciate Ligament
67. TS=Posterior Cruciate Ligaments
68. TS=Cruciate

69. TS=PCL
70. 38 or 29 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69
71. TS=randomized controlled trial
72. TS=randomization
73. TS=triple blind procedure
74. TS=double blind procedure
75. TS=single blind procedure
76. TS=placebo
77. TS="random allocation"
78. TS="double-blind*"
79. TS="single-blind*"
80. TS=placebo
81. TS=placebos
82. TS=random*
83. TS=ramdom*
84. TS=ramdon*
85. TS=randon*
86. TS=rct
87. TS=rcts
88. TS=single
89. TS=double
90. TS=treble
91. TS=triple
92. 88 or 89 or 90 or 91
93. TS=mask*
94. TS=blind*
95. 93 or 94
96. 92 and 95
97. TS=placebo*
98. TS=random*
99. TI=compare*
100. TI=versus
101. TI=vs
102. 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86 or 87 or 96 or 97 or 98 or 99 or 100 or 101
103. 37 and 70 and 102

Current Contents Connect

1. TS="knee arthroplasty"
2. TS="knee replacement arthroplasty"
3. TS="total knee arthroplasty"
4. TS="total knee"
5. TS=tka
6. TS="total knee replacement"
7. TS="knee prosthesis"
8. TS="knee implantation"
9. TS="knee implant"
10. TS="knee implants"
11. TS="knee prosthesis"
12. TS="knee joint replacement"
13. TS="knee joint arthroplasty"
14. TS=tkr
15. TS="Knee Replacement Arthroplasties"

16. TS="Total Knee Replacements"
17. TS="Knee Prostheses"
18. TS="Knee endoprosthesis"
19. TS="Knee endoprostheses"
20. TS="Knee joint arthroplasty"
21. TS="Knee joint arthroplasties"
22. TS="knee joint prosthesis"
23. TS="knee joint prostheses"
24. TS="knee prosthetic"
25. TS="Knee endoprosthetic"
26. TS="knee joint prosthetic"
27. TS="Knee joint endoprosthetic"
28. TS="knee prosthetics"
29. TS="Knee endoprosthetics"
30. TS="knee joint prosthetics"
31. TS="Knee joint endoprosthetics"
32. TS="Knee replacement"
34. TS="Knee replacements"
35. TS="knee arthroplasty"
36. TS="knee arthroplasties"
37. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36
38 TS=osteoarthriti*
39. TS=arthriti*
40. TS=Osteoarthrosis
41. TS=Osteoarthroses
42. TS=Osteoarthritides
43. TS=Osteoarthritis
44. TS=Osteoartrosis
45. TS=Osteoartroses
46. TS=Osteoartritides
47. TS=Osteoartritis
48. TS=Degenerative Arthritis
49. TS=Degenerative Arthritides
50. TS=Degenerative Artritis
51. TS=Degenerative Artritides
52. TS=Arthrosis
53. TS=Arthroses
54. TS=Arthritides
55. TS=Arthritis
56. TS=arthritic
57. TS=RA
58. TS=rheumatoid
59. TS=rheumatic
60. TS=Artrosis
61. TS=Artroses
62. TS=Artritides
63. TS=Artritis
64. TS=Osteoarthrosis Deformans
65. TS=Osteoartrosis Deformans
66. TS=Posterior Cruciate Ligament
67. TS=Posterior Cruciate Ligaments
68. TS=Cruciate

69. TS=PCL
70. 38 or 29 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69
71. TS=randomized controlled trial
72. TS=randomization
73. TS=triple blind procedure
74. TS=double blind procedure
75. TS=single blind procedure
76. TS=placebo
77. TS="random allocation"
78. TS="double-blind*"
79. TS="single-blind*"
80. TS=placebo
81. TS=placebos
82. TS=random*
83. TS=ramdom*
84. TS=ramdon*
85. TS=randon*
86. TS=rct
87. TS=rcts
88. TS=single
89. TS=double
90. TS=treble
91. TS=triple
92. 88 or 89 or 90 or 91
93. TS=mask*
94. TS=blind*
95. 93 or 94
96. 92 and 95
97. TS=placebo*
98. TS=random*
99. TI=compare*
100. TI=versus
101. TI=vs
102. 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86 or 87 or 96 or 97 or 98 or 99 or 100 or 101
103. 37 and 70 and 102

Cochrane CENTRAL

1. "knee replacement arthroplasty"
2. "total knee arthroplasty"
3. "total knee"
4. tka
5. "total knee replacement"
6. "knee prosthesis"
7. "knee implantation"
8. "knee implant"
9. "knee implants"
10. "knee prosthesis"
11. "knee joint replacement"
12. "knee joint arthroplasty"
13. tkr
14. "Knee Replacement Arthroplasties"
15. "Total Knee Replacements"

16. "Knee Prostheses"
17. "Knee endoprosthesis"
18. "Knee endoprostheses"
19. "Knee joint arthroplasty"
20. "Knee joint arthroplasties"
21. "knee joint prosthesis"
22. "knee joint prostheses"
23. "knee prosthetic"
24. "Knee endoprosthetic"
25. "knee joint prosthetic"
26. "Knee joint endoprosthetic"
27. "knee prosthetics"
28. "Knee endoprosthetics"
29. "knee joint prosthetics"
30. "Knee joint endoprosthetics"
31. "Knee replacement"
32. "Knee replacements"
33. "knee arthroplasty"
34. "knee arthroplasties"
35. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34
36. Osteoarthrosis
37. Osteoarthroses
38. Osteoarthritides
39. Osteoarthritis
40. Osteoartrosis
41. Osteoartroses
42. Osteoartritides
43. Osteoartritis
44. Degenerative Arthritis
45. Degenerative Arthritides
46. Degenerative Artritis
47. Degenerative Artritides
48. Arthrosis
49. Arthroses
50. Arthritides
51. Arthritis
52. arthritic
53. RA
54. rheumatoid rheumatic
55. Artrosis
56. Artroses
57. Artritides
58. Artritis
59. Osteoarthrosis
60. Deformans
61. Osteoartrosis Deformans
62. Posterior Cruciate Ligament
63. Posterior Cruciate Ligaments
64. Cruciate
65. PCL
66. 36 or 37 or 38 or 29 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65

67. 35 and 66

CINAHL

1. "knee replacement arthroplasty"
2. "total knee arthroplasty"
3. "total knee"
4. tka
5. "total knee replacement"
6. "knee prosthesis"
7. "knee implantation"
8. "knee implant"
9. "knee implants"
10. "knee prosthesis"
11. "knee joint replacement"
12. "knee joint arthroplasty"
13. tkr
14. "Knee Replacement Arthroplasties"
15. "Total Knee Replacements"
16. "Knee Prostheses"
17. "Knee endoprosthesis"
18. "Knee endoprostheses"
19. "Knee joint arthroplasty"
20. "Knee joint arthroplasties"
21. "knee joint prosthesis"
22. "knee joint prostheses"
23. "knee prosthetic"
24. "Knee endoprosthetic"
25. "knee joint prosthetic"
26. "Knee joint endoprosthetic"
27. "knee prosthetics"
28. "Knee endoprosthetics"
29. "knee joint prosthetics"
30. "Knee joint endoprosthetics"
31. "Knee replacement"
32. "Knee replacements"
33. "knee arthroplasty"
34. "knee arthroplasties"
35. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34
36. Osteoarthrosis
37. Osteoarthroses
38. Osteoarthritides
39. Osteoarthritis
40. Osteoartrosis
41. Osteoartroses
42. Osteoartritides
43. Osteoartritis
44. Degenerative Arthritis
45. Degenerative Arthritides
46. Degenerative Artritis
47. Degenerative Artritides
48. Arthrosis
49. Arthroses
50. Arthritides

51. Arthritis
52. arthritic
53. RA
54. rheumatoid rheumatic
55. Artrosis
56. Artroses
57. Artritides
58. Artritis
59. Osteoarthrosis
60. Deformans
61. Osteoartrosis Deformans
62. Posterior Cruciate Ligament
63. Posterior Cruciate Ligaments
64. Cruciate
65. PCL
66. 36 or 37 or 38 or 29 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65
67. randomized controlled trial
68. randomization
69. triple blind procedure
70. double blind procedure
71. single blind procedure
72. placebo
73. "random allocation"
74. "double-blind*"
75. "single-blind*"
76. placebo
77. placebos
78. random*
79. ramdom*
80. ramdon*
81. randon*
82. rct
83. rcts
84. single
85. double
86. treble
87. triple
88. 84 or 85 or 86 or 87
89. mask*
90. blind*
91. 89 or 90
92. 88 and 91
93. placebo*
94. random*
95. 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 92 or 93 or 94
96. 35 and 66 and 95

Academic Search Premier

1. "knee replacement arthroplasty" in TI/AB/KW/SU
2. "total knee arthroplasty" in TI/AB/KW/SU
3. "total knee" in TI/AB/KW/SU
4. tka in TI/AB/KW/SU
5. "total knee replacement" in TI/AB/KW/SU

6. "knee prosthesis" in TI/AB/KW/SU
7. "knee implantation" in TI/AB/KW/SU
8. "knee implant" in TI/AB/KW/SU
9. "knee implants" in TI/AB/KW/SU
10. "knee prosthesis" in TI/AB/KW/SU
11. "knee joint replacement" in TI/AB/KW/SU
12. "knee joint arthroplasty" in TI/AB/KW/SU
13. tkr in TI/AB/KW/SU
14. "Knee Replacement Arthroplasties" in TI/AB/KW/SU
15. "Total Knee Replacements" in TI/AB/KW/SU
16. "Knee Prostheses" in TI/AB/KW/SU
17. "Knee endoprosthesis" in TI/AB/KW/SU
18. "Knee endoprostheses" in TI/AB/KW/SU
19. "Knee joint arthroplasty" in TI/AB/KW/SU
20. "Knee joint arthroplasties" in TI/AB/KW/SU
21. "knee joint prosthesis" in TI/AB/KW/SU
22. "knee joint prostheses" in TI/AB/KW/SU
23. "knee prosthetic" in TI/AB/KW/SU
24. "Knee endoprosthetic" in TI/AB/KW/SU
25. "knee joint prosthetic" in TI/AB/KW/SU
26. "Knee joint endoprosthetic" in TI/AB/KW/SU
27. "knee prosthetics" in TI/AB/KW/SU
28. "Knee endoprosthetics" in TI/AB/KW/SU
29. "knee joint prosthetics" in TI/AB/KW/SU
30. "Knee joint endoprosthetics" in TI/AB/KW/SU
31. "Knee replacement" in TI/AB/KW/SU
32. "Knee replacements" in TI/AB/KW/SU
33. "knee arthroplasty" in TI/AB/KW/SU
34. "knee arthroplasties" in TI/AB/KW/SU
35. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34
36. Osteoarthrosis in TI/AB/KW/SU
37. Osteoarthroses in TI/AB/KW/SU
38. Osteoarthritides in TI/AB/KW/SU
39. Osteoarthritis in TI/AB/KW/SU
40. Osteoartrosis in TI/AB/KW/SU
41. Osteoartroses in TI/AB/KW/SU
42. Osteoartritides in TI/AB/KW/SU
43. Osteoartritis in TI/AB/KW/SU
44. Degenerative Arthritis in TI/AB/KW/SU
45. Degenerative Arthritides in TI/AB/KW/SU
46. Degenerative Artritis in TI/AB/KW/SU
47. Degenerative Artritides in TI/AB/KW/SU
48. Arthrosis in TI/AB/KW/SU
49. Arthroses in TI/AB/KW/SU
50. Arthritides in TI/AB/KW/SU
51. Arthritis in TI/AB/KW/SU
52. arthritic in TI/AB/KW/SU
53. RA in TI/AB/KW/SU
54. rheumatoid rheumatic in TI/AB/KW/SU
55. Artrosis in TI/AB/KW/SU
56. Artroses in TI/AB/KW/SU
57. Artritides in TI/AB/KW/SU

58. Artritis in TI/AB/KW/SU
59. Osteoarthrosis in TI/AB/KW/SU
60. Deformans in TI/AB/KW/SU
61. Osteoartrosis Deformans in TI/AB/KW/SU
62. Posterior Cruciate Ligament in TI/AB/KW/SU
63. Posterior Cruciate Ligaments in TI/AB/KW/SU
64. Cruciate in TI/AB/KW/SU
65. PCL in TI/AB/KW/SU
66. 36 or 37 or 38 or 29 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65
67. randomized controlled trial in TI/AB/KW/SU
68. randomization in TI/AB/KW/SU
69. triple blind procedure in TI/AB/KW/SU
70. double blind procedure in TI/AB/KW/SU
71. single blind procedure in TI/AB/KW/SU
72. placebo in TI/AB/KW/SU
73. "random allocation" in TI/AB/KW/SU
74. "double-blind*" in TI/AB/KW/SU
75. "single-blind*" in TI/AB/KW/SU
76. placebo in TI/AB/KW/SU
77. placebos in TI/AB/KW/SU
78. random* in TI/AB/KW/SU
79. ramdom* in TI/AB/KW/SU
80. ramdon* in TI/AB/KW/SU
81. randon* in TI/AB/KW/SU
82. rct in TI/AB/KW/SU
83. rcts in TI/AB/KW/SU
84. single in TI/AB/KW/SU
85. double in TI/AB/KW/SU
86. treble in TI/AB/KW/SU
87. triple in TI/AB/KW/SU
88. 84 or 85 or 86 or 87
89. mask* in TI/AB/KW/SU
90. blind* in TI/AB/KW/SU
91. 89 or 90
92. 88 and 91
93. placebo* in TI/AB/KW/SU
94. random* in TI/AB/KW/SU
95. 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 92 or 93 or 94
96. 35 and 66 and 95

ScienceDirect

1. TITLE-ABSTR-KEY("knee replacement")
2. TITLE-ABSTR-KEY("total knee")
3. TITLE-ABSTR-KEY(tka)
4. TITLE-ABSTR-KEY("knee prosthesis")
5. TITLE-ABSTR-KEY("knee implantation")
6. TITLE-ABSTR-KEY("knee implant")
7. TITLE-ABSTR-KEY("knee implants")
8. TITLE-ABSTR-KEY("knee joint replacement")
9. TITLE-ABSTR-KEY("knee joint arthroplasty")
10. TITLE-ABSTR-KEY(tkr)
11. TITLE-ABSTR-KEY("Knee Prostheses")
12. TITLE-ABSTR-KEY("Knee endoprosthesis")

13. TITLE-ABSTR-KEY("Knee endoprostheses")
14. TITLE-ABSTR-KEY("Knee joint arthroplasty")
15. TITLE-ABSTR-KEY("Knee joint arthroplasties")
16. TITLE-ABSTR-KEY("knee joint prosthesis")
17. TITLE-ABSTR-KEY("knee joint prostheses")
18. TITLE-ABSTR-KEY("knee prosthetic")
19. TITLE-ABSTR-KEY("Knee endoprosthetic")
20. TITLE-ABSTR-KEY("knee joint prosthetic")
21. TITLE-ABSTR-KEY("Knee joint endoprosthetic")
22. TITLE-ABSTR-KEY("knee prosthetics")
23. TITLE-ABSTR-KEY("Knee endoprosthetics")
24. TITLE-ABSTR-KEY("knee joint prosthetics")
25. TITLE-ABSTR-KEY("Knee joint endoprosthetics")
26. TITLE-ABSTR-KEY("Knee replacements")
27. TITLE-ABSTR-KEY("knee arthroplasty")
28. TITLE-ABSTR-KEY("knee arthroplasties")
29. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28
30. TITLE-ABSTR-KEY(Osteoarthritis)
31. TITLE-ABSTR-KEY(Arthritis)
32. TITLE-ABSTR-KEY(Posterior Cruciate Ligament)
33. TITLE-ABSTR-KEY(Posterior Cruciate Ligaments)
34. TITLE-ABSTR-KEY(Cruciate)
35. TITLE-ABSTR-KEY(PCL)
36. 30 or 31 or 32 or 33 or 34 or 35
37. TITLE-ABSTR-KEY(randomized)
38. TITLE-ABSTR-KEY(randomization)
39. TITLE-ABSTR-KEY(random*)
40. TITLE-ABSTR-KEY(ramdom*)
41. TITLE-ABSTR-KEY(ramdon*)
42. TITLE-ABSTR-KEY(randon*)
43. TITLE-ABSTR-KEY(rct)
44. 37 or 38 or 39 or 40 or 41 or 42 or 43
45. 29 and 36 and 44

WHAT'S NEW

Date	Event	Description
7 December 2012	New search has been performed	New search with 10 new studies.
6 December 2012	New citation required but conclusions have not changed	New authorship.

HISTORY

Protocol first published: Issue 1, 2004

Review first published: Issue 4, 2005

Date	Event	Description
13 June 2008	Amended	Converted to new review format. CMSG ID C071-R

CONTRIBUTIONS OF AUTHORS

Original review

W Jacobs and D Clement: writing the protocol, selecting the studies, extracting data, and writing the manuscript

A Wymenga: clinical interpretation of the results

Update review

W Verra, L vd Boom and W Jacobs: updating the protocol, selecting studies, extracting data, writing manuscript

R Nelissen: writing manuscript, interpretation of results

A Wymenga, D Clement: correcting the manuscript

DECLARATIONS OF INTEREST

None known

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

Compared to the protocol, some deviations occurred during the process of developing the review.

First, the decision was made, as requested by the reviewer and editor, to included quasi-randomised trials.

Furthermore, in accordance with the reviewers and editor, the definitions of the major and minor outcomes changed slightly.

The seven major outcomes now are, 1. performance based: range of motion, 2. patients' experience: knee pain, 3. implant survival rate, 4. validated questionnaires on quality of life or function (that is WOMAC), 5. patient satisfaction, 6. complication rate, 7. re-operations other than revision surgery.

The 'rheumatoid arthritis' is removed from the title because we felt it did not add anything to the rest of the title.

INDEX TERMS

Medical Subject Headings (MeSH)

Arthritis, Rheumatoid [*surgery]; Arthroplasty, Replacement, Knee [*methods]; Organ Sparing Treatments [*methods]; Osteoarthritis, Knee [*surgery]; Posterior Cruciate Ligament [*surgery]; Randomized Controlled Trials as Topic; Range of Motion, Articular

MeSH check words

Humans