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One-incision versus two-incision techniques for arthroscopically assisted anterior cruciate ligament reconstruction in adults (Review)

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[Intervention Review]

One-incision versus two-incision techniques for arthroscopically assisted anterior cruciate ligament reconstruction in adults

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ABSTRACT

Background

Anterior cruciate ligament (ACL) tears are serious knee injuries that are frequently treated surgically in the form of arthroscopically assisted reconstruction with grafts from the patella or hamstrings tendons. We reviewed the evidence for the choice of arthroscopically assisted ACL reconstruction technique in terms of whether it should involve one incision (femoral tunnel drilled from inside the knee joint under arthroscopic visualisation) or two incisions (femoral tunnel drilled from outside to inside the knee joint).

Objectives

To assess the effects (benefits and harms) of one-incision versus two-incision techniques for arthroscopically assisted ACL reconstruction in adults.

Search methods

We searched the Cochrane Bone, Joint and Muscle Trauma Group Specialised Register, the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, Embase, Latin American and Caribbean Health Sciences (LILACS), the World Health Organization International Clinical Trials Registry Platform, ClinicalTrials.gov, reference lists, and conference abstracts. The date of the search was 16 August 2017.

Selection criteria

Randomised and quasi-randomised controlled clinical trials evaluating one-incision versus two-incision techniques for arthroscopically assisted ACL reconstruction in adults.

Data collection and analysis

Two review authors independently searched and selected studies, and extracted data and assessed the risk of bias of the eligible studies. We undertook limited pooling of data using the fixed-effect model.

Main results

We included five trials (four randomised and one quasi-randomised) evaluating a total of 320 participants who were mainly in their 20s. All participants underwent ACL reconstruction with patella tendon grafts. All five included trials were at a high risk of bias, particularly performance bias. Based on these limitations and the insufficiency of the available data resulting in imprecision of effect estimates, we judged the quality of the evidence as very low for all outcomes. This means that we are uncertain of the findings of the review.

We found very low-quality evidence of no clinically important differences between the two techniques in self reported knee function, measured using the Lysholm knee score (scale 0 to 100: best outcome), at short-term (3 months) (mean difference (MD) 2.73 favours one-incision technique, 95% confidence interval (CI) -2.70 to 8.15; 79 participants, 2 studies), intermediate-term (12 months) (MD -3.68 favours two-incision technique, 95% CI -6.61 to -0.75; 79 participants, 2 studies), and long-term follow-up. The data available for long-term follow-up (2 to 5 years) was expressed in terms of the numbers of participants with excellent Lysholm scores (90 points or more); we found no difference between the two groups (42/45 versus 36/40; risk ratio (RR) 1.04, 95% CI 0.91 to 1.18; 1 study). There were no data for quality of life measures or for overall numbers of participants incurring an adverse event. We found very low-quality evidence of little between-group differences in individual adverse events such as infection, knee stiffness, reoperation, and graft failure.

We found very low-quality evidence from one study (59 participants) of little difference between the two groups in activity levels measured using Tegner scores (scale 0 to 10: highest sport activity) at two years (MD -0.80 favours two-incision technique, 95% CI -1.90 to 0.30). There was very low-quality evidence from four studies of minimal between-group difference in the number of participants with normal or nearly normal objectively measured knee function (International Knee Documentation Committee objective assessment grading) at intermediate follow-up (means 12 to 28 months): 56/78 versus 63/89; RR 1.01, 95% CI 0.85 to 1.21; 167 participants).

Authors' conclusions

The very low-quality and often absent evidence means that we are uncertain whether one-incision arthroscopically assisted ACL reconstruction techniques yield better, worse, or equivalent results compared with two-incision techniques in terms of short-, intermediate-, or long-term subjective function, quality of life, adverse outcomes, activity levels, and objectively rated knee function. The evidence was available only for single-bundle ACL reconstruction using patella tendon grafts.

When considering priorities for high-quality randomised trials on techniques for ACL reconstruction, it is important to note the insufficiency of the evidence available to inform this key comparison.

PLAIN LANGUAGE SUMMARY

One-incision versus two-incision surgical techniques for anterior cruciate ligament reconstruction in adults

Background

The anterior cruciate ligament (ACL) is a band of tough tissue inside the knee that helps stabilise the knee during movement. Rupture of the ACL is a common injury during some sporting activities, such as football and skiing. Anterior cruciate ligament injuries are often treated surgically. This usually involves keyhole (arthroscopic) ACL reconstruction, where the torn ACL is replaced by a piece of tendon (graft). The graft is usually extracted from another place near the patient's affected knee. In ACL reconstruction, bone tunnels are drilled at the knee into the tibia (shin bone) and the femur (thigh bone) to place the ACL graft in almost the same position as the torn ACL.

This review compared two ACL reconstruction techniques: one-incision versus two-incision. The more common two-incision technique involves drilling the femoral (from the thigh bone) tunnel from outside to inside the knee joint with an incision made in the outward aspect of the thigh to reach the bone. In the one-incision technique, there is no (second) incision into the thigh. Instead the graft is fixed to the femur from inside to outside the joint through arthroscopic guidance.

Results of the search

We searched the medical literature databases up to August 2017 for randomised studies comparing one-incision versus two-incision arthroscopic ACL reconstruction techniques. We included five trials involving 320 people undergoing ACL reconstruction with patella tendon grafts. Most of the study participants were in their 20s.

Key results

We found no differences between the two techniques in self reported knee function at around three months, 12 months, or between two and five years. There were no data for quality of life or for the overall number of participants incurring an adverse event. However, we found evidence of little between-group differences in individual adverse events such as infection, knee stiffness, and graft failure. There was evidence of little difference between the two groups in final activity levels or the numbers of participants with normal or nearly normal knee function assessed by clinicians at a year or more after surgery.

Quality of the evidence

All five studies had weaknesses that could seriously affect the reliability of their results. We considered the evidence to be of very low quality, meaning that we are unsure of the results.

Conclusions

The lack of reliable evidence means that we are uncertain whether one-incision arthroscopically assisted ACL techniques are any better (or worse) than two-incision techniques. Further research would help to answer this question but may not be a current priority.

SUMMARY OF FINDINGS

Summary of findings for the main comparison. One-incision compared to two-incision techniques for arthroscopically assisted anterior cruciate ligament reconstruction in adults

One-incision compared to two-incision techniques for arthroscopically assisted anterior cruciate ligament (ACL) reconstruction in adults

Patient or population: adults undergoing arthroscopically assisted ACL reconstruction¹

Setting: hospital operating theatre

Intervention: one-incision technique

Comparison: two-incision technique

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No. of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Two-incision technique (control)	One-incision technique (intervention)				
Subjective function (short term)²: Lysholm knee score (0 to 100: higher scores = better function) Follow-up: 3 months	The mean Lysholm score in the two-incision groups ranged from 84 to 90.	The mean Lysholm score in the one-incision groups was 2.73 higher (2.70 lower to 8.15 higher).	-	79 (2 studies)	⊕⊕⊕⊕ VERY LOW ³	The 95% CI are unlikely to include a clinically important difference. ⁴
Subjective function (intermediate term)²: Lysholm knee score (0 to 100: higher scores = better function) Follow-up: 12 months	The mean Lysholm score in the two-incision groups ranged from 94 to 97.	The mean Lysholm score in the one-incision groups was 3.68 lower (0.75 to 6.61 lower).	-	79 (2 studies)	⊕⊕⊕⊕ VERY LOW ³	The 95% CI are unlikely to include a clinically important difference. ⁴ A similar lack of differences was found in 2 studies at 24 months (very low-quality evidence). ⁵
Subjective function (long term)²: Lysholm knee score (0 to 100: higher scores = better function) Excellent score (90 or above)	900 per 1000 ⁶	936 per 1000 (819 to 1000)	RR 1.04 (0.91 to 1.18)	85 (1 study)	⊕⊕⊕⊕ VERY LOW ⁷	-

Follow-up: mean 43 months; range 2 to 5 years						
Quality of life(intermediate term)²	See comment	See comment	-	-	See comment	No quality of life measures were reported.
Adverse events (overall)	See comment	See comment	-	-	See comment	4 studies reported on specific complications but not overall numbers. There was very low-quality evidence of little between-group differences. ⁸
Activity level (intermediate term) Tegner activity score (0 to 10: highest sport activity) Follow-up: 24 months	The mean Tegner activity score in the two-incision group was 5.7.	The mean Tegner activity score in the one-incision group was 0.8 lower (1.9 lower to 0.3 higher)	-	59 (1 study)	⊕⊕⊕⊕ VERY LOW ⁹	-
Objective functional knee assessments using IKDC¹⁰ (intermediate term) (normal or nearly normal assessment) Follow-up: 12 to 28 months	698 per 1000 ¹¹	705 per 1000 (594 to 845)	RR 1.01 (0.85 to 1.21)	167 (4 studies)	⊕⊕⊕⊕ VERY LOW ¹²	-

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: confidence interval; **IKDC:** International Knee Documentation Committee; **MD:** mean difference; **RR:** risk ratio

GRADE Working Group grades of evidence

High quality: We are very confident that the true effect lies close to that of the estimate of the effect.

Moderate quality: We are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low quality: Our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.

Very low quality: We have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

¹All grafts used in the five included trials were patellar tendons. The participants were mainly in their 20s.

²We defined short term as less than six months, intermediate term as six months to two years, and long term as two years or longer after ACL reconstruction.

³We downgraded the quality of the evidence two levels for very serious risk of bias (in particular high risk of selection and performance bias), and one level for imprecision, primarily reflecting the small sample size.

⁴The minimum detectable change (the minimum difference in an outcome score below which cannot be distinguished from random error in the measurement) for the Lysholm score has been estimated as 8.9.

- ⁵One study (59 participants) reported a 1-point difference (MD -1.00 favouring one-incision group, 95% CI -7.34 to 5.34), and the other study (61 participants) found a 2-point difference (one-incision group: 96.81 versus two-incision group: 94.65; reported not statistically significant).
- ⁶The assumed control risk is that of the study reporting this outcome.
- ⁷We downgraded the quality of the evidence two levels for very serious risk of bias (in particular high risk of selection, performance, and selective reporting bias), and one level for serious imprecision, reflecting the small sample size and wide confidence interval.
- ⁸Reported adverse events were infection, nerve palsy, haemarthrosis requiring treatment, knee stiffness, recurrent knee instability, persistent knee swelling, reoperation (for meniscal and cartilage lesions, removal of deep hardware, etc.), and graft failure.
- ⁹We downgraded the quality of the evidence two levels for very serious risk of bias (in particular high risk of selection and performance bias), and one level for serious imprecision, reflecting the small sample size.
- ¹⁰Objective assessment included that of symptoms, range of motion, one-leg hop test, and ligament examination categorised into four groups: A (normal), B (nearly normal), C (abnormal), and D (severely abnormal).
- ¹¹The assumed risk is the median control risk across studies.
- ¹²We downgraded the quality of the evidence two levels for very serious risk of bias (in particular high risk of selection and performance bias), and one level for imprecision, primarily reflecting the small sample size.

BACKGROUND

Description of the condition

The anterior cruciate ligament (ACL) is a tough band of tissue located in the centre of the knee joint that connects the tibia (shin bone) with the femur (thigh bone). It acts mainly to stabilise the knee against forward movement of the tibia relative to the femur. It also helps resist rotatory motion of the knee. The ACL courses from its posterior (back) attachment in the lateral (outer relative to the midline) femoral condyle (one of two rounded prominences of the femur that articulate with the tibia) towards the tibial attachment in its anterior (front) and slightly medial (inner relative to the midline) aspect (Girgis 1975).

Rupture of the ACL is a common injury in young adults involved in physical activities, especially sports such as football, rugby, and skiing. As participation in sports and recreational activities increases, the incidence of these injuries tends to increase. Anterior cruciate ligament injury may be the result of sudden deceleration, hyperextension, or a cutting action (Griffin 2000). The resultant instability of the knee prevents the resumption of a person's former level of activities. Moreover, recurrent episodes of knee instability may cause further injuries, such as meniscal tears, which might lead to early onset of knee osteoarthritis.

Current surgical treatment of ACL rupture comprises ACL reconstruction under arthroscopic guidance (Jackson 1987). Over 100,000 ACL reconstructions are conducted each year in the United States alone (Lyman 2009). In ACL reconstruction, the torn ligament is replaced by a piece of tendon (graft), which is either an autograft that is harvested from the patient him or herself or an allograft obtained from a cadaver.

Description of the intervention

Arthroscopically assisted ACL reconstruction is typically performed through two standard portals (small stab incisions through which a camera (arthroscope) and instruments are introduced). The general aim is to place the graft as near as possible to that of the native ligament. The structures within the knee joint are visualised through the arthroscope, and surgery is performed with small instruments. Bone tunnels are drilled into the tibia and the femur to place the ACL graft in almost the same position as the torn ACL. After introduction and positioning of the graft, the ends are fixed into place at or near the original attachment sites of the torn ACL with the use of various devices. These devices can be grouped according to their underlying mechanisms of fixation: compression (interference screw), expansion (a cross pin system (Rigidfix)), or suspension (button) (Zeng 2013). We illustrate here the procedures used in reconstruction with interference screws, which are threaded conical devices made of either metal or bioabsorbable material.

The choice of ACL reconstruction technique is not straightforward. One issue concerns the method of drilling the tunnel into the femur. Traditionally, the femoral tunnel is drilled from outside to inside the knee joint, and an incision is made in the outward aspect of the thigh to reach the bone (two-incision technique) (Bach 1989). In this procedure, the graft is fixed to the femur from outside to inside the joint with an interference screw by direct visualisation of the tunnel through the thigh incision.

The one-incision arthroscopic technique consists of drilling the femoral tunnel from inside the knee joint under arthroscopic visualisation, thereby sparing the thigh incision and quadriceps (anterior muscles of the thigh) dissection (Hardin 1992; Howell 1999). The graft is fixed to the femur from inside to outside the joint through arthroscopic guidance and then fixed with an interference screw. The only incision thus needed is the one for drilling the tunnel into the tibia, which is done (as in the two-incision technique) through an anterior incision below the knee.

How the intervention might work

Anterior cruciate ligament reconstruction aims to restore knee stability. An additional goal of strong graft fixation is to facilitate early postsurgical rehabilitation during the so-called 'weak link' time, when the process of tendon-bone healing is incomplete.

Because there is no dissection of the tissues on the outward-facing part of the knee, it has been suggested that the one-incision technique should facilitate rehabilitation more successfully than the two-incision technique (Hess 2002; Paulos 1994). However, the one-incision technique is technically more challenging since the fixation of the graft to bone is done from inside the joint under arthroscopic control (Fanelli 1994). As the ultimate success of the ACL reconstruction procedure depends on secure and well-placed fixation of the graft to the bone, compromises in graft fixation might be more relevant than avoiding a second incision. In the choice between the two techniques, there is thus a balance to be achieved between the potential for speedier recovery in the one-incision technique and the potential for more reliable graft fixation in the technically less challenging two-incision technique (Arciero 1996; Gill 2002).

Why it is important to do this review

Anterior cruciate ligament reconstruction is a common surgical procedure that involves many choices in terms of the type of graft, fixation devices, and surgical technique. Some treatment decisions have already been addressed in other Cochrane Reviews; these include the type of autograft (Mohtadi 2011), use of computer-assisted reconstruction (Meuffels 2011), and double- versus single-bundle reconstruction (Tiamklang 2012). However, research on ACL reconstruction is far from exhausted, and many other key treatment decisions have not yet reached consensus, nor have they been systematically reviewed. This includes the use of one-incision versus two-incision techniques, the subject of this review.

OBJECTIVES

To assess the effects (benefits and harms) of one-incision versus two-incision techniques for arthroscopically assisted anterior cruciate ligament (ACL) reconstruction in adults.

METHODS

Criteria for considering studies for this review

Types of studies

We included randomised and quasi-randomised (a method of allocating participants to a treatment that is not strictly random, e.g. by medical record number or date of birth) controlled clinical trials evaluating one-incision versus two-incision techniques for arthroscopically assisted ACL reconstruction in adults.

Types of participants

Adults (skeletally mature individuals) with ACL rupture who have undergone primary ACL reconstruction, irrespective of the presence of associated soft tissue knee injuries. We included trials irrespective of the type of graft used.

We excluded trials in which participants were treated surgically using open (that is through open arthrotomy reconstruction) rather than arthroscopic methods. We also excluded trials focusing on the treatment of people with previous ACL reconstruction requiring revision surgery.

Types of interventions

One-incision versus two-incision arthroscopically assisted reconstruction of ACL injuries. For a study to be included, the same grafts, fixation devices, and other techniques needed to be used in both intervention groups under comparison.

Types of outcome measures

Primary outcomes

1. Functional assessments based on subjectively assessed, preferably validated questionnaires of knee function, e.g. the International Knee Documentation Committee (IKDC) subjective part for knee ligament injuries and the Lysholm score (Irrgang 2001; Lysholm 1982).
2. Quality of life assessments based on subjective and preferably validated questionnaires, e.g. the ACL Quality of Life outcome measure (Mohtadi 1998), the Knee Injury and Osteoarthritis Outcome Score (KOOS) for the knee in general (Roos 1998), and the Medical Outcomes Study 36-item short-form health survey (SF-36) for general measures (Ware 1992).
3. Adverse events including treatment failure (implant breakage, screw migration, graft loss, residual instability, infection, knee stiffness).

Secondary outcomes

1. Activity level measured by instruments (e.g. Tegner activity level scale) (Tegner 1985).
2. Return to previous activity level.
3. Clinical composite scores (e.g. clinician-rated IKDC objective part categories) (Irrgang 2001).
4. Objective function tests (e.g. one-leg hop test, vertical jump test).
5. Static stability measures (e.g. Lachman, Pivot-Shift, Anterior Drawer tests, KT-arthrometer side-to-side difference).
6. Pain measured by scales (such as a visual analogue scale) (Revill 1976).
7. Knee range of motion.
8. Muscle strength (Cybex isokinetic muscle strength testing or equivalent).
9. Thigh circumference.
10. Lateral and posteroanterior knee radiographs (femoral tunnel position - anatomic or isometric).

Timing of outcome measurement

Where data were presented at different follow-up times, we presented data separately for the short term (within six months of ACL reconstruction), intermediate term (six months up to two

years of ACL reconstruction), and long term (greater than two years of ACL reconstruction). Additionally, based on data availability, we presented long-term data separately for two to five years and six years and above.

Search methods for identification of studies

Electronic searches

We searched the Cochrane Bone, Joint and Muscle Trauma Group Specialised Register (to 16 August 2017), the Cochrane Central Register of Controlled Trials (CENTRAL) (2017; Issue 8), MEDLINE (including Epub Ahead of Print, In-Process & Other Non-Indexed Citations, MEDLINE Daily and Versions) (Ovid online) (1946 to 16 August 2017), Embase (Ovid online) (1974 to 16 August 2017), and Latin American and Caribbean Health Sciences (LILACS) (Virtual Health Library, IAHx platform) (1982 to 16 August 2017). We also searched the World Health Organization International Clinical Trials Registry Platform (WHO ICTRP) (apps.who.int/trialsearch) and ClinicalTrials.gov (clinicaltrials.gov/) (16 August 2017) for ongoing and recently completed studies. We did not apply any restrictions based on language or publication status.

In MEDLINE, a subject-specific strategy was combined with the sensitivity-maximising version of the Cochrane Highly Sensitive Search Strategy for identifying randomised trials (Lefebvre 2011). The search strategies for CENTRAL, MEDLINE, Embase, and LILACS are shown in Appendix 1.

Searching other resources

We checked the reference lists from relevant articles. We searched the conference abstracts of the following annual meetings from 2013: International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) (isakos.com/) (to March 2015), American Orthopaedic Society for Sports Medicine (AOSSM) (www.sportsmed.org/) (to March 2015), and American Academy of Orthopaedic Surgeons (AAOS) (aaos.org/) (to March 2015). We contacted the authors of trials identified by searching conference proceedings for any unpublished trial reports and results.

Data collection and analysis

We described the intended methodology for data collection and analysis in our published protocol (Rezende 2013), which was based on the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011).

Selection of studies

Two review authors (FR and VM) independently searched abstracts and titles for potentially eligible studies. After we obtained the full-text reports of these studies, the same two review authors independently performed study selection. Any disagreements were discussed. When consensus was not achieved, a third review author (JB) was consulted.

Data extraction and management

Two review authors (FR and PD) independently extracted the trial characteristics and results data from eligible studies using a piloted data collection form. We attempted to contact trial authors in order to obtain missing data or for clarification. Disagreements were resolved by discussion, with a third review author (JB) consulted when necessary.

Assessment of risk of bias in included studies

Two review authors (FR and CF) assessed the risk of bias of the included studies using Cochrane's 'Risk of bias' tool (Higgins 2011). This consists of seven domains: sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting, and other bias (e.g. bias from major differences in baseline characteristics, performance bias due to disparity in the experience of the surgeons performing the procedures, and the influence of funding sources as a potential cause of bias). We assessed each domain as being 'low risk', 'high risk', or 'unclear risk'. We decided against considering objective and subjective outcomes separately for the two blinding domains and incomplete outcome data, as specified in our protocol; see [Differences between protocol and review](#). Disagreements were resolved by discussion, with a third review author (JB) consulted when necessary.

Measures of treatment effect

We calculated risk ratios (RRs) and 95% confidence intervals (95% CIs) for dichotomous outcomes, and mean differences and 95% CIs for continuous outcomes. We would have used standardised mean differences rather than mean differences had we needed to pool data from continuous outcome measures based on different scoring schemes (e.g. functional outcomes such as the IKDC, ACL Quality of Life, and Lysholm scores). We would have collected results based on change scores only if final values were not available.

Unit of analysis issues

Clinical trials included in this review followed the 'standard model', in which participants with unilateral ACL rupture are randomised to either a one- or a two-incision technique. Bilateral ACL ruptures are rare, but had these been included in trials and no adjustments made, we planned to present the data for knees rather than for individual participants if the disparity between the units of analysis and randomisation was small. We have taken steps to avoid unit of analysis issues relating to presentation of data at multiple time points and the presentation of outcomes, such as overall complications, that could have occurred more than once in individual participants by performing separate analyses for different follow-up times.

Dealing with missing data

We attempted to contact trial investigators to request missing information and data, such as the number of events or participants, means and standard deviations. Where possible, we performed intention-to-treat analyses. In the absence of standard deviations (SDs), we would have calculated these from other statistics such as standard errors, 95% CIs, and exact P values had these been available. As previously stipulated, we did not impute missing means or SDs.

Where data continued to be unavailable, we assessed whether or not these data were missing at random. When data were thought to be missing at random, or considered to be irrelevant, we ignored them and worked only with the available and relevant data. If data were assumed to not be missing at random, we would have conducted sensitivity analyses to explore the potential effects of these missing data on the results.

Assessment of heterogeneity

We appraised the heterogeneity of intervention effects of studies visually by observing the overlapping of results in the analyses. We would have interpreted the lack of overlapping as indicative of possible heterogeneity. Using Review Manager 5 software (RevMan 2014), we calculated I^2 values, which we interpreted as follows: insignificant heterogeneity (between 0% to 40%), moderate heterogeneity (30% to 60%), substantial heterogeneity (50% to 90%), and considerable (very substantial) heterogeneity (75% to 100%) (Deeks 2011).

Assessment of reporting biases

Had we included more than 10 studies in the meta-analysis, we would have assessed reporting bias by generating a funnel plot. This would have been evaluated through observing the symmetry of the distribution of intervention effects in the plot: the more symmetrical, the higher the chance of absence of reporting bias. In addition, in order to diminish the publication bias effect on asymmetry, we would have added pre-established contour lines containing boundaries of statistical significance (Peters 2008). We would have been cautious in our interpretation of the funnel plots and considered different possible causes for funnel plot asymmetry before attributing any asymmetry to reporting bias.

Data synthesis

When considered appropriate, we pooled results of comparable groups of trials using the fixed-effect model calculated via Review Manager 5 software (RevMan 2014). The choice of the model to report in the review was guided by careful consideration of the extent of any heterogeneity and whether it could be explained, in addition to other factors such as the number and size of the included studies. We would have considered using a random-effects model, especially when there was unexplained heterogeneity. We used 95% CIs throughout. We also considered not pooling data where there was considerable heterogeneity (I^2 greater than 75%) that could not be explained by the diversity of methodological or clinical features among the trials. Where we considered pooling data to be inappropriate, we have presented trial data in the analyses or tables for illustrative purposes and reported these in the text.

Subgroup analysis and investigation of heterogeneity

Insufficient data precluded our intended subgroup analyses to assess the effects of the following.

- Concomitant meniscal injuries: isolated ACL injuries versus ACL injury with associated meniscal tears
- Delay between ACL injury and reconstruction surgery (acute versus chronic lesions)
- Different methods of making femoral tunnels: inside-out versus outside-in, inside-out versus transportal, and outside-in versus transportal

Should it be possible to conduct these subgroup analyses in updates of this review, we will investigate whether the results of subgroups are significantly different by inspecting the overlap of CIs and by performing the test for subgroup differences available in Review Manager 5 (Deeks 2011).

Sensitivity analysis

Had sufficient trials been available, we would have performed sensitivity analyses to examine various aspects of the trial and review methodology, including the effects of missing data, the selection of a statistical model (fixed-effect versus random-effects) for pooling, and the effects of excluding trials at high or unclear risk of bias, such as selection bias arising from lack of allocation concealment, trials with unit of analysis problems related to the inclusion of participants with bilateral ACL injuries, and trials with short-term follow-up after ACL reconstruction.

Assessing the quality of the evidence and 'Summary of findings' table

We used the GRADE approach to assess the quality of the body of evidence for each primary outcome and one of our secondary outcomes, thus subjective assessment of function (in the short, intermediate, and long term), quality of life (preferably intermediate term), adverse events including treatment failure, activity level (intermediate or long term), and objective functional knee assessment using the IKDC (intermediate term) (Schünemann 2011). We preferred intermediate- and long-term outcomes because these would have been more representative of final outcome after the rehabilitation period. The quality rating 'high' is reserved for a body of evidence based on randomised controlled trials. We downgraded the quality rating to 'moderate', 'low', or 'very low' depending on the presence and extent of five factors: study limitations, inconsistency of effect, imprecision, indirectness, or publication bias. We presented the main results

together with the quality assessments in a 'Summary of findings' table (Schünemann 2011).

RESULTS

Description of studies

Results of the search

Appendix 1 shows the results from searches of CENTRAL, MEDLINE, Embase, LILACS, the WHO ICTRP, and ClinicalTrials.gov up to August 2017.

We screened a total of 1261 records from the following databases: Cochrane Bone, Joint and Muscle Trauma Group Specialised Register (25 records), CENTRAL (113), MEDLINE (181), Embase (254), LILACS (29), the WHO ICTRP (448 records), and ClinicalTrials.gov (211). We did not identify potentially eligible studies from other sources.

The search identified a total of 28 articles for potential inclusion, for which full reports were obtained. Upon study selection, we included five studies (six reports) (Brandsson 1999; Hess 2002; O'Neill 2001 (two reports); Reat 1997; Santori 1996), and excluded 18 studies (22 reports) (Aglietti 1995; Aglietti 2007; Barrett 1996; Benea 2014; Garfinkel 1994 (two reports); Gerich 1997 (three reports); Howell 1999; Hussein 2012; Iorio 2012; Jonsson 1994; Kim 2012; Kim 2013 (two reports); Lubowitz 2013; Merchant 2001; Monaco 2017; Panni 2001; Yanasse 2016; Zhang 2012). We found no ongoing studies and no further studies await classification.

A flow diagram summarising the study selection process is shown in Figure 1.

Figure 1. Study flow diagram.

Included studies

For further details, please see the [Characteristics of included studies](#).

Design

All five studies were single-centre studies. Of these, four were randomised controlled trials ([Brandsson 1999](#); [Hess 2002](#); [Reat 1997](#); [Santori 1996](#)), and [O'Neill 2001](#) was a quasi-randomised controlled trial. [O'Neill 2001](#) had three groups, of which two were relevant to this review. [O'Neill 2001](#) was reported in two articles: [O'Neill 1996](#) was an interim report of participants recruited between August 1989 and August 1992, and [O'Neill 2001](#) was a follow-up report that included additional participants recruited up to October 1994.

Sample sizes

The number of participants included in the studies was as follows: [Brandsson 1999](#) (59 participants), [Hess 2002](#) (20 participants), [O'Neill 2001](#) (150 participants relevant to this review by the end of their study), [Reat 1997](#) (30 participants), and [Santori 1996](#) (61 participants).

Setting

The five studies were conducted in four countries: Germany ([Hess 2002](#)), Italy ([Santori 1996](#)), Sweden ([Brandsson 1999](#)), and the United States ([O'Neill 2001](#); [Reat 1997](#)). All five studies were conducted in university hospital settings.

Participants

The five included studies evaluated a total of 320 participants. Most participants were young adults, with mean ages in study population ranging from 25.6 to 29.4 years. [O'Neill 2001](#) recorded the youngest and oldest participants, at 14 and 56 years respectively. People with acute or chronic ACL injury were included, with 34 (40% of 85 participants in the interim report of [O'Neill 2001](#)) being operated on within three weeks of their injury in [O'Neill 2001](#), and the longest recorded delay between injury and surgery of 364 months in [Reat 1997](#). [Hess 2002](#) limited the time from injury to surgery to a maximum of six months and also included only isolated ACL injuries ([Hess 2002](#)). Meniscal and chondral lesions were included as associated injuries in the other four trials. None of the participants had bilateral ACL involvement.

Interventions

Four of the five trials were comparisons between two groups, one of which had the two-incision (outside-in) technique and the other the one-incision (transtibial) technique. Although [O'Neill 2001](#) had three groups, we excluded one of the two-incision groups because it differed from the other two groups in the use of a different graft (hamstrings tendon rather than patellar tendon and graft fixation with staples rather than interference screw). The type of tendon graft harvested was from patellar tendon in all trial participants included in the review. The type of graft fixation was interference screw in both femur and tibia in three trials ([Brandsson 1999](#); [Hess 2002](#); [Santori 1996](#)), and interference screw or sutures tied over a post screw in the other two trials ([O'Neill 2001](#); [Reat 1997](#)). Two trials used immobilisation with a brace ([Brandsson 1999](#); [Reat 1997](#)); two trials used no brace ([Hess 2002](#); [Santori 1996](#)); and [O'Neill 2001](#) did not report brace use. The rehabilitation programme was the same in both groups for each included study.

Outcomes

Timing of outcome assessment varied among the studies. Minimum final follow-up times were two years in [Brandsson 1999](#) and [Santori 1996](#); one year in [Hess 2002](#) and [Reat 1997](#); and two years in the interim report and six years in the final report of [O'Neill 2001](#).

Primary outcomes

Subjectively assessed knee function was reported using Lysholm scores in all trials except [Reat 1997](#). None of the trials reported any quality of life measures.

Four trials reported adverse events such as knee stiffness, infection, recurrent lesions, recurrent instability, and graft failure ([Brandsson 1999](#); [O'Neill 2001](#); [Reat 1997](#); [Santori 1996](#)). [Hess 2002](#) only reported on complications during the "clinical course".

Secondary outcomes

Secondary outcomes available were objective measures of knee stability (Tegner activity level) ([Brandsson 1999](#)), return to previous activity level, [O'Neill 2001](#), and level of activity ([Reat 1997](#)), IKDC knee examination ([Brandsson 1999](#); [Hess 2002](#); [O'Neill 2001](#); [Reat 1997](#); [Santori 1996](#)), objective function tests (one-leg hop test) ([Brandsson 1999](#); [O'Neill 2001](#); [Reat 1997](#)), static stability measures (Pivot-Shift, Lachman, mean side-to-side differences, measured by a KT-1000 or KT-2000) ([Brandsson 1999](#); [O'Neill 2001](#); [Reat 1997](#); [Santori 1996](#)), pain ([Brandsson 1999](#); [Reat 1997](#)), knee range of motion ([Hess 2002](#); [Reat 1997](#)), muscle strength ([Hess 2002](#); [O'Neill 2001](#)), and thigh circumference ([Hess 2002](#)).

All included studies used the original IKDC knee form, which provides an overall grade (A, B, C, or D) that incorporates the patient's subjective score ([Hefti 1993](#)). The newer version provides an overall group grade (A, B, C, or D) in addition to a patient-based subjective score out of 100 ([Irrgang 2001](#)).

Excluded studies

We excluded 18 studies for the reasons provided in the [Characteristics of excluded studies](#) table. Seven studies were not randomised or quasi-randomised controlled trials ([Aglietti 1995](#); [Aglietti 2007](#); [Barrett 1996](#); [Garfinkel 1994](#); [Howell 1999](#); [Merchant 2001](#); [Panni 2001](#)). The other 11 randomised controlled trials did not undertake the comparison covered in this review ([Benea 2014](#); [Gerich 1997](#); [Hussein 2012](#); [Iorio 2012](#); [Jonsson 1994](#); [Kim 2012](#); [Kim 2013](#); [Lubowitz 2013](#); [Monaco 2017](#); [Yanasse 2016](#); [Zhang 2012](#)). Of note is that [Gerich 1997](#) was excluded because the two-incision technique was performed through mini-open arthrotomy rather than through arthroscopy; [Iorio 2012](#) and [Monaco 2017](#) were excluded because different fixation devices were used for femoral fixation of the graft; [Jonsson 1994](#) was excluded because the femoral tunnel was performed using a different technique ("over the top"); and [Yanasse 2016](#) was excluded because the femoral graft fixation for the transtibial group was performed through a lateral incision, similar to the two-incision group.

Risk of bias in included studies

All five trials had methodological weaknesses that put them at unclear or high risk of bias in many 'Risk of bias' domains (see [Figure 2](#)). We previously considered separate reporting of patient-rated and clinician-rated outcomes of some 'Risk of bias' domains (blinding of participants and personnel, blinding of outcome

assessment, and incomplete outcome data), but chose not to do this because of their high likelihood of being comparable (same

results irrespective of subjective or objective outcomes). An overall summary of 'Risk of bias' domains can be found in [Figure 3](#).

Figure 2. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Brandsson 1999	?	-	-	?	?	?	?
Hess 2002	?	?	-	?	?	?	?
O'Neill 2001	-	-	-	?	+	-	?
Reat 1997	?	?	-	?	-	?	?
Santori 1996	+	?	-	?	+	?	?

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

Allocation

We judged selection bias of trials by considering the method of random sequence generation and whether there was allocation concealment.

We considered the quasi-randomised controlled trial as at high risk of selection bias both in relation to lack of random sequence generation and allocation concealment (O'Neill 2001). We judged two trials that did not describe their method of randomisation as at unclear risk of bias for both domains (Hess 2002; Reat 1997). Although Brandsson 1999 described the use of closed envelopes, they did not describe the method of sequence generation (we judged this domain to be at unclear risk of bias) or safeguards to allocation concealment. Furthermore, it appears that participants in this trial could withdraw consent if they were unhappy with their allocation group, the participants being operated on in two consecutive series. We rated Brandsson 1999 as at high risk of selection bias relating to allocation concealment. Santori 1996's use of a coin toss put it at low risk of bias for sequence generation but at unclear risk of bias for allocation concealment, as safeguards were not described.

Blinding

All studies were at high risk of performance bias, since no trial described blinding of the participants, and blinding of the surgeon is understood to be impossible.

All trials were at unclear risk of detection bias since no mention was made of blinding of outcome assessors. We considered the reference to outcome data collection by independent observers in two trials as insufficient information to judge detection bias (Brandsson 1999; O'Neill 2001).

Incomplete outcome data

We considered two trials as at low risk of bias since they either reported no loss to follow-up, Santori 1996, or minimal loss to follow-up (O'Neill 2001). We considered two trials as at unclear risk of bias due to insufficient information on losses (Brandsson 1999;

Hess 2002). Reat 1997 reported on losses, but these occurred only in one group at final follow-up and were disproportionately large for a small trial.

Selective reporting

Initially we rated all trials at unclear risk of selective reporting bias because neither trial registration nor published study protocols were available. However, we then rated O'Neill 2001 at high of bias for this domain due to inclusion of participants in the follow-up report who were not considered in the early report (O'Neill 2001). Contact with the author was unsuccessful, so it was not possible to obtain the reasons for this.

Other potential sources of bias

We rated all five studies as at unclear risk of other bias, generally reflecting insufficient information to assess whether there was bias from major differences in baseline characteristics, performance bias due to disparity in the experience of the surgeons performing the procedures, and the influence of funding sources as a potential cause of bias. Of note is the lack of information to determine whether there were differences in baseline characteristics in three trials (Brandsson 1999; Hess 2002; O'Neill 2001), with a major imbalance in the mean time between injury and surgery noted in Reat 1997. Although there did not appear to be major imbalances in baseline characteristics in Santori 1996, the imbalance between groups in the numbers randomised remains of some concern. All surgical procedures were performed by experienced surgeons except for Reat 1997, in which orthopaedic residents performed the surgeries under the supervision of a single experienced surgeon. However, confirmation of equivalent experience or familiarity in both techniques by the experienced surgeons was not confirmed in O'Neill 2001 or Santori 1996. We identified no other obvious sources were bias, including those relating to inappropriate influence of funding source, but no statement on funding was given in three trials (Brandsson 1999; Reat 1997; Santori 1996).

Effects of interventions

See: [Summary of findings for the main comparison One-incision compared to two-incision techniques for arthroscopically assisted anterior cruciate ligament reconstruction in adults](#)

This review compared two techniques for ACL reconstruction: the two-incision (outside-in) technique and the one-incision (inside-out) technique. All five studies used bone-patellar tendon bone grafts. When possible, we presented outcomes separately for the short term (less than six months after ACL reconstruction), intermediate term (six months to two years), and long term (greater than two years after ACL reconstruction). The outcomes in the included studies were for the most part available for the intermediate term. Based on available data, we made a distinction between long-term follow-ups of two to five years and six years and above.

The planned subgroup analyses for comparing concomitant meniscal injuries, acute versus chronic ACL injuries, and different methods of making femoral tunnels were not possible due to insufficient data.

Primary outcomes

Subjectively rated knee function

Of the four studies reporting Lysholm scores (scale from 0 to 100: best outcome), two provided mean and standard deviation results ([Brandsson 1999](#); [Hess 2002](#)); one reported on participants with 'excellent' scores (90 or more) ([O'Neill 2001](#)); and one reported mean scores only ([Santori 1996](#)). Pooled data from two studies (79 participants) showed little difference between the two groups at three months (mean difference (MD) 2.73 favouring one-incision technique, 95% confidence interval (CI) -2.70 to 8.15; 79 participants; very low-quality evidence) or 12 months (MD -3.68 favouring two-incision technique, 95% CI -6.61 to -0.75; very low-quality evidence; [Analysis 1.1](#)). We found very low-quality evidence of a similar lack of clinically important difference at 24 months or more in [Brandsson 1999](#) (MD -1.00 favouring two-incision technique, 95% CI -7.34 to 5.34; 59 participants; [Analysis 1.1](#)) and in [Santori 1996](#) (means: one-incision technique 96.81 versus two-incision technique 94.65; 61 participants; difference reported as not statistically significant). Of note is that the results (MDs and 95% CIs) are all below the minimum detectable change (the minimum difference in an outcome score below which cannot be distinguished from random error in the measurement) of 8.9 for the Lysholm score ([Briggs 2009](#)). [O'Neill 2001](#) found no difference between the two groups in the participants with excellent Lysholm scores (90 points or more) at two- to five-year follow-up: 42/45 versus 36/40; risk ratio (RR) 1.04, 95% CI 0.91 to 1.18; very low-quality evidence; [Analysis 1.2](#).

None of the studies reported functional assessments using the subjective part of the more recent International Knee Documentation Committee (IKDC) score ([Irrgang 2001](#)).

Quality of life measures

None of the included studies reported quality of life assessments such as the ACL Quality of Life outcome measure or more general measures such as the Medical Outcomes Study 36-item short-form health survey (SF-36) ([Mohtadi 1998](#)).

Adverse effects and complications

With the exception of [Hess 2002](#) (20 participants), which reported an absence of complications affecting the "clinical courses" in all cases at 12 months' follow-up, the included trials did not report on overall numbers of participants incurring one or more complications in the two groups. The individual adverse effects reported by the trials are presented in [Analysis 1.3](#); none indicated a significant difference between the two groups (very low-quality evidence). We have not included data from [Hess 2002](#) if they did not describe the specific adverse events that had not occurred.

Infection

[Brandsson 1999](#) reported one case in each group of superficial infection, and [Reat 1997](#) reported no cases of wound infection (1/44 versus 1/45; RR 1.03, 95% CI 0.07 to 15.77).

Nerve palsy

[Brandsson 1999](#) reported one case of nerve palsy, which resolved by 12 months' follow-up, in the two-incision group (0/29 versus 1/30).

Haemarthrosis requiring treatment

[Brandsson 1999](#) reported four cases of haemarthrosis (bleeding into the joint) that required arthrocentesis (joint aspiration) (1/29 versus 3/30).

Knee stiffness

Two trials reported on knee stiffness at two to five years, either in terms of loss of terminal extension (4/74 versus 2/70; RR 1.77, 95% 0.40 to 7.79) or loss of terminal flexion (3/74 versus 6/70; RR 0.50, 95% 0.14 to 1.72) ([Brandsson 1999](#); [O'Neill 2001](#)).

Recurrent instability

[Reat 1997](#) reported one case of recurrent instability (giving away) in the two-incision group (1/15 versus 0/12).

Knee swelling

[Reat 1997](#) reported 12 cases of knee swelling, occurring with sedentary, light, moderate, or strenuous activity (7/15 versus 5/12).

Reoperation

Three trials reported on reoperations occurring up to two to five years' follow-up ([Brandsson 1999](#); [O'Neill 2001](#); [Santori 1996](#)). In two trials ([Brandsson 1999](#); [Santori 1996](#)), reoperation was for meniscal or cartilage injury. Additional operations in [O'Neill 2001](#) included one reconstruction, one lateral retinacular release, and four for removal of deep hardware. Pooled results showed little difference between the two groups (8/98 versus 9/107; RR 0.89, 95% CI 0.37 to 2.14; 205 participants; 3 studies; [Analysis 1.3](#)).

Graft failure

[O'Neill 2001](#) reported nine cases of graft failure at 6 to 11 years' follow-up (5/75 versus 4/75).

Secondary outcomes

Activity levels

The only study reporting on Tegner activity level scores (assessment based on the highest activity in which the patient can participate: scale 0 to 10: highest sport activity) found neither

group returned to their pre-injury levels by 24 months (one-incision technique mean 7.0; two-incision technique mean 6.8), with no clear difference between the two groups (MD -0.80 favours two-incision technique, 95% CI -1.90 to 0.30; 59 participants; very low-quality evidence; [Analysis 1.4](#)) ([Brandsson 1999](#)). Similar numbers of participants were engaged in strenuous or moderate activity at final follow-up (between 5 and 28 months) in [Reat 1997](#): 11/15 (one-incision technique) versus 9/12 (two-incision technique) (RR 0.98, 95% CI 0.63 to 1.53; data not shown, very low-quality evidence).

[O'Neill 2001](#) found little difference between the two groups at two to five years' follow-up in reported return to previous activity (40/45 versus 38/40; RR 0.94, 95% CI 0.83 to 1.06; very low-quality evidence; [Analysis 1.5](#)). [Reat 1997](#) provided incomplete data on return to previous activity by focusing only on those participants (11 versus 13) who had engaged in "strenuous" activity prior to their injury: at 5 to 28 months' follow-up, 4 of 11 participants in the one-incision group and 5 of 13 in the two-incision group were participating in strenuous activity (very low-quality evidence).

IKDC knee examination (objective part)

All five trials presented results from the IKDC knee examination (primarily objective assessment of aspects such as symptoms, range of motion, and ligament examination) categorised into four groups: A (normal), B (nearly normal), C (abnormal), and D (severely abnormal) ([Hefti 1993](#)).

Pooled data for participants with normal or nearly normal scores at three time intervals are presented in [Analysis 1.6](#). However, the data from two studies (43 participants) for three to six months' follow-up were significantly heterogeneous ($P = 0.02$, $I^2 = 81\%$; very low-quality evidence) and should be regarded as inconclusive. There was minimal between-group difference at either 12 to 28 months' average follow-up (56/78 versus 63/89; RR 1.01, 95% CI 0.85 to 1.21; 167 participants; 4 studies; $I^2 = 0\%$; very low-quality evidence) or at 6 to 11 years (70/75 versus 71/75; RR 0.99, 95% CI 0.91 to 1.07; 150 participants; 1 study; very low-quality evidence).

Objective function tests (one-leg hop test)

Three trials reported this outcome in terms of the percentage of the test results relative to the contralateral (non-operated) leg ([Brandsson 1999](#); [O'Neill 2001](#); [Reat 1997](#)). None of the trials found evidence of a difference between the two groups. Both groups in [Brandsson 1999](#) (59 participants) had a mean of 95% result compared with non-operated legs at 24 months (MD 0.00, 95% CI -3.73 to 3.73; very low-quality evidence; [Analysis 1.7](#)). [Reat 1997](#) reported no significant difference between the two groups at around 15 months' follow-up (one-incision group mean 89%; two-incision group mean 92%). [O'Neill 2001](#), reporting on one-leg hop test results at two to five years, found minimal difference between the two groups in the number of participants with one-leg hop test greater than 90% of contralateral leg (40/45 versus 37/40; RR 0.96, 95% CI 0.84 to 1.10; very low-quality evidence; [Analysis 1.8](#)).

Static stability measures

Knee stability measured by arthrometer

[Brandsson 1999](#) (59 participants) found small between-group differences at three months in favour of the two-incision group in the mean side-to-side differences in anterior translation measured by a KT-1000 arthrometer at 89 N (MD 0.90 mm, 95% CI 0.13 to 1.67) and at 135 N (MD 1.10 mm, 95% CI 0.35 to 1.85). However, the clinical

importance of these differences is marginal, and there were no between-group differences at 24 months at either setting (MD 0.30, 95% CI -0.59 to 1.19; MD 0.20, 95% CI -0.65 to 1.05; very low-quality evidence; [Analysis 1.9](#)). Pooled data for side-to-side differences of less than 3 mm showed no evidence of a difference between the two groups, either when measured by a KT-1000 arthrometer at 12 to 24 months (34/44 versus 35/42; RR 0.95, 95% CI 0.78 to 1.15; 2 studies) or when measured by a KT-2000 arthrometer at two to five years (72/99 versus 81/112; RR 0.97, 95% CI 0.83 to 1.14; 2 studies). Overall pooled results also did not show a difference between the two groups (106/143 versus 116/154; RR 0.96, 95% CI 0.85 to 1.09; 297 participants; 4 studies; very low-quality evidence; [Analysis 1.10](#)).

[Hess 2002](#) (20 participants) also reported no differences in the mean side-to-side differences (mm), measured by a KT-1000 arthrometer at manual maximal force with 30 degrees of flexion between the two groups at three months (one-incision group mean 0.18 mm versus two-incision group mean 0.79 mm) and at 12 months (one-incision group mean 1.18 mm versus two-incision group mean 1.03 mm).

Other measures of stability: Pivot-Shift Test and Lachman test

At three months, [Reat 1997](#) found all 23 cases with data at three months had normal or nearly normal Pivot-Shift Test and Lachman test results (very low-quality evidence; [Analysis 1.11](#)); 25 of 27 cases with data at 12 months also had normal or nearly normal Pivot-Shift Test and Lachman test results (13/15 versus 12/12; RR 0.88, 95% CI 0.69 to 1.11; very low-quality evidence; [Analysis 1.11](#)). At two to five years, [O'Neill 2001](#) found little difference between the two groups in cases with normal or nearly normal results (39/45 versus 37/40; RR 0.94, 95% CI 0.81 to 1.08; very low-quality evidence; [Analysis 1.11](#)). Anterior Drawer Tests were not reported.

Pain

[Brandsson 1999](#) (59 participants) found lower (worse) patellofemoral pain scores (0 to 20: best outcome) in the one-incision group at 3 months (MD -2.00, 95% CI -3.96 to -0.04) and 12 months (MD -1.00, 95% CI -2.81 to 0.81) but no between-group differences at 24 months (MD 0.00, 95% CI -2.31 to 2.31); very low-quality evidence; [Analysis 1.12](#). The actual scale used was not reported, and the clinical significance of any difference is not known. [Reat 1997](#) reported early pain at one, three, and six weeks categorised into four groups: none, mild, moderate, and severe pain. At six weeks, six participants in each group had mild or worse pain (6/11 versus 6/13; RR 1.18, 95% CI 0.53 to 2.62; very low-quality evidence; [Analysis 1.13](#)). There was also no between-group difference in those reporting pain at 15 months' follow-up (9/15 versus 8/12; RR 0.90, 95% CI 0.51 to 1.60; very low-quality evidence; [Analysis 1.13](#)).

Knee range of motion

[Hess 2002](#) reported on mean range of motion in both flexion and (hyper)extension at 3, 6, and 12 months. Although tending to favour the two-incision group, the small differences (1 to 4 degrees for flexion; 0.2 to 2.0 degrees for extension) between the two groups at all follow-up times were not clinically important, and normal levels were reached at 12 months' postsurgery; very low quality evidence; [Analysis 1.14](#). [Reat 1997](#) reported no difference between the two groups at one, three, and six weeks and last follow-up (mean 16 months) in the mean extension, flexion, and overall range of motion; very low-quality evidence; [Analysis 1.15](#).

Muscle strength (Cybex isokinetic muscle strength testing)

[Hess 2002](#) (20 participants) evaluated peak torque forces measured by Cybex isokinetic muscle strength at 3, 6, and 12 months, reporting the results as a percentage of the contralateral side for extensor muscles and flexor muscles at 60°/s and 180°/s under eccentric and concentric isokinetic movement. [Hess 2002](#) reported a "continuous increase of peak torque ratio" over time with a faster improvement in the one-incision group; between-group differences in the eight measures ranged from 13.5% to 27.7% at three months and 0.7% to 37.5% at six months ([Analysis 1.16](#)). The results at 12 months (standard deviations were estimated from graphs) continued to favour the one-incision group, although the between-group differences were smaller with all 95% CI crossing the line of no effect; very low-quality evidence; [Analysis 1.17](#).

[O'Neill 2001](#) (150 participants) reported on deficits of 10% or more in isokinetic muscle strength at 6 and 11 years' follow-up. There were fewer cases in the one-incision group of quadriceps deficit (20/75 versus 31/75; RR 0.65, 95% CI 0.41 to 1.02; very low-quality evidence) and hamstrings muscle deficit (5/75 versus 10/75; RR 0.50, 95% CI 0.18 to 1.39; very low-quality evidence) ([Analysis 1.18](#)).

Thigh circumference

[Hess 2002](#) (20 participants) provided very low-quality evidence of no between-group difference in the mean thigh circumference (cm), 10 cm above the joint line, at 12 months (one-incision group mean 43 cm versus two-incision group mean 44 cm).

Femoral tunnel position - anatomic or isometric

None of the included studies reported on this outcome.

DISCUSSION

Summary of main results

This review included four randomised controlled trials and one quasi-randomised controlled trial comparing one-incision versus two-incision ACL reconstruction techniques. The studies randomised a total of 320 participants, most of whom were in their 20s. Participants in all five trials underwent ACL reconstruction with patellar tendon grafts.

The main results of the comparison of one-incision versus two-incision ACL reconstruction are presented in [Summary of findings for the main comparison](#). These show a consistent picture, albeit supported by very low-quality evidence, of no clinically important differences between the two techniques in self reported knee function, measured using the Lysholm knee score, in short-term (3 months), intermediate-term (12 months), and long-term (2 to 5 years) follow-up. There were no data for quality of life measures or for participants incurring an adverse event. We found very low-quality evidence of little between-group differences in individual adverse events such as those in the postoperative period (e.g. infection), those reported at final follow-up (e.g. knee stiffness), and by final follow-up (e.g. reoperation and graft failure). There was very low-quality evidence from one study of little difference between the two groups in activity levels measured using Tegner scores at two years. We found very low-quality evidence from four studies of minimal between-group difference in the number of participants with normal or nearly normal objectively measured knee function at intermediate-term follow-up.

It should be noted that the quality of the evidence was also very low for all other secondary outcomes for which data are presented in [Effects of interventions](#).

Overall completeness and applicability of evidence

All five methodologically flawed studies were small, with data available for a maximum of 205 participants (3 studies) for reoperation and 297 participants for objectively measured knee stability. Pooled data for subjective function were only available from two trials (79 participants), with no data for quality of life measures or overall numbers with adverse events. The available data to inform on this comparison are thus very limited and incomplete.

The trial participants are generally representative of those who receive ACL reconstruction, but it should be noted that all grafts used in the trials were patellar tendons. The results may thus not be applicable to reconstruction with other grafts, notably hamstring tendon ([Mohtadi 2011](#)). In addition to deficiencies in outcome measurement, such as for subjective outcome and activity level, the large variation in the length of follow-up data in studies such as [Reat 1997](#) and [O'Neill 2001](#) also hinders interpretation and applicability of trial findings.

Quality of the evidence

All five trials had methodological weaknesses that put them at unclear or high risk of bias in many 'Risk of bias' domains (see [Figure 2](#) and [Figure 3](#)). This applied particularly to the largest trial ([O'Neill 2001](#)), which was quasi-randomised. In our assessment of the quality of evidence based on the GRADE approach ([Schünemann 2011](#)), we thus downgraded two levels for very serious risk of bias ([Summary of findings for the main comparison](#)). We further downgraded the evidence one level for imprecision, reflecting the small sample size. We did not downgrade for inconsistency, indirectness, or potential publication bias. We thus rated the quality of the evidence as very low for all outcomes for which data were available, meaning we have very little confidence in the effect estimates.

Potential biases in the review process

We used the standard methods described in the *Cochrane Handbook for Systematic Reviews of Interventions* ([Higgins 2011](#)). We cross-checked data extracted from study reports, resolving any disagreements by discussion. We attempted to contact trial authors for missing data and unpublished trials. We have reported any changes to our protocol in [Differences between protocol and review](#). An important change was in our definition of the key outcomes for inclusion in the 'Summary of findings' table, in particular our post hoc inclusion of normal or nearly normal IKDC objective knee assessment at intermediate-term follow-up.

Although our literature search was comprehensive, it is possible that we did not identify all trials, especially unpublished trials presented in conference abstracts only.

The evidence was dominated (150 participants) by the results of [O'Neill 2001](#), a quasi-randomised controlled trial that was reported in two papers ([O'Neill 1996](#); [O'Neill 2001](#)), with the inclusion of a further 65 participants (in this review) at follow-up of 6 to 11 years whose results were not included in the early report at 2- to 5-year follow-up. We took care in our processing and interpretation

of the data from this unsatisfactory trial in order to avoid both double-counting and losing data. Overall the data were insufficient to perform sensitivity analyses to explore in a meaningful way the inclusion of O'Neill 2001, the only explicit quasi-randomised controlled trial, or other decisions made in the review process.

Agreements and disagreements with other studies or reviews

We identified one other systematic review of randomised controlled trials comparing one-incision with two-incision ACL arthroscopic reconstruction (George 2007). George 2007 included four trials, one of which we excluded from our review because a non-arthroscopic technique (mini-open arthrotomy) was used (Gerich 1997). Two trials were not identified (Hess 2002; Santori 1996), and the follow-up report of O'Neill was not considered (O'Neill 2001). George 2007 did not assess the methodological quality of the included studies and gave emphasis to outcomes, such as operative time, with significant statistical differences between the two techniques, which we did not consider in our review. In terms of outcomes considered in both reviews, such as function and activity scores (e.g. Lysholm and Tegner), George 2007 reported similar findings of a lack of significant differences between one-incision and two-incision ACL reconstruction techniques.

AUTHORS' CONCLUSIONS

Implications for practice

The very low-quality and often absent evidence means that we are uncertain whether one-incision arthroscopically assisted anterior cruciate ligament (ACL) reconstruction techniques yield better, worse, or equivalent results compared with two-incision techniques in terms of short-, intermediate-, or long-term subjective function, quality of life, adverse outcomes, and final activity levels and objectively rated knee function. Evidence was only available for single-bundle ACL reconstruction using patella tendon grafts.

Implications for research

When considering priority topics for high-quality randomised trials on techniques for ACL reconstruction, it is important

to note the insufficient evidence available to inform this comparison. Additionally, it is important to set the comparison in the context of the evolving nature of ACL reconstruction surgery, where these two techniques are part of an increasing spectrum of ACL reconstruction techniques. Conceptually, two-incision techniques have been expanded to a greater myriad of techniques known as independent drilling or anatomical ACL reconstruction technique. Similarly, one-incision techniques have been expanded to transtibial drilling or non-anatomical techniques. Some consideration to these conceptual changes should be given in updates of this review.

Given the rapid growth of more modern ACL reconstruction procedures, we consider that further randomised trials undertaking the comparison tested in this review are not a priority. Any future randomised trial undertaking this or a related comparison must be robust in design, implementing up-to-date methods aimed at avoiding bias, and conform to CONSORT reporting requirements. Notably, it is feasible to reduce the risk of detection bias for this comparison by covering scars with bandages for data collection by independent observers. Future trials should focus on collecting outcomes that are important to patients with ACL rupture (such as subjective knee function, quality of life, levels of activity, and adverse outcomes), with final follow-up at five years or more.

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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Brandsson 1999

Methods	<p>Study design: randomised controlled trial.</p> <p>Single-centre study, secondary care setting.</p> <p>Place of study: Sahlgrenska University - Hospital/Östra, Göteborg, Sweden.</p> <p>Randomisation method: allocation to 2 groups using closed envelopes.</p> <p>Assessor blinding: independent observer, not involved in the surgical procedure.</p> <p>No loss to follow-up</p>
Participants	<p>Inclusion criteria: 59 people with symptomatic ACL instability who had previously undergone supervised rehabilitation without success.</p> <p>Sex: 39 male (66%); 20 female.</p> <p>Median age: 27 years (range 15 to 45).</p> <p>Mean time since injury: not stated, range 3 to 92 months.</p>
Interventions	<ol style="list-style-type: none"> One-incision (n = 29): patellar tendon fixed with interference screw in both femur and tibia. The femoral guide was passed through the tibial tunnel and the femoral tunnel was drilled. Two-incision (n = 30): patellar tendon fixed with interference screw in both femur and tibia. A lateral thigh incision was made over the iliotibial band and a guidewire was advanced into the knee and passed into the posterior intercondylar notch.
Outcomes	<p>Follow-up: 3, 12, and 24 months after surgery. The IKDC score was registered at the final 2-year follow-up.</p> <ol style="list-style-type: none"> Knee scores: Lysholm knee scores, Tegner activity scores, the IKDC scores. Anterior knee laxity measurement (side-to-side differences): KT 1000 arthrometer. Objective functional tests: one-leg hop quotient (comparison with non-operated leg). Adverse events: knee stiffness, infection, recurrent lesions. Pain: patellofemoral pain score.

Notes

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	<p>Quotes: "patients were allocated randomly"; "Patients were allocated to the two treatment groups using closed envelopes"</p> <p>Comment: There is no description of method of sequence generation, but randomisation appears to be timed before patient consent.</p>

Brandsson 1999 (Continued)

		<p>“In order to ensure that the surgical procedures were as uniform as possible, the patients were operated on in two consecutive series, starting with the 'out-side-in' technique (pre-randomisation)”</p> <p>Comment: It thus appears that the 2 techniques were not performed concurrently.</p> <p>Quote: "All patients were informed about this randomisation procedure before surgery and only those who accepted the randomisation were included in the study"</p> <p>Comment: The number of postrandomisation exclusions is not stated.</p>
Allocation concealment (selection bias)	High risk	<p>Quote: “Patients were allocated to the two treatment groups using closed envelopes”</p> <p>Comments: Sequence generation was not appropriate, and the allocation concealment was performed with closed envelopes, but it is not clear whether the closed envelopes were opaque and numbered.</p> <p>Quote: "All patients were informed about this randomisation procedure before surgery and only those who accepted the randomisation were included in the study"</p> <p>Comment: Irrespective of whether allocation was concealed, this approach is likely to have led to post-randomisation exclusions and thus make selection bias likely.</p>
Blinding of participants and personnel (performance bias) All outcomes	High risk	<p>No available information about blinding of participants.</p> <p>Impossible to blind the surgeon.</p>
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	<p>Quote: "all patients were followed up by an independent observer, who was not involved in the surgical procedure"</p> <p>Comments: It is not specified if the therapist was blind to the type of procedure.</p>
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	No available information
Selective reporting (reporting bias)	Unclear risk	No trial registration or published protocol available.
Other bias	Unclear risk	<p>Surgery was performed by 1 of 3 experienced knee surgeons, who were well acquainted with both methods.</p> <p>Due to overall poor reporting in the article, we are unable to judge whether there were other sources of bias (such as major differences in baseline characteristics and the influence of funding sources as a potential cause of bias).</p>

Hess 2002

Methods	Study design: randomised controlled trial.
	Single-centre study, secondary care setting.
	Place of study: Homburg/Saar, Germany.

One-incision versus two-incision techniques for arthroscopically assisted anterior cruciate ligament reconstruction in adults (Review)

Hess 2002 (Continued)

Randomisation method: not cited.

Assessor blinding: not cited.

No loss to follow-up

Participants	<p>Inclusion criteria: 20 people with isolated ACL deficiency of no greater than 6 months, side-to-side difference in thigh circumference of no more than 2 cm (measured 10 cm proximal to joint line), and the patient's ability to participate in a standardised rehabilitation programme.</p> <p>Sex: 12 male (60%), 8 female.</p> <p>Mean age: 29.4 years (range 19 to 42).</p> <p>Mean time since injury: not stated.</p>
Interventions	<p>Period of study: 12 months.</p> <ol style="list-style-type: none"> 1. One-incision (n = 10): bone-patellar tendon-bone autograft and interference screw fixation in both femur and tibia. 2. Two-incision (n = 10): bone-patellar tendon-bone autograft and interference screw fixation in both femur and tibia. For the two-incision method, the proximal femur was approached by splitting the vastus lateralis muscle.
Outcomes	<p>Follow-up: 6 weeks, 3, 6, and 12 months postoperatively.</p> <ol style="list-style-type: none"> 1. Knee scores: Lysholm and IKDC scores. 2. Measurement of thigh circumferences. 3. Muscle strength (Cybex isokinetic muscle strength testing). 4. Knee range of motion. 5. Complication (none).
Notes	We extracted standard deviations for Lysholm scores from the graph of this outcome.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	<p>Quote: "... who underwent unilateral anterior cruciate ligament reconstruction with bone-patellar tendon-bone autografts were randomly assigned to one of the two procedures"</p> <p>Comment: Insufficient information</p>
Allocation concealment (selection bias)	Unclear risk	No available information
Blinding of participants and personnel (performance bias) All outcomes	High risk	<p>No available information about blinding of participants.</p> <p>Impossible to blind the surgeon.</p>
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No available information
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	The power calculation revealed that the sample size was sufficient, however information was insufficient to determine if there was attrition.

Hess 2002 (Continued)

Selective reporting (reporting bias)	Unclear risk	No trial registration or published protocol available. Potentially inadequate recording and reporting of adverse events
Other bias	Unclear risk	No information to assess whether baseline characteristics were comparable. “No author or related institution has received any financial benefit from research in this study” “Both operative procedures were standardized and performed by two experienced surgeons”

O'Neill 2001

Methods	<p>Study design: quasi-randomised 3-arm controlled trial.</p> <p>Single-centre study, secondary care setting.</p> <p>Place of study: Nassau Bay, Texas, United States.</p> <p>Randomisation method: allocation according to birth month.</p> <p>Assessor blinding: all evaluations were done by the same independent physical therapist.</p> <p>Loss to final follow-up: 3 participants.</p> <p>This trial, which included 3 groups, was published in 2 reports: O'Neill 1996, where 127 participants were recruited, of whom 125 were followed up for 2 to 5 years; and O'Neill 2001, where 1 of the original participants was excluded and an additional group of 101 participants was added, giving a total of 225 participants followed for a minimum of 6 years. In the following we provide separate summaries for participant characteristics, and the outcomes available in the 2 reports.</p> <p>1 of the groups was not relevant to this review, thus the numbers are adjusted below to those included in this review.</p>
Participants	<p>No mention of inclusion or exclusion criteria.</p> <p>1996 report:</p> <p>87 participants (2 lost to follow-up). Sex: 54 male (64%), 31 female.</p> <p>Mean age: 27 years (range 14 to 56).</p> <p>Mean time since injury: ? but 34 (40%) operated on within 3 weeks and 65 within 1 year.</p> <p>2001 report:</p> <p>150 participants.</p> <p>Sex: male:female ratio was 2:1 "in all groups", thus 100 male (67%), 50 female.</p> <p>Mean age: no information.</p> <p>Mean time since injury: not stated.</p>
Interventions	<ol style="list-style-type: none"> One-incision (n = 46, but 45 assessed (1996 report); 75 (2001 report)): patellar ligament graft with interference screw fixation in both femur and tibia. Two-incision (n = 41, but 40 assessed (1996 report); 75 (2001 report)): patellar ligament graft with interference screw fixation in both femur and tibia. A 4 cm vertical incision was made laterally, superior to the lateral femoral condyle, and the vastus lateralis was elevated anteriorly from the femur.

O'Neill 2001 (Continued)

Outcomes

1996 report:

Follow-up: mean 43 months (range 24 to 60 months).

1. Knee scores: Lysholm, Tegner, IKDC.
2. Objective functional tests: one-leg hop test.
3. Muscle strength (Cybex isokinetic muscle strength testing).
4. Anterior knee laxity measurement (side-to-side differences): KT-2000 arthrometer.
5. Degenerative changes (radiographs).
6. Return to pre-injury level.
7. Adverse events: graft failure, knee stiffness, patellar crepitus, additional surgery.

2001 report:

Follow-up: mean 102 months (range 6 to 11 years).

1. Knee scores: IKDC score.
2. Muscle strength (Cybex isokinetic muscle strength testing).
3. Anterior knee laxity measurement (side-to-side differences): Lachman, KT-2000 arthrometer.
4. Degenerative changes (radiographs).
5. Adverse events: knee stiffness, recurrent lesions, graft failure.
6. Objective functional tests: one-leg hop test.
7. Return to previous activity level.

Notes

Data are not included in this review from the participants in the third group (40 participants in [O'Neill 1996](#) and 75 in [O'Neill 2001](#)), which tested a two-incision technique using a double-stranded semitendinosus-gracilis graft. Graft fixation was performed with 2 staples in the femur and 2 in the tibia. We did not include this group in the analyses due to relevant differences (different grafts and graft fixation devices) between this group and the one-incision group that would confound the comparison of one- versus two-incision technique.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Quote: "The patients were randomly assigned to the type of operative procedure according to the month in which they had been born" Comments: Inadequate method of sequence generation
Allocation concealment (selection bias)	High risk	Comments: Inadequate method of allocation concealment
Blinding of participants and personnel (performance bias) All outcomes	High risk	No available information about blinding of participants. Impossible to blind the surgeon.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Quote: "All of the instrumented tests and scoring evaluations were done by the same independent physical therapist, to enhance reproducibility" Comments: It is not specified if the therapist was blind to the type of procedure.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "125 patients were included in the previous two-to-five-year follow-up study. One of these patients died from a gunshot wound less than six years postoperatively and therefore was not eligible for the present study. In addition, 101 patients who had had insufficient follow-up for inclusion in the origi-

O'Neill 2001 (Continued)

nal study were eligible for the present study. Thus, the final analysis included 225 patients"

Comments: The reasons for exclusion of participants were given.

Selective reporting (reporting bias)	High risk	No trial registration or published protocol available. Introduction of participants not considered in the early report introduces substantial reporting bias.
Other bias	Unclear risk	<p>"The author did not receive payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity"</p> <p>The author (O'Neill) performed all operative procedures.</p> <p>Due to overall poor reporting in the article, we are unable to judge whether there were other sources of bias (such as major differences in baseline characteristics). In the first cohort, more associated injuries were present in one-incision group (35 (78%) versus 24 (60%)), and more meniscal injuries were operated on. However, O'Neill 2001 claimed there "were no significant differences with regard to the number of previous operations, associated injuries, or concomitant operations".</p>

Reat 1997

Methods	<p>Study design: randomised controlled trial.</p> <p>Single-centre study, secondary care setting.</p> <p>Place of study: Baylor Sports Medicine, Texas, United States.</p> <p>Randomisation method: not available.</p> <p>Assessor blinding: not available.</p> <p>Loss to follow-up: 3 participants (at final follow-up).</p>
Participants	<p>Inclusion criteria: 30 people with chronic ACL instability.</p> <p>Exclusion criteria: medial collateral ligament instability > 1+, any posterior or lateral instability, previous surgery other than arthroscopic debridement or partial meniscectomy, flexion contracture, varus or valgus deformity, degenerative joint disease.</p> <p>Sex: 21 male (70%), 9 female.</p> <p>Mean age: 27 years (range 17 to 43 years).</p> <p>Mean time since injury: 29.5 months (range 3 to 264).</p>
Interventions	<ol style="list-style-type: none"> One-incision (n = 15): patellar ligament graft with interference screw fixation in the femur and screw-post fixation in the tibia. Two-incision (n = 15): patellar ligament graft with screw-post fixation in both femur and tibia.
Outcomes	<p>Follow-up: mean 15 months (range 5 to 28 months), also 1, 3, and 6 weeks, and 3, 6, and 12 months postoperatively</p> <ol style="list-style-type: none"> Knee scores: IKDC score. Muscle strength (Cybex isokinetic muscle strength testing). Static stability measures: Lachman, Pivot-Shift, KT-1000 arthrometer side-to-side difference. Objective functional tests: one-leg hop test. Adverse events: pain (early and late pain), recurrent instability.

Reat 1997 (Continued)

6. Knee range of motion.
7. Level of activity (strenuous; moderate; light; sedentary).

Notes

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "They were randomized as they were scheduled for surgery" Comments: Insufficient information about the randomisation process
Allocation concealment (selection bias)	Unclear risk	No available information
Blinding of participants and personnel (performance bias) All outcomes	High risk	No available information about blinding of participants. Impossible to blind the surgeon.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No available information
Incomplete outcome data (attrition bias) All outcomes	High risk	Three participants (20%) of the two-incision group were lost to final follow-up, but the reasons for this were not provided. Different losses at different follow-up times are large due to the small numbers in the trial (e.g. pain at 6 weeks: 4 (27%) versus 2 (13%)) and are also likely to be a source of bias.
Selective reporting (reporting bias)	Unclear risk	No trial registration or published protocol available.
Other bias	Unclear risk	"Surgery was performed by orthopaedic residents under the direct supervision of the senior investigator (D.M.L)." Due to overall poor reporting in the article, we are unable to judge whether there were other sources of bias (performance bias due to disparity in the experience of the surgeons performing the procedures, and the influence of funding sources as a potential cause of bias). Although the groups were comparable in age, sex ratio, and incidence of associated pathology, the time between injury and surgery differed considerably in the 2 groups (one-incision: mean 12 months (range 5 to 29 months); two-incision: mean 47 months (range 3 to 264 months)). The implications of this are unclear.

Santori 1996

Methods	Study design: randomised controlled trial. Single-centre study, secondary care setting. Place of study: Clinic Orthopaedic University, Rome, Italy. Randomisation method: heads and tails method. Assessor blinding: 2 "blindly" randomised groups were analysed.
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Santori 1996 (Continued)

No loss to follow-up

Participants	<p>Inclusion criteria: 61 people with isolated chronic ACL instability.</p> <p>Exclusion criteria: acute injuries (< 2 months), multiple ligament injuries, extra-articular reconstructions.</p> <p>Sex: 39 male (64%), 22 female.</p> <p>Mean age: 25.6 years (range 17 to 42).</p> <p>Mean time since injury: not stated.</p>
Interventions	<p>Period of study: 24 months.</p> <ol style="list-style-type: none"> 1. One-incision (n = 24): bone-patellar tendon-bone autograft and interference screw fixation in both femur and tibia. 2. Two-incision (n = 37): bone-patellar tendon-bone autograft and interference screw fixation in both femur and tibia. "A second short incision over the flare of the lateral femoral condyle was made, the vastus lateralis was retracted anteriorly and the periosteum was detached."
Outcomes	<p>Follow-up: 27.6 months (range 24 to 30 months).</p> <ol style="list-style-type: none"> 1. Knee scores: IKDC score, Lysholm. 2. Static stability measures: KT-2000 arthrometer side-to-side difference 3. Adverse events: recurrent instability, recurrent lesions
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	<p>Quote: "Patients randomly assigned to one of the two treatment groups. Criteria of randomization was the heads and tails method"</p> <p>Comments: Coin-tossing method seems to be appropriate for random sequence generation.</p>
Allocation concealment (selection bias)	Unclear risk	<p>Quote: "Patients randomly assigned to one of the two treatment groups. Criteria of randomization was the heads and tails method"</p> <p>Comments: No information regarding safeguards to ensure that the allocation was accepted (no concealment)</p>
Blinding of participants and personnel (performance bias) All outcomes	High risk	<p>No available information about blinding of participants.</p> <p>Impossible to blind the surgeon.</p>
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	<p>Quote: "We analysed two blindly randomized groups at 2 years' follow-up"</p> <p>No details available of how this was achieved and it refers to analysis rather than data collection</p>
Incomplete outcome data (attrition bias) All outcomes	Low risk	No loss to follow-up

Santori 1996 (Continued)

Selective reporting (re-reporting bias)	Unclear risk	No trial registration or published protocol available.
Other bias	Unclear risk	The reported baseline characteristics appeared comparable and "no significant differences were observed between groups" was reported with regard to level of pre-injury activity, type and frequency of sport. "All the ACL reconstructions were performed by the senior surgeon (PPM)." However, confirmation of equivalent experience or familiarity in both techniques by the experienced surgeon was not provided.

ACL: anterior cruciate ligament

IKDC: International Knee Documentation Committee

Characteristics of excluded studies [ordered by study ID]

Study	Reason for exclusion
Aglietti 1995	Not a randomised trial: 2 parallel series
Aglietti 2007	Not a randomised trial: a prospective comparative cohort study that compared two-incision versus one-incision double-bundle ACL reconstruction
Barrett 1996	Not a randomised trial: a retrospective cohort study that compared one-incision versus two-incision ACL reconstruction techniques
Benea 2014	Interventions not in the scope of the review: this randomised controlled trial compared full-length tibial tunnel technique with all-inside techniques (tibial tunnel with partial length).
Garfinkel 1994	Not a randomised trial: a prospective comparative cohort analysis of one-incision versus two-incision ACL reconstruction techniques
Gerich 1997	Interventions not in the scope of the review: this randomised controlled trial compared one-incision arthroscopic technique with two-incision technique through mini-open arthrotomy; the latter is an exclusion criterion of this review.
Howell 1999	Not a randomised trial: 2 parallel series
Hussein 2012	Interventions not in the scope of the review: this randomised controlled trial compared anatomical double-bundle, anatomic single-bundle, and conventional (transtibial) single-bundle ACL reconstruction techniques.
Iorio 2012	Interventions not in the scope of the review: trial compared different fixation devices.
Jonsson 1994	Interventions not in the scope of the review: this randomised controlled trial compared different methods of the femoral placement of the graft, but the modified "over the top" intervention that involved no femoral tunnel used a different fixation device.
Kim 2012	Interventions not in the scope of the review: this randomised controlled trial compared transportal versus outside-in technique double-bundle ACL reconstruction.
Kim 2013	Interventions not in the scope of the review: this randomised controlled trial compared transportal versus outside-in technique double-bundle ACL reconstruction.
Lubowitz 2013	Interventions not in the scope of the review: this randomised controlled trial compared full-length tibial tunnel technique with all-inside techniques (tibial tunnel with partial length).

Study	Reason for exclusion
Merchant 2001	Not a randomised trial: a retrospective study
Monaco 2017	Interventions not in the scope of the review: trial compared different fixation devices.
Panni 2001	Not a randomised trial: a prospective comparative cohort analysis of one-incision versus two-incision ACL reconstruction techniques
Yanasse 2016	Interventions not in the scope of the review: trial compared two-incision technique with transtibial technique with femoral fixation through a lateral approach, instead of avoiding the lateral incision.
Zhang 2012	Interventions not in the scope of the review: this randomised controlled trial compared transportal versus outside-in technique single-bundle ACL reconstruction.

ACL: anterior cruciate ligament

DATA AND ANALYSES

Comparison 1. One-incision versus two-incision anterior cruciate ligament reconstruction techniques

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Subjectively rated knee function: Lysholm scores (0 to 100: best function)	2		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
1.1 At 3 months	2	79	Mean Difference (IV, Fixed, 95% CI)	2.73 [-2.70, 8.15]
1.2 At 12 months	2	79	Mean Difference (IV, Fixed, 95% CI)	-3.68 [-6.61, -0.75]
1.3 At 24 months	1	59	Mean Difference (IV, Fixed, 95% CI)	-1.0 [-7.34, 5.34]
2 Subjectively rated knee function: Lysholm scores 90 or more	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
2.1 Long term: mean 43 months	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
3 Adverse events	4		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only
3.1 Infection	2	89	Risk Ratio (M-H, Fixed, 95% CI)	1.03 [0.07, 15.77]
3.2 Nerve palsy	1	59	Risk Ratio (M-H, Fixed, 95% CI)	0.34 [0.01, 8.13]
3.3 Haemarthrosis requiring joint aspiration	1	59	Risk Ratio (M-H, Fixed, 95% CI)	0.34 [0.04, 3.13]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
3.4 Deep vein thrombosis	1	30	Risk Ratio (M-H, Fixed, 95% CI)	3.0 [0.13, 68.26]
3.5 Knee stiffness (loss of terminal extension) (2 to 5 years)	2	144	Risk Ratio (M-H, Fixed, 95% CI)	1.77 [0.40, 7.79]
3.6 Knee stiffness (loss of terminal flexion) (2 to 5 years)	2	144	Risk Ratio (M-H, Fixed, 95% CI)	0.50 [0.14, 1.72]
3.7 Recurrent instability (giving way)	1	27	Risk Ratio (M-H, Fixed, 95% CI)	2.44 [0.11, 54.97]
3.8 Knee swelling at final follow-up	1	27	Risk Ratio (M-H, Fixed, 95% CI)	1.12 [0.47, 2.65]
3.9 Reoperations	3	205	Risk Ratio (M-H, Fixed, 95% CI)	0.89 [0.37, 2.14]
3.10 Graft failure (6 to 11 years)	1	150	Risk Ratio (M-H, Fixed, 95% CI)	1.25 [0.35, 4.47]
4 Tegner activity score (0 to 10: top activity) at 24 months	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5 Return to previous activity level (2 to 5 years)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
6 IKDC objective assessment: normal or nearly normal	5		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only
6.1 At 3 to 6 months	2	43	Risk Ratio (M-H, Fixed, 95% CI)	0.59 [0.33, 1.03]
6.2 At 12 to 28 months	4	167	Risk Ratio (M-H, Fixed, 95% CI)	1.01 [0.85, 1.21]
6.3 At 6 to 11 years	1	150	Risk Ratio (M-H, Fixed, 95% CI)	0.99 [0.91, 1.07]
7 Objective function tests: one-leg hop quotient (% of other leg) (24 months)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8 Objective function tests: one-leg hop > 90% contralateral (2 to 5 years)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
9 Static stability measures - anterior translation, difference between sides (injured - healthy knee)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
9.1 Difference (mm) measured by KT-1000 arthrometer at 89 N (3 months)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
9.2 Difference (mm) measured by KT-1000 arthrometer at 135 N (3 months)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
9.3 Difference (mm) measured by KT-1000 arthrometer at 89 N (24 months)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
9.4 Difference (mm) measured by KT-1000 arthrometer at 135 N (12 months)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
10 Static stability measures - anterior translation side-to-side difference < 3 mm	4	297	Risk Ratio (M-H, Fixed, 95% CI)	0.96 [0.85, 1.09]
10.1 Measured by KT-1000 arthrometer (12 to 24 months)	2	86	Risk Ratio (M-H, Fixed, 95% CI)	0.95 [0.78, 1.15]
10.2 Measured by KT-2000 arthrometer (2 to 5 years)	2	211	Risk Ratio (M-H, Fixed, 95% CI)	0.97 [0.83, 1.14]
11 Static stability measures - various	2		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
11.1 Pivot-Shift (normal or nearly normal) (3 months)	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
11.2 Lachman (normal or nearly normal) (3 months)	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
11.3 Pivot-Shift (normal or nearly normal) (12 months)	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
11.4 Lachman (normal or nearly normal) (12 months)	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
11.5 Lachman (normal or nearly normal) (2 to 5 years)	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
12 Patellofemoral pain score (0 to 20: best outcome)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
12.1 Patellofemoral pain score (3 months)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
12.2 Patellofemoral pain score (12 months)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
12.3 Patellofemoral pain score (24 months)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
13 Pain (early and late postoperative pain)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
13.1 Pain (6 weeks)	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
13.2 Late pain (mean 15 months)	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
14 Knee range of motion (degrees)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
14.1 Flexion (3 months)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
14.2 Flexion (6 months)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
14.3 Flexion (12 months)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
14.4 Extension (3 months)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
14.5 Extension (6 months)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
14.6 Extension (12 months)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
15 Range of motion at mean 15 months follow-up (range 5 to 28 months)			Other data	No numeric data
16 Peak torque forces (% contralateral side) at 3 and 6 months			Other data	No numeric data
16.1 3 months			Other data	No numeric data
16.2 6 months			Other data	No numeric data
17 Muscle strength (peak torque forces) at 12 months	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
17.1 Extensors (60°) under concentric isokinetic movement	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
17.2 Extensors (180°) under concentric isokinetic movement	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
17.3 Extensors (60°) under eccentric isokinetic movement	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
17.4 Extensors (180°) under eccentric isokinetic movement	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
17.5 Flexors (60°) under concentric isokinetic movement	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
17.6 Flexors (180°) under concentric isokinetic movement	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
17.7 Flexors (60°) under eccentric isokinetic movement	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
17.8 Flexors (180°) under eccentric isokinetic movement	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
18 Deficits in isokinetic muscle strength (6 to 11 years)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
18.1 Quadriceps deficit > or = 10%	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
18.2 Hamstrings deficit > or = 10%	1		Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]

Analysis 1.1. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 1 Subjectively rated knee function: Lysholm scores (0 to 100: best function).

Analysis 1.2. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 2 Subjectively rated knee function: Lysholm scores 90 or more.

Study or subgroup	One-incision n/N	Two-incision n/N	Risk Ratio M-H, Fixed, 95% CI	Risk Ratio M-H, Fixed, 95% CI
1.2.1 Long term: mean 43 months				
			1	
			Favours Two-incision	Favours One-incision

Study or subgroup	One-incision n/N	Two-incision n/N	Risk Ratio M-H, Fixed, 95% CI	Risk Ratio M-H, Fixed, 95% CI
O'Neill 2001	42/45	36/40		1.04[0.91,1.18]
Favours Two-incision			1	Favours One-incision

Analysis 1.3. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 3 Adverse events.

Study or subgroup	One-incision n/N	Two-incision n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
1.3.1 Infection					
Brandsson 1999	1/29	1/30		100%	1.03[0.07,15.77]
Reat 1997	0/15	0/15			Not estimable
Subtotal (95% CI)	44	45		100%	1.03[0.07,15.77]
Total events: 1 (One-incision), 1 (Two-incision)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.02(P=0.98)					
1.3.2 Nerve palsy					
Brandsson 1999	0/29	1/30		100%	0.34[0.01,8.13]
Subtotal (95% CI)	29	30		100%	0.34[0.01,8.13]
Total events: 0 (One-incision), 1 (Two-incision)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.66(P=0.51)					
1.3.3 Haemarthrosis requiring joint aspiration					
Brandsson 1999	1/29	3/30		100%	0.34[0.04,3.13]
Subtotal (95% CI)	29	30		100%	0.34[0.04,3.13]
Total events: 1 (One-incision), 3 (Two-incision)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.95(P=0.34)					
1.3.4 Deep vein thrombosis					
Reat 1997	1/15	0/15		100%	3[0.13,68.26]
Subtotal (95% CI)	15	15		100%	3[0.13,68.26]
Total events: 1 (One-incision), 0 (Two-incision)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.69(P=0.49)					
1.3.5 Knee stiffness (loss of terminal extension) (2 to 5 years)					
Brandsson 1999	4/29	1/30		38.26%	4.14[0.49,34.86]
O'Neill 2001	0/45	1/40		61.74%	0.3[0.01,7.09]
Subtotal (95% CI)	74	70		100%	1.77[0.4,7.79]
Total events: 4 (One-incision), 2 (Two-incision)					
Heterogeneity: Tau ² =0; Chi ² =1.83, df=1(P=0.18); I ² =45.22%					
Test for overall effect: Z=0.75(P=0.45)					
1.3.6 Knee stiffness (loss of terminal flexion) (2 to 5 years)					
Brandsson 1999	1/29	0/30		7.19%	3.1[0.13,73.14]
O'Neill 2001	2/45	6/40		92.81%	0.3[0.06,1.39]
Subtotal (95% CI)	74	70		100%	0.5[0.14,1.72]
Favours One-incision			0.01 0.1 1 10 100	Favours Two-incision

Analysis 1.4. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 4 Tegner activity score (0 to 10: top activity) at 24 months.

Study or subgroup	One-incision		Two-incision		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Brandsson 1999	29	4.9 (2.3)	30	5.7 (2)		-0.8[-1.9,0.3]
					Favours Two-incision -10 -5 0 5 10 Favours One-incision	

Analysis 1.5. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 5 Return to previous activity level (2 to 5 years).

Study or subgroup	One-incision	Two-incision	Risk Ratio					Risk Ratio
	n/N	n/N	M-H, Fixed, 95% CI					M-H, Fixed, 95% CI
O'Neill 2001	40/45	38/40						0.94[0.83,1.06]
			Favours Two-incision 0.01 0.1 1 10 100 Favours One-incision					

Analysis 1.6. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 6 IKDC objective assessment: normal or nearly normal.

Study or subgroup	One-incision n/N	Two-incision n/N	Risk Ratio M-H, Fixed, 95% CI		Weight	Risk Ratio M-H, Fixed, 95% CI
1.6.1 At 3 to 6 months						
Hess 2002	7/10	7/10			46.94%	1[0.56,1.78]
Reat 1997	2/13	7/10			53.06%	0.22[0.06,0.84]
Subtotal (95% CI)	23	20			100%	0.59[0.33,1.03]
Total events: 9 (One-incision), 14 (Two-incision)						
Heterogeneity: Tau ² =0; Chi ² =5.4, df=1(P=0.02); I ² =81.47%						
Test for overall effect: Z=1.87(P=0.06)						
1.6.2 At 12 to 28 months						
Brandsson 1999	25/29	28/30			47.14%	0.92[0.78,1.1]
Hess 2002	8/10	8/10			13.7%	1[0.65,1.55]
Reat 1997	7/15	5/12			9.51%	1.12[0.47,2.65]
Santori 1996	16/24	22/37			29.65%	1.12[0.76,1.65]
Subtotal (95% CI)	78	89			100%	1.01[0.85,1.21]
Total events: 56 (One-incision), 63 (Two-incision)						
Heterogeneity: Tau ² =0; Chi ² =1.37, df=3(P=0.71); I ² =0%						
Test for overall effect: Z=0.12(P=0.9)						
1.6.3 At 6 to 11 years						
O'Neill 2001	70/75	71/75			100%	0.99[0.91,1.07]
Subtotal (95% CI)	75	75			100%	0.99[0.91,1.07]
Total events: 70 (One-incision), 71 (Two-incision)						
Heterogeneity: Not applicable						
Test for overall effect: Z=0.34(P=0.73)						
			Favours Two-incision 0.01 0.1 1 10 100 Favours One-incision			

Analysis 1.7. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 7 Objective function tests: one-leg hop quotient (% of other leg) (24 months).

Study or subgroup	One-incision		Two-incision		Mean Difference		Mean Difference	
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI		Fixed, 95% CI	
Brandsson 1999	29	95 (9)	30	95 (5)	<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></d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Analysis 1.8. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 8 Objective function tests: one-leg hop > 90% contralateral (2 to 5 years).

Study or subgroup	One-incision n/N	Two-incision n/N	Risk Ratio M-H, Fixed, 95% CI	Risk Ratio M-H, Fixed, 95% CI
O'Neill 2001	40/45	37/40		0.96[0.84,1.1]
Favours Two-incision 0.5 0.7 1 1.5 2 Favours One-incision				

Analysis 1.9. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 9 Static stability measures - anterior translation, difference between sides (injured - healthy knee).

Study or subgroup	One-incision N	One-incision Mean(SD)	Two-incision N	Two-incision Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
1.9.1 Difference (mm) measured by KT-1000 arthrometer at 89 N (3 months)						
Brandsson 1999	29	0.8 (1.5)	30	-0.1 (1.5)		0.9[0.13,1.67]
1.9.2 Difference (mm) measured by KT-1000 arthrometer at 135 N (3 months)						
Brandsson 1999	29	0.8 (1.7)	30	-0.3 (1.2)		1.1[0.35,1.85]
1.9.3 Difference (mm) measured by KT-1000 arthrometer at 89 N (24 months)						
Brandsson 1999	29	0.8 (2.1)	30	0.5 (1.3)		0.3[-0.59,1.19]
1.9.4 Difference (mm) measured by KT-1000 arthrometer at 135 N (12 months)						
Brandsson 1999	29	0.8 (1.9)	30	0.6 (1.4)		0.2[-0.65,1.05]
Favours One-incision -5 -2.5 0 2.5 5 Favours Two-incision						

Analysis 1.10. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 10 Static stability measures - anterior translation side-to-side difference < 3 mm.

Study or subgroup	One-incision n/N	Two-incision n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
1.10.1 Measured by KT-1000 arthrometer (12 to 24 months)					
Brandsson 1999	26/29	27/30		23.66%	1[0.84,1.18]
Reat 1997	8/15	8/12		7.92%	0.8[0.43,1.49]
Subtotal (95% CI)	44	42		31.59%	0.95[0.78,1.15]
Total events: 34 (One-incision), 35 (Two-incision) Heterogeneity: Tau ² =0; Chi ² =0.62, df=1(P=0.43); I ² =0% Test for overall effect: Z=0.55(P=0.58)					
1.10.2 Measured by KT-2000 arthrometer (2 to 5 years)					
O'Neill 2001	60/75	61/75		54.38%	0.98[0.84,1.15]
Santori 1996	12/24	20/37		14.03%	0.93[0.56,1.52]
Subtotal (95% CI)	99	112		68.41%	0.97[0.83,1.14]
Total events: 72 (One-incision), 81 (Two-incision) Heterogeneity: Tau ² =0; Chi ² =0.06, df=1(P=0.8); I ² =0% Test for overall effect: Z=0.35(P=0.72)					
Total (95% CI)	143	154		100%	0.96[0.85,1.09]
Total events: 106 (One-incision), 116 (Two-incision) Favours Two-incision 0.5 0.7 1 1.5 2 Favours One-incision

Analysis 1.11. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 11 Static stability measures - various.

Analysis 1.12. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 12 Patellofemoral pain score (0 to 20: best outcome).

Analysis 1.13. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 13 Pain (early and late postoperative pain).

Analysis 1.14. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 14 Knee range of motion (degrees).

Analysis 1.15. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 15 Range of motion at mean 15 months follow-up (range 5 to 28 months).

Range of motion at mean 15 months follow-up (range 5 to 28 months)				
Study	Variable (degrees)	One-incision n = 15	Two-incision n = 12	Mean difference
Reat 1997	Extension	-4°	-2°	-2°
Reat 1997	Flexion	135°	134°	1°
Reat 1997	Range of motion	139°	136°	3°

Analysis 1.16. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 16 Peak torque forces (% contralateral side) at 3 and 6 months.

Study	Muscle and conditions	Peak torque forces (% contralateral side) at 3 and 6 months			MD	Reported P
		One-incision n = 10	Two-incision n = 10			
3 months						
Hess 2002	Extensor, 60 deg/sec, concentric	65.8	52.3	13.5	0.05	
Hess 2002	Extensor, 180 deg/sec, concentric	80.3	57.7	22.6	0.01	
Hess 2002	Extensor, 60 deg/sec, eccentric	67.1	51	16.1	> 0.05	
Hess 2002	Extensor, 180 deg/sec, eccentric	68.8	51.7	17.1	> 0.05	
Hess 2002	Flexor, 60 deg/sec, concentric	110.4	82.7	27.7	0.02	
Hess 2002	Flexor, 180 deg/sec, concentric	118.3	91.5	26.8	> 0.05	
Hess 2002	Flexor, 60 deg/sec, eccentric	82.3	67.7	14.6	> 0.05	
Hess 2002	Flexor, 180 deg/sec, eccentric	92.2	75.7	16.5	> 0.05	
6 months						
Hess 2002	Extensor, 60 deg/sec, concentric	79.3	61.1	18.2	0.03	
Hess 2002	Extensor, 180 deg/sec, concentric	82.2	78.3	3.9	> 0.05	
Hess 2002	Extensor, 60 deg/sec, eccentric	92.5	55	37.5	0.02	
Hess 2002	Extensor, 180 deg/sec, eccentric	77.9	65	12.9	0.05	
Hess 2002	Flexor, 60 deg/sec, concentric	108.1	91.5	16.6	0.03	
Hess 2002	Flexor, 180 deg/sec, concentric	100.6	99.9	0.7	> 0.05	
Hess 2002	Flexor, 60 deg/sec, eccentric	94.5	79.8	14.7	> 0.05	
Hess 2002	Flexor, 180 deg/sec, eccentric	107.8	87.9	19.9	> 0.05	

Analysis 1.17. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 17 Muscle strength (peak torque forces) at 12 months.

Study or subgroup	One-incision		Two-incision		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
1.17.1 Extensors (60°) under concentric isokinetic movement						
Hess 2002	10	87.7 (9.8)	10	87 (16)		0.7[-10.93,12.33]
1.17.2 Extensors (180°) under concentric isokinetic movement						
Hess 2002	10	86.1 (9.9)	10	88.7 (16.3)		-2.6[-14.42,9.22]
1.17.3 Extensors (60°) under eccentric isokinetic movement						
Hess 2002	10	92 (7)	10	80.3 (23.7)		11.7[-3.62,27.02]
1.17.4 Extensors (180°) under eccentric isokinetic movement						
Hess 2002	10	89.5 (15.5)	10	82.3 (14.7)		7.2[-6.04,20.44]
					<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></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Analysis 1.18. Comparison 1 One-incision versus two-incision anterior cruciate ligament reconstruction techniques, Outcome 18 Deficits in isokinetic muscle strength (6 to 11 years).

APPENDICES

Appendix 1. Search strategies

CENTRAL

Search 1: Wiley Online Library, 2016 Issue 4

#1 MeSH descriptor: [Anterior Cruciate Ligament] this term only (727)
 #2 MeSH descriptor: [Anterior Cruciate Ligament Reconstruction] this term only (127)
 #3 ((anterior near/2 cruciate* near/2 ligament*) or ACL):ti,ab,kw (Word variations have been searched) (1500)
 #4 #1 or #2 or #3 (1500)
 #5 ((single or double or one or two or "1" or "2") near/2 (incision* or tunnel*)):ti,ab,kw (Word variations have been searched) (723)
 #6 rear-entry or endoscopic or outside-in or all-inside or inside-out:ti,ab,kw (Word variations have been searched) (7633)
 #7 #5 or #6 (8304)
 #8 #4 and #7 (71)

Search 2: Central Register of Studies Online, 2016 Issue 5 to 2017 Issue 8

#1 MESH DESCRIPTOR Anterior Cruciate Ligament (708)
 #2 MESH DESCRIPTOR Anterior Cruciate Ligament Reconstruction EXPLODE ALL TREES (257)
 #3 ((anterior and cruciate* and ligament*) or ACL):TI,AB,KY (1818)
 #4 #1 OR #2 OR #3 (1819)
 #5 ((single or double or one or two or "1" or "2") and (incision* or tunnel*)):TI,AB,KY (7341)
 #6 (rear-entry or endoscopic or outside-in or all-inside or inside-out):TI,AB,KY (10552)
 #7 #5 OR #6 (17534)

#8 #4 AND #7 (236)
#9 30/04/2016 TO 31/08/2017:DL (150202)
#10 #8 AND #9 (42)

MEDLINE (Ovid online)

1 Anterior Cruciate Ligament/ (10407)
2 Anterior Cruciate Ligament Reconstruction/ (2755)
3 ((anterior adj2 cruciate\$ adj2 ligament\$) or ACL).tw. (20457)
4 or/1-3 (21949)
5 ((single or double or one or two or "1" or "2") adj2 (incision* or tunnel*)).tw. (8442)
6 (rear-entry or endoscopic or outside-in or all-inside or inside-out).tw. (140265)
7 or/5-6 (147896)
8 and/4,7 (861)
9 Randomized controlled trial.pt. (475790)
10 Controlled clinical trial.pt. (96078)
11 randomized.ab. (416562)
12 placebo.ab. (194648)
13 Drug therapy.fs. (2041802)
14 randomly.ab. (288546)
15 trial.ab. (437632)
16 groups.ab. (1778441)
17 or/9-16 (4214062)
18 exp Animals/ not Humans/ (4526085)
19 17 not 18 (3643066)
20 and/8,19 (181)

Lines 9-19 = Cochrane highly sensitive search strategy for identifying randomised trials (Lefebvre 2011)

/ = MeSH term

Tw = text word (in title, abstract or keywords)

Pt = publication type

Ab = abstract

Fs = floating subheading

Adj = proximity operator

Embase (Ovid online)

1 Anterior cruciate ligament/ (10244)
2 Anterior cruciate ligament reconstruction/ (6783)
3 Anterior cruciate ligament rupture/ (4035)
4 Anterior cruciate ligament injury/ (2923)
5 ((anterior adj2 cruciate* adj2 ligament*) or ACL).tw. (23511)
6 or/1-5 (26786)
7 ((single or double or one or two or "1" or "2") adj2 (incision* or tunnel*)).tw. (12017)
8 (rear-entry or endoscopic or outside-in or all-inside or inside-out).tw. (198275)
9 or/7-8 (208964)
10 and/6,9 (999)
11 Randomized controlled trial/ (467381)
12 Clinical trial/ (944815)
13 Controlled clinical trial/ (445014)
14 Randomization/ (75003)
15 Single blind procedure/ (29066)
16 Double blind procedure/ (141975)
17 Crossover procedure/ (52966)
18 Placebo/ (312139)
19 Prospective study/ (396003)
20 ((clinical or controlled or comparative or placebo or prospective* or randomi#ed) adj3 (trial or study)).tw. (1049382)
21 (random* adj7 (allocat* or allot* or assign* or basis* or divid* or order*)).tw. (257320)
22 ((singl* or doubl* or trebl* or tripl*) adj7 (blind* or mask*)).tw. (208208)
23 (cross?over* or (cross adj1 over*)).tw. (90411)
24 ((allocat* or allot* or assign* or divid*) adj3 (condition* or experiment* or intervention* or treatment* or therap* or control* or group*)).tw. (349124)
25 RCT.tw. (25366)

26 or/11-25 (2520669)
27 Case Study/ or Abstract Report/ or Letter/ (1079490)
28 26 not 27 (2473882)
29 and/10,28 (254)

LILACS (Virtual Health Library, IAHx platform)

(MH:"Anterior Cruciate Ligament" OR MH:"Anterior Cruciate Ligament Reconstruction" OR TW:"anterior cruciate ligament" OR TW:"anterior cruciate" OR TW:"ACL" OR TW:"Ligamento Cruzado Anterior")

Type of study: Controlled Clinical Trial (29)

World Health Organization International Clinical Trials Registry Platform

1. anterior cruciate AND incision OR anterior cruciate AND reconstruction OR anterior cruciate AND outside-in OR anterior cruciate AND all-inside (273)

2. ACL AND incision OR ACL AND reconstruction OR ACL AND outside-in OR ACL AND all-inside (175)

ClinicalTrials.gov

(anterior cruciate OR ACL) AND (incision OR reconstruction OR outside-in OR all-inside) (211)

CONTRIBUTIONS OF AUTHORS

Fernando Cury Rezende, Vinícius de Moraes, and Carlos Franciozi conceived and drafted the protocol and review. Vinícius de Moraes and João Carlos Belloti provided input on methodological issues. All authors revised and approved the final version of the review.

Fernando Cury Rezende is the guarantor of this review.

DECLARATIONS OF INTEREST

Fernando C Rezende: none known

Vinícius Y Moraes: none known

Carlos ES Franciozi: none known

Pedro Debieux: none known

Marcus V Luzo: none known

João Carlos Belloti: none known

SOURCES OF SUPPORT**Internal sources**

- Escola Paulista de Medicina - Universidade Federal de São Paulo, Brazil.

External sources

- No sources of support supplied

DIFFERENCES BETWEEN PROTOCOL AND REVIEW**Types of interventions**

We clarified that the same grafts, fixation devices, and other techniques needed to be used for both intervention groups to ensure that the comparison was strictly one-incision versus two-incision techniques.

Types of outcome measures

In our protocol, we omitted to include composite clinical (clinician-rated) scores, specifically the objective part of the International Knee Documentation Committee (IKDC). The IKDC results are categorised as normal (level A), nearly normal (level B), abnormal (level C), and severely abnormal (level D). In our analyses, as recommended by [Irrgang 2001](#), we opted to pool the first two groups (A and B) to compare data of participants with normal or nearly normal results with participants of the other two groups (C and D), allowing meta-analyses of dichotomous outcomes.

In the protocol, we set the threshold for distinguishing between intermediate- and long-term follow-up at three years. In the review we changed this to two years, which was consistent with follow-up times of the contributing trials and a related Cochrane Review ([Mohtadi 2011](#)). Additionally, based on data availability, we presented long-term data separately for two to five years and six years and above.

Furthermore, we made a post hoc decision to report outcome of longer duration if an outcome was reported at different time points classed under the same follow-up period (short, intermediate, or long term). Thus if data for two different time points belonging to the same period were available, we reported the longer-duration data.

'Risk of bias' assessment

We decided against performing separate analyses of subjective and objective outcomes of the following 'Risk of bias' domains: blinding of participants and personnel, blinding of outcome assessment, and incomplete outcome data, because we considered that the judgements for the two categories of outcome would be comparable.

'Summary of findings' table

We adjusted the list of outcomes stipulated for inclusion in the 'Summary of findings' table to make clear the time frames selected for subjective assessment of function, quality of life, and activity level outcomes. We added objective functional knee assessments (IKDC) at intermediate-term follow-up.

INDEX TERMS

Medical Subject Headings (MeSH)

Anterior Cruciate Ligament Injuries [*surgery]; Anterior Cruciate Ligament Reconstruction [adverse effects] [*methods]; Arthroscopy [*methods]; Femur [surgery]; Non-Randomized Controlled Trials as Topic; Postoperative Complications; Randomized Controlled Trials as Topic; Treatment Outcome

MeSH check words

Adult; Humans