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Interventions for treating supracondylar elbow fractures in children (Review)

Marson BA, Ikram A, Craxford S, Lewis SR, Price KR, Ollivere BJ

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[Intervention Review]

Interventions for treating supracondylar elbow fractures in children

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ABSTRACT

Background

Elbow supracondylar fractures are common, with treatment decisions based on fracture displacement. However, there remains controversy regarding the best treatments for this injury.

Objectives

To assess the effects (benefits and harms) of interventions for treating supracondylar elbow fractures in children.

Search methods

We searched CENTRAL, MEDLINE, and Embase in March 2021. We also searched trial registers and reference lists. We applied no language or publication restrictions.

Selection criteria

We included randomised and quasi-randomised controlled trials comparing different interventions for the treatment of supracondylar elbow fractures in children. We included studies investigating surgical interventions (different fixation techniques and different reduction techniques), surgical versus non-surgical treatment, traction types, methods of non-surgical intervention, and timing and location of treatment.

Data collection and analysis

We used standard methodological procedures expected by Cochrane. We collected data and conducted GRADE assessment for five critical outcomes: functional outcomes, treatment failure (requiring re-intervention), nerve injury, major complications (pin site infection in most studies), and cosmetic deformity (cubitus varus).

Main results

We included 52 trials with 3594 children who had supracondylar elbow fractures; most were Gartland 2 and 3 fractures. The mean ages of children ranged from 4.9 to 8.4 years and the majority of participants were boys. Most studies (33) were conducted in countries in South-East Asia.

We identified 12 different comparisons of interventions: retrograde lateral wires versus retrograde crossed wires; lateral crossed (Dorgan) wires versus retrograde crossed wires; retrograde lateral wires versus lateral crossed (Dorgan) wires; retrograde crossed wires versus posterior intrafocal wires; retrograde lateral wires in a parallel versus divergent configuration; retrograde crossed wires using a mini-open technique or inserted percutaneously; buried versus non-buried wires; external versus internal fixation; open versus closed reduction; surgical fixation versus non-surgical immobilisation; skeletal versus skin traction; and collar and cuff versus backslab.

We report here the findings of four comparisons that represent the most substantial body of evidence for the most clinically relevant comparisons.

All studies in these four comparisons had unclear risks of bias in at least one domain. We downgraded the certainty of all outcomes for serious risks of bias, for imprecision when evidence was derived from a small sample size or had a wide confidence interval (CI) that included the possibility of benefits or harms for both treatments, and when we detected the possibility of publication bias.

Retrograde lateral wires versus retrograde crossed wires (29 studies, 2068 children)

There was low-certainty evidence of less nerve injury with retrograde lateral wires (RR 0.65, 95% CI 0.46 to 0.90; 28 studies, 1653 children). In a post hoc subgroup analysis, we noted a greater difference in the number of children with nerve injuries when lateral wires were compared to crossed wires inserted with a percutaneous medial wire technique (RR 0.41, 95% CI 0.20 to 0.81, favours lateral wires; 10 studies, 552 children), but little difference when an open technique was used (RR 0.91, 95% CI 0.59 to 1.40, favours lateral wires; 11 studies, 656 children). Although we noted a statistically significant difference between these subgroups from the interaction test ($P = 0.05$), we could not rule out the possibility that other factors could account for this difference.

We found little or no difference between the interventions in major complications, which were described as pin site infections in all studies (RR 1.08, 95% CI 0.65 to 1.79; 19 studies, 1126 children; low-certainty evidence). For functional status (1 study, 35 children), treatment failure requiring re-intervention (1 study, 60 children), and cosmetic deformity (2 studies, 95 children), there was very low-certainty evidence showing no evidence of a difference between interventions.

Open reduction versus closed reduction (4 studies, 295 children)

Type of reduction method may make little or no difference to nerve injuries (RR 0.30, 95% CI 0.09 to 1.01, favours open reduction; 3 studies, 163 children). However, there may be fewer major complications (pin site infections) when closed reduction is used (RR 4.15, 95% CI 1.07 to 16.20; 4 studies, 253 children). The certainty of the evidence for these outcomes is low. No studies reported functional outcome, treatment failure requiring re-intervention, or cosmetic deformity. The four studies in this comparison used direct visualisation during surgery. One additional study used a joystick technique for reduction, and we did not combine data from this study in analyses.

Surgical fixation using wires versus non-surgical immobilisation using a cast (3 studies, 140 children)

There was very low-certainty evidence showing little or no difference between interventions for treatment failure requiring re-intervention (1 study, 60 children), nerve injury (3 studies, 140 children), major complications (3 studies, 126 children), and cosmetic deformity (2 studies, 80 children). No studies reported functional outcome.

Backslab versus sling (1 study, 50 children)

No nerve injuries or major complications were experienced by children in either group; this evidence is of very low certainty. Functional outcome, treatment failure, and cosmetic deformity were not reported.

Authors' conclusions

We found insufficient evidence for many treatments of supracondylar fractures. Fixation of displaced supracondylar fractures with retrograde lateral wires compared with crossed wires provided the most substantial body of evidence in this review, and our findings indicate that there may be a lower risk of nerve injury with retrograde lateral wires. In future trials of treatments, we would encourage the adoption of a core outcome set, which includes patient-reported measures. Evaluation of the effectiveness of traction compared with surgical fixation would provide a valuable addition to this clinical field.

PLAIN LANGUAGE SUMMARY

What are the benefits and risks of different treatments for elbow fractures in children?

Key messages

- A child with a supracondylar elbow fracture (a broken bone in the upper elbow, approximately 5 cm above the elbow joint) may have a lower risk of nerve injury if two or more wires are inserted from the outside of the elbow rather than having one wire inserted from the inside of the elbow and one from the outside (crossed wires). The method used by the doctor to manually move the bones back into position may not increase or reduce the risk of nerve injury, but using a closed method may reduce the risk of an infection.

- Because we did not find enough studies about other treatments for these elbow fractures, their benefits and risks are unclear.

- More, well-designed studies are needed to give better estimates of the benefits and harms of other treatments. These studies should focus on outcomes related to elbow movement, as well as quality of life and how upset the child is.

What are supracondylar elbow fractures?

This type of broken bone is in the upper arm bone, approximately 5 cm above the elbow joint. It is the most common broken bone in the elbow during childhood, and can affect a child's day-to-day function as well as their ability to play and do sport.

How are these broken bones treated?

Treatment varies according to whether the bone has moved out of position. If it has moved, the doctor may manually move it back into a normal position. Doctors do this using a 'closed reduction' (without opening up the skin) or 'open reduction' (after the skin has been opened up).

During surgery, metal wires are used to hold the bone in place whilst it heals. Doctors may use different types and numbers of wires, which are inserted from different angles.

If the bone has not moved, surgery may not be necessary. In which case, treatments to hold the bone in place whilst it heals include using a plaster cast, a sling, or using traction (with weights, ropes and pulleys).

What did we want to find out?

We wanted to find out:

- which types of treatments work best to heal the bone effectively; and
- whether these treatments are associated with any unwanted effects.

What did we do?

We searched for studies that compared a range of treatments. The most common treatments were:

- surgical treatments using different types of metal wires after the bone has been put back into position;
- open reduction or closed reduction;
- surgery or non-surgical treatments; and
- different non-surgical treatments.

We compared and summarised their results, and rated our confidence in the evidence, based on factors such as study methods and sizes.

What did we find?

We found 52 studies with 3594 children. Most children were about 5 to 8 years of age and most were boys. The studies were conducted in countries around the world; 33 studies were conducted in countries in South-East Asia. Very few studies reported how they were funded.

Main results

- Wires inserted only from the outside of the elbow may reduce the risk of nerve injury compared with crossed wires (inserted from the outside and also from the inside of the elbow). However, there is probably little or no difference between these treatments in the number of children who develop an infection where the metal wires have been inserted (pin site infections). We do not know if either of these treatments affect elbow function, the risk of needing additional surgery, or any long-term elbow deformity (where the elbow is no longer the normal shape).

- The initial method used to move the bone back into position may make little or no difference to the risk of nerve injury. However, children may have fewer pin site infections when closed reduction is used.

- There may be little or no difference between using metal wires to fix the bone or holding the bone in place with a cast in the need for additional surgery, nerve injury, pin site infections, or elbow deformity. But we are uncertain of these findings.

- We do not know if a plaster cast compared to a sling has any effect on the risk of nerve injury or pin site infections.

What are the limitations of the evidence?

Most of the studies were either not well-designed or did not clearly report how they were conducted. This meant that we either had little confidence or no confidence in their findings. Our confidence was also reduced because there were not enough children in the studies to be certain about their findings. It is also possible that the studies that we found had exaggerated findings and that some studies with alternative results may be missing.

How up to date is this evidence?

The evidence is up to date to March 2021.

SUMMARY OF FINDINGS

Summary of findings 1. Retrograde lateral wires compared with retrograde crossed wires for treatment of displaced supracondylar elbow fractures in children

Retrograde lateral wires compared with retrograde crossed wires for treatment of displaced supracondylar elbow fractures in children

Population: children with displaced supracondylar elbow fractures

Settings: inpatient management settings. Included studies were conducted in: Egypt, India, Iraq, Italy, Malaysia, Nepal, Pakistan, USA

Intervention: retrograde lateral wires in a parallel or divergent configuration

Comparison: retrograde crossed wires

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	Number of children (studies)	Certainty of the evidence (GRADE)	Comments
	Assumed risk with crossed wires ^a	Corresponding risk with lateral wires				
Functional outcome Measured by Mayo Elbow Performance Score (range 0 to 100, with higher scores indicating better function) Mean follow-up: 42 to 44 months	Mean score of 96	Mean score 2 points higher		35 children (1 study)	⊕⊕⊕⊕ Very low^b	Unable to calculate relative effect estimate because distribution values were unavailable. There is no formal MCID for the Mayo Elbow Performance Score in childhood fractures. However, a 2-point difference is unlikely to be clinically significant.
Treatment failure requiring re-intervention Follow-up: 6 months	0 out of 30	1 out of 30^c	RR 3.00 (0.13 to 70.83)	60 children (1 study)	⊕⊕⊕⊕ Very low^b	
Nerve injury Follow-up: range from 2 months to 67 months	86 per 1000	56 per 1000 (40 to 78)	RR 0.65 (0.46 to 0.90)	1653 children (28 studies)	⊕⊕⊕⊕ Low^d	In post hoc subgroup analysis, we noted fewer injuries when lateral wires were used with a percutaneous technique (RR 0.41, 95% CI 0.20 to 0.81, favours lateral wires; 10 studies, 552 participants), but little difference in nerve injuries when an open technique was used (RR 0.91, 95% CI 0.59 to 1.40, favours lateral wires;

11 studies, 656 participants). In formal tests for subgroup interactions, we noted a possible difference between these subgroups ($P = 0.05$).

Major complications	43 per 1000	47 per 1000 (28 to 78)	RR 1.08 (0.65 to 1.79)	1126 children (19 studies)	⊕⊕⊕⊕ Low^e
In all studies, these were pin site infections.					
Follow-up: range from 3 months to 67 months					
Cosmetic deformity	Study population		RR 3.13 (0.55 to 17.98)	95 children (2 studies)	⊕⊕⊕⊕ Very low^b
Measured as number of children with cubitus varus	19 per 1000	60 per 1000 (11 to 346)			
Follow-up: long-term Time points in the included studies ranged from 6 months to 44 months					

*The basis for the **assumed risk** is provided in footnotes. The **corresponding risk** (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; **MCID:** minimal clinically important difference; **RR:** risk ratio

GRADE Working Group grades of evidence

High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: 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 certainty: our confidence in the effect estimate is limited; the true effect may be substantially different from the estimate of the effect.

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

^aDerived from the data reported in the included studies for the crossed wires group, or from the pooled estimate of the crossed wires group when data is available from more than one study

^bDowngraded by one level for serious risk of bias owing to unclear risks of bias in at least one domain, and two levels for very serious imprecision because of the small sample size and small difference between mean scores

^cData reported in the included study in the lateral wires group

^dDowngraded by one level for serious risk of bias owing to unclear risks of bias in at least one domain, and one level because we detected possible publication bias (from visual inspection of a funnel plot, and from sensitivity analysis of studies published in journals that are not indexed in PubMed)

^eDowngraded by one level for serious risk of bias owing to unclear risks of bias in at least one domain, and one level for serious imprecision because the CI includes possible benefits and harms for both treatments

Summary of findings 2. Open reduction compared with closed reduction position for treatment of displaced supracondylar fractures in children

Open reduction compared with closed reduction position for treatment of displaced supracondylar elbow fractures in children

Population: children with displaced supracondylar elbow fractures

Settings: inpatient management. Included studies were conducted in India, Iran, and Thailand

Intervention: fracture reduced with an open technique using direct visualisation

Comparison: fracture reduced with a closed technique

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	Number of children (studies)	Certainty of the evidence (GRADE)	Comments
	Assumed risk with closed re- duction ^a	Corresponding risk with open reduction				
Functional outcome	-	-	Not estimable	-		No studies reported this outcome
Treatment failure requiring re-intervention	-	-	Not estimable	-		No studies reported this outcome
Nerve injury Follow-up: range from 3 to 12 months	111 per 1000	33 per 1000 (10 to 112)	RR 0.30 (0.09 to 1.01)	163 children (3 studies)	⊕⊕⊕⊖ Low^b	In addition, 1 study (68 participants) used a joystick technique for visualisation and reported no incidences of nerve injury.
Major complications Follow-up: range from 3 to 22 months All complications were pin site infections	16 per 1000	66 per 1000 (17 to 257)	RR 4.15 (1.07 to 16.20)	253 children (4 studies)	⊕⊕⊕⊖ Low^b	In addition, 1 study (59 participants) used a joystick technique for visualisation and reported little or no difference in pin site infections.
Cosmetic deformity Measured as the presence of cubitus varus Follow-up: long-term	-	-	Not estimable	-	-	No studies using direct visualisation reported this outcome.

1 study (59 participants) used a joystick technique for visualisation and reported little or no difference in cubitus varus

*The basis for the **assumed risk** is provided in footnotes. The **corresponding risk** (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; **MCID:** minimal clinically important difference; **RCT:** randomised controlled trial; **RR:** risk ratio

GRADE Working Group grades of evidence

High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: 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 certainty: our confidence in the effect estimate is limited; the true effect may be substantially different from the estimate of the effect.

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

^aAssumed risk taken to be mean risk in control group

^bDowngraded one level for serious risk of bias because included studies had unclear risks of bias in at least one domain, and one level for serious imprecision because the CI included possible benefits and harms for both treatments

Summary of findings 3. Surgical fixation versus non-surgical immobilisation for displaced fractures

Surgical fixation compared with non-surgical immobilisation for displaced fractures

Population: children with displaced fractures

Settings: inpatient setting. Included studies conducted in India and Nepal

Intervention: surgical fixation with wires

Comparison: non-surgical immobilisation with cast

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	Number of children (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk with non-surgical immobilisation ^a	Corresponding risk with surgical fixation				

Functional outcome	-	-	Not estimable	-	-	No studies reported this outcome
Treatment failure requiring re-intervention Follow-up: 6 months	33 per 1000	11 per 1000 (0 to 262)	RR 0.33 (0.01 to 7.87)	60 children (1 study)	⊕⊕⊕⊕ Very low^b	
Nerve injury Follow-up: 6 to 12 months	14 per 1000	36 per 1000 (7 to 178)	RR 2.50 (0.50 to 12.46)	140 children (3 studies)	⊕⊕⊕⊕ Very low^b	4 postoperative ulnar nerve injuries that recovered by end of follow-up in the surgical fixation groups. 2 preoperative (1 ulnar nerve and 1 radial nerve palsy) injuries in each group
Major complications Pin site infections. Follow-up: 6-12 months	0 out of 62	3 out of 64	RR 4.00 (0.47 to 34.11)	126 children (3 studies)	⊕⊕⊕⊕ Very low^b	In addition, 1 study reported a single preoperative vascular injury in the non-surgical treatment group
Cosmetic deformity measured as presence of cubitus varus Follow-up: long-term (6 to 12 months)	175 per 1000	35 per 1000 (7 to 191)	RR 0.20 (0.04 to 1.09)	80 children (2 studies)	⊕⊕⊕⊕ Very low^b	

*The basis for the **assumed risk** is provided in footnotes. The **corresponding risk** (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; **RCT:** randomised controlled trial; **RR:** risk ratio

GRADE Working Group grades of evidence

High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: 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 certainty: our confidence in the effect estimate is limited; the true effect may be substantially different from the estimate of the effect.

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

^aAssumed risk taken to be mean risk in control group

^bDowngraded by one level for serious risk of bias owing to unclear or high risks of bias in at least one domain, and two levels for very serious risk of bias imprecision because of the small sample size and wide CI

^cData as reported in the included studies

BACKGROUND

Description of the condition

A supracondylar fracture is a break in the humerus (upper arm bone) occurring up to two inches (5 cm) above the elbow joint. The condyles of the humerus are the two rounded prominences at the end of the bone that are part of the elbow joint. Supracondylar fractures are the most common form of elbow fracture in children, with an annual incidence between 60 and 177 per 100,000 children (Holt 2018; Houshian 2011); these fractures are rare in adults. Supracondylar elbow fractures can occur throughout childhood, but are most common in children between five and six years of age (Barr 2014; Holt 2018; Houshian 2011). Several epidemiological studies have reported little gender difference in the incidence of these injuries (Barr 2014; Farnsworth 1998; Holt 2018; Houshian 2011). However, a study of children in Hong Kong reported a higher incidence in boys, equating to a ratio of 17 boys to 10 girls (Cheng 1999).

The typical mechanism of injury is a fall onto an outstretched hand or a direct fall onto a flexed (bent) elbow (Farnsworth 1998). Only 1% of supracondylar fractures are open, with an associated wound providing a direct route for contamination of the bone ends; the remaining 99% are closed (with no open wound). Open fractures require urgent surgical treatment to reduce the risk of serious infection (Holt 2018).

Successful treatment of a supracondylar elbow fracture in a child leads to normal function with no lasting symptoms. However, complications of this injury can occur as a result of the initial injury or as a result of problems during surgery. The major blood vessels and nerves in the arm can be damaged during the injury, the operation, or as a result of compartment syndrome. The last mentioned is a very rare complication where there is excessive swelling in the arm, increasing pressure in the arm and compressing the blood vessels; this can cause permanent damage to the muscles and nerves if not identified and treated promptly. The other significant complication relates to the alignment of the arm. This can arise as a result of malunion (the bone healing up in the wrong position after injury), or as a result of altered growth around the elbow. Children may end up with an arm with cubitus varus (the forearm pointing towards the midline), cubitus valgus (excessive bending away from the midline), or rotational abnormalities. Cubitus varus is commonly unsightly and can be associated with reduced function of the limb.

To identify and try to prevent these serious complications, an adequate history and examination to identify nerve or blood

vessel compromise are essential when assessing children with this fracture. Clinical findings along with fracture pattern and the level of displacement on X-ray can be used to predict the risk of complications. In displaced supracondylar fractures, the reported rate of vascular injury ranges from 5% to 31% and nerve injury at presentation from 5% to 15% (Barr 2014; Del Valle-Hernández 2017; Farnsworth 1998; Houshian 2011).

When describing the local vascular status of the arm of a child with a supracondylar fracture, a three-class system is typically used, as described in Omid 2008.

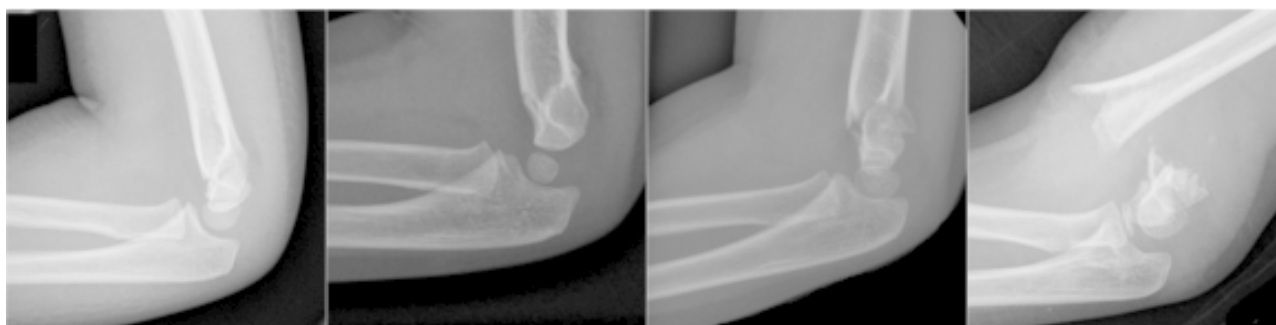
1. A class 1 injury maintains palpable pulses and a pink hand and indicates normal vascular supply (pink, pulsed). The capillary refill time (how quickly the fingers return to a normal colour after squeezing the finger tip for 5 seconds) is rapid.
2. A class 2 injury is a pink, pulseless hand where the radial artery can no longer be felt but the capillary refill time after pressure is applied is still normal. This may indicate a compensated vascular insufficiency because of reduced blood flow.
3. A class 3 injury is the most worrying, with a white, pulseless hand with delayed capillary refill time indicating severe vascular compromise.

Ninety-five per cent of supracondylar fractures are extension-type injuries, where the elbow has been over-extended and the elbow moves backwards in relation to the humerus. Five per cent are flexion type injuries, where the elbow has been over-bent and the elbow has been pushed forwards in relation to the humerus; these are typically more unstable and more challenging to treat.

There are two commonly used classifications for describing the radiographic appearance of supracondylar fractures. The Gartland classification has been used extensively to describe these injuries and is useful for identification of type 1 (undisplaced) and type 3 (completely displaced) fractures (Gartland 1959). Type 2 fractures (intact posterior cortex) may rotate or have angulation and therefore represent a heterogeneous group of fractures. The Gartland classification has been modified to further describe type 2 fractures based on the presence of rotation (Wilkins 1996), and expanded to include fractures with no intact periosteum (Leitch 2006), as shown in Table 1.

Alternatively, the Arbeitsgemeinschaft für Osteosynthesefragen group (German for 'Association for the Study of Internal Fixation') or AO/ASIF classification offers improved clarity in describing the expected stability of these fractures (Figure 1; Slongo 2006).

Figure 1. Supracondylar elbow fractures. Left to right AO/ASIF Classification 1, 2, 3, and 4



1. Type 1 fractures are incomplete and undisplaced.
2. Type 2 fractures are incomplete but displaced (hinged backwards).
3. Type 3 fractures are complete breaks with some contact between the bone fragments but with rotation or angulation of the elbow.
4. Type 4 fractures are off-ended with no bony contact between the two fragments.

Types 1 and 2 fractures are usually stable with a very low complication rate. Typically, stable fractures require no realignment of the broken (fractured) bone. Types 3 and 4 are unstable injuries with a much higher incidence of malunion (not healing in the correct position). Type 4 injuries are highly associated with damage to blood vessels and nerves, along with the risk of compartment syndrome.

All these injuries usually require three to six weeks of immobilisation followed by a gentle, phased return to activity. It commonly takes two to three months for the recovery of normal function, although this can be much longer if complications occur.

Description of the intervention

There are several treatments available for supracondylar fractures, the choice of which will depend on factors including the severity of the injury, nerve and vascular status of the limb, and surgeon's preference. Recent studies have demonstrated divergence of surgeon preference practice from national guidelines, with unclear consequences for long-term recovery ([Tzatzairis 2021](#)).

Non-surgical treatments of undisplaced fractures involve immobilisation of the arm in a sling, splint, or cast for three to five weeks to keep the elbow in the correct position. A cast is typically constructed of plaster of Paris or a synthetic resin, and extends from above the elbow to the forearm or the hand. Minimally displaced fractures can be treated in a number of ways. Some displacement can be accepted, relying on the child's ability to remodel (grow the bone out straight), or it can be reduced. Reduction (repositioning the broken bone back to the normal alignment) commonly involves bending the elbow up to bring the bone into the normal position and then treating it in a sling, cast, or splint as above. Some displaced fractures can be treated with traction. Traction can be applied as skin traction (where the traction is strapped to the child's arm) or skeletal traction (where the traction is applied directly to the bone using a screw, pin, or wire). The non-surgical method of skin traction is more common than skeletal traction, which requires an operation to insert the screw, pin or wire. In both methods, the limb is kept straight whilst it heals using weights attached through pulleys. The arm can be positioned to the side of the child (Dunlop traction) or above the child (overhead traction). Treatment with traction requires a prolonged hospital stay.

Surgical management of supracondylar fractures in children is achieved following general anaesthesia, using a closed or open technique to reduce (realign) the fractured bone. Stabilisation of the fracture is most commonly performed using percutaneous wires: smooth metal Kirschner wires (K-wires) are placed through tiny incisions in the skin. Two or more wires are inserted, depending on the stability of the break. A crossed K-wire technique will have an entry point on either side of the elbow forming an 'X' on X-ray, whereas a lateral wire divergent technique has the wires inserted

only from the outside part of the elbow. Children treated in this manner are commonly treated in cast to protect the wires until wire removal three to four weeks after the fixation. Alternative but rarer stabilisation techniques include the use of a plate and screws; or an external fixator, where a frame is seen on the outside of the limb, which holds the bones together whilst they heal.

The timing of surgery is typically dictated by the vascular status of the limb. The presence of a class 3 injury (white, pulseless hand) is a surgical emergency as it represents a limb-threatening injury. Class 1 and 2 injuries (pink hand with or without radial pulse) are treated as urgent cases with careful monitoring to ensure that they do not evolve into class 3. The optimal timing of surgery for class 1 and 2 injuries is unclear, although it is accepted that those without a palpable pulse are of higher urgency.

Minimally displaced fractures are routinely reduced in the hospital emergency department and immobilised. Very displaced fractures require a more formal reduction with significant sedation or a general anaesthetic. Most centres will perform this in theatre as fixation of the fracture can be performed at the same time. Some centres will attempt reduction with sedation in the hospital emergency department to reduce the delay to reduction. Most severely displaced fractures are unstable and so require fixation in theatre even after an initial reduction. This leads to two procedures instead of one. Waiting for theatre availability often adds a significant delay that can cause an increase in nerve or vascular damage.

How the intervention might work

The fracture pattern and the presence of neurological or vascular compromise will impact the treatment proposed for a child with a supracondylar elbow fracture. More stable fractures are often treated without surgery whereas complete fractures typically require surgery.

Non-operative interventions, including traction, immobilise the arm for enough time to allow bone healing and avoid the risk of surgical complications. However, potential complications associated with the non-operative treatment of these fractures include malunion (bone healing with a deformity if the bones are not reduced and fixed), compartment syndrome, and pressure injury from casts.

Surgical reduction and stabilisation results in a more anatomical restoration of bony anatomy and better stabilisation of the fracture, though a cast is still required if percutaneous fixation is performed. The most common form of surgical fixation is to use two or three smooth K-wires. Crossed wires (one entering the bone from each side of the elbow in a cross formation) is the most stable pattern for the wires. The main risk with this procedure is damage from the wire to the ulnar nerve on the inside part of the elbow. Many methods have been employed to try to protect this nerve, including explorations, minimal open reduction, and digital pressure from the thumb over the bone to keep the nerve out of the way. Rates of nerve injury with these techniques vary from 0% to 14%. The alternative treatment is to use two laterally-placed wires on the outside part of the elbow. This reduces the chance of causing iatrogenic injury of the nerve on the inside part of the elbow but does not remove the risk completely. It is technically more challenging to do and has less stability to rotation in comparison

with crossed wires. This may lead to higher rates of malunion than crossed wires.

Following surgery, pins can migrate or cause damage to local structures, including nerves. Internal fixation involves making a more substantial scar and can also lead to nerve injury. Surgery also introduces risks, including infection which can be superficial (skin) or deep (involving the bones); and risks associated with receiving a general anaesthetic. External fixation is recognised to be technically challenging but offers a more rigid fixation compared with percutaneous wires (Horst 2011). Many surgical techniques leave pins, wires, or screws that need to be removed at a second operation or in clinic. When these are removed in theatre, there is need for an additional (i.e. repeat) anaesthetic and a second risk of injury to nerves as the scars are opened and the metalwork is removed.

There is also uncertainty regarding the optimum time to take a child to theatre with this injury. Many surgeons are guided by the perfusion of the hand and neurological status at time of presentation (the pink pulsed hand or the white pulseless hand). It remains unclear if children benefit from having surgery overnight, or if outcomes are improved by waiting for surgery on a daytime routine trauma list (Terpstra 2022).

The timing and location of the reduction of a supracondylar fracture may be an indicator of the severity of injury or the availability of theatre time and sedation protocols in the hospital emergency department. A reduction in theatre can be supplemented with internal fixation with percutaneous wires or other fixation technique, but introduces additional delays as the child is admitted to the hospital and prepared for an anaesthetic. This delay may result in additional complications but may improve the quality of reduction and fixation options.

Why it is important to do this review

There is little controversy regarding non-surgical treatment for completely undisplaced supracondylar fractures in children. These should be treated in a cast or a sling to keep the elbow bent until the break heals. There is uncertainty, however, regarding the ideal treatment for minimally displaced breaks that are hinged backwards (AO Type 2 fractures). Many centres treat these in a sling or a cast, but some surgeons will take these children to theatre for reduction and surgical fixation. This requires two procedures with uncertain evidence of improved outcome.

For significantly displaced fractures (AO Type 4), the only clear agreement in the literature is that they require some form of reduction (Vaquero-Picado 2018). Treatment options vary from traction to reduction and fixation. There is no agreement on the timing of surgical intervention. It is well established that the longer a fracture remains displaced, the greater the risk of complications. It is known that vascular compromise and nerve injuries are commonly seen in these injuries and, rarely, compartment syndrome can develop. There is still no consensus as to the reasonable timing of surgical intervention (Terpstra 2022).

For surgical fixation, fractures are most commonly fixed using two or three smooth K-wires. There is controversy regarding the configuration of these wires to maximise the fracture stability whilst minimising the risks of complications (American Academy of Orthopaedic Surgeons 2011).

Two areas of further uncertainty and variation in practice are: what is the best treatment for these injuries when there is also a vascular injury; and how much displacement can be accepted, given the ability of children's bones to remodel and align over time (Griffin 2008; Hell 2021; Mangat 2009).

In the USA, national database analysis suggests that there has been a decrease in the rate of open reduction for displaced supracondylar fractures, with an associated increase in closed reductions (Holt 2017). There is relatively little long-term follow-up available in the literature. Using the Flynn criteria (Flynn 1974), Sinikumpu 2016 included a 12-year follow-up showing that only 75% of those treated for a supracondylar fracture in childhood reported good or excellent function, whereas 17/51 (33%) of those with displaced fractures reported an unsatisfactory outcome post injury.

The 2012 American Association of Orthopedic Surgeons (AAOS) guidelines for the management of paediatric supracondylar fractures identified several areas of care with limited or inconclusive evidence, including the use of lateral-only wires or crossed wires, the time threshold for reduction of displaced fractures, or the need for an open surgical exploration of vascular structures in a class 2 vascular injury (pink pulseless hand) (American Academy of Orthopaedic Surgeons 2011). The 2016 National Institute for Health and Care Excellence (NICE) NG38 guideline was unable to deliver any recommendations for the management of childhood supracondylar fractures (NICE 2016).

This review will analyse the current evidence to inform evidence-based practice.

OBJECTIVES

To assess the effects (benefits and harms) of interventions for treating supracondylar elbow fractures in children.

METHODS

Criteria for considering studies for this review

Types of studies

We included randomised controlled trials (RCTs) and quasi-RCTs (method of allocating participants to a treatment that is not strictly random, e.g. by hospital number) that assess interventions for treating supracondylar elbow fractures in children. We were not anticipating any cluster-RCTs where the unit of randomisation was a ward or other grouping of individuals. We would have included these studies if they had been appropriately designed.

Types of participants

We included studies where children have sustained an acute (usually presenting for treatment within seven days) supracondylar elbow fracture. We included children of all ages; thus, from birth to skeletal maturity.

Studies with mixed populations (e.g. children with other elbow fractures) were eligible for inclusion, provided children meeting the above inclusion criteria were the predominant subgroup, or data relating to their outcomes could be extracted either from the study manuscript or through contacting study authors.

Types of interventions

We divided interventions into non-surgical and surgical categories. We did not include trials that investigated the management of soft tissue complications, pharmacological analgesia regimens, or rehabilitation strategies.

We planned to make the following comparisons.

1. Different forms of surgical intervention. Our main comparisons were:
 - a. different fixation techniques (e.g. crossed K-wires versus lateral only; K-wires versus internal fixation; internal versus external fixation);
 - b. different reduction techniques (open reduction, where the pieces of broken bone are put back into place through a surgical approach, versus closed reduction, where the bone is put into place without making a surgical wound).
2. Surgical versus non-surgical treatment.
3. Different forms of traction. Our main comparison was:
 - a. type of traction: skeletal traction (placing a wire, screw, or pin into the bone) versus skin traction (strapping the traction to the arm).
4. Different methods of non-surgical intervention. Our main comparisons were:
 - a. form of immobilisation (cast and sling versus sling alone versus skin traction);
 - b. duration of prescribed immobilisation (either following surgery or as primary treatment).
5. Timing and location of treatment:
 - a. location of closed reduction (hospital emergency department versus operating theatre);
 - b. timing of surgery as emergent (within 6 hours) or urgent (within 24 hours).

Types of outcome measures

Critical outcomes

The critical outcomes for presentation in the summary of findings tables are as follows.

1. Functional outcome, at medium- or long-term follow-up, as rated by the child or their parent using a validated outcome measure, such as the Activity Scale for Kids performance version (ASK-p; [Young 2000](#)), Paediatric Outcome Data Collection Instrument (PODCI; [Daltroy 1998](#)), Disabilities of the Arm, Shoulder and Hand Score (DASH or quickDASH; [Beaton 2005](#); [Hudak 1996](#)), or ABILHAND-Kids score ([Arnould 2004](#)).
2. Treatment failure at any follow-up point, as indicated by a loss of reduction requiring a re-intervention (e.g. re-fixation) or a symptomatic malunion or unacceptable deformity requiring re-intervention after the fracture has healed. We expressed this as the number of children who experienced a treatment failure.
3. Nerve injury at any follow-up point: this may be transient or permanent and affecting the radial, ulnar, or median nerve, singly or in combination. We expressed this as the number of children who experienced a nerve injury.
4. Major complications, including compartment syndrome, vascular injury, and infection, at any follow-up point, expressed as the number of children who experienced a complication.

5. Cosmetic deformity measured either objectively or subjectively at medium- and long-term follow-up. In order to account for patient variation, we extracted carrying angle from studies as a marker of cosmetic deformity when presented as a loss of carrying angle. We did not include absolute values for carrying angle, as the range of carrying angles measured in children without elbow disorders ranges from 0° to 29° and also changes with age ([Golden 2007](#); [Sharma 2013](#)). We set a threshold of 10° change as clinically significant to be consistent with the widely-used grading system proposed by Flynn ([Flynn 1974](#)), and because it exceeds the measurement error of 6.5° when using a goniometer to measure carrying angle ([Chapleau 2011](#)).

Other outcomes

We also collected the following outcomes that were not for presentation in the summary of findings tables:

1. functional outcome, as rated by the child or their parent using a validated outcome measure, at early follow-up;
2. range of movement at the elbow (flexion and extension) at medium-term and long-term follow-up;
3. pain as assessed by child or parent using a child-appropriate scale, such as Faces Pain Scale ([Bieri 1990](#)), at early, medium-, and long-term follow-up;
4. quality of life for children assessed using a patient- or parent/carer-reported outcome tool, such as EQ-5D-Y ([Wille 2010](#)), at early, medium-, and long-term follow-up;
5. child or parent satisfaction at early, medium-, and long-term follow-up;
6. return to sport and normal activities;
7. radiographic deformity, including that measured through loss of Baumann's angle and humeral-capitellar angle at medium- and long-term follow-up;
8. emotional distress of the child, as measured using a validated tool such as the Paediatric Index of Emotional Distress (PI-ED; [O'Connor 2016](#)) or the Pediatric Emotional Distress Scale (PEDS; [Saylor 1999](#)), at early follow-up.

We included measurements for range of motion and radiographic parameters (e.g. Baumann's angle) where a relative change of movement or angle was presented. This was to account for the individual patient variation, with a wide spectrum of normal values for these outcomes. Where possible, we dichotomised range of motion using a threshold of 10° loss of movement to be consistent with the widely-used grading system proposed by Flynn ([Flynn 1974](#)), and to exceed the measurement error of 7° to 10° when using a goniometer to measure range of movement ([Chapleau 2011](#)).

We planned to analyse timing of outcomes as early (less than three months following injury), medium-term (three months to less than six months following injury) and long-term (six months or longer) outcomes.

Resource use

We also recorded resource use (e.g. number of outpatient visits and routine cast changes; duration of hospitalisation), other costs, and findings of included trials reporting cost-effectiveness analysis.

Search methods for identification of studies

Electronic searches

We searched for all published and unpublished relevant RCTs, without restrictions on language or publication status and in consultation with the Bone, Joint and Muscle Trauma (BJMT) Group Information Specialist.

We identified published, unpublished, and ongoing studies by searching the following databases from their inception:

1. Cochrane Central Register of Controlled Trials (CENTRAL, 9 March 2021, Issue 3) in the CRS-Web;
2. MEDLINE (Ovid MEDLINE and Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Daily and Versions 1946 to 9 March 2021);
3. Embase Ovid (1974 to 9 March 2021);
4. [ClinicalTrials.gov](https://clinicaltrials.gov) (to 21 April 2020);
5. [World Health Organization International Clinical Trials Registry Platform](https://www.who.int/clinical-trials-registry) (WHO ICTRP);
6. relevant conference proceedings, including the [Bone and Joint Journal \(BJJ\) Orthopaedic Proceedings](#), proceedings of the annual meetings of the Pediatric Orthopaedic Society of North America (POSNA), and the European Paediatric Orthopaedic Society (EPOS).

At the time of the search, CENTRAL was fully up to date with all records from the BJMT Group's Specialised Register so it was not necessary to search this separately.

In MEDLINE, we combined the subject-specific terms with the sensitivity-maximizing version of the Cochrane Highly Sensitive Search Strategy for identifying randomised trials ([Lefebvre 2019](#)). Search strategies can be found in [Appendix 1](#).

Searching other resources

We checked the bibliographies of included studies and any relevant systematic reviews we identified for further references to relevant trials. We contacted experts and organisations in the field to obtain additional information on relevant trials. We did not perform a separate search for adverse effects of interventions used for the treatment of supracondylar elbow fractures.

Data collection and analysis

Selection of studies

Two review authors (BAM and SC) independently screened search results for eligible studies. We sought full-text articles for any study judged eligible by either review author. The same two review authors then performed independent study selection. We resolved any disagreements by discussion or, if necessary, we obtained adjudication by a third author (BJO). We did not mask the source and authorship of the trial citations or reports.

Data extraction and management

Two review authors (BAM and SC or AI) independently extracted qualitative and quantitative data from each included trial using a data extraction form, which was piloted on two trials. We collected information on study characteristics, such as the study design and setting, the intended and actual study population, the study interventions and other care provided, outcomes measurement,

and results. We contacted trialists for further details as necessary. We resolved any differences or disagreements by checking trial reports, contacting trial authors, discussion between the two review authors (BAM and SC or AI), or adjudication by a third review author (BJO). Two review authors (BAM and SC) entered the data into Review Manager 5 ([Review Manager 2014](#)).

Assessment of risk of bias in included studies

Two review authors (BAM and SC or AI) independently assessed risk of bias using Cochrane's risk of bias tool, without masking of the source and authorship of the trial reports ([Higgins 2011](#)). We resolved any disagreement by involving the senior review author (BJO). We judged each study as 'low risk', 'unclear', or 'high risk' of bias for the following domains:

1. random sequence generation (selection bias);
2. allocation concealment (selection bias);
3. blinding of participants and personnel (performance bias);
4. blinding of outcome assessment (detection bias);
5. completeness of outcome data (attrition bias);
6. selective outcome reporting (reporting bias);
7. other potential sources of bias.

We considered subjectively- (parent or child) reported outcomes and objectively- (including clinician-rated) reported outcomes separately in our assessment of blinding and completeness of outcome data.

Measures of treatment effect

To measure treatment effect, we calculated risk ratios (RR) for binary outcomes and mean differences (MD) for continuous outcomes. We planned to calculate standardised mean differences when pooling data from continuous outcomes based on different scoring schemes. We planned to present final scores in preference to change scores. For all outcomes, we presented 95% confidence intervals (95% CIs).

Unit of analysis issues

We anticipated that for individually randomised trials, the unit of analysis would be individual children randomised to treatments, as bilateral supracondylar fractures are very rare. Although cluster-randomised trials were unlikely, we took appropriate measures to avoid unit-of-analysis issues as described in the *Cochrane Handbook for Systematic Reviews of Interventions* ([Higgins 2011](#)). Whilst we did not expect to identify any cross-over trials, given their study design is inappropriate for the condition and interventions covered by this review, we planned to use data from the first phase only if such trials were included. Where study participants crossed from one treatment group to another, we planned to analyse the results according to their allocation group (intention-to-treat analysis). We were aware of potential issues with multiple measurements if studies reported repeated follow-up or described a total number of complications without expressing how many children had multiple complications. When reporting a composite measure of all major complications, we confirmed with study authors that individual children did not experience more than one complication.

Dealing with missing data

We contacted study authors to obtain missing data and information. Where possible, we calculated missing standard deviations from other data (standard errors, 95% CIs, exact P values). We did not impute missing standard deviations or other data. We performed a sensitivity analysis to investigate the possible effects of missing data.

Assessment of heterogeneity

We performed assessment for heterogeneity through visual inspection of forest plots and calculation of the χ^2 statistic. We calculated study inconsistency using the I^2 statistic. Interpretation of these statistics followed the *Cochrane Handbook for Systematic Reviews of Interventions* with a statistically significant level of 0.10 for the χ^2 test. We interpreted I^2 statistic values using recommendations from the *Cochrane Handbook for Systematic Reviews of Interventions*: 0% to 40% might not be important; 30% to 60% may represent moderate heterogeneity; 50% to 90% may represent substantial heterogeneity; and 75% to 100% may represent very substantial heterogeneity (Higgins 2011).

Assessment of reporting biases

Where more than 10 studies contributed data to an analysis, we constructed a funnel plot to explore the potential for publication bias as well as for possible small-study biases. We planned to assess the magnitude of publication bias first by visual inspection of the asymmetry of the funnel plot. If this appeared markedly asymmetric, we planned to consider performing formal statistical tests (Egger 1997).

Data synthesis

When we considered it appropriate, we pooled the results of comparable studies using both fixed-effect and random-effects models. Our choice of model was guided by careful consideration of the extent of heterogeneity and whether it could be explained, in addition to other factors, such as the number and size of included studies. We used 95% CIs throughout. We did not pool data where there was substantial heterogeneity ($I^2 \geq 75\%$) that could not be explained by the diversity of methodological or clinical features among studies. Where pooling data was inappropriate, we still presented study data in the analyses or tables for illustrative purposes and reported these in the text.

Subgroup analysis and investigation of heterogeneity

We planned to perform subgroup analysis for the following groups but found that insufficient studies reported study characteristics to allow for meaningful analysis.

1. Levels of displacement: e.g. using the AO/ASIF classification 1 and 2 versus 3 and 4.
2. Presence of vascular injury (pink pulsed versus pink pulseless versus white hand).
3. Timing of surgery as defined by emergent (within 6 hours) or urgent (within 24 hours).
4. Presence or not of nerve injury.
5. Age of child at time of injury: age 0 to 4 (preschool), 5 to 10 (primary school), 11+ (secondary school).

In addition to these planned subgroups, we performed a post hoc subgroup analysis for the nerve injury outcome for comparisons

that involved inserting a K-wire through the medial epicondyle: medial wire inserted with a percutaneous (through the skin) technique versus medial wire inserted using an open technique (where a cut in the skin was made to identify the bone before inserting the wire).

We investigated whether the results of subgroups were significantly different by inspecting the overlap of CIs and performing the test for subgroup differences available in Review Manager 5 (Review Manager 2014).

Sensitivity analysis

For critical outcomes reported in the summary of findings tables, we performed sensitivity analyses to detect the following:

1. influence of any small-study effects by comparing the random-effects model output to a fixed-effect model calculated with the Mantel-Haenszel method;
2. impact of inclusion and exclusion of studies published only as abstracts;
3. impact of including studies with high risk of bias; in particular, those identified with allocation bias or a lack of blinding for outcome assessors;
4. analysis of the result of any missing data on review conclusions.

Whilst conducting the search, we noted that some studies appeared to have duplicate publications with different author teams. We also noted that several studies were published in journals that were not indexed in PubMed. Because we could not rule out the possibility of compromised data integrity, we conducted two additional sensitivity analyses on the critical outcomes reported in the summary of findings tables:

1. impact of inclusion and exclusion of studies published in journals that were not indexed in PubMed;
2. impact of inclusion and exclusion of studies that had multiple publications from different author teams.

Summary of findings and assessment of the certainty of the evidence

Two review authors used the GRADE system to assess the certainty of the body of evidence associated with the five critical outcomes in the review (Schünemann 2019):

1. functional outcome at final study follow-up;
2. treatment failure requiring re-intervention at final study follow-up;
3. nerve injury at final study follow-up;
4. Major complications (all complications) during study follow-up;
5. cosmetic deformity in the long term (from six months onwards).

Cosmetic deformity was measured using various criteria. For the summary of findings tables, we used the number of children with cubitus varus.

The GRADE approach assesses the certainty of a body of evidence based on the extent to which we can be confident that an estimate of effect or association reflects the item being assessed. Evaluation of the certainty of a body of evidence considers within-study risk of bias (study limitations), directness of the evidence (indirectness), heterogeneity of the data (inconsistency), precision of the effect

estimates (imprecision), and risk of publication bias. The certainty of the evidence could be high, moderate, low or very low, being downgraded by one or two levels depending on the presence and extent of concerns in each of the five GRADE domains. We used footnotes to describe reasons for downgrading the certainty of the evidence for each outcome, and we used these judgements when drawing conclusions in the review.

We did not construct summary of findings tables for all comparisons in this review. Instead, we selected comparisons which we judged to have the most clinical relevance and which also provided the most substantial body of evidence. We therefore constructed summary of findings tables for the following comparisons in this review, using the GRADE profiler software ([GRADEpro GDT](#)):

1. different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires;
2. different forms of surgical intervention: open versus closed reduction;
3. surgical versus non-surgical intervention: surgical fixation versus immobilisation.

We also planned to construct a summary of findings table for backslab versus sling (from the comparison of different methods of non-surgical intervention). However, only one study investigated this comparison and data were either not reported for the critical outcomes or included no events in either group; thus, we did not construct this table.

RESULTS

Description of studies

Results of the search

After the removal of duplicates from the search results, we screened 1222 titles and abstracts, which included handsearching of conference proceedings, backward citation searches, and searches of clinical trials registers. We reviewed the full text of 130 records, and selected 52 studies (with 69 records) for inclusion in the review. We excluded 48 records, and report the details of 35 key studies from these excluded records. Ten studies are awaiting classification, and we identified three ongoing studies. See [Figure 2](#).

Figure 2. Study flow diagram

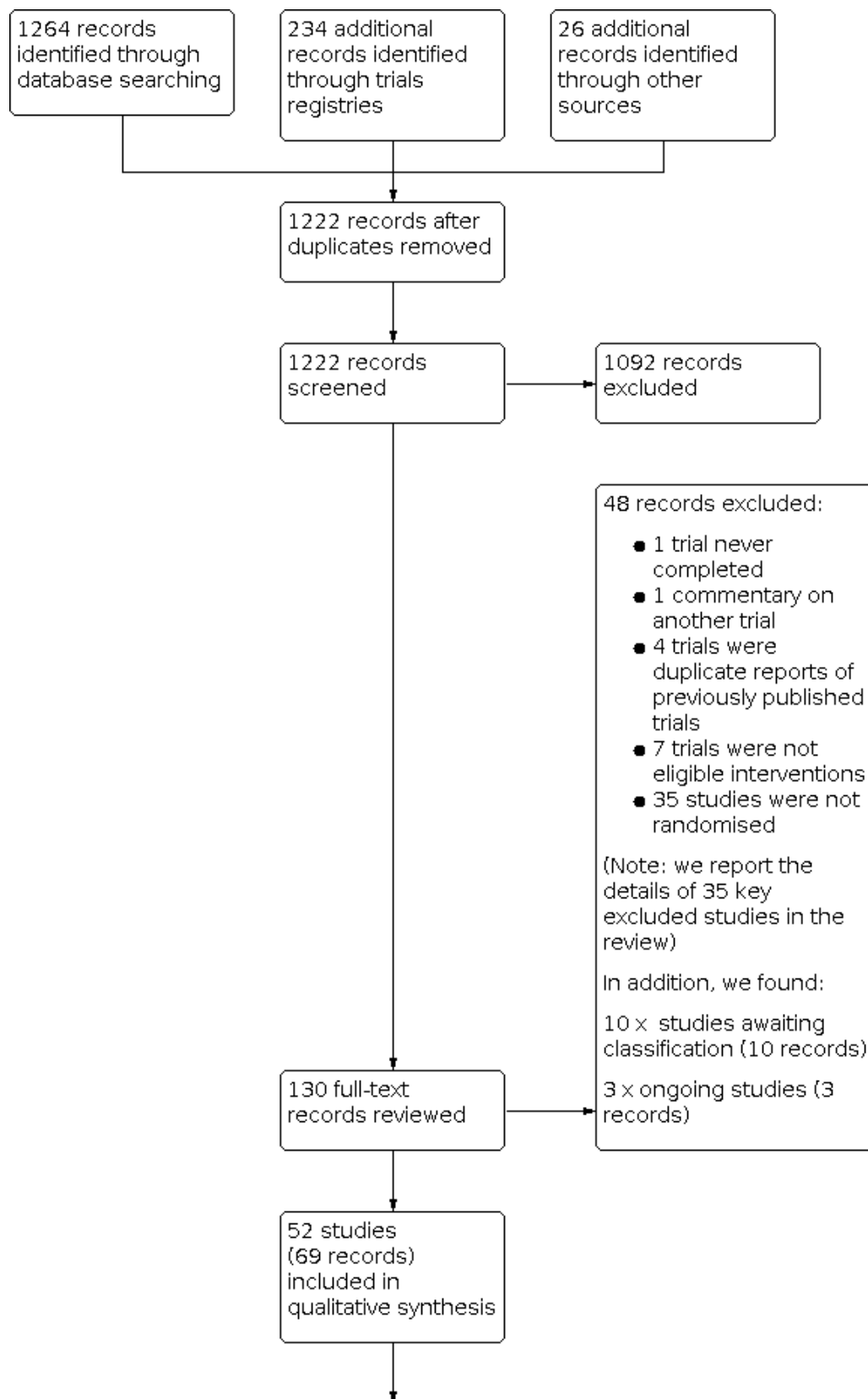
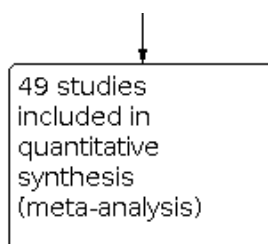


Figure 2. (Continued)



Included studies

Two studies were available as conference reports (Mulpuri 2016; Said 2015), and two studies were available as theses (Raj 2018; Vaidya 2009). The remaining studies were published as full reports in scientific journals. All reports were in English, aside from Dehghan 2012, the full text of which was written in Persian and for which we obtained a translation.

We requested additional information from study authors of all included trials. We received additional unpublished information for six trials (Abubeih 2019; Gaston 2010; Gopinathan 2018; Naik 2017; Oakley 2009; Subash 2020). We had insufficient detail to report outcome data for three included studies (Ahmad 2020; Das 2019; Rakha 2020). We report the details of the individual studies' designs, participants, interventions, outcomes, conflicts of interest, and funding in [Characteristics of included studies](#).

Setting

A summary of study setting and characteristics is shown in [Table 2](#). The publication dates of the included trials ranged from 2004 to 2021. The trials were completed in 16 different countries, with 33 studies from South-East Asia (India: Aher 2018; Ajmera 2013; Arun 2018; Das 2019; Gholap 2020; Gopinathan 2018; Jain 2019; Kalia 2018; Kumar 2021; Maity 2012; Mandal 2018; Naik 2017; Naveen 2017; Raj 2018; Palange 2019; Patil 2017; Prashant 2016; Ray 2019; Sankar 2019; Shah 2017; Subash 2020, Pakistan: Ahmad 2020; Anwar 2011; Majeed 2020; Rakha 2020; Saeed 2020; Shafi-Ur-Rehman 2013, Nepal: Afaque 2020; Pandey 2008; Vaidya 2009, China: Zhu 2016, Malaysia: Foad 2004, Thailand: Kaewpornsawan 2001); four studies from North America (USA: Gaston 2010; Kocher 2007; Tripuraneni 2009, Canada: Mulpuri 2016); two studies from Europe (Croatia: Ducic 2016a, Italy: Pavone 2016); 11 studies from Middle Eastern countries (Egypt: Abdel Karim 2016; Abubeih 2019; Othman 2017; Rizk 2019; Sadek 2018; Said 2015; Shamma 2020, Turkey: Altay 2011; Ercin 2016, Iraq: Dawood 2011, Iran Dehghan 2012); and two studies from Oceania (Australia: Oakley 2009, Papua New Guinea: Kuzma 2014).

Participants

Sex and age

The 52 included trials recruited a total of 3594 children. Four studies did not report the mean age or the gender split of the included children (Ahmad 2020; Kumar 2021; Mulpuri 2016; Shah 2017), three studies did not report the gender split of their participants (Foad 2004; Othman 2017; Tripuraneni 2009), and one study did not report the mean age (Das 2019).

The majority of the participants in most studies were male. In four studies, more than 75% of participants were male (Aher

2018; Gopinathan 2018; Rakha 2020; Shafi-Ur-Rehman 2013). In 19 studies, 65% to 74.9% of the participants were male (Abdel Karim 2016; Abubeih 2019; Altay 2011; Anwar 2011; Arun 2018; Ducic 2016a; Gholap 2020; Jain 2019; Kaewpornsawan 2001; Mandal 2018; Raj 2018; Pandey 2008; Pavone 2016; Prashant 2016; Sadek 2018; Said 2015; Sankar 2019; Shamma 2020; Vaidya 2009). In 21 studies, 50% to 64.9% of the participants were male (Afaque 2020; Ajmera 2013; Das 2019; Dawood 2011; Dehghan 2012; Ercin 2016; Gaston 2010; Kalia 2018; Kuzma 2014; Maity 2012; Majeed 2020; Naik 2017; Naveen 2017; Oakley 2009; Palange 2019; Patil 2017; Ray 2019; Rizk 2019; Saeed 2020; Subash 2020; Zhu 2016). In one study, there were more females than males, with 44.2% male participants (Kocher 2007).

The upper age limit for inclusion in studies varied, with two studies using an upper limit of 18 years (Gholap 2020; Oakley 2009), one study using 16 years (Kuzma 2014), four studies using 15 years (Jain 2019; Majeed 2020; Raj 2018; Ray 2019), one study using 14 years (Shah 2017), four studies using 13 years (Naik 2017; Naveen 2017; Palange 2019; Patil 2017), 18 studies using 12 years (Afaque 2020; Aher 2018; Ahmad 2020; Ajmera 2013; Anwar 2011; Arun 2018; Foad 2004; Gopinathan 2018; Kaewpornsawan 2001; Kumar 2021; Maity 2012; Mandal 2018; Prashant 2016; Rakha 2020; Said 2015; Sankar 2019; Vaidya 2009; Zhu 2016), one study using 11 years (Pandey 2008), six studies using 10 years (Abdel Karim 2016; Dawood 2011; Dehghan 2012; Kocher 2007; Shafi-Ur-Rehman 2013; Shamma 2020), one study using nine years (Abubeih 2019), and one study using seven years (Mulpuri 2016). One study had an upper limit of skeletal maturity (Gaston 2010), and 12 studies did not report an upper age limit (Altay 2011; Das 2019; Ducic 2016a; Ercin 2016; Kalia 2018; Othman 2017; Pavone 2016; Rizk 2019; Sadek 2018; Saeed 2020; Subash 2020; Tripuraneni 2009).

The lower age limit for study inclusion also varied, with 12 studies recruiting children from birth (Abdel Karim 2016; Afaque 2020; Dehghan 2012; Jain 2019; Kuzma 2014; Majeed 2020; Naik 2017; Raj 2018; Oakley 2009; Palange 2019; Pandey 2008; Shamma 2020), five studies from one year (Ahmad 2020; Anwar 2011; Foad 2004; Kaewpornsawan 2001; Shah 2017), five studies from two years (Aher 2018; Gopinathan 2018; Maity 2012; Ray 2019; Said 2015), 11 studies from three years (Abubeih 2019; Ajmera 2013; Gholap 2020; Kocher 2007; Kumar 2021; Mulpuri 2016; Naveen 2017; Prashant 2016; Sankar 2019; Shafi-Ur-Rehman 2013; Vaidya 2009), three studies from four years (Arun 2018; Dawood 2011; Zhu 2016), and three studies from five years (Mandal 2018; Patil 2017; Rakha 2020). A lower age limit was not reported by 13 studies (Altay 2011; Das 2019; Ducic 2016a; Ercin 2016; Gaston 2010; Kalia 2018; Othman 2017; Pavone 2016; Rizk 2019; Sadek 2018; Saeed 2020; Subash 2020; Tripuraneni 2009).

Despite the variability in inclusion criteria, the mean age of participants in each study was more consistent. The mean age of the participants in studies ranged from 4.9 years (Tripuraneni 2009) to 8.4 years (Arun 2018; Raj 2018; Prashant 2016). The mean age was less than 5 years in one study (Tripuraneni 2009), between 5 to 5.9 years in nine studies (Abdel Karim 2016; Abubeih 2019; Foead 2004; Kocher 2007; Oakley 2009; Othman 2017; Said 2015; Shamma 2020; Vaidya 2009), between 6 to 6.9 in 16 studies (Dawood 2011; Ducic 2016a; Dehghan 2012; Erzin 2016; Gaston 2010; Gholap 2020; Jain 2019; Kalia 2018; Maity 2012; Majeed 2020; Naik 2017; Pavone 2016; Rizk 2019; Sadek 2018; Shafi-Ur-Rehman 2013; Subash 2020), between 7 to 7.9 years in 16 studies (Afaq 2020; Aher 2018; Ajmera 2013; Altay 2011; Anwar 2011; Gopinathan 2018; Kaewpornasawan 2001; Kuzma 2014; Naveen 2017; Palange 2019; Pandey 2008; Rakha 2020; Ray 2019; Saeed 2020; Sankar 2019; Zhu 2016), and between 8 to 8.4 years in five studies (Arun 2018; Mandal 2018; Raj 2018; Patil 2017; Prashant 2016). The mean age was not reported in Ahmad 2020

Fracture types

The Gartland classification was used almost universally to describe the included fracture types. Children with Gartland 3 fractures were included in 28 studies (Abubeih 2019; Aher 2018; Ajmera 2013; Altay 2011; Arun 2018; Dawood 2011; Dehghan 2012; Erzin 2016; Gaston 2010; Gholap 2020; Gopinathan 2018; Kaewpornasawan 2001; Kocher 2007; Mulpuri 2016; Naik 2017; Raj 2018; Rakha 2020; Palange 2019; Patil 2017; Pavone 2016; Prashant 2016; Ray 2019; Rizk 2019; Said 2015; Sankar 2019; Shafi-Ur-Rehman 2013; Shah 2017; Vaidya 2009), children with a combination of Gartland 2 and 3 fractures were included in 16 studies (Abdel Karim 2016; Anwar 2011; Ducic 2016a; Foead 2004; Jain 2019; Kalia 2018; Kuzma 2014; Maity 2012; Mandal 2018; Naveen 2017; Othman 2017; Pandey 2008; Sadek 2018; Shamma 2020; Tripuraneni 2009; Zhu 2016), children with a combination of Gartland 3 and 4 were included in one study (Das 2019), and children with a combination of Gartland 2, 3, and 4 in one study (Afaq 2020). One study exclusively included children with Gartland 1 fractures (Oakley 2009), and one study included Gartland 1 and 2 fractures (Ahmad 2020). Four studies did not specify the amount of displacement or Gartland classification for inclusion in the study (Kumar 2021; Majeed 2020; Saeed 2020; Subash 2020).

None of the studies undertook a subgroup analysis or presented results for different fracture types.

Comparisons

We grouped the trials according to their primary comparisons. The majority of the trials addressed different types of surgical intervention, particularly the use of crossed K-wires compared with lateral entry wires. One study involving 47 children performed a three-way comparison of retrograde crossed wires, retrograde lateral wires and lateral crossed (Dorgan) wires (Othman 2017); this study is included in three comparisons, below.

Different forms of surgical interventions

Forty-one studies involving 2931 children compared different forms of surgical interventions. A summary of the different pinning techniques identified are summarised in Table 3.

- **Retrograde lateral wires versus retrograde crossed wires.** Following reduction, the use of retrograde crossed wires with a

medial and lateral entry point or retrograde lateral wires were compared in 31 studies involving a total of 2188 children. In 29 of these studies, the initial reduction was performed closed (Abdel Karim 2016; Abubeih 2019; Afaq 2020; Aher 2018; Ahmad 2020; Anwar 2011; Arun 2018; Das 2019; Foead 2004; Gaston 2010; Gholap 2020; Kocher 2007; Maity 2012; Majeed 2020; Mandal 2018; Mulpuri 2016; Naik 2017; Naveen 2017; Othman 2017; Palange 2019; Patil 2017; Pavone 2016; Prashant 2016; Raj 2018; Said 2015; Shafi-Ur-Rehman 2013; Subash 2020; Tripuraneni 2009; Vaidya 2009). In two studies, the initial reduction was performed with an open approach with direct visualisation of the fracture (Dawood 2011; Sankar 2019).

- **Lateral crossed (Dorgan) wires versus retrograde crossed wires.** Five studies involving 310 children compared the use of lateral crossed (Dorgan) wires with retrograde crossed wires with a medial and lateral entry point (Altay 2011; Ducic 2016a; Kalia 2018; Othman 2017; Rizk 2019). All fixations were completed after a closed reduction.
- **Retrograde lateral wires versus lateral crossed (Dorgan) wires.** Two studies involving 72 children compared the use of retrograde crossed wires with a medial and lateral entry point with lateral crossed (Dorgan) wires following a closed reduction (Othman 2017; Sadek 2018).
- **Retrograde crossed wires versus posterior intrafocal wires.** One study including 168 children compared the use of retrograde crossed wires and a posterior intrafocal technique where lateral and posterior wires were used following closed reduction (Jain 2019).
- **Retrograde lateral wires in a parallel versus divergent configuration.** Two studies involving a total of 60 children compared a parallel and divergent configuration for laterally placed wires (Gopinathan 2018; Shamma 2020).
- **Retrograde crossed wires using a mini-open technique or inserted percutaneously.** One study including 104 children compared the insertion of the medial wire in a retrograde crossed wire configuration using a mini-open technique compared with a percutaneous technique (Erzin 2016).
- **Buried versus non-buried wires.** One study including 80 children compared buried with non-buried wires following open reduction (Saeed 2020).
- **External fixation or internal fixation.** We identified no studies that compared external fixation with internal fixation.

Open versus closed reduction of displaced fractures

Different reduction techniques were compared by six studies including 493 children (Ajmera 2013; Dehghan 2012; Kaewpornasawan 2001; Rakha 2020; Ray 2019; Zhu 2016). Four studies compared an open reduction using a posterior approach followed by retrograde crossed wires with a closed reduction followed by retrograde crossed wires (Ajmera 2013; Dehghan 2012; Rakha 2020; Ray 2019). One study compared a lateral approach open reduction followed by lateral crossed (Dorgan) wires with a closed reduction and retrograde crossed wires (Kaewpornasawan 2001). One study compared a joystick-assisted reduction followed by retrograde crossed wires with a closed reduction followed by retrograde crossed wires (Zhu 2016).

Surgical versus non surgical treatment

Three studies involving 140 children compared application of posterior backslab with fixation with retrograde crossed K-wires (Kumar 2021; Pandey 2008; Shah 2017).

Different forms of traction

One study including 133 children compared different forms of traction for Gartland 3 supracondylar fractures (Kuzma 2014). This study compared the use of skeletal traction with a pin in the olecranon to skin traction for two to three weeks. Skeletal traction was applied using a general anaesthetic with a pin inserted into the olecranon and overhead traction with the elbow in flexion and the forearm supported on a sling. Skin traction was applied under sedation and was held to the skin using elastic bandage. The elbow was maintained in extension with the shoulder in 90° to 100° abduction.

Different methods of non-surgical intervention

One study including 100 children evaluated the use of a collar and cuff sling compared to a posterior fibreglass backslab, both of which were prescribed for an initial 12 to 16 days but could be extended for an additional 14 days if symptoms had not resolved (Oakley 2009). In this study, children had undisplaced or minimally displaced fractures.

No studies compared cast and sling or sling alone versus skin traction, and no studies compared different durations of immobilisation.

Timing and location of treatment

We identified no studies that compared different locations for closed reduction (i.e. the hospital emergency department versus the operating theatre) or the timing of surgery for displaced fractures.

Outcomes

We included three studies in the review for which there were no available outcome data (Ahmad 2020; Das 2019; Rakha 2020). For retrograde lateral wires versus retrograde crossed wires, Shafi-Ur-Rehman 2013 was the only study contributing data for other important outcomes and not for the critical review outcomes. All other studies reported data for at least one critical outcome. Data were mostly reported at medium term (three months to less than six months following injury) and long term (six months or longer).

Funding sources

Eleven studies stated that they had received no funding (Abubeih 2019; Afaque 2020; Altay 2011; Anwar 2011; Gopinathan 2018; Kumar 2021; Maity 2012; Naveen 2017; Rizk 2019; Sankar 2019; Zhu 2016). The remaining studies did not report sources of funding.

Excluded studies

Here, we report the details of 35 key excluded studies (see [Characteristics of excluded studies](#)).

We excluded seven studies because the interventions were not eligible for inclusion in the review. Three studies compared different approaches to reduction (Arif 2014; Ensafdar 2005; Siddiq 2020), two studies compared prone versus supine positions

for surgery (Rawoot 2014; Venkatadass 2015), and two studies compared different forms of elbow casting (Chen 2001; Silva 2018).

We excluded one clinical trials registration report as the study was withdrawn owing to a failure to recruit a sufficient number of participants (NCT00904137).

We excluded four studies which we believed were copies of other eligible studies; these copy study reports were published using different author names but with sufficiently similar study characteristics to another study. In the review, we used the study publication which we believed to be the original report and excluded the copy report. We therefore excluded El-Ngehy 2018 (which we believed to be a copy of Naik 2017), Hegazy 2020 (which we believed to be a copy of Shamma 2020), Sadik 2015 (which we believed to be a copy of Maity 2012), and Shah 2013 (which we believed to be a copy of Shafi-Ur-Rehman 2013). We reported this information to the relevant journal editors for further investigation.

We excluded the remaining studies because they used a non-randomised study design which was not apparent until we had viewed the full text.

Studies awaiting classification

We categorised 10 studies as awaiting classification. We identified five studies during title and abstract screening but we were unable to access the full texts of these study reports to confirm if they were RCTs (Afridi 2002; Andreasi 1985; Boparai 2006; Botchu 2006; Evans 1998). We identified two studies during backward citation searching of relevant systematic reviews (Bing 2017; Lu 2011), but we were unable to source the abstracts or full texts to confirm eligibility. He 2009 compares different forms of splint. However, we could not determine from a translated manuscript whether the study was randomised. Similarly, we could not determine whether Sapkota 2019 was randomised. Attempts to contact the study authors for these two studies were unsuccessful.

NCT04582123 compared fixation with two crossed pins versus three crossed pins. This study is listed in a clinical trials register as complete but the results are not reported and we await publication of the full text.

Ongoing studies

We identified three ongoing studies that are potentially eligible. ACTRN12612000480886 is a trial registration for an RCT of immobilisation position being completed in Australia. The study start date was in 2012 and we attempted to contact the study authors for a status update but the email address is no longer active. PACTR201702001960109 is a trial registration for an RCT of crossed wires versus lateral wires registered in 2016; attempts to contact the study authors have been unsuccessful. CTRI/2020/06/025504 is a trial registration for an RCT of two versus three lateral wires; this study was registered in June 2020.

Risk of bias in included studies

All studies had methodological or reporting limitations that prevented them from being rated as low risk of bias for all domains (Figure 3; Figure 4). We did not conduct risk of bias assessment for three studies because these studies did not report outcome data

for this review (Ahmad 2020; Das 2019; Rakha 2020). The risk of bias figures therefore include blank spaces for these trials.

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

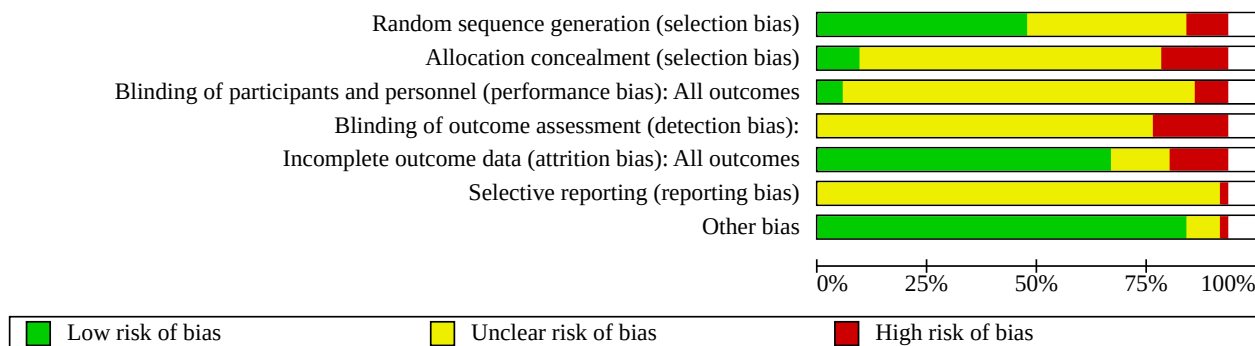


Figure 4. Risk of bias summary: review authors' judgements about each risk of bias item for each included study. Blank spaces indicate that we did not conduct risk of bias assessment; we did not include outcome data for these studies.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias): All outcomes	Blinding of outcome assessment (detection bias):	Incomplete outcome data (attrition bias): All outcomes	Selective reporting (reporting bias)	Other bias
Abdel Karim 2016	+	?	-	-	+	?	+
Abubeih 2019	+	+	-	-	+	?	+
Afaque 2020	+	?	?	?	+	?	+
Aher 2018	+	?	?	?	?	?	+
Ahmad 2020							
Ajmera 2013	?	?	?	?	?	?	+
Altay 2011	?	?	?	?	+	?	+
Anwar 2011	+	?	?	?	+	?	+
Arun 2018	?	?	?	?	+	?	+
Das 2019							
Dawood 2011	?	?	?	?	+	?	+
Dehghan 2012	+	?	?	?	+	?	+
Ducic 2016a	+	+	?	-	+	?	+
Ercin 2016	-	-	?	?	-	?	+
Foead 2004	+	?	-	?	+	?	+
Gaston 2010	-	-	+	-	?	?	+
Gholap 2020	?	?	?	?	+	?	+
Gopinathan 2018	+	-	?	?	+	?	+
Jain 2019	-	-	?	?	+	?	+
Kaewpornsawan 2001	+	?	-	?	+	?	+
Kalia 2018	?	?	?	?	+	?	+
Kocher 2007	+	?	?	-	?	?	+
Kumar 2021	?	?	?	?	+	?	+

Figure 4. (Continued)

Kocher 2007	+	?	?	-	?	?	+
Kumar 2021	?	?	?	?	+	?	+
Kuzma 2014	+	-	+	-	-	?	+
Maity 2012	+	+	?	-	-	?	?
Majeed 2020	?	?	?	?	+	?	+
Mandal 2018	?	?	?	?	-	?	+
Mulpuri 2016	+	?	?	?	-	-	+
Naik 2017	-	-	?	?	+	?	?
Naveen 2017	+	?	?	?	+	?	+
Oakley 2009	+	+	?	-	+	?	+
Othman 2017	?	?	?	?	?	?	+
Palange 2019	+	?	+	?	+	?	+
Pandey 2008	?	?	?	?	-	?	+
Patil 2017	?	?	?	?	+	?	+
Pavone 2016	?	?	?	?	+	?	+
Prashant 2016	+	?	?	?	+	?	+
Raj 2018	?	?	?	?	+	?	-
Rakha 2020							
Ray 2019	+	?	?	?	+	?	+
Rizk 2019	?	?	?	?	+	?	+
Sadek 2018	?	?	?	?	+	?	+
Saeed 2020	?	?	?	?	+	?	+
Said 2015	+	?	?	?	+	?	+
Sankar 2019	+	?	?	?	?	?	+
Shafi-Ur-Rehman 2013	?	?	?	?	+	?	?
Shah 2017	?	?	?	?	+	?	+
Shamma 2020	+	?	?	?	+	?	?
Subash 2020	+	+	?	?	?	?	+
Tripuraneni 2009	-	-	?	?	+	?	+
Vaidya 2009	+	?	?	?	+	?	+
Zhu 2016	+	-	?	-	-	?	+

Allocation

Twenty-five studies used an adequate method for random sequence generation and we judged these studies to be at low risk of bias for this domain (Abdel Karim 2016; Abubeih 2019; Afaq 2020; Aher 2018; Anwar 2011; Dehghan 2012; Ducic 2016a; Foad 2004; Gopinathan 2018; Kaewpornsawan 2001; Kocher 2007; Kuzma 2014; Maity 2012; Mulpuri 2016; Naveen 2017; Oakley 2009; Palange 2019; Prashant 2016; Ray 2019; Said 2015; Sankar 2019; Shamma 2020; Subash 2020; Vaidya 2009; Zhu 2016). We judged five of these studies to also be at low risk of bias for allocation concealment (Abubeih 2019; Ducic 2016a; Maity 2012; Oakley 2009; Subash 2020).

Quasi-randomised techniques were reported in five studies (Ercin 2016; Gaston 2010; Jain 2019; Naik 2017; Tripuraneni 2009). Three studies allocated participants to treatments based on the day of admission and the surgeon who was on call to perform

the operation (Ercin 2016; Gaston 2010; Tripuraneni 2009). Jain 2019 allocated treatments to children on an alternating basis, and Naik 2017 used the child's inpatient number to allocate treatments. We judged these studies to be at high risk of bias. Opaque envelopes were used in the Gopinathan 2018, Kuzma 2014 and Zhu 2016 studies but these were not pre-numbered and were drawn from a box with a limited number of envelopes. For these three studies, we judged the random sequence generation to be at low risk of bias and the allocation concealment to be at high risk.

The remaining studies were at unclear risk of selection bias because of insufficient reporting.

Blinding

Most studies were at high or unclear risk of blinding due to a lack of blinding or independence of personnel, participants, and outcome assessors.

As the majority of the comparisons are of surgical procedures, we judged it would not be possible to blind an operating surgeon or surgical team to allocated treatments in the same way that can be accomplished in blinded drug trials. Equally, it is near-impossible to blind participants to their treatment allocation due to the presence of external devices, pins, or scars. We felt that this lack of personnel and participant blinding might impact performance if the practitioner providing the intervention was a part of the study team. This was confirmed to be the case in four studies; we therefore assigned high risk of performance bias to these studies (Abdel Karim 2016; Abubeih 2019; Foad 2004; Kaewpornawan 2001).

We judged three studies to have low risk of performance bias because interventions were provided by practitioners who were independent of the study team (Gaston 2010; Kuzma 2014; Palange 2019). We judged risk of performance bias in the remaining studies to be unclear.

The use of non-blinded assessors was explicit in nine studies and we judged these studies to be at high risk of detection bias (Abdel Karim 2016; Abubeih 2019; Ducic 2016a; Gaston 2010; Kocher 2007; Kuzma 2014; Maity 2012; Oakley 2009; Zhu 2016). However, risk of detection bias was unclear in the remaining studies.

Incomplete outcome data

We agreed that the minimum requirements for a study to be assigned a low risk of bias in this domain would be:

1. a follow-up rate exceeding 70%;
2. evidence that any participants lost to follow-up were missing at random (i.e. loss to follow-up balanced between groups);
3. an intention-to-treat analysis provided in the study report.

Twenty-five studies reported no losses (Abdel Karim 2016; Altay 2011; Anwar 2011; Arun 2018; Dawood 2011; Dehghan 2012; Ducic 2016a; Gholap 2020; Gopinathan 2018; Kaewpornawan 2001; Kalia 2018; Kumar 2021; Majeed 2020; Naik 2017; Raj 2018; Palange 2019; Patil 2017; Pavone 2016; Ray 2019; Rizk 2019; Sadek 2018; Saeed 2020; Shafi-Ur-Rehman 2013; Shah 2017; Shamma 2020). Eight studies had a small loss to follow-up which was balanced between groups (Abubeih 2019; Afaque 2020; Foad 2004; Jain 2019; Naveen 2017; Oakley 2009; Prashant 2016; Vaidya 2009). During the study by Tripuraneni 2009, seven children did not attend follow-up following pin removal but it was judged that this was unlikely to impact the extracted outcome of nerve injury. We judged these 34 studies to have a low risk of attrition bias.

We deemed seven studies to be at high risk of attrition bias. Ercin 2016 excluded 15 children following allocation for having fixation with two rather than three wires. Kuzma 2014 and Maity 2012 had loss to follow-up rates of 16% and 18%, respectively, but adjusted for missing data using a 'last result carried forward' technique with no presentation of unadjusted results. Two children with significant complications were excluded following randomisation and intervention in Mandal 2018. In the abstracts of the Mulpuri 2016 study, a per-protocol analysis was performed, with a

disproportionate exclusion of children with lateral wires who were more likely to receive an additional medial wire if there were intra-operative concerns about stability. Pandey 2008 had an imbalance in loss to follow-up of 27% and 20% with more children in the cast group absconding. This may be related to children in a cast with good outcomes not returning for follow-up as it is easier to remove a cast at home than remove wires. Zhu 2016 had an imbalance of children excluded from analysis in the closed reduction group and presented a per-protocol analysis.

We judged the remaining seven studies to have an unclear risk of attrition bias with insufficient information to assess the impact of loss to follow-up on the intervention groups (Aher 2018; Ajmera 2013; Gaston 2010; Kocher 2007; Othman 2017; Sankar 2019; Subash 2020).

Selective reporting

A prospective trial registration or protocol was available for only one study (Mulpuri 2016). This identified long-term radiographic outcomes that were not reported in the published abstracts and it is possible that this planned long-term analysis will be presented in a full paper; we judged this study to have a high risk of selective reporting bias in this review. For all other studies, no prospective trial registration or protocol was available so we judged all the remaining studies to have an unclear risk of selective reporting bias.

Other potential sources of bias

One study had an unexplained difference in open reduction rates between intervention groups (80% versus 20%) which may have impacted on outcomes (Raj 2018), and we judged this study to be at high risk of bias.

We judged four studies to have an unclear risk of other bias (Maity 2012; Naik 2017; Shafi-Ur-Rehman 2013; Shamma 2020). We identified apparent copy publications of these studies (see Excluded studies), and although we assumed that these four studies were the original publications, we could not rule out the possibility that these studies were in fact conducted by other study author teams.

Effects of interventions

See: **Summary of findings 1** Retrograde lateral wires compared with retrograde crossed wires for treatment of displaced supracondylar elbow fractures in children; **Summary of findings 2** Open reduction compared with closed reduction position for treatment of displaced supracondylar fractures in children; **Summary of findings 3** Surgical fixation versus non-surgical immobilisation for displaced fractures

We report detailed data for critical outcomes for five comparisons; data for other important outcomes are summarised in the text and in additional tables. The first comparison (different forms of surgical interventions) included seven different comparisons of fixation techniques. Because most data were available for retrograde lateral versus retrograde crossed wires, and because this is the most clinically relevant comparison, we presented the findings for other types of fixation techniques in summary text with additional tables.

See the summary of findings tables for the critical outcomes for: retrograde lateral versus retrograde crossed wires (**Summary of findings 1**), open reduction versus closed reduction (**Summary**

of findings 2), and surgical fixation versus non-surgical immobilisation (Summary of findings 3).

1a. Different forms of surgical interventions: different fixation techniques

Retrograde lateral versus retrograde crossed wires

Twenty-nine studies evaluated the use of retrograde crossed wires and retrograde lateral wires (see Table 2).

Critical outcomes

1. Functional outcome

Long-term functional outcome was measured in one study (35 children) using the Mayo Elbow Performance Score at 42 to 44 months after surgery (Pavone 2016). This scoring system ranges from 0 to 100 with higher scores indicating better function; we note that this score is designed for use in adult elbow disorders (Morrey 1993), but has not been formally validated for use in childhood fractures (Marson 2020a). We were unable to calculate an effect estimate because study authors did not report distribution values or P values. Study authors reported a difference of two points between the lateral and crossed wires groups, with higher scores in the lateral wires group (98 points in the lateral wires group versus 96 points in the crossed wires group). We judged the certainty of this evidence to be very low. We downgraded by one level for serious risk of bias and two levels for very serious imprecision.

2. Treatment failure requiring intervention

Only one study (60 children) reported treatment failure requiring revision surgery (Mandal 2018). We found little or no difference according to the two interventions (risk ratio (RR) 3.00, 95% confidence interval (CI) 0.13 to 70.83, favours crossed wires; 1 study, 60 children; very low-certainty evidence; Analysis 1.1). The single event for this outcome, a varus collapse of the fracture) occurred with lateral wires. We downgraded the evidence by one level for serious risk of bias and two levels for very serious imprecision.

3. Nerve injury

Of the 29 studies in this comparison, all except Shafi-Ur-Rehman 2013 reported nerve injury. We found fewer incidences of nerve injury when lateral wires were used (RR 0.65, 95% CI 0.46 to 0.90, favours lateral wires; $I^2 = 0\%$; 28 studies, 1653 children; low-certainty evidence; Analysis 1.2; Figure 5). All nerve injuries were transient and resolved within 12 months of injury. We noted that two studies included ulnar nerve injuries in children allocated to retrograde lateral wires (Abdel Karim 2016; Gaston 2010); these injuries were the result of an additional medial wire being inserted due to a perceived lack of stability in the operating room. We generated a funnel plot for this analysis and, from visual inspection of this plot, we could not rule out the possibility of publication bias or small-study effects (Figure 6); sensitivity analysis also indicated a possible bias from studies published in non-indexed journals (see below). We downgraded the certainty of the evidence by one level owing to serious risks of bias and one level for publication bias.

Figure 5. Forest plot of comparison 6: different forms of surgical intervention: retrograde crossed wires versus retrograde lateral wires, outcome 6.1 nerve injury

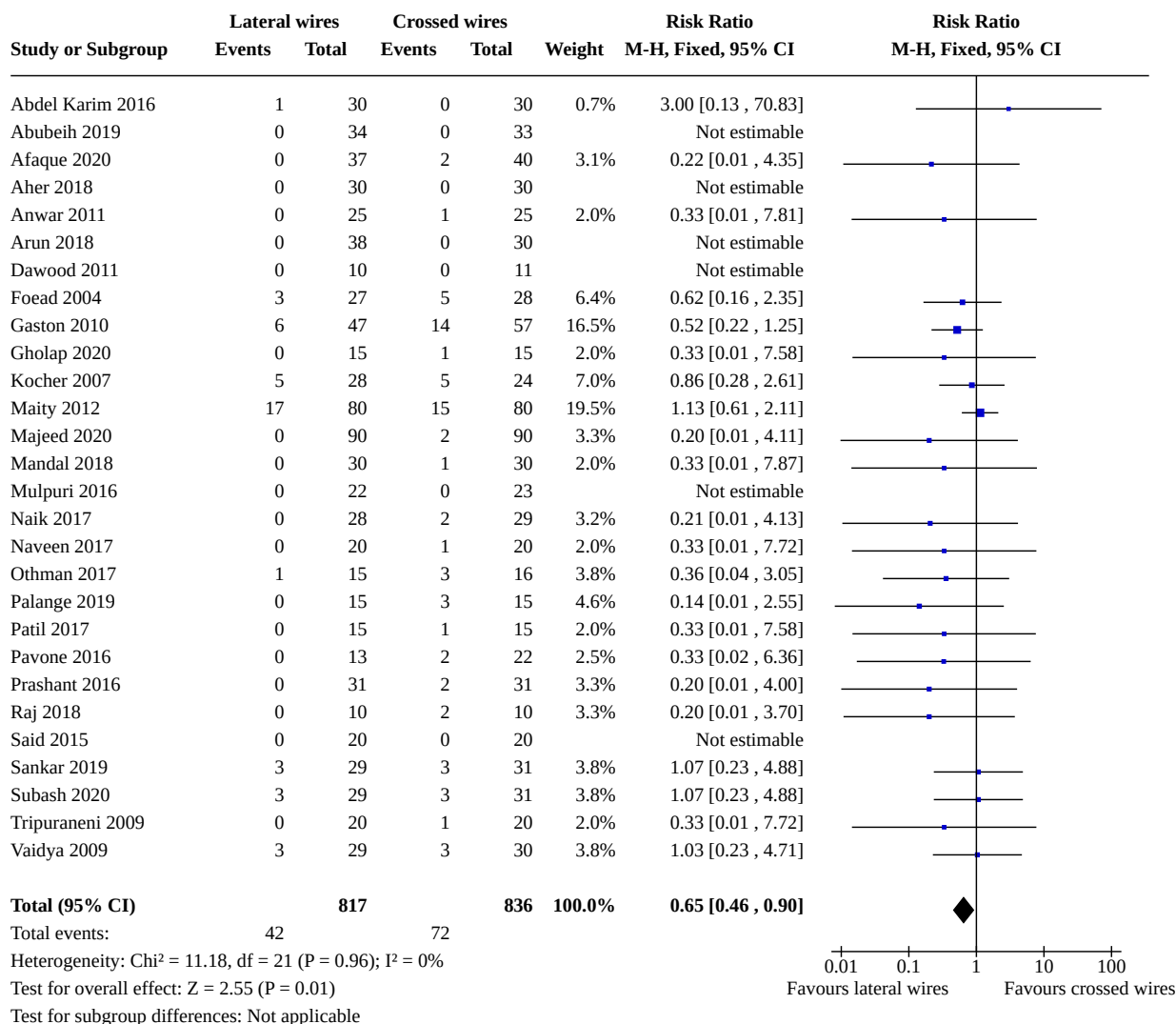
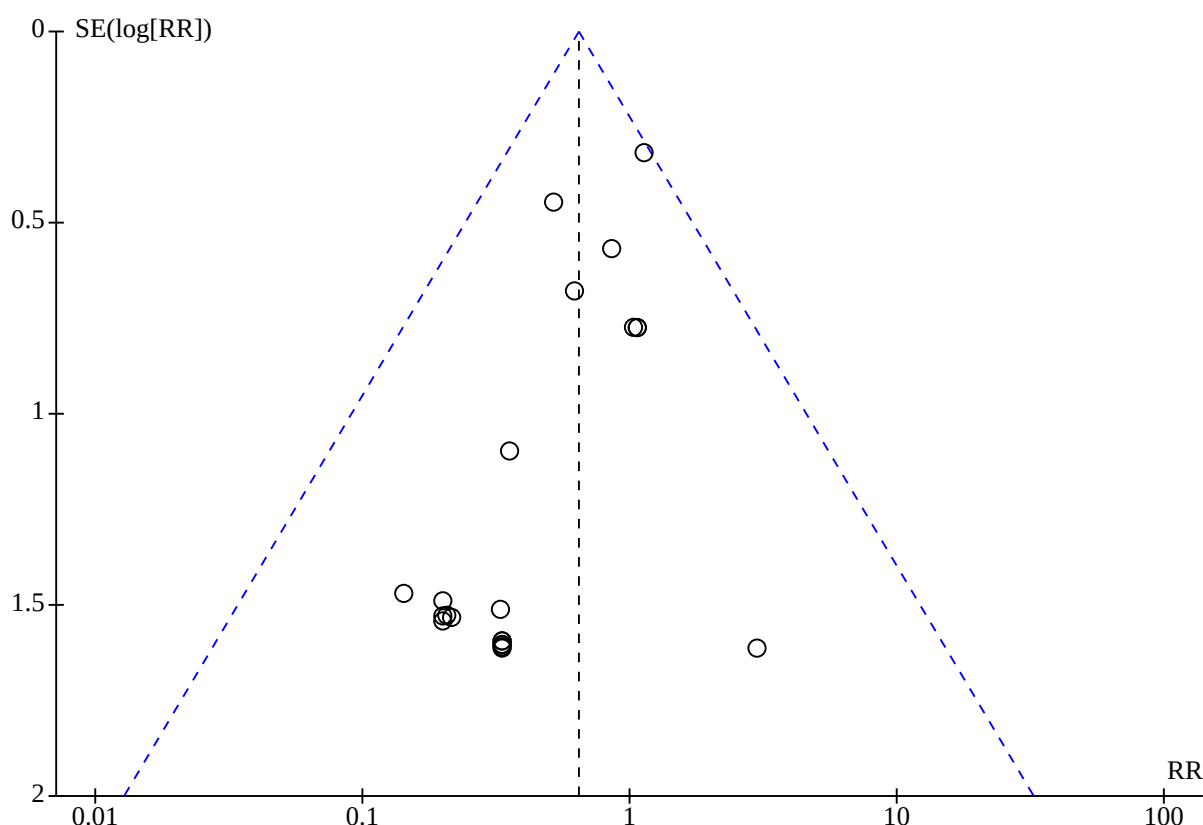


Figure 6. Funnel plot for retrograde lateral wires compared with retrograde crossed wires: Analysis 1.2 Nerve injury



4. Major complications

Major complications were reported in 18 studies (Abdel Karim 2016; Abubeih 2019; Afaque 2020; Aher 2018; Foead 2004; Kocher 2007; Maity 2012; Mandal 2018; Naik 2017; Naveen 2017; Othman 2017; Patil 2017; Pavone 2016; Prashant 2016; Raj 2018; Said 2015; Sankar 2019; Vaidya 2009). The effect estimate was imprecise, indicating possible benefits as well as harms for both interventions (RR 1.08, 95% CI 0.65 to 1.79, favours crossed wires; $I^2 = 0\%$; 19 studies, 1126 children; Analysis 1.3); all complications were pin site infections. We judged the certainty of this evidence to be low, downgrading one level for serious risks of bias and one level for serious imprecision owing to the wide CI in the effect estimates. We did not detect possible publication bias from a funnel plot generated for this outcome.

5. Cosmetic deformity

In the medium term:

- **Cubitus varus.** One study reported children with this deformity measured three months after surgery (Abubeih 2019). The effect estimate was imprecise, indicating possible benefits and harms for both interventions in the medium term (RR 2.91, 95% CI 0.12 to 69.08, favours crossed wires; 1 study, 67 children; Analysis 1.4).
- **Loss of carrying angle of more than 10° (measured as number of events).** One study reported children with a loss of carrying angle of more than 10° measured at four months (Dawood 2011). The effect estimate was imprecise, indicating possible

benefits and harms for both interventions in the medium term (RR 1.10, 95% CI 0.08 to 15.36, favours crossed wires; 1 study, 21 children; Analysis 1.4).

- **Loss of carrying angle (measured as degrees of loss).** Five studies reported the mean degree of loss of the carrying angle at three months (Afaque 2020; Kocher 2007; Maity 2012), and four months (Dawood 2011; Said 2015). We found little or no difference in degrees of loss in the medium term between the intervention groups (mean difference (MD) -0.10° , 95% CI -0.44° to 0.23° , favours lateral wires; $I^2 = 0\%$; 5 studies, 320 children; Analysis 1.5).

In the long term:

- **Cubitus varus.** Two studies reported this outcome in the longer term, at six months (Mandal 2018), and at four years (Pavone 2016), and the effect estimate was also imprecise (RR 3.13, 95% CI 0.55 to 17.98, favours crossed wires; $I^2 = 41\%$; 2 studies, 95 children; Analysis 1.4). We downgraded the certainty of the evidence by one level for serious risk of bias and two levels for imprecision owing to the small sample size and wide CI.
- **Loss of carrying angle of more than 10° (measured as number of events).** Six studies reported this outcome in the longer term at six months (Anwar 2011; Foead 2004; Mandal 2018), seven months (Othman 2017), two years (Naik 2017), and four years (Pavone 2016). The effect estimate was imprecise (RR 1.27, 95% CI 0.39 to 4.20, favours crossed wires; $I^2 = 0\%$; 6 studies, 288 children; Analysis 1.4); this analysis included three studies in

which there were no events in either group (Anwar 2011; Mandal 2018; Pavone 2016).

- **Loss of carrying angle (measured as degrees of loss).** Ten studies reported this outcome in the longer term at six months (Aher 2018; Anwar 2011; Foad 2004; Gholap 2020; Mandal 2018; Palange 2019; Prashant 2016; Subash 2020; Vaidya 2009), and at four years (Pavone 2016). We similarly found little or no difference (MD 0.14°, 95% CI -0.26° to 0.54°, favours crossed wires; $I^2 = 0\%$; 10 studies, 502 children). The MD in loss of carrying angle between groups is less than 1°, which is much lower than the measurement error of using a goniometer to measure carrying angle, and is thus highly unlikely to be clinically significant.

Other important outcomes

Studies reported range of movement, return to sport or normal activities, and radiographic deformity. We noted that fewer children had loss of reduction in the medium term when crossed wires were used (RR 2.00, 95% CI 1.21 to 3.30, favours crossed wires; $I^2 = 14\%$; 7 studies, 469 children; Analysis 1.10). However, the effect estimates at other time points and for all other measures of radiographic deformity, as well as effect estimates for the other clinical outcomes, were all imprecise and included the possibility of benefits and harms for both treatments. For resource use, we did not pool the data for operative time because of substantial statistical heterogeneity in the two included studies, and we found little or no difference between treatments in the length of hospital stay in one study. See Table 4. No studies reported functional outcome in the early follow-up period, pain, quality of life, child or parent satisfaction, or emotional distress of the child.

Subgroup analysis

We found that insufficient studies reported study characteristics to allow for meaningful subgroup analysis using our pre-specified subgroups. We conducted a post hoc subgroup analysis for nerve injury according to the technique used to insert the medial wire. This analysis included only studies that reported whether wires were inserted using a percutaneous or open technique, and therefore does not include data for seven studies that did not describe this detail (Anwar 2011; Foad 2004; Majeed 2020; Mandal 2018; Mulpuri 2016; Pavone 2016; Raj 2018). The formal test for subgroup differences indicated a difference according to technique ($P = 0.05$), with fewer injuries when lateral wires were used with a percutaneous technique (RR 0.41, 95% CI 0.20 to 0.81, favours lateral wires; $I^2 = 0\%$; 10 studies, 552 children). There was little difference in nerve injuries when an open technique was used (RR 0.91, 95% CI 0.59 to 1.40, favours lateral wires; $I^2 = 0\%$; 11 studies, 656 children). We could not rule out the possibility that other factors could explain this difference in results for these subgroups.

Sensitivity analysis

1. Influence of any small-study effects by comparing the random-effects model output to a fixed-effect model calculated with the Mantel-Haenszel method. We recalculated all effect estimates for critical outcomes using the random-effects model. For nerve injury, we noted a wider confidence interval (CI) with random-effects model (RR 0.71, 95% CI 0.50 to 1.00, favours lateral wires). We noted no other important changes to the effect estimates.
2. Impact of inclusion and exclusion of studies published only as abstracts. Two studies were available only as abstracts (Mulpuri

2016; Said 2015). Exclusion of these studies made no difference to our interpretation of the effect estimates.

3. Impact of including studies with high risk of bias; in particular, those identified with allocation bias or lack of blinding for outcome assessors. We excluded two studies from relevant primary analyses owing to risk of bias concerns (Gaston 2010; Naik 2017). For nerve injury, we noted a wider CI when pooling the data without these studies (RR 0.69, 95% CI 0.48 to 1.00, favours lateral wires; 26 studies, 1492 children). However, we noted no other differences to our interpretation of the effect estimates.
4. Analysis of the result of any missing data on the review conclusions: we excluded studies that we judged to have high or unclear risk of attrition bias owing to participant loss. This did not alter our interpretation of the effect estimates.
5. Impact of studies published in journals that are not indexed in PubMed. We excluded 15 studies from the primary analysis of nerve injury (Abubeih 2019; Aher 2018; Anwar 2011; Arun 2018; Dawood 2011; Gholap 2020; Majeed 2020; Mandal 2018; Naveen 2017; Othman 2017; Palange 2019; Raj 2018; Sankar 2019; Subash 2020; Vaidya 2009). We noted that the effect estimate without these studies was imprecise and now included the possibility of benefit with crossed wires (RR 0.71, 95% CI 0.48 to 1.05; 13 studies, 817 children). For major complications, we excluded nine studies (Abubeih 2019; Aher 2018; Mandal 2018; Naveen 2017; Othman 2017; Patil 2017; Raj 2018; Sankar 2019; Vaidya 2009); this sensitivity analysis did not alter our interpretation of the effect estimate.
6. Impact of studies published in duplicate by different author teams. We excluded two studies from the primary analyses of nerve injury and major complications (Maity 2012; Naik 2017). This did not alter our interpretation of the effect estimates.

Other comparisons of different fixation techniques

We report the summary effects for those outcomes reported by study authors of other forms of surgical interventions in Table 5. This table includes data for the following comparisons:

- lateral crossed (Dorgan) wires versus retrograde crossed wires;
- lateral crossed (Dorgan) wires versus retrograde lateral wires;
- posterior intrafocal wires versus retrograde crossed wires;
- retrograde lateral wires in a parallel versus divergent configuration;
- mini-open crossed wires versus percutaneous crossed wires;
- buried versus non-buried wires.

Whilst most effect estimates were imprecise, indicating little or no difference between treatments, we noted an effect in favour of the following treatments:

- lateral crossed (Dorgan wires) versus retrograde crossed wires: children treated with Dorgan wires had fewer nerve injuries (RR 0.26, 95% CI 0.09 to 0.76, favours Dorgan wires; $I^2 = 0\%$; 5 studies, 307 children; Analysis 2.1);
- posterior intrafocal wires versus retrograde crossed wires: children treated with retrograde crossed wires were less likely to have a loss of reduction in the long term (RR 1.79, 95% CI 1.28 to 2.52, favours crossed wires; 1 study, 168 children; Analysis 4.5);
- buried versus non-buried wires: children treated with buried wires were less likely to have pin site infections (RR 0.13, 95% CI

0.02 to 0.95, favours buried wires; 1 study, 80 children; [Analysis 7.1](#)).

1b. Different forms of surgical intervention: different reduction techniques

Open versus closed reduction for displaced fractures

Five studies with a total of 222 children compared open with closed techniques for the reduction of displaced supracondylar fractures (see [Table 2](#)). [Ajmera 2013](#), [Dehghan 2012](#), [Kaewpornasawan 2001](#), and [Ray 2019](#) used direct visualisation of the fracture as part of the open reduction, whereas [Zhu 2016](#) used an open technique to position a joystick pin in the humeral shaft to facilitate reduction without exposing the fracture site. We analysed the data for this study separately to the direct visualisation techniques because it is clinically distinct from the direct visualisation technique. We did not conduct subgroup analysis for this comparison because there were insufficient studies.

Critical outcomes

1. Functional outcome

No studies reported this outcome.

2. Treatment failure requiring intervention

No studies reported this outcome.

3. Nerve injury

Four studies reported nerve injury ([Ajmera 2013](#); [Kaewpornasawan 2001](#); [Ray 2019](#); [Zhu 2016](#)). For those studies in which direct visualisation was used, we found little or no difference between reduction techniques (RR 0.30, 95% CI 0.09 to 1.01, favours open reduction; $I^2 = 0\%$; 3 studies, 163 children; low-certainty evidence; [Analysis 8.1](#)); we downgraded by one level for serious imprecision and one level for serious risks of bias.

There were no incidences of nerve injury in either group in [Zhu 2016](#).

4. Major complications

Five studies reported pin site infections ([Ajmera 2013](#); [Dehghan 2012](#); [Kaewpornasawan 2001](#); [Ray 2019](#); [Zhu 2016](#)). For those studies in which direct visualisation was used, we found fewer infections after closed reduction was used (RR 4.15, 95% CI 1.07 to 16.20; $I^2 = 0\%$; 4 studies, 253 children; low-certainty evidence; [Analysis 8.2](#)); we downgraded by one level for serious imprecision and one level for serious risks of bias.

The effect estimate was imprecise for this outcome when a joystick technique was used to support visualisation (RR 1.10, 95% CI 0.20 to 6.12, favours closed reduction; 1 study, 59 children; [Analysis 8.2](#)).

5. Cosmetic deformity

In the medium term:

- **Cubitus varus.** At three months, [Ajmera 2013](#) found little or no difference in the risk of development of cubitus varus (RR 0.19, 95% CI 0.01 to 3.89, favours open reduction; 1 study, 65 children; [Analysis 8.3](#)).
- **Loss of carrying angle of more than 10° (measured as number of events).** At three months, [Ajmera 2013](#) found little or no difference in the risk of developing a loss of carrying angle

greater than 10° (RR 0.28, 95% CI 0.06 to 1.23, favours open reduction; 1 study, 65 children; [Analysis 8.3](#)).

In the long term:

- **Cubitus varus.** [Zhu 2016](#) found no difference in cubitus varus rates between joystick and open reduction when measured at 30 to 33 months follow-up (RR 1.10, 95% CI 0.20 to 6.12, favours closed reduction; 1 study, 59 children; [Analysis 8.3](#)).
- **Loss of carrying angle (measured as degrees of loss).** [Ray 2019](#) reported an improved outcome (a reduced loss of carrying angle) at 12 months when closed reduction was used (MD -1.12°, 95% CI -2.11° to -0.13°, favours open reduction; [Analysis 8.4](#)).

Other important outcomes

Studies reported range of movement at the elbow, patient satisfaction, and radiographic deformity. We found that fewer children had a loss of range of movement in the medium term after closed reduction (RR 3.20, 95% CI 1.05 to 9.77, favours closed reduction; 2 studies, 93 children; [Analysis 8.5](#)). There was less satisfaction with scar appearance following open reduction, when evaluated by children or parent (MD -0.60, 95% CI -1.09 to -0.11; 1 study, 28 children; [Analysis 8.7](#)), and by assessors blinded to treatment allocation (MD -0.50, 95% CI -0.87 to -0.13; 1 study, 28 children; [Analysis 8.7](#)). We also noted less deformity according to Baumann's angle at 12 months when open reduction was used (MD 1.14°, 95% CI 0.21° to 2.07°, favours open reduction; 1 study, 70 children; [Analysis 8.8](#)). [Ray 2019](#) reported a shorter hospital stay after closed reduction (MD 1.30 days, 95% CI 0.99 to 1.61, favours closed reduction; 1 study, 70 children; [Analysis 8.10](#)). [Zhu 2016](#) reported a much shorter operative time for the closed reduction group when a joystick technique was used (MD 17.70 minutes, 95% CI 11.41 to 23.99, favours closed reduction; 1 study, 68 children; [Analysis 8.10](#)). Effects estimates for other outcomes were imprecise and included the possibility of benefits and harms for both treatments. See [Table 6](#). No studies reported functional outcome, pain, quality of life, return to sport and normal activities, and emotional distress of the child.

Sensitivity analysis

1. Influence of any small-study effects by comparing the random-effects model output to a fixed-effect model calculated with the Mantel-Haenszel method. We recalculated all effect estimates for critical outcomes using the random-effects model. For pin site infections, we noted that the effect estimate was imprecise when a random-effects model was used (RR 3.53, 95% CI 0.87 to 14.43; 4 studies, 253 children). We noted no other important changes to the effect estimates.

We did not conduct other planned sensitivity analyses because studies in this comparison were all published with full study reports, were not at high risk of bias, or had no notable missing data. We did not conduct post hoc sensitivity analysis. We noted that three studies in this comparison were published in journals that are not indexed in PubMed ([Ajmera 2013](#); [Dehghan 2012](#); [Ray 2019](#)); this left only one study and thus sensitivity analysis was not meaningful. No studies in this comparison had duplicate publications and this post hoc sensitivity analysis was therefore not applicable to this comparison.

2. Surgical versus non-surgical treatment

Surgical fixation versus non-surgical immobilisation for displaced fractures

Three studies with 140 children compared surgical fixation with non-surgical immobilisation for displaced fractures (see [Table 2](#)).

Critical outcomes

1. Functional outcome

No studies reported this outcome.

2. Treatment failure requiring intervention

Only [Pandey 2008](#) reported this outcome, with only one child (in the non-surgical group) experiencing treatment failure (RR 0.33, 95% CI 0.01 to 7.87, favours surgical treatment; 1 study, 60 children; [Analysis 9.1](#)). The child with treatment failure required open reduction one week after the index procedure. We downgraded the certainty of the evidence by three levels: one for serious risk of bias and two for very serious imprecision because of the small sample size and wide CI indicating possible benefits and harms for both treatments.

3. Nerve injury

Three studies reported nerve injury ([Kumar 2021](#); [Pandey 2008](#); [Shah 2017](#)). We found little or no difference between treatments in nerve injury (RR 2.50, 95% CI 0.50 to 12.46, favours non-surgical treatment; $I^2 = 0\%$; 3 studies, 140 children; very low-certainty evidence; [Analysis 9.2](#)). In [Pandey 2008](#), the nerve injury in the cast group was present pre-intervention and an ulnar nerve injury was identified in the wire group following treatment. In [Shah 2017](#), a radial nerve injury was identified pre-procedure in the wire fixation group with no nerve injuries in the group treated without wires. [Kumar 2021](#) reported that two children developed an ulnar nerve injury following percutaneous pinning with no post-manipulation injuries in the group treated in above-elbow cast. Two preoperative nerve injuries were reported (one radial and one median) but it was not specified to which group the children with these injuries were allocated. We downgraded the certainty of the evidence by three levels: one for serious risk of bias and two for very serious imprecision because of the small sample size and wide CI indicating possible benefits and harms for both treatments.

4. Major complications

Major complications were reported in three studies ([Kumar 2021](#); [Pandey 2008](#); [Shah 2017](#)). We found little or no difference between treatments in pin site infections (RR 4.00, 95% CI 0.47 to 34.11, favours non-surgical treatment; $I^2 = 0\%$; 3 studies, 126 children; very low-certainty evidence; [Analysis 9.3](#)); we noted that there were no events in [Pandey 2008](#). In [Shah 2017](#), one child from the non-surgical treatment group had a pre-intervention vascular injury which we did not include in this analysis. We downgraded the certainty of the evidence by three levels: one for serious risk of bias and two for very serious imprecision because of the small sample size and wide CI indicating possible benefits and harms for both treatments.

5. Cosmetic deformity

In all studies, long-term cosmetic deformity was measured at 6 months ([Kumar 2021](#); [Pandey 2008](#)), or 6 to 12 months ([Shah 2017](#)). No studies measured this outcome in the medium term.

- **Cubitus varus.** Two studies reported this outcome ([Kumar 2021](#); [Shah 2017](#)). The effect estimate was imprecise and we found little or no difference between treatments (RR 0.20, 95% CI 0.04 to 1.09, favours surgical fixation; $I^2 = 0\%$; 2 studies, 80 children; very low-certainty evidence; [Analysis 9.4](#)). We downgraded the certainty of the evidence by three levels: one level for serious risk of bias and two levels for imprecision because of the small sample size and the wide CI indicating possible benefits and harms for both treatments.
- **Loss of carrying angle of more than 10° (measured as number of events).** Two studies reported this outcome ([Pandey 2008](#); [Shah 2017](#)). We found that the risk of loss was less likely after surgical treatment (RR 0.29, 95% CI 0.10 to 0.81, favours surgical fixation; $I^2 = 0\%$; 2 studies, 66 children; [Analysis 9.4](#)).
- **Cubitus valgus.** Reported in only one study ([Shah 2017](#)), we found little or no difference between treatments for this outcome (RR 0.33, 95% CI 0.02 to 7.32, favours surgical fixation; 1 study, 20 children; [Analysis 9.4](#)).
- **Loss of carrying angle (degrees of loss).** Two studies reported this outcome ([Pandey 2008](#); [Shah 2017](#)). In [Pandey 2008](#), we noted that there was a better outcome when surgical fixation was used (MD -3.20°, 95% CI -6.09° to -0.31°; 1 study, 46 children; [Analysis 9.5](#)). In [Shah 2017](#), degrees of loss were reported without standard deviations (mean of 6.8° with internal fixation and a mean of 5.8° with non-surgical immobilisation).

Other important outcomes

Studies reported range of movement (number of children with loss of movement > 10°, degrees of loss of flexion and extension, and loss of total range of movement). The effect estimates were all imprecise and included the possibility of benefits and harms for both treatments ([Table 7](#)). No studies reported functional outcome, pain, quality of life, child or parent satisfaction, return to sport and normal activities, or emotional distress of the child.

Sensitivity analysis

1. Influence of any small-study effects by comparing the random-effects model output to a fixed-effect model calculated with the Mantel-Haenszel method. We recalculated all effect estimates for critical outcomes using the random-effects model which did not alter our interpretation of any effect estimates.
2. Analysis of the result of any missing data on the review outcomes. We reconsidered analysis of long-term loss of carrying angle which had been reported by [Shah 2017](#) without standard deviations (SDs). In a best case and worst case scenario, where the SDs were the same as the smallest or largest SD measured by [Pandey 2008](#), there was no difference in the loss of carrying angle (MD -1.69, 95% CI -4.00 to 0.63; and MD -2.09, 95% CI -4.57 to 0.39).

We did not conduct sensitivity analysis for other pre-defined criteria because all studies were published with full study reports and none were at high risk of allocation bias and detection bias. We note that all the studies in this comparison group were published in journals that were not indexed in PubMed, but none of these studies had duplicate publications; post hoc subgroup analysis was therefore not possible.

3. Different forms of traction

Skin traction versus olecranon skeletal traction for displaced fractures

Only one study compared the use of traction applied to the skin with elasticated bandage to overhead skeletal traction with a pin placed in the olecranon under general anaesthetic (Kuzma 2014). Skin traction was provided to 66 children and skeletal traction to 67 children (see Table 2).

Critical outcomes

1. Functional outcome

Kuzma 2014 did not report this outcome.

2. Treatment failure requiring intervention

Kuzma 2014 did not report this outcome.

3. Nerve injury

We found little difference in the number of children who experienced a nerve injury according to the type of traction (RR 1.69, 95% CI 0.42 to 6.80, favours skeletal traction; 1 study, 133 children; very low-certainty evidence; Analysis 10.1). Five children treated in skin traction and three children treated in skeletal traction experienced nerve injury. We note that all nerve injuries were present before the treatment was applied. We downgraded the certainty of the evidence by one level for serious risk of bias and two levels for very serious imprecision because the evidence was from few participants and the CI indicated possible benefits and harms for both treatments.

4. Major complications

No children treated in skin traction had major complications in the form of pin site infection, whilst four children in skeletal traction experienced pin site infection (RR 0.11, 95% CI 0.01 to 2.05, favours skin traction; 1 study, 133 children; very low-certainty evidence; Analysis 10.2). We downgraded the certainty of the evidence by one level for serious risk of bias and two levels for very serious imprecision because the evidence was from few participants and the CI indicated possible benefits and harms for both treatments.

5. Cosmetic deformity

Cosmetic deformity was assessed through the development of cubitus varus at 3 months. Cubitus varus was present in three children treated in skin traction and five children treated in skeletal traction (RR 0.61, 95% CI 0.15 to 2.45, favours skin traction; 1 study, 133 children; very low-certainty evidence; Analysis 10.3). We downgraded the certainty of the evidence by one level for serious risk of bias and two levels for very serious imprecision because the evidence was from few participants and the CI indicated possible benefits and harms for both treatments.

Other important outcomes

Kuzma 2014 reported range of movement at the elbow (loss of > 10° of flexion or > 5° of hyperextension). Loss of flexion was experienced by 33 children treated in skin traction and 42 children treated in skeletal traction (RR 0.80, 95% CI 0.59 to 1.08, favours skin traction; 1 study, 133 children; Analysis 10.4), and hyperextension was found in five children treated in skin traction and one child treated in skeletal traction (RR 5.08, 95% CI 0.61 to 42.28, favours skeletal

traction; 1 study, 133 children; Analysis 10.4). For resource use, we noted a shorter duration of traction when skin traction was used (MD -2.7 days, 95% CI -3.95 to -1.45, favours skin traction; 1 study, 133 children; Analysis 10.5).

This study did not report data for functional outcome, pain, quality of life, child or parent satisfaction, return to sport and normal activities, and emotional distress of the child.

4. Different forms of non-surgical intervention

Backslab versus sling for undisplaced fractures

The treatment of undisplaced, Gartland 1 supracondylar fractures was evaluated in one study with 50 children (Oakley 2009). See Table 2.

Critical outcomes

Oakley 2009 did not report functional outcome, treatment failure, and cosmetic deformity. No nerve injuries or major complications were experienced by children in either group; we judged the certainty of this evidence to be very low owing to serious risks of imprecision in the small sample size and risks of bias in the included study.

Other important outcomes

Oakley 2009 also reported pain (intensity of pain, duration of pain, and duration of analgesia use), parental satisfaction, and ability to return to normal activities (number of children returning to normal activities within two weeks, and the time to resume normal activities). Study authors reported data for pain and time to resume normal activities using median (interquartile range (IQR)) values, and we did not calculate effect estimates for these data because they may have been skewed. Study authors noted that children resumed normal activities sooner when a backslab was used ($P = 0.01$). However, the effects for other reported outcomes showed little or no difference between treatments. See Table 8. This study did not report functional outcome, range of movement, quality of life, radiographic deformity, or emotional distress of the child.

DISCUSSION

Summary of main results

We included 52 studies (47 RCTs and five quasi-RCTs) with 3594 children who had supracondylar elbow fractures. We also identified three ongoing studies.

We found evidence for seven different surgical fixation techniques. We also found evidence for open compared with closed reduction, surgical fixation compared with non-surgical immobilisation, different forms of traction, and different forms of non-surgical intervention. No studies compared different timings of the intervention or different locations. We report below the main findings of four of these comparisons, representing the most clinically relevant and the most substantial bodies of evidence in the review.

Retrograde lateral wires versus retrograde crossed wires (29 studies, 2068 children)

We found low-certainty evidence of less nerve injury with retrograde lateral wires. We conducted a post hoc subgroup analysis of this data, using only the studies that reported whether

an open or closed technique was used, and we noted fewer injuries when lateral wires were used with a percutaneous technique, but little difference in nerve injuries when an open technique was used. In formal tests for subgroup interactions, we noted a difference between these subgroups ($P = 0.05$), but could not rule out the possibility that other factors could explain the difference between these groups.

We also found little or no difference between the intervention in major complications, which were described as pin site infections in all studies (low-certainty evidence). For functional status, treatment failure requiring re-intervention, and cosmetic deformity, there was very low-certainty evidence showing no evidence of a difference between interventions; this evidence was derived from only one or two studies.

Open reduction versus closed reduction (4 studies, 295 children)

We found little or no difference between open and closed reduction techniques in the risk of nerve injuries (low-certainty evidence). However, there may be fewer major complications (pin site infections) when closed reduction is used. No studies reported functional outcome, treatment failure requiring re-intervention, or cosmetic deformity. The four studies in this comparison used direct visualisation during surgery. One additional study used a joystick technique for visualisation and we did not combine data from this study in analyses.

Surgical fixation using wires versus non-surgical immobilisation using a cast (3 studies, 140 children)

We found very low-certainty evidence showing little or no difference between interventions for treatment failure requiring re-intervention, nerve injury, major complications, and cosmetic deformity. No studies reported functional outcome.

Backslab versus sling (1 study, 50 children)

In this single study, no nerve injuries or major complications were experienced by children in either group; this evidence is of very low certainty. Functional outcome, treatment failure, and cosmetic deformity were not reported.

Overall completeness and applicability of evidence

The availability of evidence for each of the comparisons completed in this review varied greatly. The comparison of retrograde lateral and retrograde crossed wires included the most studies, with outcome data for nerve injury and major complications. Whilst only one study reported a functional outcome using an elbow-specific score, many studies provided a functional grading through presentation of a Flynn score (Flynn 1974). In its original version, this score is a composite of loss of total range of motion and carrying angle, and has also been modified to include loss of flexion and extension. Many of the studies used this grading system in some form, and where studies presented domains separately, it was possible to include those data in this review. For other outcomes, there was a lack of consistency in reporting, with several different parameters, particularly in the assessment of range of motion and radiographic deformity. Disappointingly, none of the included studies reported a quality of life score for children or emotional distress for children, which we identified as important outcomes in the development of the review protocol. For comparisons besides

retrograde lateral versus retrograde crossed wires, there was limited evidence from relatively few RCTs to evaluate the impact of different interventions on the outcomes for the children.

The overall study population in this review had a male predominance with a maximum mean age of 8.4 years; this is in keeping with the baseline characteristics of this injury. Undisplaced fractures were universally excluded from the studies of different surgical interventions. Some of the studies of surgical interventions included fractures that were not completely displaced, though results for this group were not presented separately in any study, preventing the subgroup analysis of this group. Equally, no studies presented results of different age groups separately, which may have an impact on outcomes related to remodelling and rehabilitation.

The majority of the interventions identified in this review are relevant to international practice.

None of the studies presented data for all the critical outcomes in the review. This suggests that the follow-up periods of the trials may be insufficient for children to become sufficiently symptomatic following a supracondylar malunion to require further corrective surgery. Major complications were typically reported as pin site infections only, with variable reporting of compartment syndrome and vascular injury. For nerve injuries, we could not easily account for the number of injuries that were evident prior to the intervention. However, because the studies were all randomised, we could infer that size of the difference between interventions groups was associated with the intervention rather than pre-intervention injuries.

Quality of the evidence

For all comparisons and outcomes, we judged that the certainty of the available evidence was very low or low. We downgraded all outcomes at least one level for risk of bias, which was usually for unclear reporting of randomisation technique or allocation concealment. We downgraded many outcomes for imprecision as a consequence of small sample sizes, low event rates, and accompanying wide confidence intervals. For nerve injury, we also could not rule out the possibility of publication bias evident in our visual inspection of a funnel plot. This outcome also included a large number of studies published in journals that were not indexed in PubMed, which appeared to influence the data more strongly in favour of retrograde lateral wires.

We did not need to downgrade any outcomes for inconsistency, as heterogeneity was low for the majority of outcomes, and the included studies provided direct evidence.

Potential biases in the review process

This review has been conducted in line with the previously published protocol (Marson 2020b). The searches have been performed using a robust search strategy, and we are confident that all relevant trials in the conventional medical literature have been included.

Searches of bibliographic databases and trials registries led to the identification of several trials not identified in the initial search that had been published in the grey literature in journals that were not indexed. We used sensitivity analysis to explore whether these studies influenced the data, and we could not rule out the

possibility that these studies influenced the effect estimate for nerve injury. We also conducted a post hoc sensitivity analysis to investigate concerns related to a small number of studies that were published by different author teams; these studies did not appear to influence the finding of the critical outcomes in the review.

Many of the additional trials identified from non-indexed journals had unclear reporting of the randomisation technique and allocation concealment, although all studies indicated that a random factor was used to allocate children to groups. Although we attempted to contact study authors, we received few responses. We could not rule out the possibility that some of these studies may be quasi-randomised in design, and we have been mindful of this when drawing our conclusions.

From discussion with our clinical authors, we agreed to conduct a subgroup analysis of nerve injury data of retrograde lateral wires versus retrograde crossed wires according to whether an open or closed technique was used. We note that this was a post hoc decision, and because technique was not reported in all studies, the subgroup analysis included fewer studies than the primary analysis. Whilst we believed it was clinically important to report the findings from this subgroup analysis, we cannot be certain whether the result of the formal tests for subgroup interaction is truly indicative of a difference in technique, as other factors may be also be responsible for this result. In order to advise caution with this finding, we have stated this uncertainty throughout the relevant sections of the review.

Agreements and disagreements with other studies or reviews

We provide a detailed review of the 21 systematic reviews identified as part of searching, in [Appendix 2](#). Whilst our findings are broadly consistent with previous reviews, we have been cautious in our interpretation of our findings, given the limitations present in the literature. Whilst we would intuitively agree with the American Academy of Orthopaedic Surgeons' (AAOS) guidelines that surgical management is not indicated for undisplaced fractures ([American Academy of Orthopaedic Surgeons 2011](#)), there is a lack of direct RCT evidence to support this, and the two RCTs that compare different non-surgical treatments have limited medium- and long-term follow-up ([Oakley 2009](#); [Silva 2018](#)). The quality of evidence to confirm or refute the findings of the [Kurer 1990](#) and [Yeomans 2018](#) reviews is very low, with one RCT comparing different forms of cast following reduction of displaced fractures, one RCT comparing different forms of traction, and two RCTs comparing surgical and non-surgical fixation. We are concerned about the high redisplacement rate described in [Pandey 2008](#), following application of a plaster cast in flexion with high rates of cosmetic deformity, similar to the rates identified in the [Kurer 1990](#) review.

AUTHORS' CONCLUSIONS

Implications for practice

For children with supracondylar elbow fractures, retrograde lateral wires may result in fewer nerve injuries than retrograde crossed wires.

Currently, there is insufficient evidence to determine the effectiveness of other treatments, and all findings in the review had low- to very low-certainty evidence.

Implications for research

There are several key directions for future research uncovered by this review. There was considerable heterogeneity of outcomes presented by different trials, which has limited our ability to combine all identified trials into the meta-analyses. There is an urgent need to agree and harmonise outcomes, and the tools to measure them, to ensure all trials measure and report key results that can then be pooled. This can be achieved with the adoption of a core outcome set to encourage harmonisation of outcome reporting ([Marson 2020c](#)). Additional preparatory work in the anticipation of future trials would be to undertake validation of functional, emotional, and quality of life scores for children with supracondylar fractures to ensure validity, reliability, and interpretability of patient-reported scores. We need to establish the maximum acceptable loss of reduction, range of motion, and cosmetic deformity that have clinical implications for children and their parents, being mindful that there may be variations based on cultural and social differences in populations.

Whilst we have been unable to answer if displaced fractures should be treated with reduction and casting or by other techniques (e.g. traction or surgical fixation), we would suggest that this is not a key research priority, given the American Academy of Orthopaedic Surgeons (AAOS) and British Orthopaedic Association/British Society for Children's Orthopaedic Surgery (BOA/BSCOS) guideline and the high treatment failure rates when casting has been used. A comparison of traction and surgical fixation would be of greater benefit, particularly for application in resource-poor environments around the world or for settings where access to anaesthesia is limited. Any further comparison of retrograde crossed and retrograde lateral wires should be high quality and capture outcomes using validated patient-reported scores with adequate follow-up. As the key uncertainty is if the increased loss of reduction has any clinical significance, such a trial would need to be large in scale.

Throughout this review, we have acknowledged that blinding of participants and outcome assessors is challenging, particularly as treatments can be viewed as they are applied or removed. We have assessed studies as low risk of bias for blinding when there is some evidence of separation between the core study team and those undertaking the majority of the interventions or performing the assessments. Children and their parents are in an ideal position to provide insight into their experience and function following an intervention, and this is unlikely to be clouded by preconceived ideas of superiority of one intervention over another. There is scope for improvements in study reporting, with prospective trial registration and publication of trial protocols to improve study transparency and confidence surrounding the quality of evidence.

Other key uncertainties that remain unanswered following this review are the following.

- Should children with undisplaced supracondylar fractures be immobilised in a plaster cast or sling?
- Should children with displaced fractures undergo reduction in the hospital emergency department prior to theatre?
- Should children with displaced fractures have emergency surgery (planned within 12 hours, including overnight) or urgent surgery (surgery within 24 hours, but not overnight)?

- What duration of immobilisation should children be prescribed following an undisplaced fracture or surgical fixation for a displaced fracture?

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Editorial and peer-reviewer contributions

Cochrane BJMT supported the authors in the development of this review. Sharon Lewis is a members of the Cochrane BJMT editorial

base, but was not involved in the editorial process or decision making for this review.

The following people conducted the editorial process for this article:

- Sign-off Editor (final editorial decision): Xavier Griffin, Coordinating Editor, Cochrane BJMT;
- Managing Editor (selected peer reviewers, collated peer-reviewer comments, provided editorial guidance to authors, edited the article): Joanne Elliott, Managing Editor, Cochrane Bone, Joint and Muscle Trauma Group;
- Methodological Editor (advised on methodology and review content): Toby Lasserson, Deputy Editor in Chief, Cochrane;
- Copy Editor (copy-editing and production): Faith Armitage, Copy Edit Support Team;
- Peer-reviewers (provided comments and recommended an editorial decision): Gregory Firth, Consultant Orthopaedic Surgeon, Barts Health NHS Trust.

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Yousri T, Tarassoli P, Whitehouse M, Monsell F, Khan WS. Systematic review of randomized controlled trials comparing efficacy of crossed versus lateral K-wire fixation in extension type Gartland type III supracondylar fractures of the humerus in children. *Ortopedia, Traumatologia, Rehabilitacja* 2012;**14**(5):397-405.

References to other published versions of this review

Marson 2020b

Marson BA, Craxford S, Price KR, Ollivere BJ. Interventions for treating supracondylar elbow fractures in children. *Cochrane Database of Systematic Reviews* 2020, Issue 5. Art. No: CD013609. [DOI: [10.1002/14651858.CD013609](https://doi.org/10.1002/14651858.CD013609)]

* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Abdel Karim 2016

Study characteristics

Methods	Design: randomised trial Study duration: December 2011 to February 2013 Power calculation: no prospective calculation of sample size
Participants	Setting: Department of Orthopaedics and Traumatology, Cairo University Hospitals, Egypt Sample size: 60 children Inclusion criteria: children aged 0 to 10 with Gartland 2-3 supracondylar fracture Exclusion criteria: open fractures, fractures with vascular injury, fractures with compartment syndrome, fractures with preoperative ulnar nerve injury, bilateral fractures
Interventions	Group 1 (30 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side

Abdel Karim 2016 (Continued)

Group 2 (30 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side using an open technique (1.5 cm to 3.0cm incision) for the medial wire

Outcomes	1) Nerve injury 2) Major complications (pin site infections) 3) Range of movement (loss of movement > 10° at 3 months) 4) Radiographic deformity (loss of reduction as defined by translation, angulation, or rotation at the fracture site at 3 months)
Notes	Loss to follow-up: none reported Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "The patients were randomized to be managed with either crossed pins or lateral pins configuration through the use of opaque sealed envelopes"
Allocation concealment (selection bias)	Unclear risk	Quote: "The patients were randomized to be managed with either crossed pins or lateral pins configuration through the use of opaque sealed envelopes" Comment: unclear if the sealed envelopes were sequentially numbered
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "All surgeries were performed by junior trainees in their first 3 years of training. The main surgeon was either a second- or third-year resident (in a 3-year residency program), and the assistant was a first-, second-, or third-year resident. They were supervised by an attending surgeon, who was present in the operative premises and who reviewed the intraoperative images on the image intensifier before the procedure was completed"... "Follow-up assessment of each patient was performed by the same team throughout the trial (a third-year resident together with an attending). Both the surgeons and the patients were not blinded of the treatment received throughout the trial". Comment: the non-blinded surgical team completed the study, surgery and outcome assessment.
Blinding of outcome assessment (detection bias)	High risk	Quote: "All surgeries were performed by junior trainees in their first 3 years of training. The main surgeon was either a second- or third-year resident (in a 3-year residency program), and the assistant was a first-, second-, or third-year resident. They were supervised by an attending surgeon, who was present in the operative premises and who reviewed the intraoperative images on the image intensifier before the procedure was completed"... "Follow-up assessment of each patient was performed by the same team throughout the trial (a third-year resident together with an attending). Both the surgeons and the patients were not blinded of the treatment received throughout the trial". Comment: the non-blinded surgical team completed the study, surgery and outcome assessment.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "All patients returned for both clinical and radiographic evaluations at 1 week, 3–4 weeks, 6 weeks and 3 months."

Abdel Karim 2016 (Continued)

Selective reporting (reporting bias)	Unclear risk	Comment: no prospective registration or trial protocol. Some participants had longer follow-up based on the development of complications. The reporting of these participants is not explicit.
Other bias	Low risk	None identified

Abubeih 2019
Study characteristics

Methods	Design: randomised trial Study duration: June 2013 to October 2015 Power calculation: no prospective calculation of sample size
Participants	Setting: Department of Orthopaedics, Assiut University, Assiut, Egypt Sample size: sample selected as the 91 children who met inclusion criteria in study period. Inclusion criteria: children aged 3 to 9 with extension type Gartland 3 supracondylar fracture Exclusion criteria: associated injury in the same limb, previous fracture in the same limb, open fracture, fracture requiring open reduction, and associated neurovascular injury requiring surgical exploration
Interventions	Group 1 (46 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (45 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side using an open technique (1.5 cm to 3.0cm incision) for the medial wire
Outcomes	1) Nerve injury 2) Major complications (pin site infection) 3) Cosmetic deformity (cubitus varus at 12 weeks) 4) Range of movement (loss of flexion at 12 weeks) 5) Radiographic deformity (loss of reduction as loss of Baumann's angle > 6° at 12 weeks)
Notes	Loss to follow-up: Group 1 12/46 (26.1%), Group 2 12/45 (26.7%) Funding source: none Declarations: none Additional information about the study received by e-mail from Dr Hossam M.A. Abubeih: "As regard Your questions about my published paper on Paediatric SCFH 1. <i>Do you have the cosmetic factors and functional factors that contribute to your two group's Flynn classification?</i> Yes, Cosmetic loss of carrying angle is an essential part of the Flynn Criteria (table 1) 2. <i>Were sequentially numbered envelopes used to in your study?</i> Yes, in our study randomization done by concealed envelope technique using Sequentially numbered, opaque, sealed envelopes.

Abubeih 2019 (Continued)

3. Were your outcome assessors blinded to treatment allocation?

No the assessors were two of the authors participating in the study as we said in the article Two authors examined all patients”

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: “The patients were randomized into two groups by the concealed envelope technique”
Allocation concealment (selection bias)	Low risk	Quote: "in our study randomization done by concealed envelope technique using Sequentially numbered, opaque, sealed envelopes"
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "Prof Wael El-Adly and Dr Hatem Bakr performed the surgical procedures." Comment: surgical procedures were performed by study authors without blinding
Blinding of outcome assessment (detection bias)	High risk	Quote: "Measurements of angles and analysis of results were done by two authors: Dr Hossam M.A. Abubeih and Prof Kamal El-Gaafary."... "the assessors were two of the authors participating in the study as we said in the article Two authors examined all patients” Comment: outcome assessment performed by two study authors. Correspondence confirmed no blinding used
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: 12 participants in each group lost to follow-up (26%). Loss to follow-up appears balanced
Selective reporting (reporting bias)	Unclear risk	Comment: no prospective registration or trial protocol
Other bias	Low risk	None identified

Afaq 2020

Study characteristics

Methods	Design: randomised trial Study duration: March 2014 to May 2015 Power calculation: no prospective calculation of sample size
Participants	Setting: Department of Orthopaedics, B.P. Koirala Institute of Health Sciences, Dharan, Nepal Sample size: 84 children Inclusion criteria: children aged 0 to 12 with Gartland 2, 3 or 4 supracondylar fracture Exclusion criteria: open fracture (Gustilo Grade II and III), neurovascular deficit and delayed presentation greater than 7 days

Afaque 2020 (Continued)

Interventions	Group 1 (41 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (43 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side using a percutaneous technique
Outcomes	1) Postoperative nerve injury 2) Major complications (pin site infections, compartment syndrome, and vascular injury) 3) Cosmetic deformity (carrying angle at 3 months) 4) Range of motion at 3 months 5) Radiographic (Baumann's angle at 3 months)
Notes	Loss to follow-up: Group 1 5/41 (9.8%) including 2 children who had open reduction, Group 2 2/43 (7.0%) including 2 who had open reduction Funding source: none Declarations: none

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Randomization was done using excel random generation technique" Comment: random element to treatment allocation
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient detail on allocation concealment to assess
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: insufficient evidence to assess blinding of personnel
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: insufficient description provided of outcome assessor to evaluate outcome blinding
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: 8% missing data – including one extra child excluded following an open reduction in group II. Appears low and balanced between groups
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration identified. Clinical review at several time points that were not reported and limited post-operative radiographic parameters. Baumann's angle measured twice but directly reported once
Other bias	Low risk	None identified

Aher 2018

Study characteristics

Methods	Design: randomised trial
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Interventions for treating supracondylar elbow fractures in children (Review)

Aher 2018 (Continued)

Study duration: January 2015 to June 2017

Power calculation: no prospective calculation of sample size.

Participants	Setting: Department of Orthopedics, Gandhi Medical College, Bhopal Madhya Pradesh, India Sample size: 60 children Inclusion criteria: children aged 2 to 12 with Gartland 3 supracondylar fracture Exclusion criteria: open fractures, floating elbow injuries, previous fractures in the same elbow, delayed presentation > 7 days
Interventions	Group 1 (30 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (30 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A percutaneous technique was used for the medial wire.
Outcomes	1) Nerve injury 2) Major complications (pin site infection) 3) Cosmetic deformity (loss of carrying angle at 4 to 12 months) 4) Range of movement (loss of total range of movement at 4 to 12 months) 5) Radiographic deformity (loss of reduction of Baumann's angle > 5° at 4 to 12 months)
Notes	Loss to follow-up: not formally specified but intended follow-up was 12 months. Average follow-up was reported as 6 months and minimum follow-up as 4 months Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "This was a prospective, randomized study"... "Patients were allocated to one of the groups (Crossed pins Vs Two Lateral Pins) with the help of computer-generated random table"
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient detail on allocation concealment to assess
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Quote: "the patient was followed up at 1-month, 2month, 4 month, 6 months and final followup at 12 months"... "The average follow-up duration for patients was of 6 months".

Aher 2018 (Continued)

Comment: there is a discrepancy between the planned follow-up and actual mean follow-up, suggesting that some participants did not complete the 12-month follow-up. No further information is specified.

Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Ahmad 2020

Study characteristics

Methods	Design: randomised study Study duration: February 2017 to February 2018 Power calculation: no prospective calculation of sample size
Participants	Setting: Nishter Hospital, Multan, Pakistan Inclusion criteria: aged 1 to 12 with displaced supracondylar fracture (however this was stated in text to be Gartland 1 or 2) Exclusion criteria: delayed presentation > 3 days, previous supracondylar fracture
Interventions	Group 1: (35 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2: (35 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side In both groups, children were admitted to the ward and immobilised in skin traction with the elbow in full extension. Following surgery, children were immobilised in an above-elbow plaster cast for three weeks.
Outcomes	1) Cosmetic deformity measured as carrying angle loss – reference and time point not specified 2) Range of motion as measured as loss of extension and loss of flexion – reference and time point not specified 3) Radiographic deformity measured as loss of Baumann's angle and loss of medial epicondylar epiphyseal angle - reference and time point not specified
Notes	We were unable to include outcome data in the review. Confirmation required of the time points for observations reported in the manuscript. We therefore did not conduct risk of bias assessment for this study. Funding source: not stated Declarations: not stated

Ajmera 2013

Study characteristics

Methods	Design: randomised trial
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Interventions for treating supracondylar elbow fractures in children (Review)

Ajmera 2013 (Continued)

Study duration: June 2010 to December 2012

Power calculation: no prospective calculation of sample size

Participants	Setting: Department of Orthopaedics, M.Y. Hospital & M.G.M. Medical College, India Sample size: 87 children Inclusion criteria: children aged 3 to 12 with Gartland 3 supracondylar fracture Exclusion criteria: delayed presentation > 7 days, nerve injuries, previous injury or surgery to the elbow and open fractures
Interventions	Group 1 (unclear how many children allocated to this group): closed manipulation of fracture in theatre with fixation using crossed wires inserted from medial and lateral side. A percutaneous technique was used for the medial wire. Group 2 (unclear how many children allocated to this group): posterior approach open reduction of fracture in theatre with fixation using crossed wires inserted from the medial and lateral side
Outcomes	1) Nerve injury 2) Major complications (pin site infection and vascular injuries) 3) Cosmetic deformity (loss of carrying angle and cubitus varus at 3 months) 4) Range of movement (loss of total range of motion at 3 months)
Notes	Loss to follow-up: not specified but final group size for group 1 of 32 and group 2 of 33 (22 lost to follow-up) Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "The patients were randomly assigned to the following two groups" ... "patients were randomly divided" Comment: unclear how randomisation was performed
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient detail on allocation concealment to assess
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Quote: "Total 87 cases were included in the study out of which 22 were lost during follow up." Comment: no indication of the original allocation of participants so unclear if imbalance in rates of loss to follow-up

Ajmera 2013 (Continued)

Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Altay 2011

Study characteristics

Methods	Design: randomised trial Study duration: not stated Power calculation: no prospective calculation of sample size
Participants	Setting: Department of Orthopaedic Surgery, Faculty of Medicine, Harran University, Turkey Sample size: 29 children Inclusion criteria: children (age not specified in inclusion criteria) with Gartland 3 supracondylar fractures Exclusion criteria: associated injuries, nerve lesions, infection, non/malunion, open fractures, bilateral injuries
Interventions	Group 1 (14 children): manipulation of fracture in theatre with fixation using one retrograde wire and one antegrade wire inserted from the lateral side (Dorgan wires) Group 2 (15 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A percutaneous technique was used for the medial wire.
Outcomes	1) Nerve injury 2) Major complications (pin site infections and compartment syndrome)
Notes	Loss to follow-up: none reported Cosmesis and range of movement recorded but not presented in sufficient detail to extract Funding source: none Declarations: none

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Comment: method not stated
Allocation concealment (selection bias)	Unclear risk	Quote: "Randomization was achieved in a double-blinded fashion using an envelope containing group assignments." Comment: unclear if the envelopes were opaque, sealed, or ordered sequentially
Blinding of participants and personnel (performance bias)	Unclear risk	Quote: "Randomization was achieved in a double-blinded fashion using an envelope containing group assignments."

Interventions for treating supracondylar elbow fractures in children (Review)

Altay 2011 (Continued)

All outcomes		Comment: no further details regarding blinding of participants or personnel
Blinding of outcome assessment (detection bias)	Unclear risk	Quote: "Randomization was achieved in a double-blinded fashion using an envelope containing group assignments" Comment: it is unclear who performed the outcome assessment for clinical nerve dysfunction, cosmesis, and range of motion, and if they were blinded to the treatment provided.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified. Cosmetic deformity and range of movements not reported in published abstract or full text
Other bias	Low risk	None identified

Anwar 2011

Study characteristics

Methods	Design: randomised trial Study duration: January 2008 to July 2009 Power calculation: no prospective calculation of sample size.
Participants	Setting: Department of Orthopedics, Hayatabad Medical Complex, Peshawar, Pakistan Sample size: 50 children Inclusion criteria: children aged 1 to 12 with a displaced (Gartland 2-3) supracondylar elbow fracture Exclusion criteria: neurovascular complications, open injuries, and patients for whom closed reduction was not possible
Interventions	Group 1: (25 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2: (25 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side
Outcomes	1) Nerve injury 2) Cosmetic deformity (change in carrying angle at 6 months and modified Flynn criteria for carrying angle) 3) Range of motion (reduction of flexion and extension at 6 months and modified Flynn criteria for flexion and extension) 4) Radiographic (Baumann's angle and diaphyseal-metaphyseal angle at 3 months)
Notes	Loss to follow-up: none reported Funding source: none Declarations: none

Anwar 2011 (Continued)

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "The patients were randomly allocated in two groups by lottery method"
Allocation concealment (selection bias)	Unclear risk	Comment: no detail on lottery technique and if it would be possible for study staff to predict next allocation
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Arun 2018

Study characteristics

Methods	Design: Randomised study Study duration: August 2016 to July 2018 Power calculation: no prospective calculation of sample size.
Participants	Setting: Department of Orthopaedics, Navodaya Medical College Hospital and Research Centre, Raichur, Karnataka, India Sample size: 68 children Inclusion criteria: children aged 4 to 12 with extension type Gartland 3 supracondylar fracture Exclusion criteria: open fracture, neurovascular injury, delayed presentation > 4 days, associated ipsilateral limb fracture and previous ipsilateral elbow injury
Interventions	Group 1 (38 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (30 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A percutaneous technique was used for the medial wire.
Outcomes	1) Nerve injury 2) Major complications 3) Cosmetic deformity at 6 months*

Arun 2018 (Continued)

- 4) Range of motion at 6 months*
- 5) Radiographic deformity at 6 months*

Notes

* Outcomes 3 & 4 were combined as a single outcome in the Flynn classification. Outcome 5 was not reported in the manuscript.

Loss to follow-up: none reported

Funding source: not stated

Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: [Abstract, methods and results] "A prospective, single blinded, randomized control trial"..."Patients were selected for Lateral entry or Medial-Lateral entry using a Randomization table."..."38 were treated with lateral pinning and 30 were treated with cross pinning technique based on randomization". [Discussion] "The limitations of this study is the lack of randomization regarding the selection of pinning technique as this was decided by the operating surgeon at the time of surgery" Comment: there is inconsistency regarding the description of the allocation in this study.
Allocation concealment (selection bias)	Unclear risk	Comment: it is unclear if the randomisation table was concealed to study staff.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified. Radiographic outcomes identified in methods but not reported
Other bias	Low risk	None identified

Das 2019

Study characteristics

Methods

Design: described as randomised study. However, we note uneven distribution of participants to each group and expect that this is a quasi-randomised trial.

Study duration: December 2017 to June 2018

Das 2019 (Continued)

	Power calculation: no prospective calculation of sample size
Participants	Setting: NRS Medical College and Hospital, Kolkata, India Inclusion criteria: children (age not specified in inclusion criteria) with Gartland 3-4 supracondylar fracture Exclusion criteria: delayed presentation > 5 days, previous supracondylar fracture neurovascular injury
Interventions	Group 1: (28 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2: (14 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side Group 3: (8 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side The preoperative treatment was not specified in the report. Following surgery, children were immobilised in a posterior plaster cast for 3 to 4 weeks.
Outcomes	1) Major complications measured as pin site infections – the groups where the infections occurred was not specified. 2) Nerve injury – the groups in which the nerve injuries occurred was not specified. 3) Range of motion as measured as range of motion of 10° to 110° - the groups in which the elbow stiffness occurred was not specified.
Notes	We were unable to include outcome data in the review because data were reported overall, rather than by group. Funding source: not stated Declarations: not stated

Dawood 2011

Study characteristics

Methods	Design: randomised trial Study duration: February 2010 to January 2011 Power calculation: no prospective calculation of sample size
Participants	Setting: Department of Surgery, College of Medicine, Tikrit University, Tikrit, Iraq Sample size: 21 children Inclusion criteria: children aged 4 to 10 with Gartland type 3 supracondylar fractures Exclusion criteria: previous fracture in either elbow, delayed presentation > 2 days
Interventions	Group 1 (10 children): posterior approach open reduction of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (11 children): posterior approach open reduction of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side

Dawood 2011 (Continued)

Outcomes	1) Nerve injury 2) Cosmetic deformity (carrying angle and carrying angle loss > 10 degrees at 4 months) 3) Range of motion (flexion and extension loss at 4 months) 4) Radiographic deformity (Baumann's angle loss at 4 months)
Notes	Loss to follow-up: no loss to follow-up reported Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "Two groups of patients were selected randomly" Comment: unclear how randomisation was performed
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient detail on allocation concealment to assess
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Dehghan 2012

Study characteristics

Methods	Design: randomised trial Study duration: 2010 Power calculation: no prospective calculation of sample size
Participants	Setting: Ayatollah Kashani hospital, Iran Sample size: 90 children Inclusion criteria: children aged 2 to 10 with Gartland 3 supracondylar fractures

Dehghan 2012 (Continued)

Exclusion criteria: delayed presentation more than 5 days, previous arm fracture, head injury, underlying disease, unavailability to attend follow-up, referral to other centres due to complications

Interventions	Group 1 (45 children): closed manipulation of fracture in theatre with fixation using wires Group 2 (45 children): posterior approach open reduction of fracture in theatre with fixation using wires
Outcomes	1) Major complications (pin site infection)
Notes	Loss to follow-up: no loss to follow-up reported Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "through Random Number Table allocated in two groups"
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient detail on allocation concealment to assess
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified. The trial was registered after recruitment was complete.
Other bias	Low risk	None identified

Ducic 2016a

Study characteristics

Methods	Design: randomised trial Study duration: February 2010 to April 2014 Power calculation: no prospective calculation of sample size
Participants	Setting: University Children's Hospital, Belgrade, Serbia Sample size: 138 children

Ducic 2016a (Continued)

Inclusion criteria: children (age not specified in inclusion criteria) with extension type (Gartland 2 or 3) supracondylar fractures

Exclusion criteria: open fractures, serious neurovascular complications and children with fractures requiring an open reduction

Interventions	Group 1 (67 children): manipulation of fracture in theatre with fixation using one retrograde wire and one antegrade wire inserted from the lateral side (Dorgan wires) Group 2 (71 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. The medial wire technique was not specified.
Outcomes	1) Nerve injury 2) Major complications (pin site infections) 3) Cosmesis (change in carrying angle at 9 to 14 months) 4) Range of movement (loss of total range of movement at 9 to 14 months)
Notes	Loss to follow-up: none reported Funding source: not stated Declarations: none

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "They were randomized by random number generator using R software environment where odd numbers were assigned to Dorgan's method of fixation"
Allocation concealment (selection bias)	Low risk	Comment: no allocation sequence to conceal therefore study staff unable to predict next allocation
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	High risk	Quote: "A prospective randomised non-blinded comparison of conventional and Dorgan's crossed pins" Comment: no blinding of outcome assessors
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Ercin 2016

Study characteristics

Methods	Design: quasi-randomised study based on day-of-week allocation Study duration: 2011 to 2013 Power calculation: power calculation: no prospective calculation of sample size. Sample of 104 children selected but not justified.
Participants	Setting: Department of Orthopaedics and Traumatology, Dr. Sadi Konuk Training and Research Hospital, Istanbul, Turkey Sample size: 104 children Inclusion criteria: children (age unspecified in inclusion criteria) with Gartland 3 supracondylar fractures fixed with 2 lateral and one medial K-wire Exclusion criteria: flexion-type fractures, neurovascular injuries, open fractures, previous ipsilateral elbow fractures, children who did not attend final follow-up or fixation with two rather than three wires
Interventions	Group 1 (63 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side using a percutaneous technique Group 2 (41 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side using a mini-open technique for the medial wire
Outcomes	1) Nerve injury 2) Major complications (pin site infections) 3) Radiographic deformity*
Notes	Loss to follow-up: no reported loss to follow-up *Mean follow-up of 8.93 months (range 3.13 to 14.73 months), with discharge when full elbow range of motion achieved. Radiographic deformity not described in sufficient detail in paper for further analysis Funding source: not stated Declarations: none

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Quote: "Children were randomized based on which orthopedic surgeon was on trauma call"
Allocation concealment (selection bias)	High risk	Comment: as treatment allocated by surgeon on take, it would be obvious what treatment the presenting child would have
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcome assessment and their relationship to the study team.
Incomplete outcome data (attrition bias)	High risk	Comment: 17 participants lost from allocation to analysis (15 fixed with 2 wires)

Interventions for treating supracondylar elbow fractures in children (Review)

Ercin 2016 (Continued)

All outcomes

Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Foead 2004
Study characteristics

Methods	Design: randomised trial Study duration: May 2000 to December 2001 Power calculation: no prospective calculation of sample size
Participants	Setting: Department of Orthopaedic Surgery, University Malaya Medical Center, Kuala Lumpur, Malaysia Sample size: 66 children Inclusion criteria: children aged 1 to 12 with displaced supracondylar fractures (Gartland 2 or 3) Exclusion criteria: late presentation (> 3 days since injury), previous elbow fracture, simultaneous fracture in the same arm
Interventions	Group 1 (32 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (34 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side
Outcomes	1) Nerve injury 2) Major complications (pin site infections, compartment syndrome, vascular deficit requiring exploration) 3) Cosmetic outcome (loss of carrying angle at 3 to 15 months) 4) Range of movement (loss of flexion and extension at 3 to 15 months) 5) Radiographic deformity (loss of Baumann's angle and medial epicondylar epiphyseal angle at 3 to 15 months)
Notes	Loss to follow-up: Group 1 5/32 (15.6%) and Group 2 6/34 (17.6%) Mean follow-up: 8.9 months Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
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Foead 2004 (Continued)

Random sequence generation (selection bias)	Low risk	Quote: "The main investigator would perform the randomisation by drawing lots—odd numbers signify medial-lateral pin fixation, while even numbers would be treated by 2 lateral pin fixation".
Allocation concealment (selection bias)	Unclear risk	Comment: unclear if there was a fixed number of lots that could be drawn that would allow study staff to predict likelihood of next treatment allocation
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "Surgery was performed by senior orthopaedic trainees supervised by one of the authors". Comment: no apparent blinding or separation of persons performing the intervention
Blinding of outcome assessment (detection bias)	Unclear risk	Quote: "All the patients were followed up at the paediatric orthopaedic out-patient clinic and reviewed by one of the authors". Comment: unclear if any blinding was used
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "11 of the 66 patients defaulted follow-up after the plaster casts were removed". Comment: participants followed up until full range of movement achieved, then outcomes assumed to have been maintained. Loss to follow-up balanced between the groups
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Gaston 2010

Study characteristics

Methods	Design: quasi-randomised study Study duration: March 2005 to July 2006 Power calculation: no prospective calculation of sample size
Participants	Setting: OrthoCarolina, Charlotte, North Carolina, USA Sample size: 104 children Inclusion criteria: children (skeletally immature) with Gartland 3 extension type supracondylar fractures Exclusion criteria: delayed presentation (> 24 hours), open fractures, inadequate perioperative radiographs, inadequate follow-up
Interventions	Group 1 (47 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (57 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side using a percutaneous technique
Outcomes	1) Nerve injury

Gaston 2010 (Continued)

2) Major complications (compartment syndrome)

Notes

Loss of reduction also reported at time of pin removal so not included in meta-analysis

Loss to follow-up: 16 participants excluded following treatment allocation for inadequate radiographs or incomplete follow-up. No information available regarding which groups these children were in.

Funding source: not stated

Declarations: nil

Additional information received from Glenn Gaston:

1. Were the surgeons who assessed postoperative nerve injury blinded to the treatment provided? - No
2. Was the panel who performed the radiographic measurements blinded to treatment allocation? - No
3. Were there any pin site infections or vascular injuries in either group? - I don't recall
4. Do you know which groups the 16 patients who did not attend follow up belonged to? unsure, sorry

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Quote: "Patients were then randomized in a blocked-randomization manner based on day of presentation to the emergency room and the on-call physician that day"
Allocation concealment (selection bias)	High risk	Comment: day of the week allocation means that children could be deferred to another day and therefore another surgeon
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Comment: surgeons performed their default preferred technique independent of the study
Blinding of outcome assessment (detection bias)	High risk	Quote [full report]: "All measurements were made by a panel consisting of an attending pediatric orthopaedist, a chief orthopaedic resident, and a junior orthopaedic resident" Quote [unpublished]: "Were the surgeons who assessed post-operative nerve injury blinded to the treatment provided? - No"... "Was the panel who performed the radiographic measurements blinded to treatment allocation? - No"
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Comment: 16 participants were excluded from the study as they did not complete follow-up. It is not specified to which group these participants were allocated.
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Gholap 2020
Study characteristics

Methods

Design: randomised trial

Study duration: 2-year period

Interventions for treating supracondylar elbow fractures in children (Review)

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Gholap 2020 (Continued)

Power calculation: no prospective calculation of sample size.

Participants	Setting: Department of Orthopedics. Dr. D.Y. Patil Medical College, Hospital and Research Center, Pimpri, Maharashtra, India Sample size: 30 children Inclusion criteria: children aged 3 to 18 with Gartland 3 supracondylar fracture Exclusion criteria: neurovascular injury, open fractures
Interventions	Group 1 (15 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (15 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side using a mini-open technique
Outcomes	1) Nerve injury 2) Major complications 3) Cosmetic deformity (loss of carrying angle at 6 months) 4) Range of movement (loss of total range of movement at 6 months)
Notes	Loss to follow-up: no reported loss to follow-up Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "The study was a single center, prospective, randomized controlled clinical trial" Comment: technique for delivering random sequence was not described
Allocation concealment (selection bias)	Unclear risk	Comment: unclear if any concealment was performed of the allocation sequence
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear who provided the treatments and if they were involved as part of the study
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: unclear who assessed the outcomes and if they were blinded to treatment allocation
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified. Mayo elbow score mentioned in abstract but not in body of report. Insufficient information to combine complication outcomes in analysis
Other bias	Low risk	None identified

Gopinathan 2018

Study characteristics

Methods	Design: randomised trial Study duration: April 2014 to September 2015 Power calculation: no prospective calculation of sample size
Participants	Setting: Department of Orthopaedics, AIIMS, Bhopal, Madhya Pradesh, India Sample size: 30 children Inclusion criteria: children aged 2 to 12 with Gartland 3 supracondylar fractures Exclusion criteria: delayed presentation > 7 days, vascular injuries, open fractures, transphyseal injuries, skin blisters, established compartment syndrome, children requiring open reduction
Interventions	Group 1 (19 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side in a parallel configuration Group 2 (11 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side using a divergent configuration
Outcomes	1) Nerve injury (iatrogenic) 2) Cosmetic deformity (change in carrying angle at 3 months) 3) Range of movement (loss of flexion or extension at 3 months) 4) Radiographic deformity (loss of reduction and change in Baumann's angle at 3 months)
Notes	Loss to follow-up: no reported loss to follow-up Funding source: none Declarations: none Additional information from Prateek Behera by email: "1. the child who developed compartment syndrome had received parallel [sic] pins for his fracture. 2 and 3. At the centre where the investigation was performed (I have moved now) around 25-35 cases of displaced SCH fractures are operated every year. Based on this and considering a maximum of 40 patients. 80 identical envelopes were taken. Half of them had a slip with parallel written and half had a slip with divergent written on them. All the 80 were sealed and were kept in a box, from which one fixed investigator used to pick up one envelope once a child was enrolled. No specific allocation sequence was considered. This was a simple method that depended on the chance of an envelope getting picked up"

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "The children were randomized into two groups using the opaque sealed envelope technique"
Allocation concealment (selection bias)	High risk	Quote: "80 identical envelopes were taken. Half of them had a slip with parallel written and the other half had a slip with divergent written on them. All the 80 were sealed and were kept in a box, from which one fixed investigator used to pick up one envelope once a child was enrolled"

Interventions for treating supracondylar elbow fractures in children (Review)

Gopinathan 2018 (Continued)

		Comment: it would be possible for the study team to begin to predict allocation as the study progressed and number of envelopes decreased.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear if the operating surgeons were involved as part of the study team
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: unclear if the outcome assessors were blinded to trial allocations
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Jain 2019
Study characteristics

Methods	Design: quasi-randomised study Study duration: February 2012 to November 2013 Power calculation: no prospective calculation of sample size
Participants	Setting: Department of Orthopaedic, SMS Medical College & Hospital, Jaipur, India Sample size: 168 children Inclusion criteria: children aged 0 to 15 with extension type Gartland 2 or 3 supracondylar fractures Exclusion criteria: vascular injuries, comminuted fractures with intra-articular extension, flexion type fracture
Interventions	Group 1 (84 children): manipulation of fracture in theatre with fixation using one retrograde wire from the lateral side and one posterior intrafocal wire Group 2 (84 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A percutaneous technique was used for the medial wire.
Outcomes	1) Nerve injury 2) Major complications (pin site infection) 3) Cosmetic deformity (cubitus varus and loss of carrying angle > 10 degrees at 6 months) 4) Range of movement (loss of total range of movement at 6 months) 5) Radiographic deformity (loss of reduction with change in Baumann's angle > 6 degrees at 6 months)
Notes	Loss to follow-up: Group 1 6/84 (7.1%) and Group 2 4/84 (4.8%) Funding source: not stated

Jain 2019 (Continued)

Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Quote: "System random sample technique: all odd number of cases allotted to CPF group and all even number of patient allotted to PILPF group" Comment: sequence generated through alternation
Allocation concealment (selection bias)	High risk	Comment: sequence generated through alternation
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: small loss to follow-up for radiographic outcomes (6.0%) that seem to be balanced between groups.
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Kaewpornswan 2001

Study characteristics

Methods	Design: randomised trial Study duration: June 1996 to April 1999 Power calculation: to detect a difference in Baumann's angle of 5 degrees at 80% power was 14 cases per group
Participants	Setting: Faculty of Medicine, Siriraj Hospital, Bangkok, Thailand Sample size: 28 children Inclusion criteria: children aged 1 to 12 with totally displaced supracondylar fractures Exclusion criteria: open fracture, delayed presentation > 7 days, ipsilateral forearm fracture, vascular injury, compartment syndrome, abnormal growth and development
Interventions	Group 1 (14 children): closed manipulation of fracture in theatre with fixation using two or three retrograde wires Group 2 (14 children): lateral approach open reduction of fracture in theatre with fixation using crossed wires inserted from the lateral side
Outcomes	1) Nerve injury

Interventions for treating supracondylar elbow fractures in children (Review)

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Kaewpornasawan 2001 (Continued)

- 2) Major complications
- 3) Cosmetic deformity (patient satisfaction with scar and appearance at 14 to 30 weeks)
- 4) Range of motion (loss of total range of motion > 10 degrees at 14 to 30 weeks)
- 5) Radiographic deformity (loss of Baumann's angle, loss of reduction at 14 to 30 weeks)

Notes	Loss to follow-up: no reported loss to follow-up Mean follow-up 20 weeks Funding source: not stated Declarations: not stated
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Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Children randomly divided into two groups by block randomization"
Allocation concealment (selection bias)	Unclear risk	Comment: method of concealment is not described.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "The operation in both groups was performed by the author" Comment: all procedures performed by a single surgeon who was not blinded to allocation and part of the study team
Blinding of outcome assessment (detection bias)	Unclear risk	Quote: "Blinded assessor provided an assessment of scar and appearance" Comment: for most outcomes, it was unclear if the outcome assessors were blinded to trial allocations. For the assessment of scar and appearance, we judged detection bias to be high risk.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Kalia 2018
Study characteristics

Methods	Design: randomised study Study duration: 2017 to 2018 Power calculation: no prospective calculation of sample size
Participants	Setting: Maharishi Markandeshwar Medical College and Hospital, Kumarhatti, Solan, India Sample size: 60 children

Interventions for treating supracondylar elbow fractures in children (Review)

Kalia 2018 (Continued)

Inclusion criteria: children (age not specified in inclusion criteria) with extension type Gartland 2 or 3 supracondylar fracture

Exclusion criteria: open fractures, fractures with vascular injury, and fractures requiring open reduction

Interventions	Group 1 (30 children): manipulation of fracture in theatre with fixation using one retrograde wire and one antegrade wire inserted from the lateral side Group 2 (30 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A mini-open technique was used for the medial wire.
Outcomes	1) Nerve injury 2) Major complications (pin site infections) 3) Cosmetic deformity (loss of carrying angle > 10 degrees at 2 to 12 months)* 4) Range of movement (loss of total range of movement > 10 degrees at 2 to 12 months)*
Notes	*Outcomes 3 and 4 unable to be combined in analysis as unclear how many participants had outcomes measured at the different time points Loss to follow-up: none reported Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "In the first method 30 patients selected at random underwent standard cross-k wiring" Comment: unclear how randomisation was performed
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient detail on allocation concealment to assess
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Kocher 2007

Study characteristics

Methods	Design: randomised trial Study duration: May 2003 to January 2005 Power calculation: prospective calculation completed – 80% power to detect a 10% difference in loss of reduction required 52 participants
Participants	Setting: Children's Hospital Boston, Massachusetts, USA Sample size: 66 children Inclusion criteria: children aged 3 to 10 years with a Gartland 3 extension type fracture Exclusion criteria: delayed presentation > 48 hours, open fractures, fracture requiring neurovascular exploration, floating elbow injury, bilateral fractures, previous ipsilateral fracture, or an inability to perform a preoperative neurovascular examination
Interventions	Group 1 (28 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (24 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side using a mini-open technique
Outcomes	1) Nerve injury 2) Major complications 3) Cosmetic deformity (carrying angle at 3 months) 4) Return to normal activities at 3 months 5) Range of motion (total range of motion loss greater than 10 degrees at 3 months) 5) Radiographic deformity (loss of Baumann's angle > 6 degrees, change in Baumann's angle and change in humeral-capitellar angle at 3 months)
Notes	Loss to follow-up: 13 children excluded following allocation for open reduction, deviation from pre-scribed pin position, not meeting inclusion criteria, and inadequate fixation on review Funding source: not stated Declarations: authors received funding from implant companies

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "patients were randomized to be treated either with lateral entry pin fixation or with medial and lateral entry pin fixation according to an assignment, produced by a random number generator, in a sealed envelope"
Allocation concealment (selection bias)	Unclear risk	Quote: "A permuted block (block size, 4) randomization design was used. The envelopes were opened in the operating room, after closed reduction and at the time of percutaneous pin fixation" Comment: unclear if the envelopes were numbered and opened sequentially
Blinding of participants and personnel (performance bias)	Unclear risk	Comment: unclear if the ten operating surgeons were involved in the study or if they may have had influence on the study findings

Kocher 2007 (Continued)

All outcomes

Blinding of outcome assessment (detection bias)	High risk	Quote: "Clinical evaluation was performed by attending pediatric orthopaedic surgeons. The surgeons and the patients were not blinded to the type of pin construct"
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Quote: "Of the sixty-six patients, five were excluded from the study because they had undergone open reduction; four, because the surgeon had added pins to the randomized pin configuration; two, because the fracture was deemed to be type II on review; two, because the pin configuration was not acceptable according to the protocol; and one, because the preoperative neurovascular examination was inadequate" Comment: it seems that 14 participants (21.2%) were excluded from analysis after randomisation and it is unclear to which groups these children were allocated. No intention-to-treat-analysis presented following exclusions
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Kumar 2021
Study characteristics

Methods	Design: randomised study Study duration: April 2019 to March 2020 Power calculation: no prospective calculation of sample size
Participants	Setting: Department of Orthopaedics, Maharaja Suheldev Autonomous State Medical College, Baharaich, India Inclusion criteria: children (aged 3 to 12) with displaced supracondylar fractures Exclusion criteria: delayed presentation > 7 days, open fractures, previous fractures to the elbow, fracture requiring open reduction
Interventions	Group 1: (30 children): manipulation of fracture in theatre and immobilisation in above-elbow plaster of Paris backslab Group 2: (30 children): closed reduction of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A percutaneous technique was used for the medial wire. The preoperative immobilisation was not described. Both groups were immobilised in an above-elbow plaster backslab and followed up at 1, 3, 12 and 24 weeks. It was not specified when the wires or plaster were removed.
Outcomes	Outcomes included in this review: 1) Nerve injury 2) Major complications measured as pin tract infections Outcomes not included in this review:

Kumar 2021 (Continued)

- 1) Cosmetic deformity as measured as loss of carrying angle at 6 months - *outcome was reported as composite outcome with range of motion as Flynn grade*
- 2) Range of motion measured as loss of extension and loss of flexion – *outcome was reported as composite outcome with cosmetic deformity as Flynn grade*
- 3) Malunion – *outcome was not specified as clinical or radiological or what definition was used for evaluation.*

Notes	Funding source: none	
	Declarations: none	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: “This prospective randomized controlled study” Comment: no further information about randomisation technique
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient information to assess allocation concealment
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Kuzma 2014

Study characteristics		
Methods	Design: randomised study Study duration: 2009 to 2012 Sample size: calculation based on a presumed effect size of 0.5, though it was unclear what the primary outcome was for this study or if the primary outcome was a continuous variable for which this sample size calculation would be appropriate. The authors report the sample size was identified to be 64 per group to achieve 80% power.	
Participants	Setting: Modilon General Hospital, Madang, Papua New Guinea Sample size: 133 children	

Kuzma 2014 (Continued)

Inclusion criteria: children aged 0 to 16 with Gartland 2 or 3 supracondylar fractures

Exclusion criteria: open fractures, flexion type fractures, intra-articular fractures, additional same-limb fractures, visceral or head injuries, previous treatment at another hospital for the same injury

Interventions	Group 1 (66 children): skin traction applied under sedation for 2 to 3 weeks Group 2 (67 children): manipulation under anaesthesia in theatre and insertion of an olecranon K-wire or Steinmann pin and application of traction for 2 to 3 weeks followed by removal of metalwork under anaesthesia in theatre
Outcomes	1) Nerve injuries 2) Major complications (compartment syndrome and pin site infection) 3) Cosmetic deformity at 3 to 6 month follow-up (cubitus varus) 4) Range of movement at 3 to 6 month follow-up (loss of flexion > 10 degrees, hyperextension > 5 degrees)
Notes	Loss to follow-up: Group 1 11/66 (16.7%), Group 2 10/67 (14.9%) Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "After taking the informed consent, the surgeon randomly allocated participants to an overhead skeletal traction or straight-arm skin traction by hand drawing from a box of sealed opaque envelopes"
Allocation concealment (selection bias)	High risk	Quote: "there were 70 envelopes in the 1st box and same amount in the 2nd box" Comment: there was a fixed number of envelopes of both treatments so study staff may have been able to predict allocation for children later in the study.
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Quote: "Skeletal traction was performed both by the consultant and registrars in orthopaedic ward, they were not formally part of the study team." Comment: interventions performed by personnel not directly involved in trial so unlikely to impact outcomes
Blinding of outcome assessment (detection bias)	High risk	Quote: "Outcome measures were assessed by the researcher... [B]linding the outcome assessors was deemed not possible because... the skeletal traction... left [a] small scar."
Incomplete outcome data (attrition bias) All outcomes	High risk	Comment: 15.8% loss to follow-up balanced between groups. Adjustment for loss to follow-up using last result carried forward. Unadjusted analysis unavailable due to computer failure
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Maity 2012

Study characteristics

Methods	Design: randomised trial Study duration: October 2007 to September 2010 Power calculation: sample of 160 to detect a 15% difference in the rate of major loss of reduction at 80% power with a 25% loss to follow-up
Participants	Setting: Department of Orthopaedics, Burdwan Medical College, Burdwan, West Bengal, India Sample size: 160 children Inclusion criteria: children aged 2 to 12 with displaced Gartland 2 or 3 extension type supracondylar fractures Exclusion criteria: bilateral fractures, delayed presentation > 72 hours, additional injury in the same limb, previous fracture in the same limb, need for open reduction, floating elbow, failure to perform an adequate preoperative neurovascular examination, neurovascular injury requiring exploration
Interventions	Group 1 (80 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (80 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side using a mini-open technique
Outcomes	1) Nerve injury 2) Major complications 3) Cosmetic deformity (carrying angle at 3 months) 4) Range of movement (passive flexion, extension and total range of movement at 3 months) 5) Radiographic deformity (Baumann's angle and change in Baumann's angle at 3 months)
Notes	Identical report published in <i>Iraqi Journal of Medical Sciences</i> (Sadik 2015). This publication preceded the duplicate by three years and is assumed to be the initial study report. Loss to follow-up: Group 1 14/80 (17.5%), Group 2 16/80 (20.0%) Funding source: none Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "The random assignment scheme was created from a table of random numbers"
Allocation concealment (selection bias)	Low risk	Quote: "Opaque prenumbered sealed envelopes containing random assignments were maintained by the hospital pharmacist."
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear who performed the interventions and their relationship to the study team

Maity 2012 (Continued)

Blinding of outcome assessment (detection bias)	High risk	Quote: "Follow-up assessment of each patient was done by the same doctor throughout the trial. Both the surgeons and the patients were not blinded of the treatment received throughout the trial".
Incomplete outcome data (attrition bias) All outcomes	High risk	Quote: "All statistical analysis was based on an "intention to treat" principle; therefore patients who withdrew from the study, the data at the time of withdrawal were carried forward to all subsequent evaluations" Comment: 30 (18.8%) participants lost to follow-up with no presentation of unadjusted scores. Last result carried forward to adjust for missing data, and loss to follow-up reasonably balanced between groups.
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Unclear risk	During our search, we identified an identical version of this report, but with a different author team (Sadik 2015). We assumed that this report was the original publication because it preceded Sadik 2015 by three years. However, we could not rule out the possibility that this publication was conducted by other study authors.

Majeed 2020

Study characteristics

Methods	Design: randomised study Study duration: January 2018 to June 2018 Power calculation: no prospective calculation of sample size.
Participants	Setting: Department of Orthopaedics Surgery, Services Hospital, Lahore, Pakistan Sample size: 180 children Inclusion criteria: children aged 0 to 15 with supracondylar fracture Exclusion criteria: children with 'complications related to fracture'
Interventions	Group 1 (90 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (90 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. The technique for the medial wire was not specified.
Outcomes	1) Nerve injury 2) Cosmetic deformity* 3) Range of motion*
Notes	*Outcomes 2 and 3 were combined in a Flynn classification score so could not be used in the analysis Loss to follow-up: none stated Funding source: not stated Declarations: not stated

Majeed 2020 (Continued)

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "Study Design: Randomized controlled trial"... "Total patients were divided into two groups (A and B)" Comment: unclear how randomisation was performed
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient detail on allocation concealment to assess
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Mandal 2018
Study characteristics

Methods	Design: randomised study Study duration: March 2015 to September 2016 Power calculation: no prospective calculation of sample size.
Participants	Setting: Medical College and Hospital, Kolkata, India Sample size: sample of 60 children selected but not justified. Inclusion criteria: children aged 5 to 15 with Gartland 2 or 3 supracondylar fractures who had failed attempted closed reduction in the emergency department Exclusion criteria: open fractures, delayed presentation > 5 days, patients unfit for surgery, neurovascular injury, compartment syndrome
Interventions	Group 1 (30 children): manipulation of fracture in theatre with fixation using three retrograde wires inserted from the lateral side Group 2 (30 children): manipulation of fracture in theatre with fixation using two retrograde wires inserted from the medial and lateral side. It was not specified if an open or percutaneous technique was used for the medial wire.
Outcomes	1) Treatment failure requiring re-fixation

Mandal 2018 (Continued)

- 2) Nerve injury
- 3) Major complications
- 4) Cosmetic deformity at 6-month follow-up
- 5) Range of movement at 6-month follow-up
- 6) Return to sport and normal activities
- 7) Radiographic deformity at 6-month follow-up

Notes

Loss to follow-up: Group 1 1/30 (3.3%), Group 2 1/30 (3.3%)

Funding source: not stated

Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "Each of the patients from the study sample was selected randomly for crossed medial and lateral pin fixation and lateral entry three divergent wires" Comment: unclear how the randomisation was performed
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient information to evaluate allocation concealment
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear who performed the interventions and their relationship to the study team
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: insufficient information to evaluate blinding
Incomplete outcome data (attrition bias) All outcomes	High risk	Comment: 2 participants excluded following complications that may have had a significant impact on results
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Mulpuri 2016
Study characteristics

Methods

'sDesign: non-inferiority randomised trial

Study duration: not stated

Power calculation: no prospective calculation of sample size provided

Participants

Setting: British Columbia Children's Hospital, Vancouver, British Columbia, Canada

Mulpuri 2016 (Continued)

Sample size: 55 children

Inclusion criteria: children aged 3 to 7 with a Gartland 3 supracondylar fracture

Exclusion criteria: open fracture, preoperative ulnar nerve injury, compartment syndrome or vascular injury

Interventions	Group 1 (23 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (29 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. It was not specified if an open or percutaneous technique was used for the medial wire.
Outcomes	1) Nerve injuries 2) Radiographic deformity (change in Baumann's angle at 3 weeks) 3) Cosmetic deformity (carrying angle at 3 years)* 4) Range of movement at 3 years* 5) Radiographic deformity (humeral-capitellar angle)*
Notes	* Outcomes 3 to 5 not presented in either available conference abstract Loss to follow-up: Group 1 1/23 (4.3%), Group 2 6/29 (20.7%) Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Consenting patients were block randomized into one of two groups"
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient information to evaluate allocation concealment
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: insufficient information to evaluate blinding
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: insufficient information to evaluate blinding
Incomplete outcome data (attrition bias) All outcomes	High risk	Comment: per-protocol analysis presented with patients excluded if an additional wire was required. This impacts the crossed wire group more than the lateral wire group.
Selective reporting (reporting bias)	High risk	Comment: prospective registration identifies Flynn scores at three years and humeral-capitellar angle which are not reported in the presented abstracts
Other bias	Low risk	None identified

Naik 2017

Study characteristics

Methods	Design: quasi-randomised study Study duration: May 2013 to May 2015 Power calculation: no prospective calculation of sample size provided
Participants	Setting: Medical College and Hospital, Kolkata, India Sample size: 60 children Inclusion criteria: children age 0 to 13 with Gartland 3 supracondylar fractures Exclusion criteria: flexion type injuries, open fractures
Interventions	Group 1 (30 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (30 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A mini-open technique was used for the medial wire.
Outcomes	1) Nerve injury 2) Major complications 3) Cosmetic deformity (carrying angle at 6 months) 4) Range of movement (loss of total range of motion at 6 months)
Notes	Loss to follow-up: Group 1 1/30, Group 2 1/30 but both with significant complications (varus collapse requiring revision and nerve injury) Funding source: not stated Declarations: not stated An identical report was published in <i>Zagazig University Medical Journal</i> with different authors (El-Ngehy 2018). This publication preceded the duplicate by one year and is assumed to be the initial study report. Additional information received through communication with study authors: Functional (range of motion) scores according to Flynn criteria for both groups at 2 years: Group A (lateral wires) Excellent 4, Good 17, Fair 7, Poor 0 Group B (crossed wires) Excellent 3, Good 21, Fair 5, Poor 0

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Quote: "The randomization process was done by the odd and even number technique in which the patients with even inpatient numbers were assigned in Group A while the odd inpatient number patients were allotted in Group B."
Allocation concealment (selection bias)	High risk	Comment: the randomisation technique was open so could be predicted by study staff deciding if a child should be approached for the study

Naik 2017 (Continued)

Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: insufficient information to evaluate blinding
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: insufficient information to evaluate blinding
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Unclear risk	During our search, we identified an identical version of this report, but with a different author team (El-Ngehy 2018). We assumed that this report was the original publication because it preceded El-Ngehy 2018 by 12 months. However, we could not rule out the possibility that this publication was conducted by other study authors.

Naveen 2017

Study characteristics

Methods	Design: randomised trial Study duration: May 2016 to January 2017 Power calculation: no prospective calculation of sample size provided
Participants	Setting: Department of Orthopedics, Shivamogga, India Sample size: 42 children Inclusion criteria: children aged 3 to 13 with Gartland 2 or 3 extension type supracondylar fracture Exclusion criteria: open fractures or neurovascular involvement
Interventions	Group 1 (21 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (21 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A percutaneous technique was used for the medial wire.
Outcomes	1) Nerve injury 2) Major complications
Notes	Loss to follow-up: 1 child (4.8%) in each group Funding source: none Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
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Naveen 2017 (Continued)

Random sequence generation (selection bias)	Low risk	Quote: "Lateral only pinning or crossed medio lateral pinning group was done according to the random assignment scheme"
Allocation concealment (selection bias)	Unclear risk	Comment: unclear how allocation sequence was concealed
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: insufficient information to assess blinding
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: insufficient information to assess blinding
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: low loss to follow-up with one child lost to follow-up in each group (4.8%)
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Oakley 2009

Study characteristics

Methods	Design: randomised trial Study duration: September 2003 to March 2005 Power calculation: prospective calculation to detect a 20 mm difference in pain intensity with 80% power required 24 per group
Participants	Setting: Department of Emergency Medicine, Royal Children's Hospital, Melbourne, Australia Sample size: 50 children Inclusion criteria: children 0 to 18 with a Gartland 1 supracondylar fracture Exclusion criteria: additional injuries to the upper limb, other serious injuries, nerve or vascular injury, inability to complete a diary in English
Interventions	Group 1 (27 children): fracture immobilised in the hospital emergency department with a fibreglass above-elbow backslab and broad arm sling for 12 to 16 days Group 2 (23 children): fracture immobilised in the hospital emergency department with a collar and cuff sling for 12 to 16 days
Outcomes	1) Nerve injury 2) Pain (pain intensity and duration) 3) Parental satisfaction at 2 to 4 weeks 4) Return to normal activities (time to return to normal activities)
Notes	Loss to follow-up: one diary not completed but all returned for clinical review

Oakley 2009 (Continued)

Additional information received through communication with study authors (20 September 2020):

Allocation sequence: used sequentially-numbered, opaque envelopes for randomisation

Resumption of normal activity was measured through use of diary and face-to-face visit

Duration of pain was defined as time before two consecutive days of no pain were reported

The pain assessment on a daily basis was a two-part question - has your child reported pain today. If "yes" then the pain was scored - (on the VAS). No pain of zero was recorded when recordings were written so the mean was calculated on the pain scores recorded.

Funding source: not stated

Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Randomization was by opaque-sealed envelope, with a computer-generated sequence in blocks of 6."
Allocation concealment (selection bias)	Low risk	Quote: "We used sequentially numbered opaque envelopes for randomisation"
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear who provided the treatments and if they were involved as part of the study
Blinding of outcome assessment (detection bias)	High risk	Quote: "Reviewers were not blinded to the method of immobilization of the patient; however, standardized questionnaires and examination were used to limit bias. Interviews were conducted by the managing clinician (not researchers) to limit bias on reported satisfaction." Comment: most outcomes assessed by parents using a visual analogue score recorded in a diary and confirmed at face-to-face review. Parents not blinded to treatment allocation
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: one participant lost to follow-up (incomplete diary) in both groups. Questionnaires filled in by all participants
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Othman 2017

Study characteristics

Methods	Design: randomised trial
	Study duration: 2013 to 2015
	Power calculation: no prospective calculation of sample size provided

Othman 2017 (Continued)

Participants	Setting: Department of Orthopedics, Faculty of Medicine, Zagazig University, Egypt Sample size: 47 children Inclusion criteria: children (age not specified in inclusion criteria) with Gartland 2 or 3 supracondylar fracture Exclusion criteria: open fractures, fractures that required open reduction, vascular injuries, previous ipsilateral elbow fracture, delayed presentation > 3 days
Interventions	Group 1 (16 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (17 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A percutaneous technique was used for the medial wire. Group 3 (16 children): manipulation of fracture in theatre with fixation using one retrograde wire and one antegrade wire inserted from the lateral side
Outcomes	1) Nerve injury 2) Major complications 3) Cosmetic deformity (carrying angle loss > 10 degrees at 6 to 10 months) 4) Range of motion (loss of range of motion > 10 degrees at 6 to 10 months) 5) Radiographic deformity (loss of Baumann's angle and humeral-capitellar angle at 6 to 10 months)
Notes	Loss to follow-up: 2 children; the allocation of these two children was not specified Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "The patients were randomised to three different methods of pinning" Comment: unclear how randomisation was performed
Allocation concealment (selection bias)	Unclear risk	Comment: technique for allocation concealment not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear who provided the treatments and if they were involved as part of the study
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: unclear who assessed the outcomes and if they were blinded to treatment allocation
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Comment: 2 participants lost to follow-up (4.3%). It was not specified to which groups these children were allocated.
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.

Othman 2017 (Continued)

Other bias	Low risk	None identified
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Palange 2019

Study characteristics

Methods	Design: randomised trial Study duration: September 2016 to September 2017 Power calculation: no prospective calculation of sample size provided
Participants	Setting: Grant Government Medical College & Sir JJ Group of Hospitals, Mumbai, Maharashtra, India Sample size: 30 children Inclusion criteria: children aged 0 to 13 with extension type Gartland 3 supracondylar fractures Exclusion criteria: open injuries, those with associated injuries to ipsilateral elbow
Interventions	Group 1 (15 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (15 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A mini-open technique was used for the medial wire.
Outcomes	1) Nerve injury 2) Cosmetic deformity at 6 months* 3) Range of movement at 6 months* 4) Radiographic deformity (loss of Baumann's angle at 6 months)
Notes	* Outcomes 2 and 3 were combined and reported as part of a Flynn classification so could not be combined in analysis Loss to follow-up: none reported Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "The randomization was done by the chit-pulling system, where a staff nurse in the operating room, who was completely unassociate[d] with the study had to draw a chit from a bowl of concealed chits which were marked either 'A' or 'B'"
Allocation concealment (selection bias)	Unclear risk	Comment: unclear if there was a fixed number of chits that decreased during the study making it possible to predict the likelihood of the next allocation
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Quote: "The operating surgeon was not shown the pre-operative x rays of the patients before this randomization procedure to avoid bias" ... "All surgeries were carried out by a single senior surgeon (Dr. SMK)"

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Palange 2019 (Continued)

		Comment: the operating surgeon is not listed as a study author and seems to be independent from the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: unclear who assessed the outcomes and if they were blinded to treatment allocation
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Pandey 2008

Study characteristics

Methods	Design: prospective randomised Study duration: January 2004 to December 2004 Power calculation: no prospective calculation of sample size provided
Participants	Setting: B.P. Koirala Institute of Health sciences, Dharan, Nepal Sample size: 60 children Inclusion criteria: children aged 0 to 11 years with extension type Gartland 2b or 3 supracondylar fractures Exclusion criteria: open fractures, delayed presentation > 7 days
Interventions	Group 1 (30 children): manipulation of fracture in theatre and immobilisation in above-elbow plaster of Paris backslab Group 2 (30 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A percutaneous technique was used for the medial wire.
Outcomes	1) Treatment failure requiring revision 2) Nerve injury 3) Major complications 4) Cosmetic deformity (carrying angle at 6 months) 5) Range of motion (loss of total range of motion > 10 degrees and loss of elbow flexion or extension at 6 months)
Notes	Loss to follow-up: Group 1 8/30 (26.7%), Group 2 6/30 (20%) Funding source: not stated Declarations: not stated

Risk of bias

Pandey 2008 (Continued)

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Comment: technique for delivering random sequence was not described
Allocation concealment (selection bias)	Unclear risk	Comment: technique for allocation concealment not described
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear who provided the treatments and if they were involved as part of the study
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: unclear who assessed the outcomes and if they were blinded to treatment allocation
Incomplete outcome data (attrition bias) All outcomes	High risk	Comment: loss to follow-up of 8 (26.7%) in plaster backslab group and 6 (20%) in K-wire group. Loss to follow-up may be related to outcome (as children with good outcomes may not return to clinic).
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Patil 2017

Study characteristics

Methods	Design: randomised trial Study duration: dates not specified Power calculation: no prospective calculation of sample size provided
Participants	Setting: Department of Orthopaedics, Krishna Institute of Medical Sciences, Karad, India Sample size: 30 children Inclusion criteria: children aged 5 to 13 with Gartland 3 supracondylar fracture Exclusion criteria: delayed presentation > 4 days, inability to take part in postoperative rehabilitation, open fractures, medical contraindications to surgery, fracture requiring open reduction or neurovascular exploration, previous ipsilateral elbow fracture, and floating elbow injury
Interventions	Group 1 (15 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (15 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A percutaneous technique was used for the medial wire.
Outcomes	1) Nerve injury 2) Major complications 3) Cosmetic deformity at 6 months* 4) Range of motion at 6 months*

Patil 2017 (Continued)

5) Radiographic deformity at 6 months*

Notes

Loss to follow-up: none reported

*insufficient information to combine results in meta-analysis

Funding source: not stated

Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "prospective comparative randomized controlled trial" Comment: technique for delivering random sequence was not described
Allocation concealment (selection bias)	Unclear risk	Comment: unclear if any concealment was performed of the allocation sequence
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Quote: "Surgery was performed by a senior orthopedic surgeon who was well trained in this technique" Comment: unclear who provided the treatments and if they were involved as part of the study
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: unclear who assessed the outcomes and if they were blinded to treatment allocation
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified. Mayo elbow score mentioned in abstract but not in body of report. Insufficient information to combine functional and radiographic outcomes in analysis
Other bias	Low risk	None identified

Pavone 2016

Study characteristics

Methods

Design: randomised trial

Study duration: May 2005 to December 2012

Power calculation: no prospective calculation of sample size

Participants

Setting: Orthopedic Clinic of the University of Catania, Catania, Italy

Sample size: 35 children

Inclusion criteria: children (age not specified in inclusion criteria) with displaced supracondylar fractures

Pavone 2016 (Continued)

Exclusion criteria: open fractures, adolescents, multiple bone fractures, admission to intensive care

Interventions	Group 1 (13 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (22 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. The technique for the medial wire was not specified.
Outcomes	1) Functional outcome (Mayo Elbow Performance Score at 13 to 67 months) 2) Nerve injury 3) Major complications 4) Cosmetic deformity (loss of carrying angle and cubitus varus at 13 to 67 months) 5) Return to sport and normal activities at 13 to 67 months 6) Radiographic deformity (loss of Baumann's angle at 13 to 67 months)
Notes	Loss to follow-up: none reported Funding source: not stated Declarations: none

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "The children, belonging to this study, were randomly submitted to two different wires techniques "... "Twenty-nine patients with displaced (Gartland type III) extension type supracondylar fractures of the humerus randomly treated by closed reduction and percutaneous fixation with crossed medial-lateral pins or two lateral pins" Comment: unclear how randomisation was performed
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient detail on allocation concealment to assess
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Prashant 2016

Study characteristics

Methods	Design: randomised trial Study duration: not stated Power calculation: no prospective calculation of sample size
Participants	Setting: Department of Orthopaedics, Gauhati Medical College and Hospital, Guwahati, Assam, India Sample size: 76 children Inclusion criteria: children aged 3 to 12 with a Gartland 3 supracondylar fracture Exclusion criteria: open fractures, delayed presentation > 4 days, neurovascular injury, contraindications to surgery, fracture requiring open reduction, previous ipsilateral elbow fracture, and floating elbow injury
Interventions	Group 1 (original number of children not stated): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (original number of children not stated): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A percutaneous technique was used for the medial wire.
Outcomes	1) Nerve injury 2) Major complications (pin site infection) 3) Cosmetic deformity (loss of carrying angle at a minimum of 6 months) 4) Range of motion (loss of total range of motion at a minimum of 6 months) 5) Radiographic deformity (loss of Baumann's angle, loss of Baumann's angle > 6 degrees loss of metaphyseal-diaphyseal angle)
Notes	Loss to follow-up: 14 children excluded following randomisation. It is unclear to which groups these children were initially assigned but the groups appeared balanced. Funding source: not stated Declarations: none

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "The method of patient selection for lateral entry or medial-lateral entry was random, using a computer generated randomization table"
Allocation concealment (selection bias)	Unclear risk	Comment: unclear if any concealment of the allocation sequence was performed
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear who provided the treatments and if they were involved as part of the study
Blinding of outcome assessment (detection bias)	Unclear risk	Quote: "We conducted a prospective, single-blinded randomized control trial"

Prashant 2016 (Continued)

		Comment: unclear who assessed the outcomes and if they were blinded to treatment allocation
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: 14 (18.4%) loss to follow-up that seem to be balanced between the groups
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Raj 2018
Study characteristics

Methods	Design: randomised trial Study duration: May 2015 to September 2017 Power calculation: no prospective calculation of sample size	
Participants	Setting: Rajiv Gandhi Government General Hospital, Chennai, India Sample size: 20 children Inclusion criteria: children aged 0 to 15 with displaced Gartland 3 supracondylar fracture Exclusion criteria: neurovascular injuries, previous elbow injury	
Interventions	Group 1 (10 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (10 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. The medial wire technique was not specified.	
Outcomes	1) Nerve injury 2) Major complication (pin site infections) 3) Cosmetic deformity (carrying angle loss at 6 months) 4) Range of motion (extension, flexion, and total range of motion at 6 months) 5) Radiographic deformity (loss of reduction and change in Baumann's angle at 6 months)	
Notes	Report available as thesis only. No peer-reviewed paper identified Loss to follow-up: none reported Funding source: not stated Declarations: not stated	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "Technique of Kirschner wire fixation of the fracture was allocated to the patients randomly"

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Raj 2018 (Continued)

		Comment: unclear how randomisation was performed
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient detail on allocation concealment to assess
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	High risk	Comment: rate of open reduction 90% in crossed wires group and 20% in lateral wires group. This difference in open reduction rates may have an impact on outcomes.

Rakha 2020

Study characteristics

Methods	Design: randomised trial Study duration: March 2018 to September 2018 Power calculation: power of study at 80% and level of significance of 5%
Participants	Setting: Department of Orthopaedics, Allied Hospital, Faisalabad, Pakistan Sample size: non-probability consecutive sampling 130 participants Inclusion criteria: either gender ranging from 5 to 12 years with supracondylar Gartland type III fracture diagnosed on X-ray within one week of fracture Exclusion criteria: open or closed Gartland type III fracture associated with neurovascular injury, previous fracture in the same elbow or associated ipsilateral fractures
Interventions	Group 1 (65 children): open reduction and fixation with K-wires in crossed pattern Group 2 (65 children): closed reduction using image intensifier and fixation with K-wires in crossed pattern
Outcomes	1) Assessment using Flynn's criteria
Notes	Loss to follow-up: not applicable as the study reported no review outcomes Funding source: not reported Declarations: study authors declare no conflicts of interest

Rakha 2020 (Continued)

Notes: we did not conduct risk of bias assessment because we were unable to include outcome data in the review

Ray 2019

Study characteristics

Methods	Design: randomised trial Study duration: August 2016 to January 2018 Power calculation: no prospective calculation of sample size provided.
Participants	Setting: Department of Orthopaedics, Regional Institute of Medical Sciences (RIMS), Imphal, India Sample size: 70 children Inclusion criteria: children aged 2 to 15 with extension type Gartland 3 supracondylar fracture Exclusion criteria: delayed presentation > 14 days, open fractures, associated neurovascular impairment following fracture, ipsilateral fracture of distal humerus or elbow joint
Interventions	Group 1 (35 children): closed manipulation of fracture in theatre with fixation using crossed wires inserted from medial and lateral side. A percutaneous technique was used for the medial wire. Group 2 (35 children): medial approach open reduction of fracture in theatre with fixation using crossed wires inserted from the medial and lateral side
Outcomes	1) Nerve injury 2) Major complications (pin site infection) 3) Cosmetic deformity (loss of carrying angle at 12 months) 4) Range of movement (loss of total range of movement at 6 and 12 months) 5) Radiographic deformity (loss of Baumann's angle at 12 months)
Notes	Loss to follow-up: none reported Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Patients fulfilling the eligibility criteria are included in the study. Restricted randomization is done using block size of 4. Each eligible patient in a block fulfilling recruitment criteria is assigned to either Group 1 or Group 2 using lottery method" Comment: unclear exactly how randomisation was performed but there seems to be a random component to allocation
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient detail on allocation concealment to assess

Ray 2019 (Continued)

Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Rizk 2019

Study characteristics

Methods	Design: randomised trial Study duration: February 2014 to October 2017 Power calculation: no prospective calculation of sample size provided. Sample of 50 children selected but not justified
Participants	Setting: Department of Orthopaedics and Traumatology, Faculty of Medicine, Benha University, Benha, Egypt Sample size: 50 children Inclusion criteria: children (age not specified in inclusion criteria) with Gartland 3 supracondylar fractures Exclusion criteria: open fractures, patients with associated ipsilateral arm or forearm fractures, patients who required open reduction, and neurovascular injury
Interventions	Group 1 (25 children): manipulation of fracture in theatre with fixation using two retrograde wires and two antegrade wires inserted from the lateral side Group 2 (25 children): manipulation of fracture in theatre with fixation using two retrograde wires inserted from the medial and lateral side using a percutaneous technique for the medial wire
Outcomes	1) Nerve injury 2) Major complications 3) Cosmesis (carrying angle at 12 to 40 months) 4) Range of motion at 12 to 40 months' follow-up 5) Radiographic deformity (loss of Baumann's angle and humeral-capitellar angle at 12 to 40 months' follow-up)
Notes	Loss to follow-up: none reported Funding source: none

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Rizk 2019 (Continued)

Declarations: none

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "This is a prospective randomized control study" Comment: no further information on randomisation technique provided
Allocation concealment (selection bias)	Unclear risk	Quote: "This is a prospective randomized control study" Comment: no further information on allocation concealment technique provided
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear who provided the treatments and if they were involved as part of the study
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: unclear who assessed the outcomes and if they were blinded to treatment allocation
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Sadek 2018
Study characteristics

Methods	Design: prospective randomised study Study duration: June 2015 to January 2016 Power calculation: no prospective calculation of sample size.
Participants	Setting: Orthopaedic Department, Sohag University Hospital, Egypt Sample size: 40 children Inclusion criteria: children (age not specified in inclusion criteria) with Gartland 2 or 3 supracondylar fracture Exclusion criteria: previous ipsilateral fracture, polytrauma, or neurovascular injury
Interventions	Group 1 (20 children): manipulation of fracture in theatre with fixation using one retrograde wire and one antegrade wire inserted from the lateral side (Dorgan wires) Group 2 (20 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side
Outcomes	1) Nerve injuries

Sadek 2018 (Continued)

- 2) Major complications (pin site infections)
- 3) Cosmetic deformity (loss of carrying angle at 23 to 29 weeks)
- 4) Range of movement (loss of range of movement at 23 to 29 weeks)
- 5) Radiographic deformity (absolute Baumann's angle, humeral-capitellar angle and metaphyseal-diaphyseal angle at 23 to 29 weeks)*

Notes	*Outcome 5 not reported in sufficient detail to include in analysis Loss to follow-up: none reported Funding source: not stated Declarations: not stated
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Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "40 children were treated for type II and type III supracondylar fracture in humerus. [C]hildren divided randomly into two groups, group A and B" Comment: unclear how randomisation was performed
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient detail on allocation concealment to assess
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Saeed 2020
Study characteristics

Methods	Design: randomised study Study duration: June 2014 to June 2017 Power calculation: to detect a 17.42% decrease in rates of pin site infections with 80% power, a sample size of 40 per group was identified
Participants	Setting: Allied Hospital/Faisalabad Medical University, Faisalabad, Pakistan

Saeed 2020 (Continued)

Inclusion criteria: children with supracondylar fracture

Exclusion criteria: none specified in manuscript

Interventions	Group 1: (40 children): open reduction of fracture through a medial approach followed by retrograde wires inserted from medial and lateral sides in a non-buried configuration Group 2: (40 children): open reduction of fracture through a medial approach followed by retrograde wires inserted from medial and lateral sides in a buried configuration Both groups were immobilised for 2 weeks in a posterior above-elbow backslab with removal of wires at 4 weeks. It was not specified if wires were removed in clinic or if they were removed following a second anaesthetic in theatre.
Outcomes	Outcomes included in this review: 1) Major complications: pin site infection by week 4
Notes	Loss to follow-up: none reported Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "All the patients were randomly divided into 2 groups by using computer generated random number"
Allocation concealment (selection bias)	Unclear risk	Comment: unclear how randomisation was performed and what techniques were used to provide allocation concealment
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear who provided the treatments and if they were involved as part of the study
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Said 2015
Study characteristics

Methods	Design: randomised trial Study duration: June 2012 to May 2013
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Interventions for treating supracondylar elbow fractures in children (Review)

Said 2015 (Continued)

Power calculation: no prospective calculation of sample size

Participants	Setting: Department of Orthopedics surgery, Qena University Hospital, Qena, Egypt Sample size: 44 children Inclusion criteria: children aged 2 to 12 with extension type Gartland supracondylar fracture Exclusion criteria: bilateral fracture, ipsilateral or previous limb injury, open fracture, failed closed reduction, neurovascular injury
Interventions	Group 1 (not specified how many children were allocated to this group): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (not specified how many children were allocated to this group): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A percutaneous technique was used for the medial wire.
Outcomes	1) Nerve injury 2) Major complications (pin site infections) 3) Cosmetic deformity (loss of carrying angle at 3 months) 4) Range of motion (flexion and extension loss and total range of movement at 3 months) 5) Return to sport and normal activities at 3 months 6) Radiographic deformity (loss of reduction and loss of Baumann's angle at 3 months)
Notes	Loss to follow-up: 4 (9.1%) children were lost. It is not specified to which groups these children were originally allocated but the final groups appear balanced. Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Patients were randomly selected by drawing lots with even numbers included in-group A (two parallel lateral wires) and odd numbers in group B (medial and lateral wires)."
Allocation concealment (selection bias)	Unclear risk	Comment: unclear if there was a fixed number of lots available to draw from which may have been predicted by study staff
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "44 children were treated for completely displaced type III supracondylar fracture humerus. 4 children were excluded from the study due to loss for follow up"

Said 2015 (Continued)

		Comment: unclear to which groups the four children lost to follow-up had been allocated but the final groups appear balanced
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Sankar 2019

Study characteristics

Methods	Design: randomised trial Study duration: July 2011 to October 2012 Power calculation: no prospective calculation of sample size	
Participants	Setting: Department of Orthopaedics, Government Medical College, Kottayam, India Sample size: 66 children Inclusion criteria: children aged 3 to 12 with Gartland 3 supracondylar fracture Exclusion criteria: delayed presentation > 4 days, previous elbow fracture, inability to perform neurological evaluation, floating elbow fracture	
Interventions	Group 1 (not specified how many children were allocated to this group): posterior approach open reduction of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (not specified how many children were allocated to this group): posterior approach open reduction of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side.	
Outcomes	1) Nerve injury 2) Major complications (wound infection and vascular injuries) 3) Cosmetic deformity (loss of carrying angle at 6 months)* 4) Range of movement (total range of movement at 3 and 6 months and loss of flexion and extension at 6 months)*	
Notes	* Outcomes 3 and 4 combined to form Flynn classification and not reported separately in study Loss to follow-up: 6 (9.1%) children were lost. It is not specified to which groups these children were originally allocated but the final groups appear balanced. Funding source: none Declarations: not stated	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Patients were randomly selected by drawing lots with even numbers included in Group A (lateral entry) and odd number in Group B (medial and lateral entry)"

Sankar 2019 (Continued)

Allocation concealment (selection bias)	Unclear risk	Comment: unclear if there was a fixed number of lots that could be drawn that would allow study staff to predict likelihood of next treatment allocation
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Quote: "During the study period 66 patients were treated for completely displaced supracondylar fractures of humerus in children. Six patients were excluded from the study due to loss of follow up" Comment: unclear to which groups the 6 children lost to follow-up belonged
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Low risk	None identified

Shafi-Ur-Rehman 2013
Study characteristics

Methods	Design: randomised trial Study duration: June 2011 to February 2012 Power calculation: no prospective calculation of sample size provided
Participants	Setting: Department of Orthopedic Surgery, Shaikh Zayed Hospital, Postgraduate Medical Institute (PGMI), Lahore, Pakistan Sample size: 200 children Inclusion criteria: children aged 3 to 10 with Gartland 2 or 3 supracondylar fractures Exclusion criteria: delayed presentation > 7 days, neurovascular injury, open fractures, ipsilateral forearm fractures
Interventions	Group 1 (100 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (100 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. It was not specified if an open or percutaneous technique was used for the medial wire.
Outcomes	1) Range of movement at 3 months' follow-up 2) Radiographic deformity (loss of reduction)
Notes	Radiographic deformity measured at 3 weeks Range of movement expressed as excellent (0 to 5 degrees loss of total range of movement) or not excellent Loss to follow-up: none reported

Interventions for treating supracondylar elbow fractures in children (Review)

Shafi-Ur-Rehman 2013 (Continued)

Funding source: not stated

Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Comment: technique for delivering random sequence was not described
Allocation concealment (selection bias)	Unclear risk	Comment: unclear if any concealment of the allocation sequence was performed
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear who provided the treatments and if they were involved as part of the study
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: unclear who undertook the outcome assessment and if they were blinded to treatment allocations
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified
Other bias	Unclear risk	During our search, we identified that a second study has also been published with identical group sizes, demographics, and outcomes, but from different hospitals and inclusion periods (Shah 2013). Although we believed that Shafi-Ur-Rehman 2013 was the original study, we could not rule out the possibility that it was in fact conducted by different study authors.

Shah 2017
Study characteristics

Methods	Design: randomised trial Study duration: August 2011 to July 2013 Power calculation: no prospective calculation of sample size
Participants	Setting: Department of Orthopaedics, Khaja Bandanawaz Institute of Medical Science (KBNIMS), Kalaburagi, Karnataka, India Sample size: 20 children Inclusion criteria: children aged 1 to 14 with Gartland 3 supracondylar fractures Exclusion criteria: nil
Interventions	Group 1 (10 children): manipulation of fracture in theatre and immobilisation in above-elbow plaster of Paris backslab

Shah 2017 (Continued)

Group 2 (10 children): open reduction of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A percutaneous technique was used for the medial wire.

Outcomes	1) Nerve injuries 2) Major complications (vascular injury and pin site infections) 3) Cosmetic deformity (loss of carrying angle, cubitus varus and cubitus valgus at 6 to 12 months) 4) Range of movement (loss of total range of movement at 6 to 12 months)
Notes	Loss to follow-up: none reported Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "20 type-III fractures were taken for comparative study. In a random manner, two equal groups were drawn" Comment: unclear how randomisation was performed
Allocation concealment (selection bias)	Unclear risk	Comment: insufficient detail on allocation concealment to assess
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Shamma 2020

Study characteristics

Methods	Design: randomised trial Study duration: March 2019 to November 2019 Power calculation: no prospective calculation of sample size provided
Participants	Setting: Department of Orthopedic Surgery, Faculty of Medicine, Al-Azhar University, Cairo, Egypt

Shamma 2020 (Continued)

Sample size: 60 children

Inclusion criteria: children aged 0 to 10 with Gartland 2 or 3 supracondylar fracture

Exclusion criteria: open fractures, fractures with neurovascular injury, fractures with compartmental syndrome,

Interventions	Group 1 (15 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side in a parallel configuration Group 2 (15 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side using a divergent configuration
Outcomes	1) Nerve injury 2) Major complications (pin site infections, vascular injuries and compartment syndrome) 3) Cosmetic deformity (loss of carrying angle at 3 months) 4) Range of motion (loss of flexion and extension at 3 months) 5) Radiographic deformity (loss of Baumann's angle at 3 months)
Notes	Loss to follow-up: none reported Funding source: not stated Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Surgery was planned and technique was selected according to random number generated by computer"
Allocation concealment (selection bias)	Unclear risk	Quote: the treatment was "enveloped securely so as to be opened at surgery time" Comment: unclear if envelopes were sequentially labelled to prevent study staff predicting next allocation
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: it is not clear who performed the interventions and their relationship to the study team.
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: it is not clear who performed the outcomes assessment and their relationship to the study team.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: no reported loss to follow-up
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Unclear risk	During our search, we identified an identical version of this report, but with a different author team (Hegazy 2020). We assumed that Shamma 2020 was the original publication. However, we could not rule out the possibility that it was in fact conducted by other study authors.

Subash 2020

Study characteristics

Methods	Design: randomised study Study duration: January 2012 to December 2015 Power calculation: no prospective calculation of sample size
Participants	Setting: Department of Orthopaedics, Saveetha Medical College and Hospital, Thandalam, Chennai, Tamil Nadu, India Inclusion criteria: children with supracondylar fractures Exclusion criteria: open fractures, fractures requiring open reduction, multiple fractures
Interventions	Group 1 (unclear how many children allocated to this group): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (unclear how many children allocated to this group): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A mini-open approach was made to protect the ulnar nerve. Children in both groups were immobilised in an arm sling prior to surgical intervention. Following surgery, both groups were immobilised in an above-elbow plaster backslab with the elbow flexed to 70-80°. The wires and plaster were removed at 3 weeks.
Outcomes	Outcomes included in this review: 1) Nerve injuries 2) Cosmetic deformity measured as loss of carrying angle at 6 months 3) Range of movement measured through total range of motion at 6 months 4) Radiographic deformity measures as loss of humeral-capitellar angle and Baumann's angle at 6 months Outcomes not included in this review: 1) Minor limitations in function at 6 months – <i>insufficiently-defined outcome</i>
Notes	6 participants lost to follow-up. The groups for these losses to follow-up were not specified but the final group size was 29 for group 1 and 31 for group 2. Funding source: not stated Declarations: not stated Additional information received on 25 March 2021 from the corresponding author regarding nerve injuries: “There were no preoperative nerve injuries in the cross pinning group Regards Dr yeshwanth Subash”

Risk of bias

Bias	Authors' judgement	Support for judgement
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Subash 2020 (Continued)

Random sequence generation (selection bias)	Low risk	Quote: "The children were then allocated into 2 groups by flipping a coin method"
Allocation concealment (selection bias)	Low risk	Comment: there was no pre-determined allocation sequence to conceal
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear who provided the treatments and if they were involved as part of the study
Blinding of outcome assessment (detection bias)	Unclear risk	Comment: unclear who undertook the outcome assessment and if they were blinded to treatment allocations
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	6 participants lost to follow-up. It was not specified to which groups these children were originally allocated. Final groups have some imbalance
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Tripuraneni 2009

Study characteristics

Methods	Design: surgeon randomised study Study duration: March 2004 to August 2006 Power calculation: no prospective calculation of sample size provided
Participants	Setting: Department of Orthopaedic Surgery, Carrie Tingley Hospital, Albuquerque, New Mexico, USA Sample size: 40 children Inclusion criteria: children (age not specified in inclusion criteria) with a Gartland type 2 or 3 supracondylar fracture Exclusion criteria: revision fixation cases
Interventions	Group 1 (20 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (20 children): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A percutaneous technique was used for the medial wire.
Outcomes	1) Nerve injury
Notes	Radiographic deformity and range of motion assessed at 4 and 8 weeks only (early follow-up) Loss to follow-up: 7 (17.5%) children did not attend final follow-up. It is not specified from which groups these 7 children were lost. Funding source: not stated Declarations: not stated

Tripuraneni 2009 (Continued)

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Quote: "Children were randomized based on which pediatric fellow-ship-trained orthopedic surgeon was on trauma call"
Allocation concealment (selection bias)	High risk	Comment: day of the week allocation means that study staff could predict allocation
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear who provided the treatments and if they were involved as part of the study
Blinding of outcome assessment (detection bias)	Unclear risk	Quote: "All postoperative visits, including radiographic evaluations, were supervised by the attending surgeons" Comment: unclear who undertook the outcome assessment and if they were blinded to treatment allocations
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: 7 participants (17.5%) were lost to final follow-up following pin removal. However, the only extracted outcome was nerve injury, which is unlikely to be impacted by this loss to follow-up.
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Vaidya 2009

Study characteristics

Methods	Design: randomised trial Study duration: January 2006 to December 2008 Power calculation: no prospective calculation of sample size
Participants	Setting: Department of Orthopaedics, Asha Hospital, Bharatpur, Nepal Sample size: 66 children Inclusion criteria: children aged 3 to 12 with Gartland 3 supracondylar fracture Exclusion criteria: delayed presentation > 4 days, previous fracture in the same limb, open fractures, fractures requiring open reduction, floating elbow, and an inability to perform an adequate neurovascular exam
Interventions	Group 1 (unclear how many children were initially allocated to this group): manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2 (unclear how many children were initially allocated to this group): manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side. A mini-open technique was used for the medial wire.
Outcomes	1) Nerve injury

Interventions for treating supracondylar elbow fractures in children (Review)

Vaidya 2009 (Continued)

- 2) Major complications
- 3) Cosmetic deformity measured as loss of carrying angle at 6-month follow-up
- 4) Return to function at 6-month follow-up
- 5) Radiographic deformity: loss of Baumann's angle and loss of reduction at 3 months

Notes

Loss to follow-up: 6 children lost from randomisation to follow-up. It is unclear to which groups these children belonged.

Funding source: not stated

Declarations: not stated

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Patients were randomly selected by drawing lots with even number included in group A and odd number in group B"
Allocation concealment (selection bias)	Unclear risk	Comment: unclear if there was a fixed number of lots that could be drawn that would allow study staff to predict likelihood of next treatment allocation
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Quote: "surgery was performed by senior orthopaedic surgeon" Comment: unclear who provided the treatments and if they were involved as part of the study
Blinding of outcome assessment (detection bias)	Unclear risk	Quote: "Clinical evaluation was performed by senior orthopaedic surgeon" Comment: unclear who undertook the outcome assessment and if they were blinded to treatment allocations
Incomplete outcome data (attrition bias) All outcomes	Low risk	6 children lost from randomisation to follow-up. It is unclear to which groups these children belonged. Final groups appear balanced
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Zhu 2016

Study characteristics

Methods	Design: randomised trial Study duration: February 2009 to December 2012 Power calculation: no prospective calculation of sample size provided. Sample of 68 children selected but not justified
Participants	Setting: Department of Orthopaedic Surgery, Second Affiliated Hospital of Wenzhou Medical College, Wenzhou, China Sample size: 68 children

Interventions for treating supracondylar elbow fractures in children (Review)

Zhu 2016 (Continued)

Inclusion criteria: children aged 4 to 12 with unstable Gartland 2 or 3 supracondylar fractures that were displaced > 2 mm in coronal and/or sagittal plane

Exclusion criteria: open fractures, neurovascular injuries, fractures and/or dislocation of other parts of the ipsilateral limb, congenital malformation of the ipsilateral elbow joint, additional vital organs damage

Interventions	Group 1 (34 children): closed manipulation of fracture in theatre with fixation using two or three retrograde wires Group 2 (34 children): joystick-assisted (mini-open) manipulation of fracture in theatre with fixation using two or three retrograde wires
Outcomes	1) Nerve injury 2) Major complications 3) Radiographic deformity (varus malunion at a mean of 30 to 33 months' follow-up)
Notes	Loss to follow-up: no reported loss to follow-up. However, 5 children who required joystick-assisted manipulation following attempted closed reduction (group 1) were excluded from the analysis, leaving a per-protocol analysis only. Funding source: none Declarations: none

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "type of treatment was chosen at random by drawing from the box containing an equal number of envelopes with either of the two fracture reduction methods"
Allocation concealment (selection bias)	High risk	Comment: there was a fixed number of envelopes of both treatments so study staff may have been able to predict allocation for children later in the study.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: unclear who provided the treatments and if they were involved as part of the study
Blinding of outcome assessment (detection bias)	High risk	Quote: "Both radiographic and clinical evaluations at last follow-up were performed by one of the authors (WH) who were not involved in the care of the patients."..."it was impossible to perform blindness to both the surgeon and patients, which might influence the results."
Incomplete outcome data (attrition bias) All outcomes	High risk	Comment: no reported loss to follow-up. However, 5 children who required joystick-assisted manipulation following attempted closed reduction (group 1) were excluded from the analysis, leaving a per-protocol analysis only.
Selective reporting (reporting bias)	Unclear risk	Comment: no published protocol or prospective trial registration was identified.
Other bias	Low risk	None identified

Characteristics of excluded studies [ordered by study ID]

Study	Reason for exclusion
AboHasan 2020	Non-randomised study comparing lateral wires with crossed wires in supracondylar elbow fractures
Aktekin 2008	Closed and open reduction via posterior approach with percutaneous pinning of posteromedial displaced supracondylar humerus fractures in children. We excluded this study because it was a retrospective study with no randomisation.
Arif 2014	RCT, children aged 2 to 11 years with a Gartland 3 supracondylar fracture. We excluded this study because the interventions were not eligible for this review (open reduction through a medial approach with retrograde crossed wire fixation of fracture versus open reduction through a lateral approach with retrograde crossed wire fixation of fracture).
Arif 2017	Non-randomised study evaluating open reduction and fixation with K-wires
Ariyawatkul 2016	Retrospective, non-randomised study to evaluate closed pinning and conservative treatment in supracondylar elbow fractures
Arnala 1991	Non-randomised study evaluating surgical fixation, traction, and reduction followed by plaster cast
Balanescu 2013	Non-randomised study evaluating reduction methods in supracondylar fractures
Bales 2010	Non-randomised study evaluating the effects of treatment (closed reduction and percutaneous pinning) within 21 hours or later than 21 hours after presentation to the urgent treatment centre
Bulbul 2011	Non-randomised, case series in which all participants were treated with closed reduction and lateral pinning with some additional participants also treated with medial pinning
Chen 2001	RCT, 95 children with Gartland 3 supracondylar fractures. We excluded this study because the study compared two forms of elbow casting (posterior plaster of Paris backslab with the elbow in at least 90° flexion or a posterior and anterior plaster of Paris backslab with the elbow in full extension and supination).
Diri 2003	Non-randomised study comparing three treatments: closed reduction and cast immobilisation; skeletal traction and cast immobilisation; open reduction and internal fixation with K-wires
Ducic 2016b	Non-randomised study comparing three treatments: closed reduction with percutaneous pinning; open reduction with K-wires fixation; closed reduction with cast immobilisation
El-Ngehy 2018	We excluded this study because it appears to be a duplicate study of Naik 2017 with identical sample size, patient demographics, and outcomes, but from different authors and institution.
Ensafadaran 2005	RCT comparing lateral versus posterior approach for reduction and fixation using two crossed pins. We excluded this study because the comparison group was not eligible for this review.
Eren 2005	Non-randomised study comparing lateral and medial approaches to pin fixation
Fahmy 2009	Non-randomised study comparing a single posterior wire with two wires for fixation of supracondylar fractures
Hegazy 2020	We excluded this study because it appears to be a duplicate study of Shamma 2020 with identical sample size, patient demographics, sample x-rays, and outcomes, but from different authors and institution.

Study	Reason for exclusion
Keskin 2014	Non-randomised study comparing open reduction with closed reduction and percutaneous pinning in displaced supracondylar fractures
Khan 2007	Non-randomised study in which supracondylar elbow fractures were treated by closed reduction and percutaneous pinning, either from lateral side only or also from medial side
Lee 2008	Non-randomised study evaluating efficacy of lateral or parallel pins using 3 K-wires or Steinmann pins for fixation of supracondylar fractures
Li 2013	No description of randomisation; we assumed that it was most likely to be a non-randomised study. Compared elbow brace with external fixation
Li 2017	Non-randomised study comparing bioabsorbable PDLLA pin fixation after open reduction with lateral external fixation after closed reduction
Marashi 2013	Non-randomised study comparing supination with pronation after cast immobilisation in children with supracondylar fractures
NCT00904137	Trial registration only: full trial failed to recruit sufficient participants and the results of this trial have not been published
Pescatori 2012	Non-randomised study comparing supine with prone position during percutaneous pinning with K-wires
Rawoot 2014	RCT, children (age not specified in inclusion criteria) with Gartland 2 or 3 supracondylar fracture. We excluded this study because the interventions were not eligible for this review (reduction and fixation of the fracture using K-wires in a supine position versus reduction and fixation of the fracture using K-wires in a prone position).
Roy 2019	Non-randomised study comparing percutaneous pinning with K-wires from lateral side and both sides
Sadik 2015	We excluded this study because it appears to be a duplicate study of Maity 2012 with identical sample size, patient demographics, and outcomes, but from different authors and institution.
Shah 2013	We excluded this study because it appears to be a duplicate study of Shafi-Ur-Rehman 2013 with identical sample size, patient demographics, and outcomes.
Shoaib 2003	Non-randomised study; all children with supracondylar fractures were treated with closed reduction and casting
Siddiq 2020	RCT, children aged 2 to 14 years with a Gartland 2 or 3 supracondylar fracture. We excluded this study because the interventions were not eligible for this review (open reduction through a medial approach with retrograde crossed wire fixation of fracture versus open reduction through a lateral approach with retrograde crossed wire fixation of fracture).
Silva 2018	RCT with 100 children with Gartland 1 supracondylar fracture. We excluded this study because it compared two different casting materials which was not an eligible comparison for this review (hard fibreglass cast (3M "Scotchcast" Plus Casting Tape) or a soft fibreglass cast (3M "Scotchcast" Soft Cast Casting Tape)).
Sutton 1992	Non-randomised study comparing traction with percutaneous pinning in supracondylar fractures
Venkatadass 2015	RCT, children aged 3 to 14 years with Gartland type 3 fractures. We excluded this study because the interventions were not eligible for this review (reduction and fixation of the fracture using K-wires in a supine position versus reduction and fixation of the fracture using K-wires in a prone position).

Study	Reason for exclusion
Young 2012	Non-randomised study comparing crossed wires fixation with skeletal traction

PDLLA: poly-D, L-lactic acid; **K-wires:** Kirschner wires; **RCT:** randomised controlled trial

Characteristics of studies awaiting classification *[ordered by study ID]*

Afridi 2002

Methods	Prospective randomised study
Participants	Children with supracondylar fractures of the humerus
Interventions	Unknown
Outcomes	Unknown
Notes	We were unable to source the abstract and full text for this review, and assessed possible eligibility only from the title

Andreasi 1985

Methods	Unknown
Participants	Children with supracondylar fractures of the humerus
Interventions	Two methods of percutaneous osteosynthesis with Kirschner wire
Outcomes	Unknown
Notes	We were unable to source the abstract and full text for this review, and assessed possible eligibility only from the title

Bing 2017

Methods	Unknown
Participants	Unknown
Interventions	Unknown; believed to be 24 children with lateral entry wires
Outcomes	Unknown; believed to be 17 children with crossed wires
Notes	Identified in 2018 systematic review. We were unable to source the abstract and full text for this review, and assessed possible eligibility only from the title

Boparai 2006

Methods	Unknown
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Boparai 2006 *(Continued)*

Participants	Children with supracondylar fractures
Interventions	Closed reduction versus open reduction
Outcomes	Unknown
Notes	We were unable to source the abstract and full text for this review, and assessed possible eligibility only from the title

Botchu 2006

Methods	Unknown
Participants	Children with displaced supracondylar fractures of the humerus
Interventions	Unknown
Outcomes	Unknown; possibly surgical versus non-surgical management of displaced fractures
Notes	We were unable to source the abstract and full text for this review, and assessed possible eligibility only from the title

Evans 1998

Methods	Randomised clinical trial
Participants	Children with supracondylar fractures of the humerus
Interventions	Unknown
Outcomes	Unknown
Notes	We were unable to source the abstract and full text for this review, and assessed possible eligibility only from the title

He 2009

Methods	Possibly randomised
Participants	Children with displaced fractures
Interventions	Two different forms of external immobilisation
Outcomes	Cosmetic deformity, range of motion
Notes	We could not determine from the translated manuscript whether the study is randomised. Attempts to contact the study authors for clarification were unsuccessful

Lu 2011

Methods	Unknown
Participants	Unknown
Interventions	Unknown; believed to be children with lateral entry wires
Outcomes	Unknown; believed to be children with crossed wires
Notes	Identified in 2018 systematic review. We were unable to source the abstract and full text for this review, and assessed possible eligibility only from the title

NCT04582123

Methods	Randomised controlled trial
Participants	Estimated enrolment: 45 Inclusion criteria: children with closed extension Type III of supracondylar fractures of humerus Exclusion criteria: Type I and Type II injuries, flexion type injuries, open fractures, > 12 years of age
Interventions	Fixation of supracondylar humerus fractures with 2 crossed pins and 3 crossed pins
Outcomes	Comparison of Flynn's grade
Notes	Study is listed as complete in the clinical trials register; however, results are not included in the register. We await publication of the full text.

Sapkota 2019

Methods	Possibly randomised
Participants	Children with Gartland 3 fractures
Interventions	Retrograde lateral wires versus retrograde crossed wires
Outcomes	Nerve injury, cosmetic deformity, range of motion, radiographic deformity
Notes	We could not determine whether the study was randomised. We attempted to contact the study authors but this was unsuccessful.

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

ACTRN12612000480886

Study name	Study of treatment methods for undisplaced supracondylar humeral (elbow) fractures in children
Methods	Randomised trial
Participants	180 children aged 3 to 8 years with Gartland 1 supracondylar fractures

ACTRN12612000480886 (Continued)

Interventions	Collar and cuff at 120° versus collar and cuff at 90° versus posterior plaster slab at 90°
Outcomes	i) Pain ii) Functional outcome using Activity Scale for Kids performance version (ASK-P) score
Starting date	1 August 2012
Contact information	Jemma Bates-Smith: Jemma.Bates-Smith@health.wa.gov.au
Notes	

CTRI/2020/06/025504

Study name	Comparison of short term functional and radiological outcomes between two versus three lateral pin fixation techniques in fractures of lower part on arm bone in children
Methods	Randomised trial
Participants	Children with Gartland 3 supracondylar fractures
Interventions	Fixation with two or three lateral wires
Outcomes	i) Flynn grade
Starting date	Not specified
Contact information	Not specified
Notes	

PACTR201702001960109

Study name	Comparison between crossing wires versus two lateral wires in the management of displaced supracondylar humerus in children
Methods	Prospective RCT using coin toss for allocation
Participants	Inclusion criteria: children aged 2 to 9 years with Gartland 2 to 3 supracondylar fracture Exclusion criteria: open fractures, failed closed reduction, floating elbow, failure to perform preoperative neurovascular assessment, neurovascular injury requiring surgical exploration
Interventions	Group 1: manipulation of fracture in theatre with fixation using retrograde wires inserted from the lateral side Group 2: manipulation of fracture in theatre with fixation using retrograde wires inserted from the medial and lateral side.
Outcomes	Radiological outcomes; grading of the clinical outcomes No additional details

PACTR201702001960109 (Continued)

Starting date 6 January 2016

Contact information Hesham Abdelsadek, Professor in Orthopedic Department, Suez Canal University Hospital
heshamsadeq58@yahoo.com

Notes

RCT: randomised controlled trial

DATA AND ANALYSES

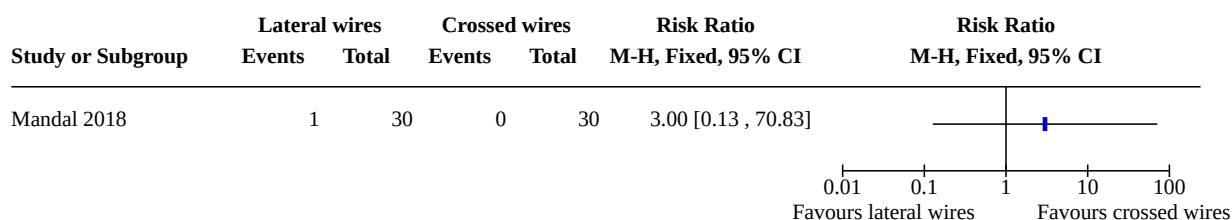
Comparison 1. Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.1 Treatment failure requiring a re-intervention	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
1.2 Nerve injury	28	1653	Risk Ratio (M-H, Fixed, 95% CI)	0.65 [0.46, 0.90]
1.3 Major complications (pin site infections)	18	1022	Risk Ratio (M-H, Fixed, 95% CI)	1.08 [0.65, 1.79]
1.4 Cosmetic deformity: loss of carrying angle > 10 degrees or elbow deformity	8		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only
1.4.1 Medium-term cubitus varus	1	67	Risk Ratio (M-H, Fixed, 95% CI)	2.91 [0.12, 69.08]
1.4.2 Medium-term loss of carrying angle > 10°	1	21	Risk Ratio (M-H, Fixed, 95% CI)	1.10 [0.08, 15.36]
1.4.3 Long-term cubitus varus	2	95	Risk Ratio (M-H, Fixed, 95% CI)	3.13 [0.55, 17.98]
1.4.4 Long-term loss of carrying angle > 10°	6	288	Risk Ratio (M-H, Fixed, 95% CI)	1.27 [0.39, 4.20]
1.5 Cosmetic deformity: loss of carrying angle (degrees of loss)	15		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
1.5.1 Medium-term loss of carrying angle	5	320	Mean Difference (IV, Fixed, 95% CI)	-0.10 [-0.44, 0.23]
1.5.2 Long-term loss of carrying angle	10	502	Mean Difference (IV, Fixed, 95% CI)	0.14 [-0.26, 0.54]
1.6 Cosmetic deformity: degrees of loss of carrying angle at long-term follow-up	8		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only

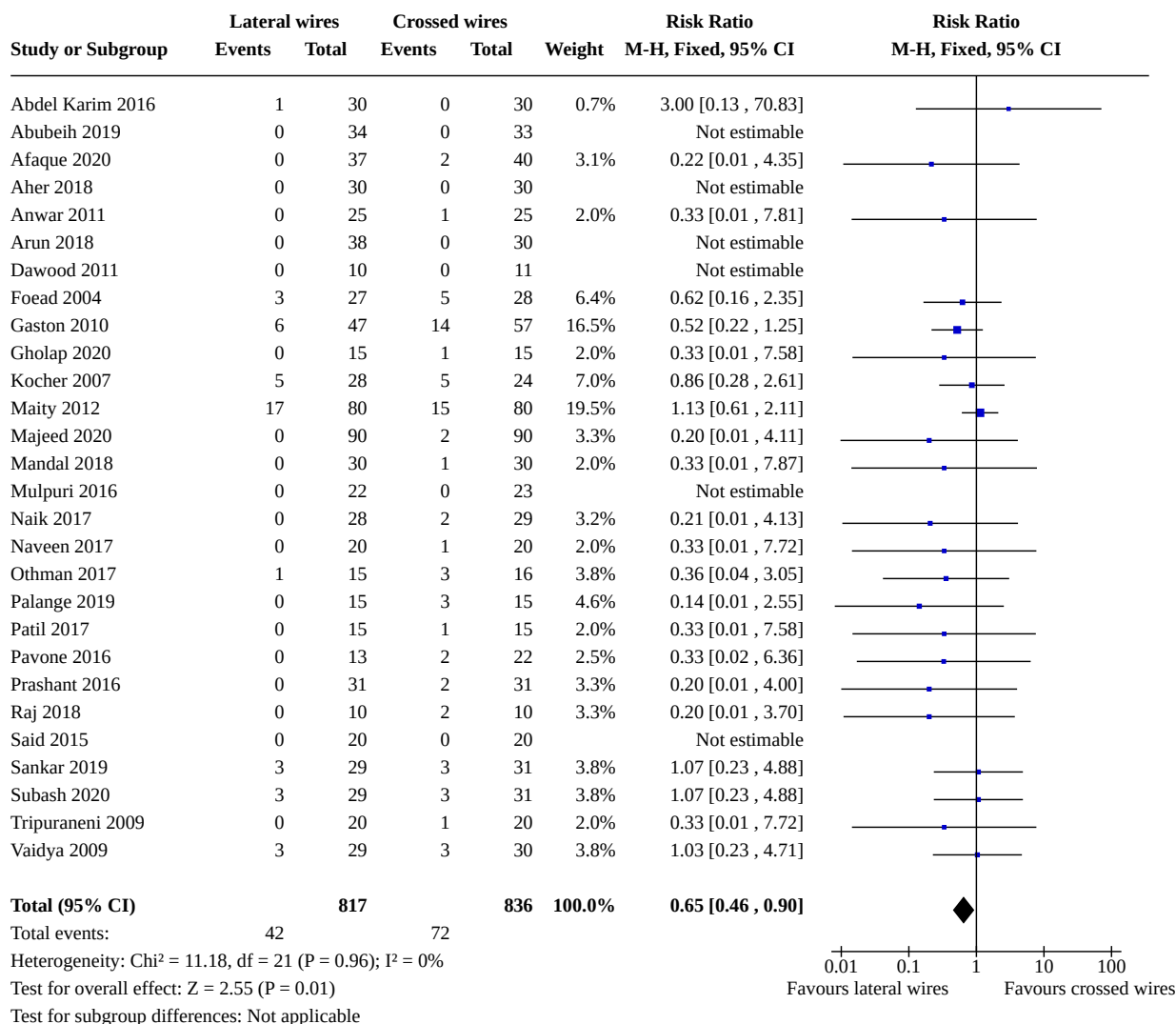
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.6.1 Medium-term loss of flexion	3	148	Risk Ratio (M-H, Fixed, 95% CI)	1.24 [0.37, 4.16]
1.6.2 Medium-term loss of extension	1	21	Risk Ratio (M-H, Fixed, 95% CI)	0.73 [0.15, 3.53]
1.6.3 Long-term loss of flexion	2	105	Risk Ratio (M-H, Fixed, 95% CI)	1.41 [0.84, 2.35]
1.6.4 Long-term loss of extension	2	105	Risk Ratio (M-H, Fixed, 95% CI)	0.85 [0.40, 1.80]
1.6.5 Long-term loss of total range of movement	3	148	Risk Ratio (M-H, Fixed, 95% CI)	1.26 [0.56, 2.82]
1.7 Range of motion: loss of movement	3		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
1.7.1 Long-term loss of elbow flexion	1	55	Mean Difference (IV, Fixed, 95% CI)	2.58 [-2.48, 7.64]
1.7.2 Long-term loss of elbow extension	1	55	Mean Difference (IV, Fixed, 95% CI)	-0.03 [-5.35, 5.29]
1.7.3 Long-term loss of total range of motion	2	92	Mean Difference (IV, Fixed, 95% CI)	0.71 [-0.52, 1.95]
1.8 Unable to return to sport and normal activities	5	246	Risk Ratio (M-H, Fixed, 95% CI)	0.91 [0.31, 2.69]
1.8.1 Medium term	3	151	Risk Ratio (M-H, Fixed, 95% CI)	1.23 [0.31, 4.83]
1.8.2 Long term	2	95	Risk Ratio (M-H, Fixed, 95% CI)	0.54 [0.08, 3.53]
1.9 Return to sport and normal activities: time to return to normal activities	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
1.10 Radiographic deformity: loss of reduction	10	761	Risk Ratio (M-H, Fixed, 95% CI)	1.67 [1.23, 2.26]
1.10.1 Early	1	200	Risk Ratio (M-H, Fixed, 95% CI)	1.37 [0.93, 2.00]
1.10.2 Medium term	7	469	Risk Ratio (M-H, Fixed, 95% CI)	2.00 [1.21, 3.30]
1.10.3 Long term	2	92	Risk Ratio (M-H, Fixed, 95% CI)	4.00 [0.46, 34.45]
1.11 Radiographic deformity: loss of radiographic angle	14		Mean Difference (IV, Fixed, 95% CI)	Subtotals only

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.11.1 Medium-term loss of Baumann's angle	7	447	Mean Difference (IV, Fixed, 95% CI)	0.06 [-0.22, 0.33]
1.11.2 Long-term loss of Baumann's angle	7	283	Mean Difference (IV, Fixed, 95% CI)	0.05 [-0.00, 0.11]
1.11.3 Medium-term loss of lateral humeral-capitellar angle	1	60	Mean Difference (IV, Fixed, 95% CI)	-0.20 [-2.86, 2.46]
1.11.4 Long-term loss of lateral humeral-capitellar angle	1	31	Mean Difference (IV, Fixed, 95% CI)	0.01 [-0.06, 0.08]
1.11.5 Long-term loss of humeral diaphyseal-metaphyseal angle	2	112	Mean Difference (IV, Fixed, 95% CI)	0.10 [-0.18, 0.39]
1.11.6 Long-term loss of humeral medial epicondylar epiphyseal angle	1	55	Mean Difference (IV, Fixed, 95% CI)	0.86 [-2.27, 3.99]
1.12 Resource use	3		Mean Difference (IV, Random, 95% CI)	Totals not selected
1.12.1 Operative time (minutes)	2		Mean Difference (IV, Random, 95% CI)	Totals not selected
1.12.2 Length of stay (days)	1		Mean Difference (IV, Random, 95% CI)	Totals not selected
1.13 Nerve injury: subgrouped according to technique for insertion of medial wire	21	1208	Risk Ratio (M-H, Fixed, 95% CI)	0.71 [0.49, 1.02]
1.13.1 Percutaneous crossed wires technique	10	552	Risk Ratio (M-H, Fixed, 95% CI)	0.41 [0.20, 0.81]
1.13.2 Open crossed wires technique	11	656	Risk Ratio (M-H, Fixed, 95% CI)	0.91 [0.59, 1.40]

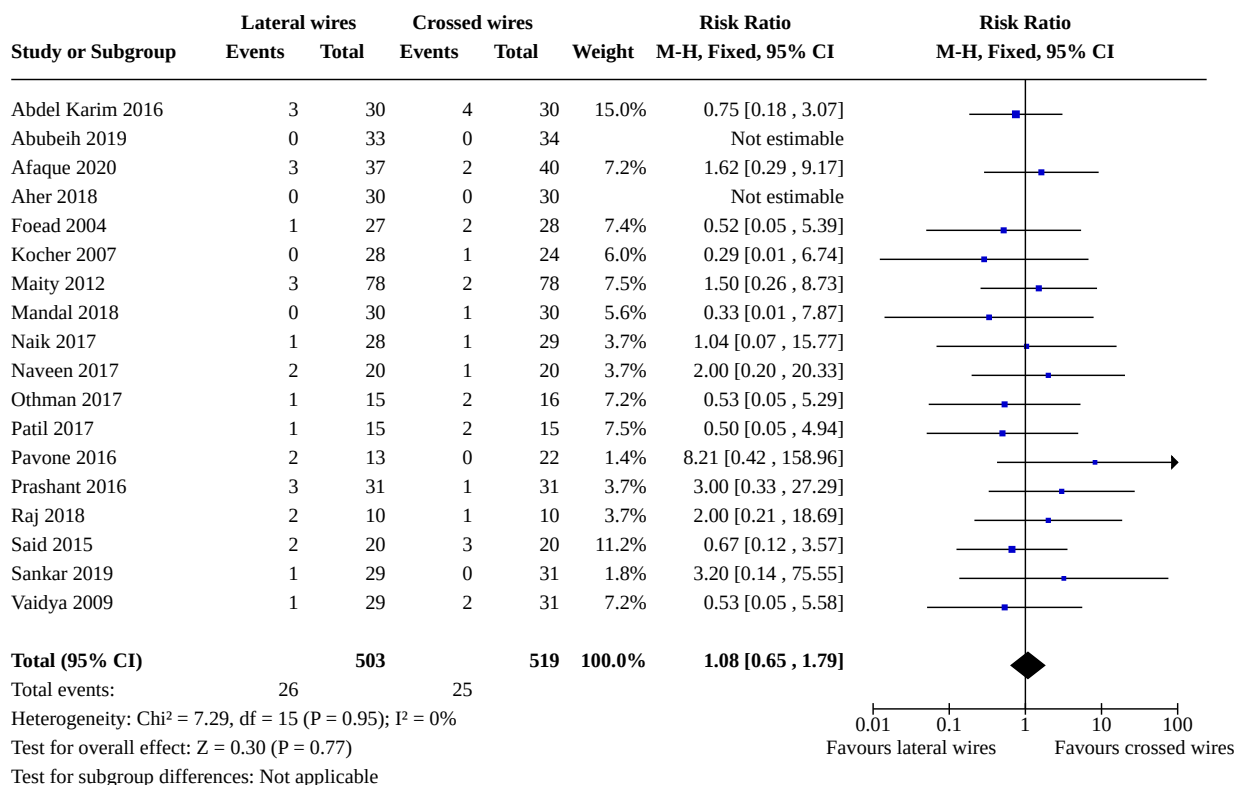
Analysis 1.1. Comparison 1: Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires, Outcome 1: Treatment failure requiring a re-intervention



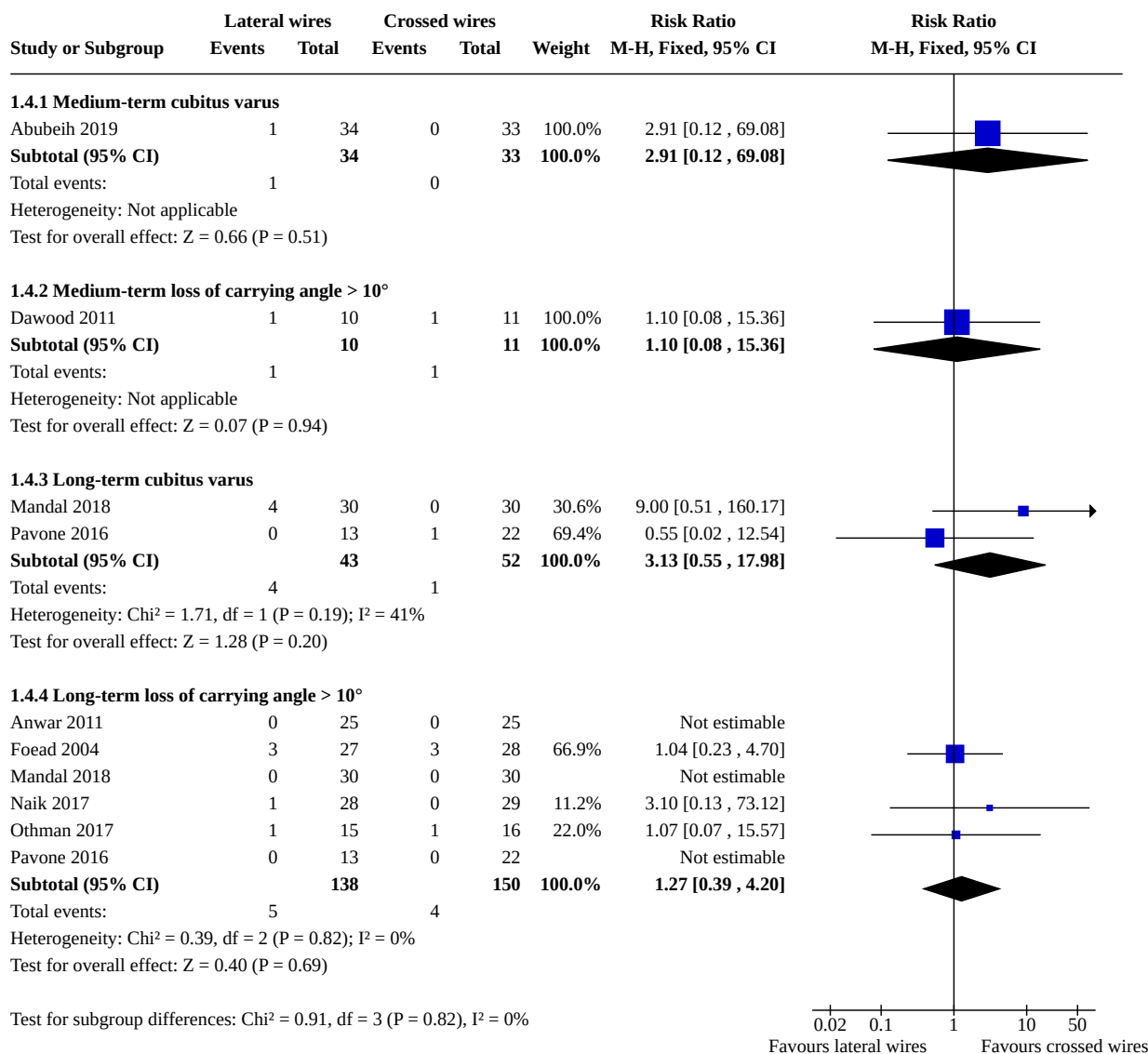
Analysis 1.2. Comparison 1: Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires, Outcome 2: Nerve injury



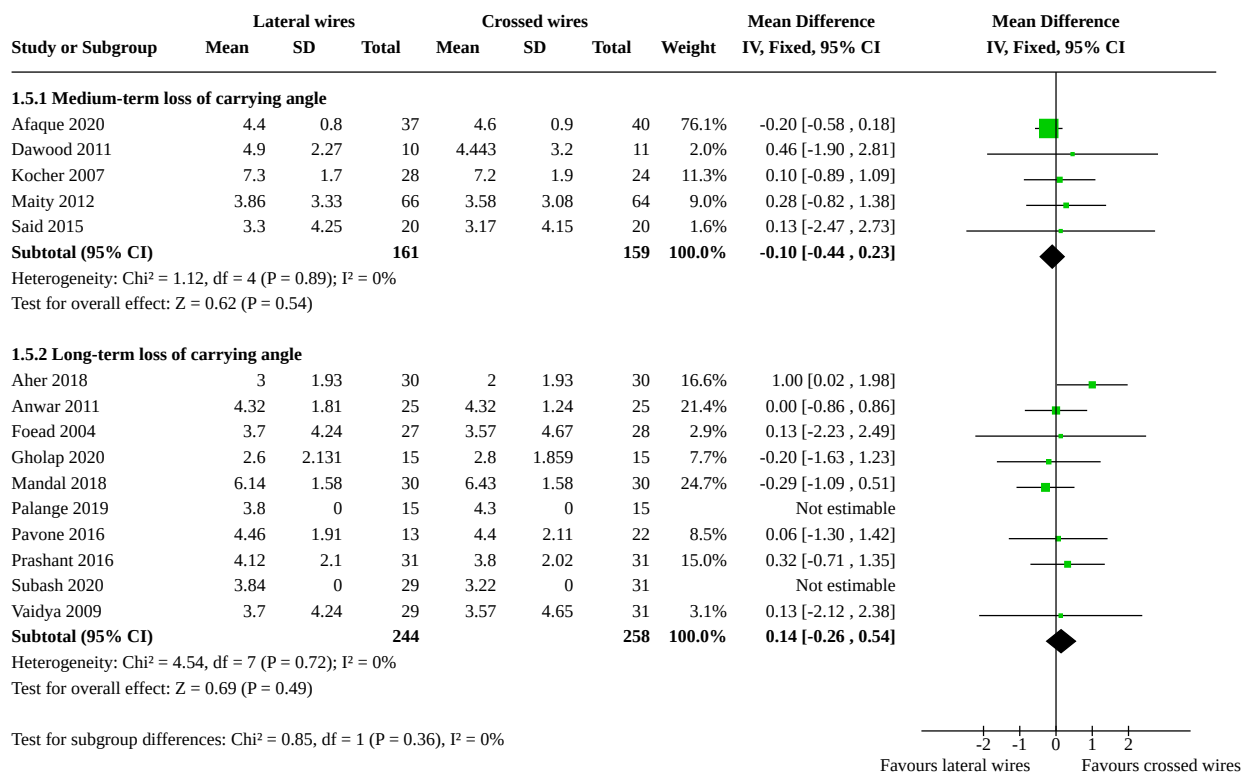
Analysis 1.3. Comparison 1: Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires, Outcome 3: Major complications (pin site infections)



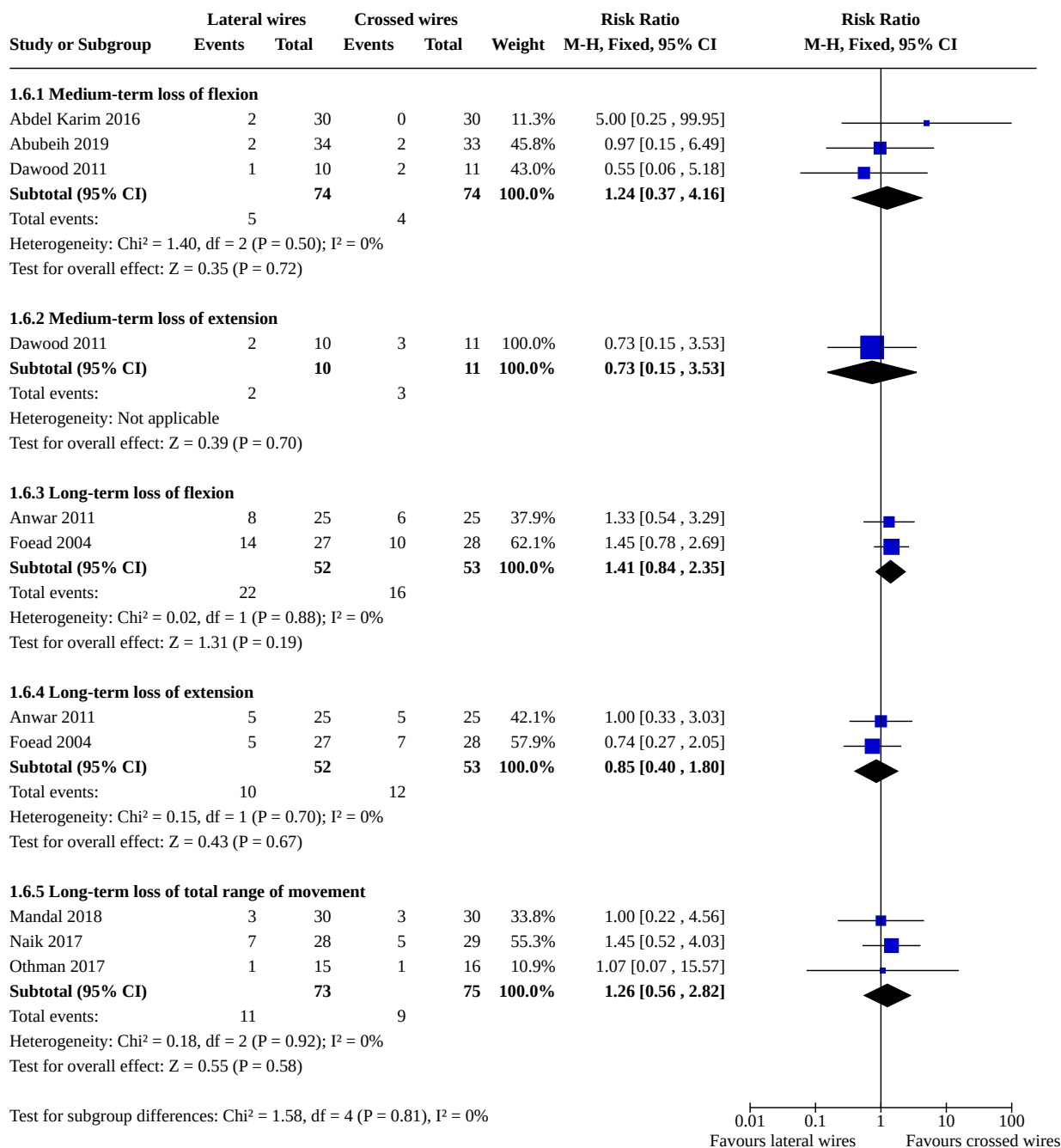
Analysis 1.4. Comparison 1: Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires, Outcome 4: Cosmetic deformity: loss of carrying angle > 10 degrees or elbow deformity



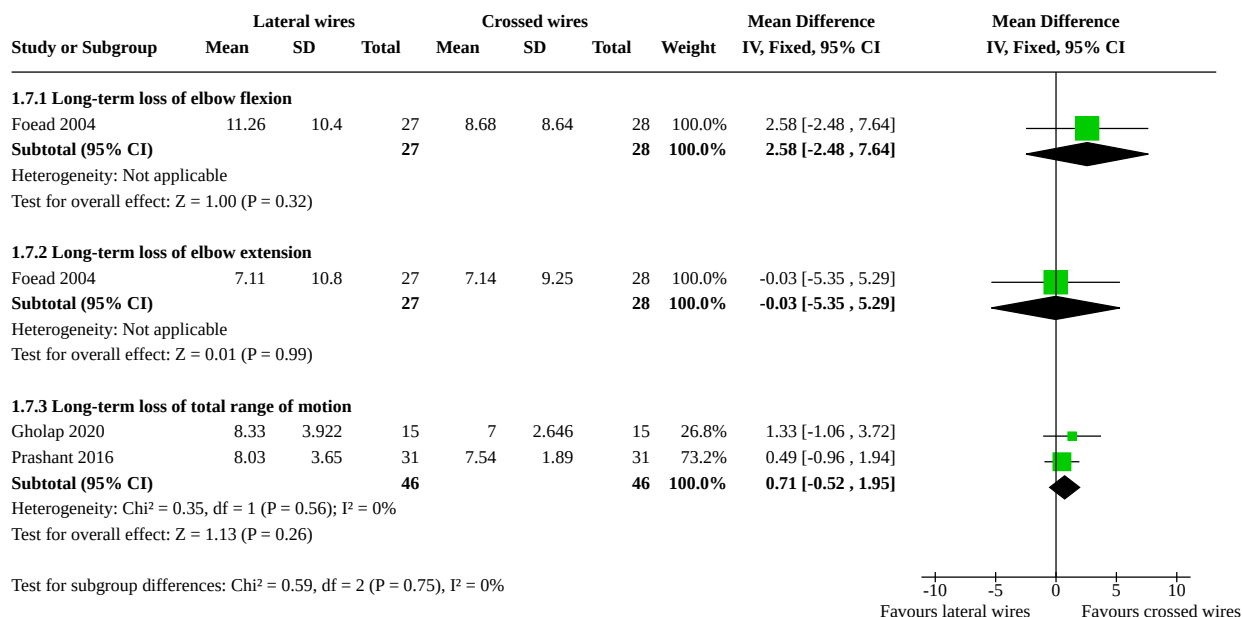
Analysis 1.5. Comparison 1: Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires, Outcome 5: Cosmetic deformity: loss of carrying angle (degrees of loss)



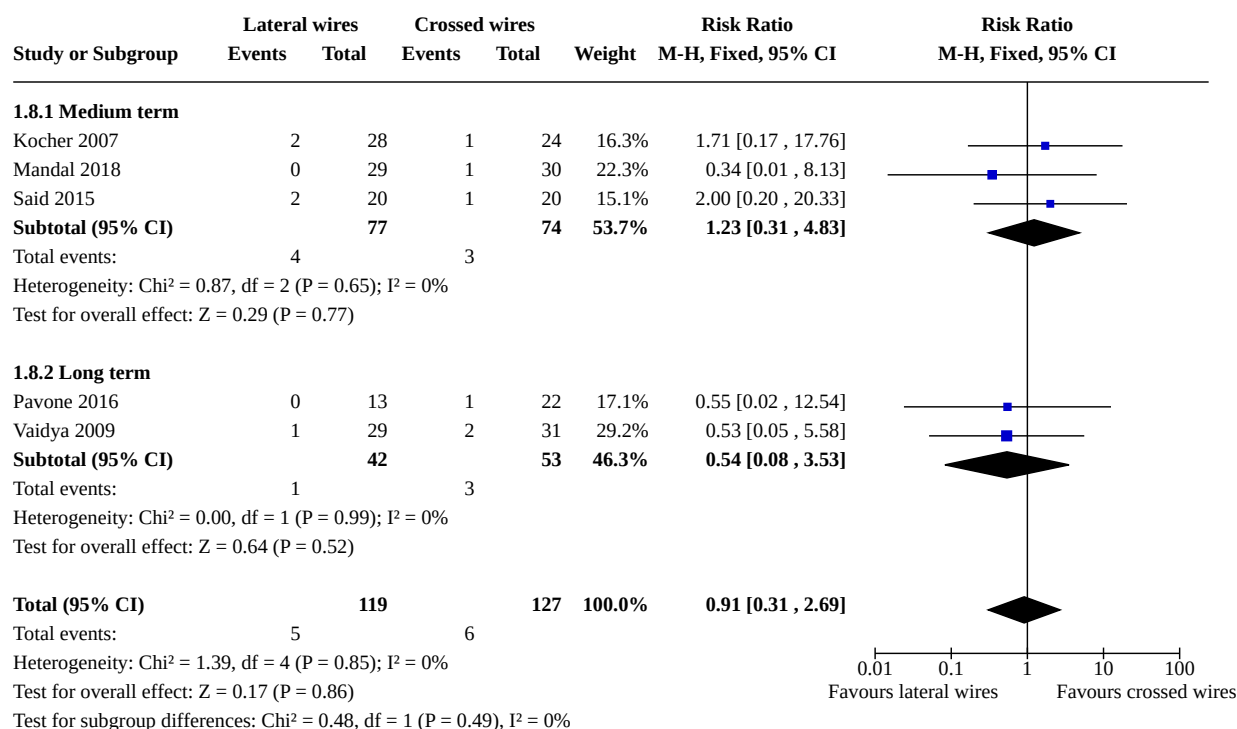
Analysis 1.6. Comparison 1: Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires, Outcome 6: Cosmetic deformity: degrees of loss of carrying angle at long-term follow-up



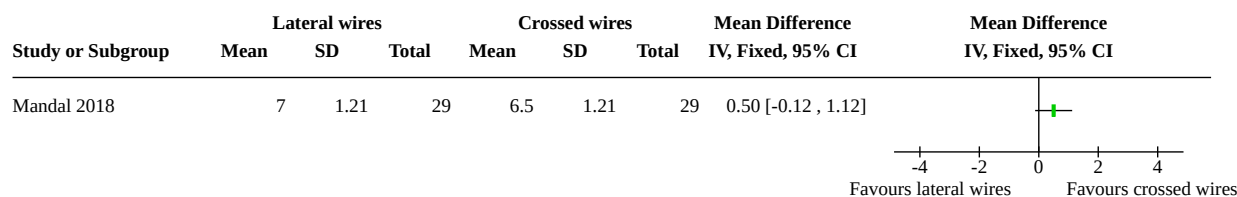
Analysis 1.7. Comparison 1: Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires, Outcome 7: Range of motion: loss of movement



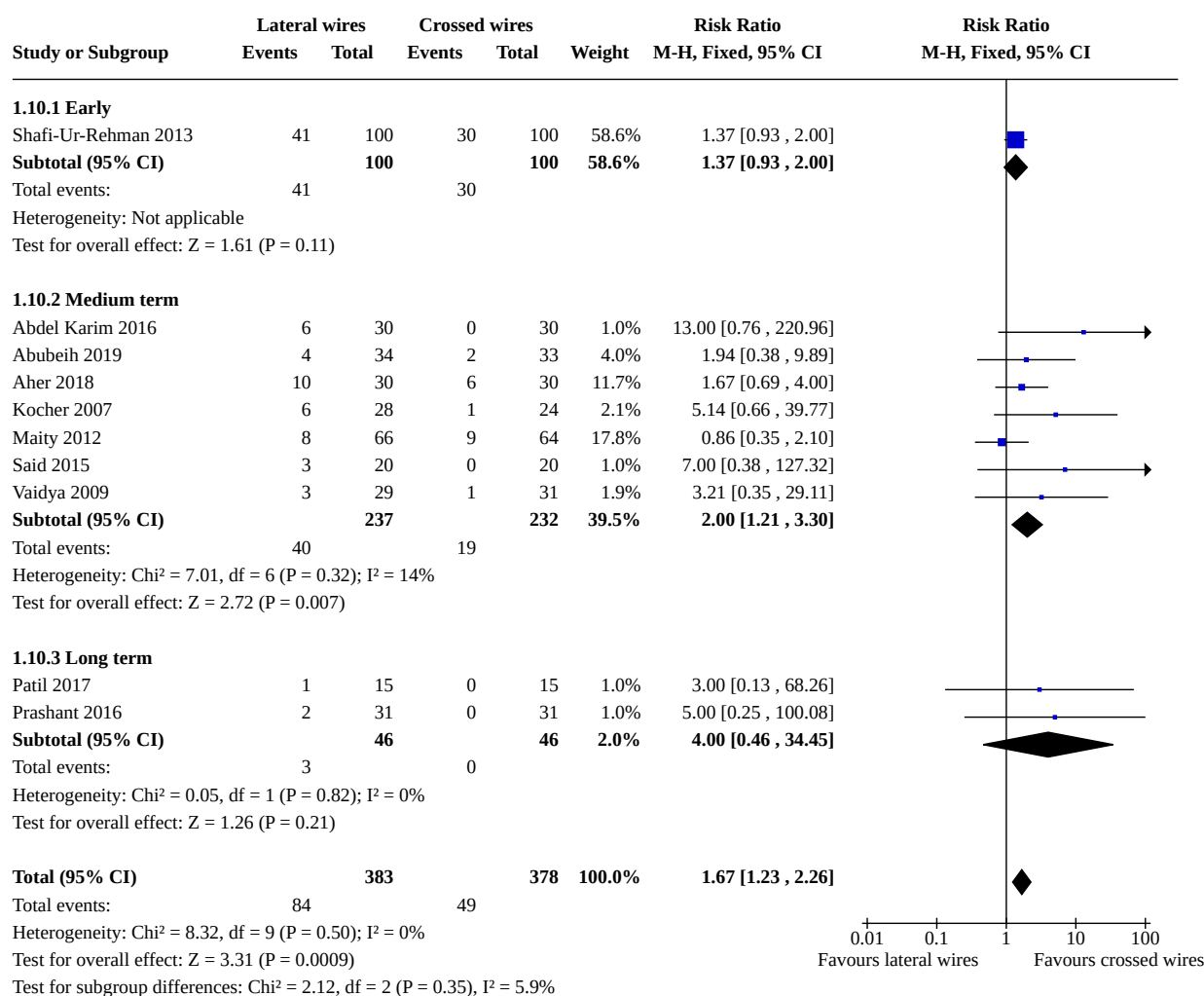
Analysis 1.8. Comparison 1: Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires, Outcome 8: Unable to return to sport and normal activities



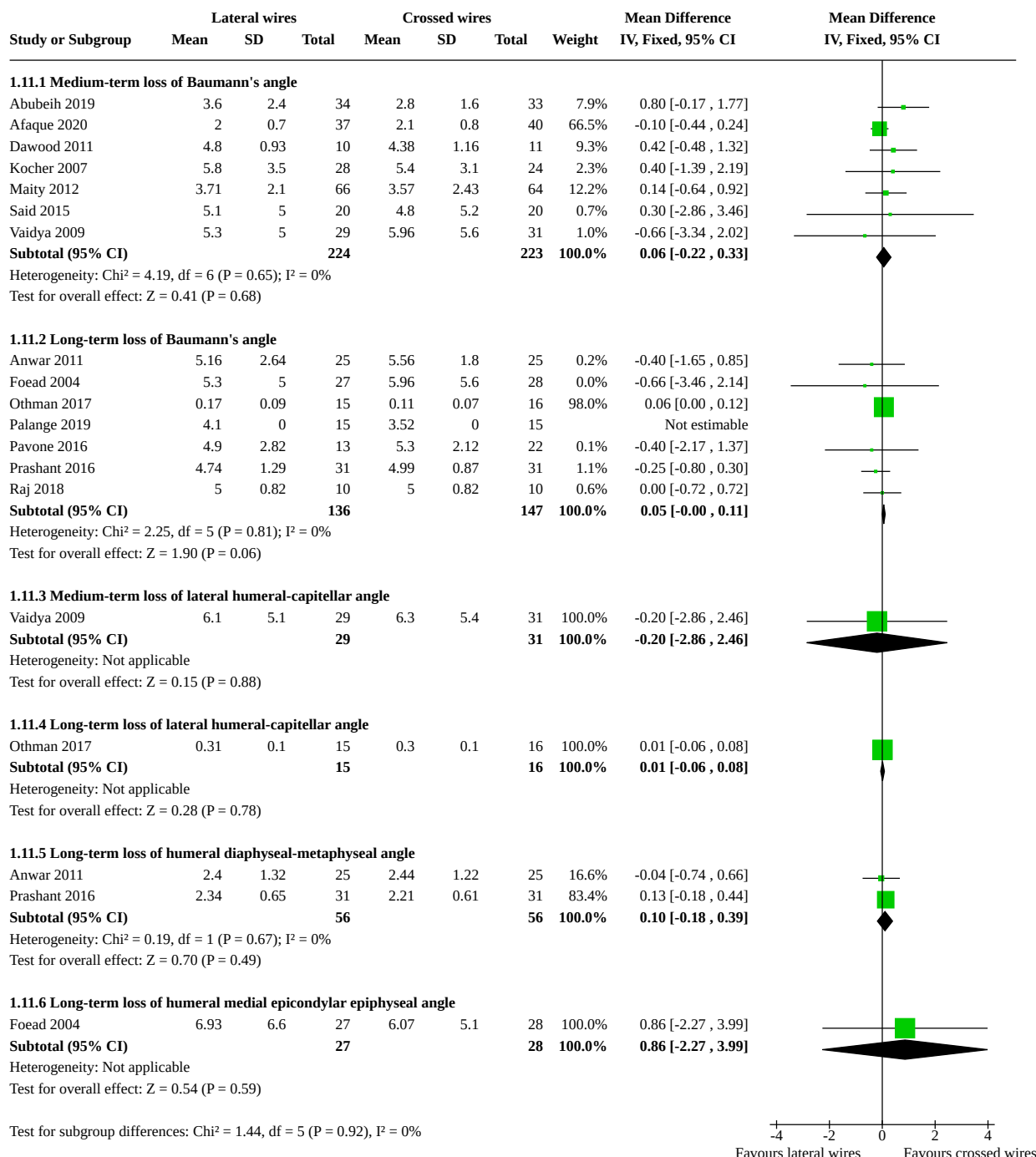
Analysis 1.9. Comparison 1: Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires, Outcome 9: Return to sport and normal activities: time to return to normal activities

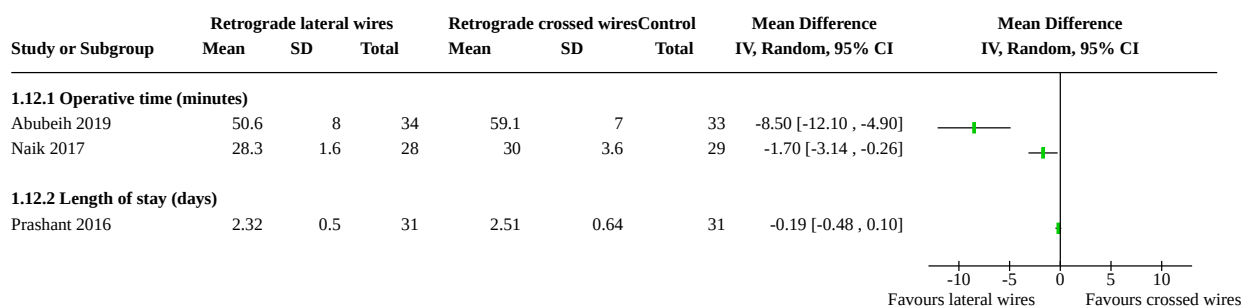
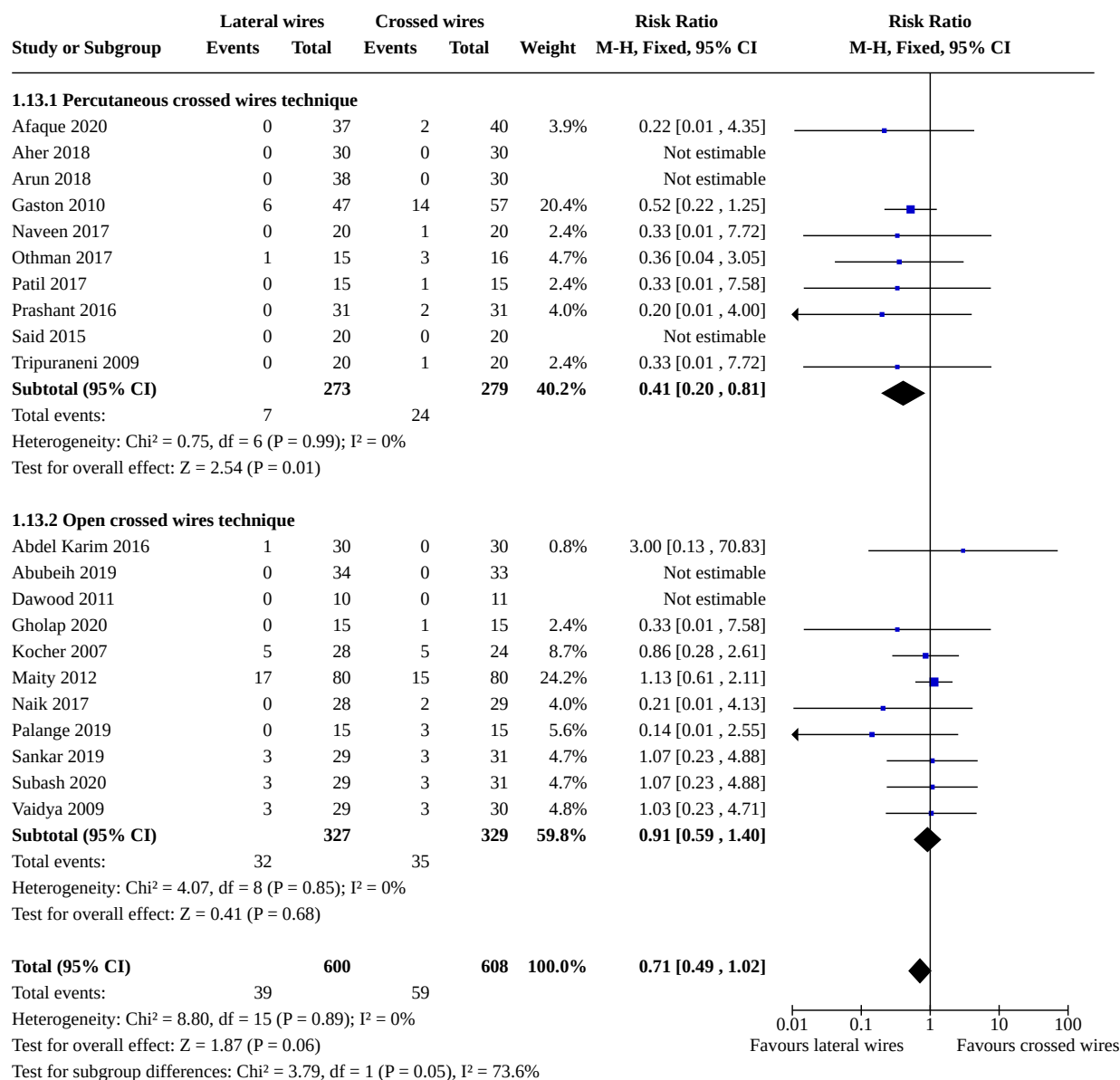


Analysis 1.10. Comparison 1: Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires, Outcome 10: Radiographic deformity: loss of reduction



Analysis 1.11. Comparison 1: Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires, Outcome 11: Radiographic deformity: loss of radiographic angle

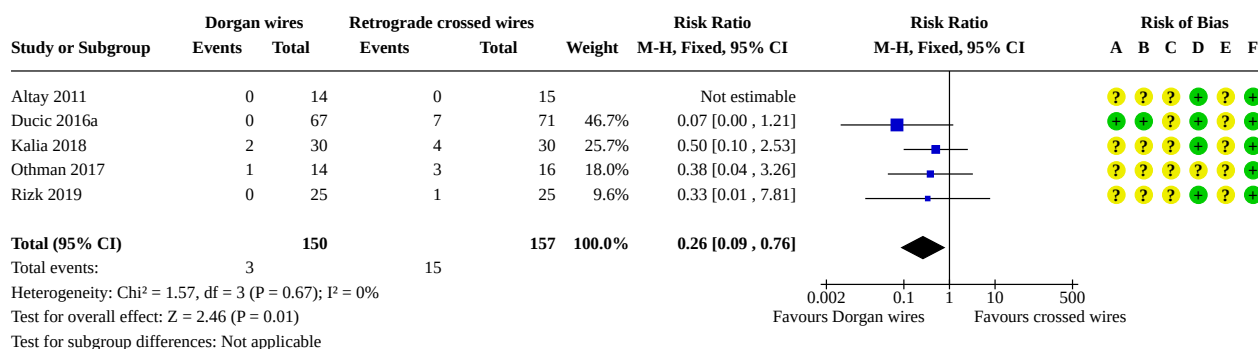


Analysis 1.12. Comparison 1: Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires, Outcome 12: Resource use**Analysis 1.13. Comparison 1: Different forms of surgical intervention: retrograde lateral wires versus retrograde crossed wires, Outcome 13: Nerve injury: subgrouped according to technique for insertion of medial wire**

Comparison 2. Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde crossed wires

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
2.1 Nerve injury	5	307	Risk Ratio (M-H, Fixed, 95% CI)	0.26 [0.09, 0.76]
2.2 Major complications	5		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only
2.2.1 All complications	5	307	Risk Ratio (M-H, Fixed, 95% CI)	1.94 [0.88, 4.30]
2.2.2 Pin site infections	5	307	Risk Ratio (M-H, Fixed, 95% CI)	2.51 [0.92, 6.82]
2.2.3 Vascular injuries	1	138	Risk Ratio (M-H, Fixed, 95% CI)	1.06 [0.28, 4.07]
2.3 Cosmetic deformity: loss of carrying angle > 10 degrees	3	218	Risk Ratio (M-H, Fixed, 95% CI)	1.35 [0.37, 4.85]
2.4 Cosmetic deformity: loss of carrying angle (degrees of loss)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.5 Range of motion: long-term loss of total range of motion > 10 degrees	3	218	Risk Ratio (M-H, Fixed, 95% CI)	1.14 [0.08, 16.63]
2.6 Radiographic deformity: long-term loss of radiographic angle	2		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
2.6.1 Long-term loss of Baumann's angle	2	80	Mean Difference (IV, Fixed, 95% CI)	0.04 [-0.01, 0.09]
2.6.2 Long-term loss of lateral humeral-capitellar angle	2	80	Mean Difference (IV, Fixed, 95% CI)	0.08 [0.00, 0.16]
2.7 Resource use	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.7.1 Operative time (minutes)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.7.2 Radiographic exposure time (minutes)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

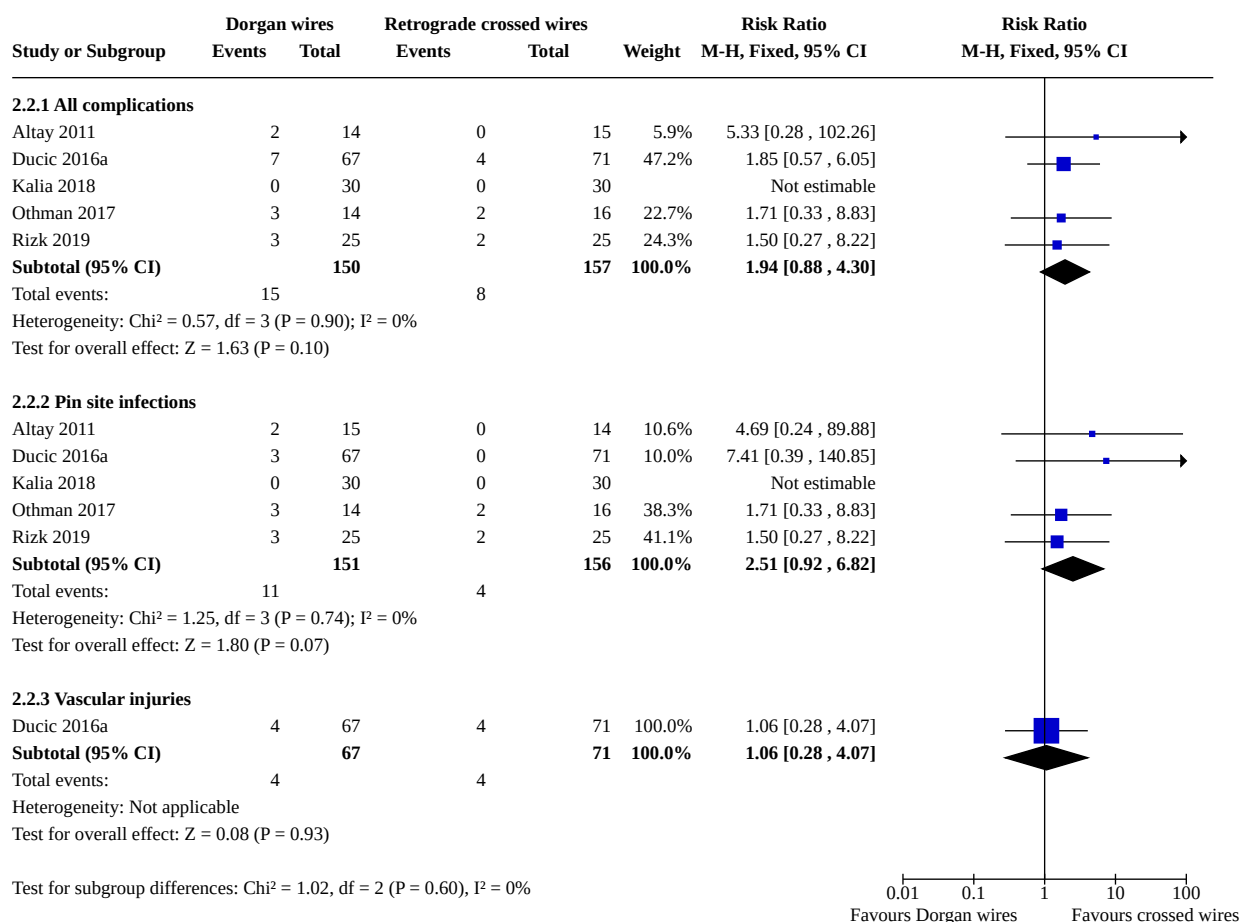
Analysis 2.1. Comparison 2: Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde crossed wires, Outcome 1: Nerve injury



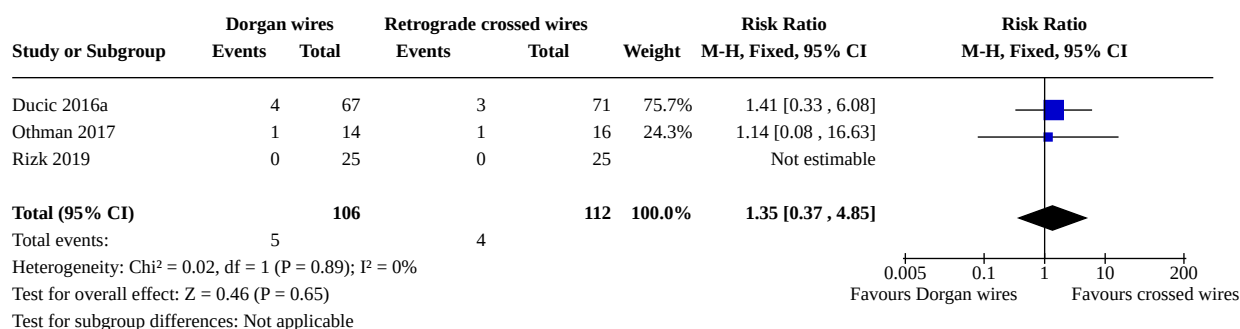
Risk of bias legend

- (A) Random sequence generation (selection bias)
- (B) Allocation concealment (selection bias)
- (C) Blinding of participants and personnel (performance bias)
- (D) Incomplete outcome data (attrition bias)
- (E) Selective reporting (reporting bias)
- (F) Other bias

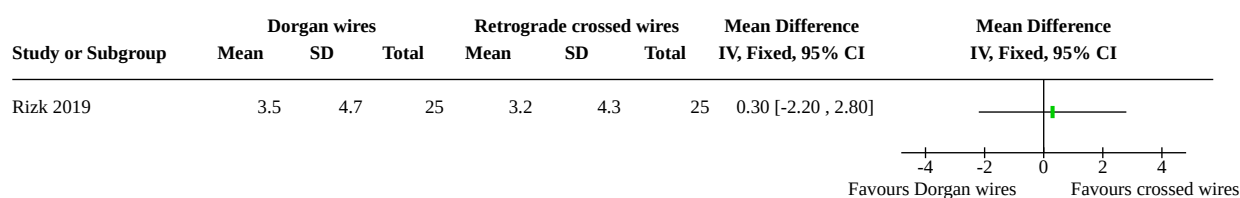
Analysis 2.2. Comparison 2: Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde crossed wires, Outcome 2: Major complications



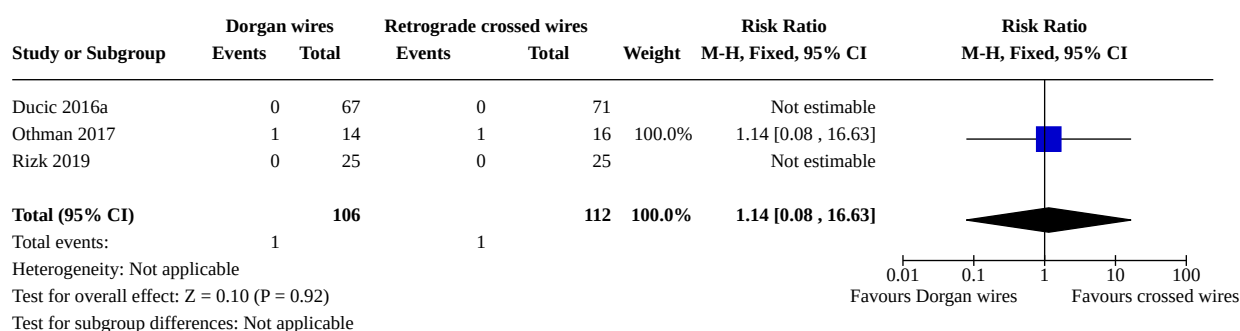
Analysis 2.3. Comparison 2: Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde crossed wires, Outcome 3: Cosmetic deformity: loss of carrying angle > 10 degrees

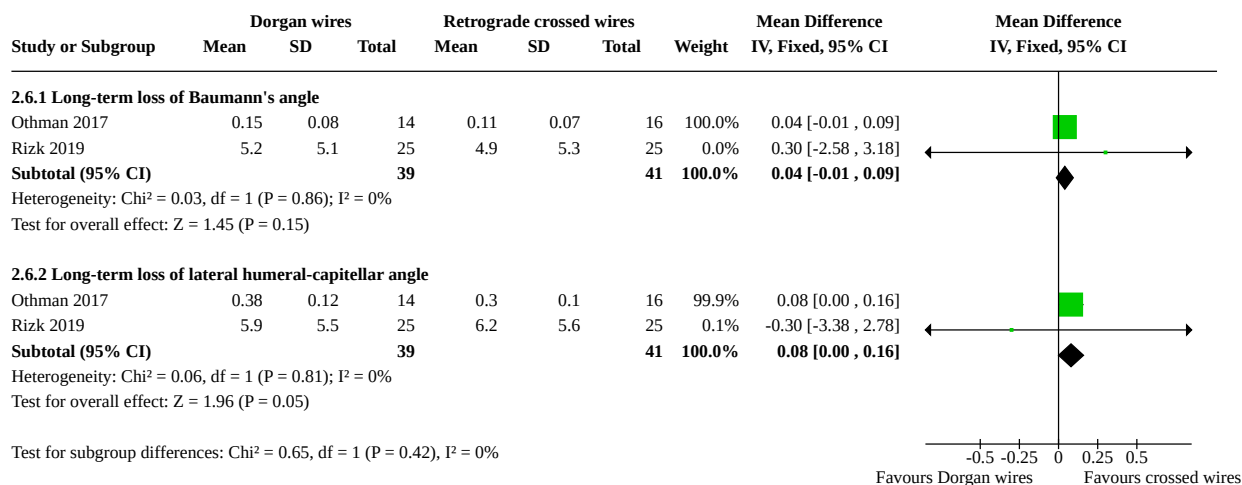
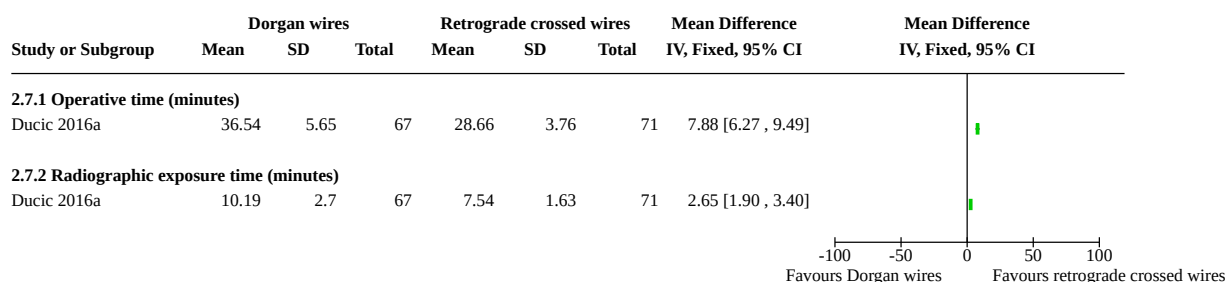


Analysis 2.4. Comparison 2: Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde crossed wires, Outcome 4: Cosmetic deformity: loss of carrying angle (degrees of loss)



Analysis 2.5. Comparison 2: Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde crossed wires, Outcome 5: Range of motion: long-term loss of total range of motion > 10 degrees

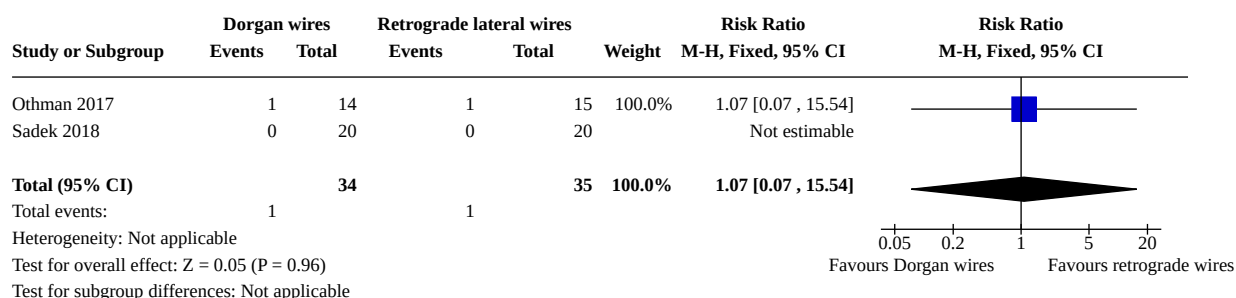


Analysis 2.6. Comparison 2: Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde crossed wires, Outcome 6: Radiographic deformity: long-term loss of radiographic angle**Analysis 2.7. Comparison 2: Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde crossed wires, Outcome 7: Resource use****Comparison 3. Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde lateral wires**

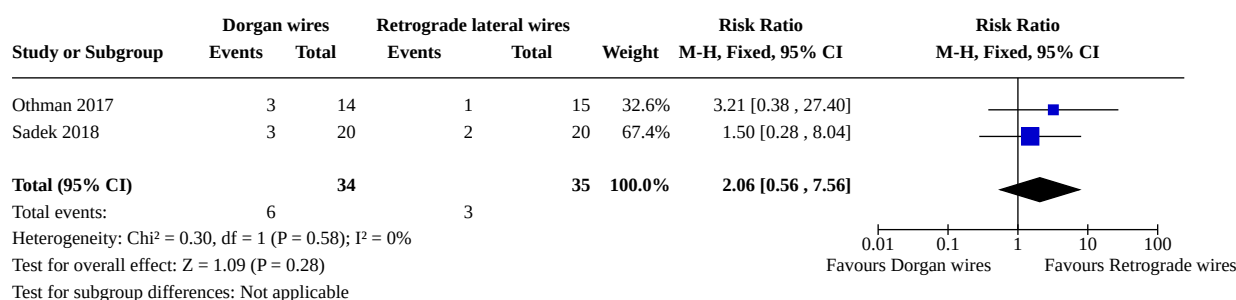
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
3.1 Nerve injury	2	69	Risk Ratio (M-H, Fixed, 95% CI)	1.07 [0.07, 15.54]
3.2 Major complications: pin site infections	2	69	Risk Ratio (M-H, Fixed, 95% CI)	2.06 [0.56, 7.56]
3.3 Cosmetic deformity: long-term loss of carrying angle > 10 degrees	2	69	Risk Ratio (M-H, Fixed, 95% CI)	0.68 [0.21, 2.15]
3.4 Range of motion: long-term loss of total range of motion > 10 degrees	2	69	Risk Ratio (M-H, Fixed, 95% CI)	0.72 [0.26, 2.00]
3.5 Radiographic deformity: long-term loss of Baumann's angle	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
3.6 Radiographic deformity: long-term loss of humeral-capitellar angle	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

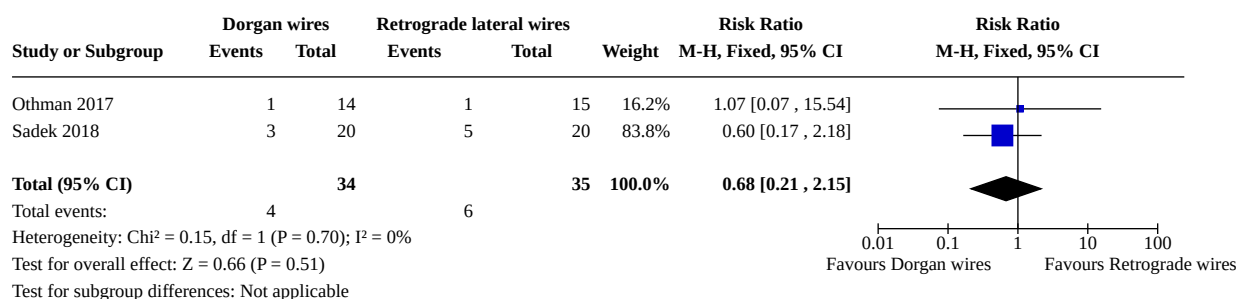
Analysis 3.1. Comparison 3: Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde lateral wires, Outcome 1: Nerve injury



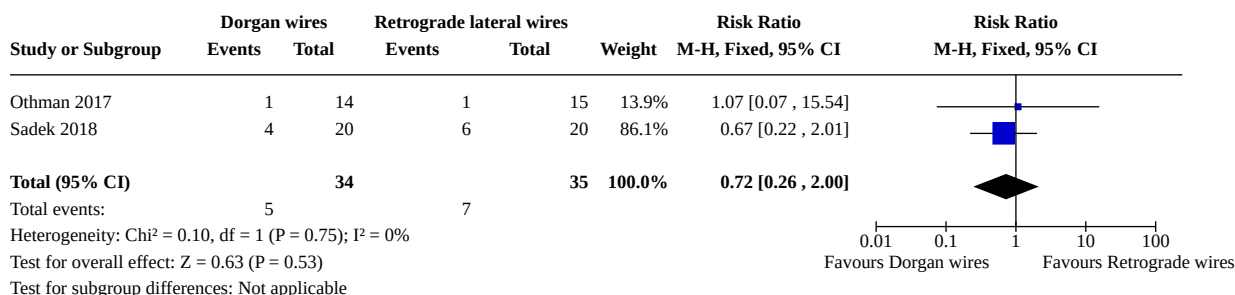
Analysis 3.2. Comparison 3: Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde lateral wires, Outcome 2: Major complications: pin site infections



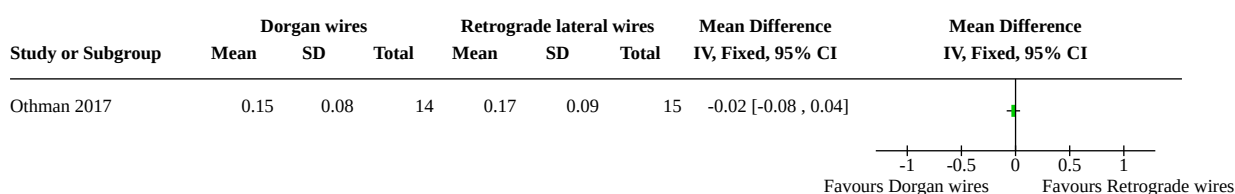
Analysis 3.3. Comparison 3: Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde lateral wires, Outcome 3: Cosmetic deformity: long-term loss of carrying angle > 10 degrees



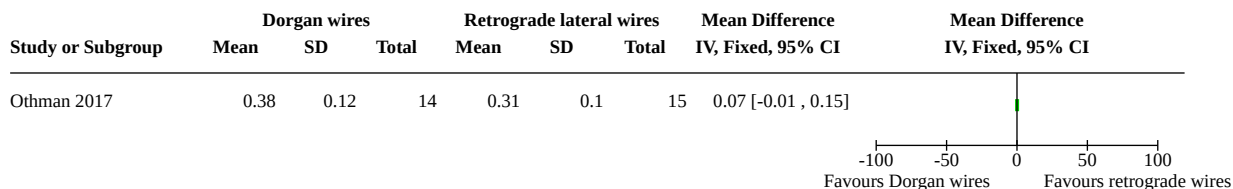
Analysis 3.4. Comparison 3: Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde lateral wires, Outcome 4: Range of motion: long-term loss of total range of motion > 10 degrees



Analysis 3.5. Comparison 3: Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde lateral wires, Outcome 5: Radiographic deformity: long-term loss of Baumann's angle



Analysis 3.6. Comparison 3: Different forms of surgical intervention: lateral crossed (Dorgan) wires versus retrograde lateral wires, Outcome 6: Radiographic deformity: long-term loss of humeral-capitellar angle

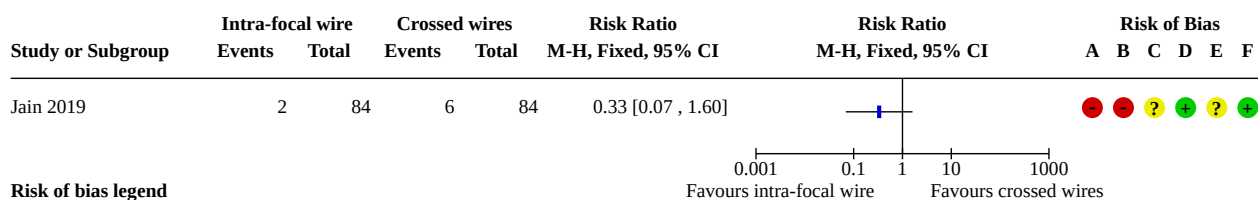


Comparison 4. Different forms of surgical intervention: posterior intrafocal wires versus retrograde crossed wires

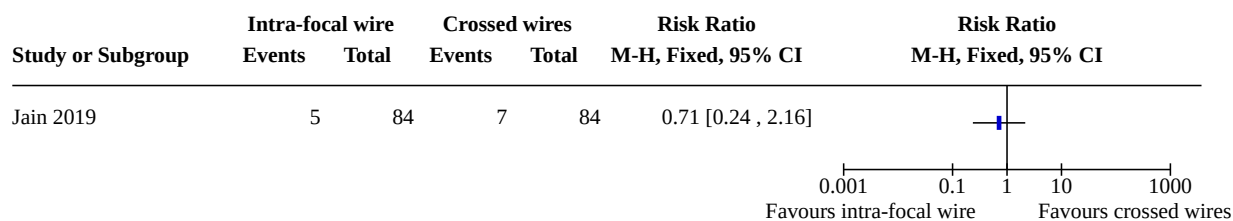
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
4.1 Nerve injury	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
4.2 Major complications (pin site infection)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
4.3 Cosmetic deformity: loss of carrying angle > 10 degrees or elbow deformity	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
4.3.1 Long-term loss of carrying angle	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
4.3.2 Long-term cubitus varus	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
4.4 Range of motion: loss of range of motion > 10 degrees at long-term follow-up	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
4.5 Radiographic deformity: loss of reduction at long-term follow-up	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected

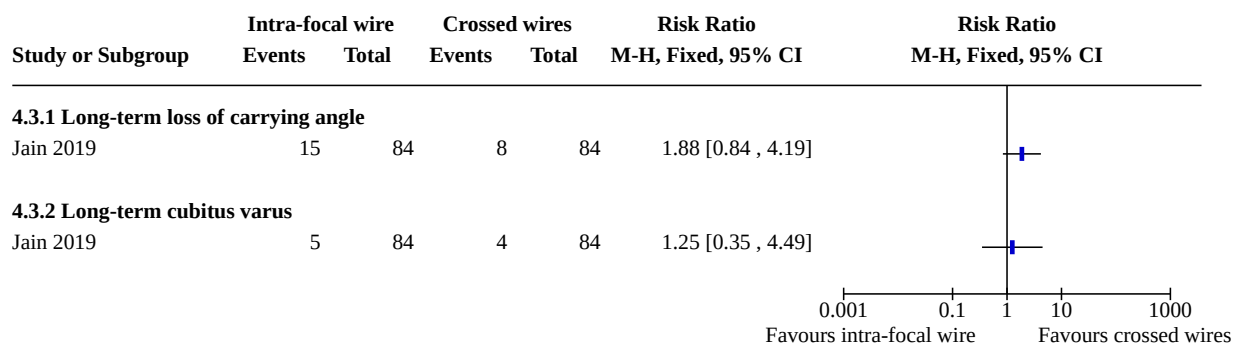
Analysis 4.1. Comparison 4: Different forms of surgical intervention: posterior intrafocal wires versus retrograde crossed wires, Outcome 1: Nerve injury



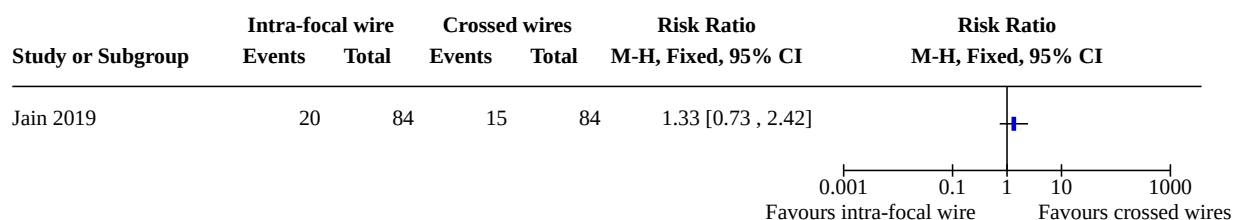
Analysis 4.2. Comparison 4: Different forms of surgical intervention: posterior intrafocal wires versus retrograde crossed wires, Outcome 2: Major complications (pin site infection)



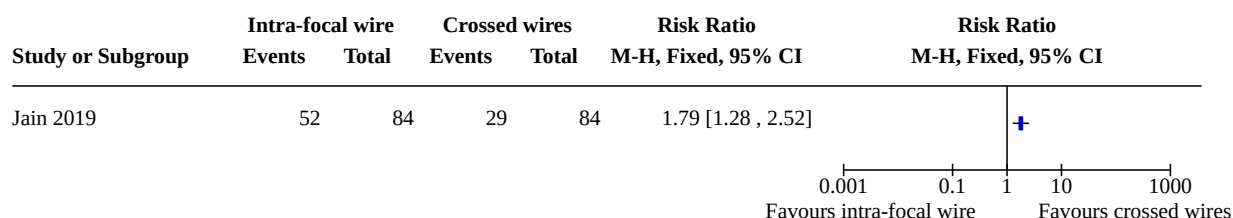
Analysis 4.3. Comparison 4: Different forms of surgical intervention: posterior intrafocal wires versus retrograde crossed wires, Outcome 3: Cosmetic deformity: loss of carrying angle > 10 degrees or elbow deformity



Analysis 4.4. Comparison 4: Different forms of surgical intervention: posterior intrafocal wires versus retrograde crossed wires, Outcome 4: Range of motion: loss of range of motion > 10 degrees at long-term follow-up



Analysis 4.5. Comparison 4: Different forms of surgical intervention: posterior intrafocal wires versus retrograde crossed wires, Outcome 5: Radiographic deformity: loss of reduction at long-term follow-up

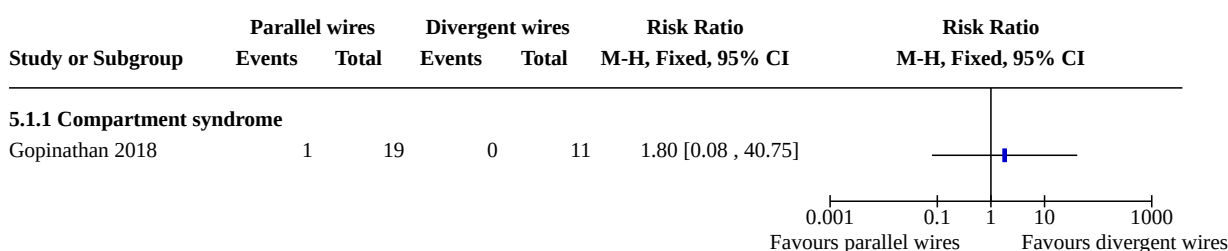


Comparison 5. Different forms of surgical intervention: retrograde lateral wires in a parallel versus divergent configuration

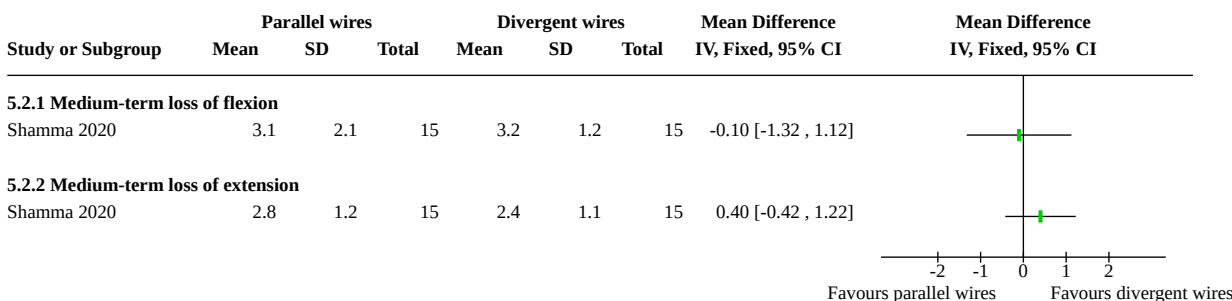
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
5.1 Major complications	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
5.1.1 Compartment syndrome	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
5.2 Range of movement: loss of movement	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
5.2.1 Medium-term loss of flexion	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5.2.2 Medium-term loss of extension	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5.3 Cosmetic deformity: medium-term loss of carrying angle	2	60	Mean Difference (IV, Fixed, 95% CI)	0.02 [-0.65, 0.69]
5.4 Range of motion: medium-term loss of flexion and extension	2	120	Risk Ratio (M-H, Fixed, 95% CI)	1.29 [0.32, 5.20]
5.4.1 Medium-term loss of flexion	2	60	Risk Ratio (M-H, Fixed, 95% CI)	0.87 [0.17, 4.42]
5.4.2 Medium-term loss of extension	2	60	Risk Ratio (M-H, Fixed, 95% CI)	3.00 [0.16, 57.36]
5.5 Radiographic deformity: medium-term loss of Baumann's angle	2	60	Mean Difference (IV, Fixed, 95% CI)	0.87 [-0.00, 1.75]

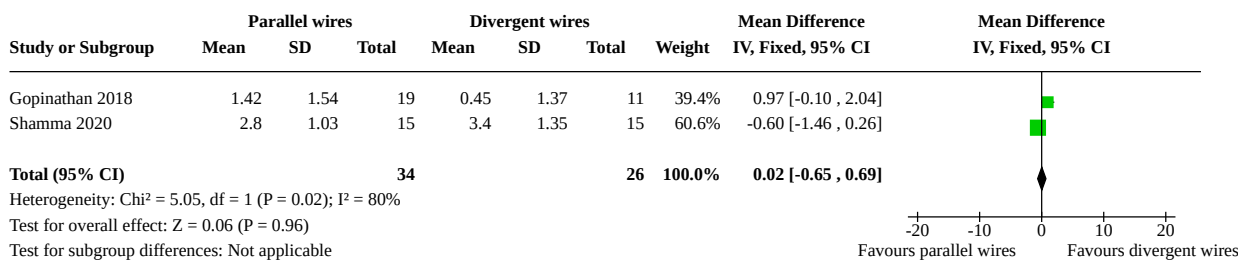
Analysis 5.1. Comparison 5: Different forms of surgical intervention: retrograde lateral wires in a parallel versus divergent configuration, Outcome 1: Major complications



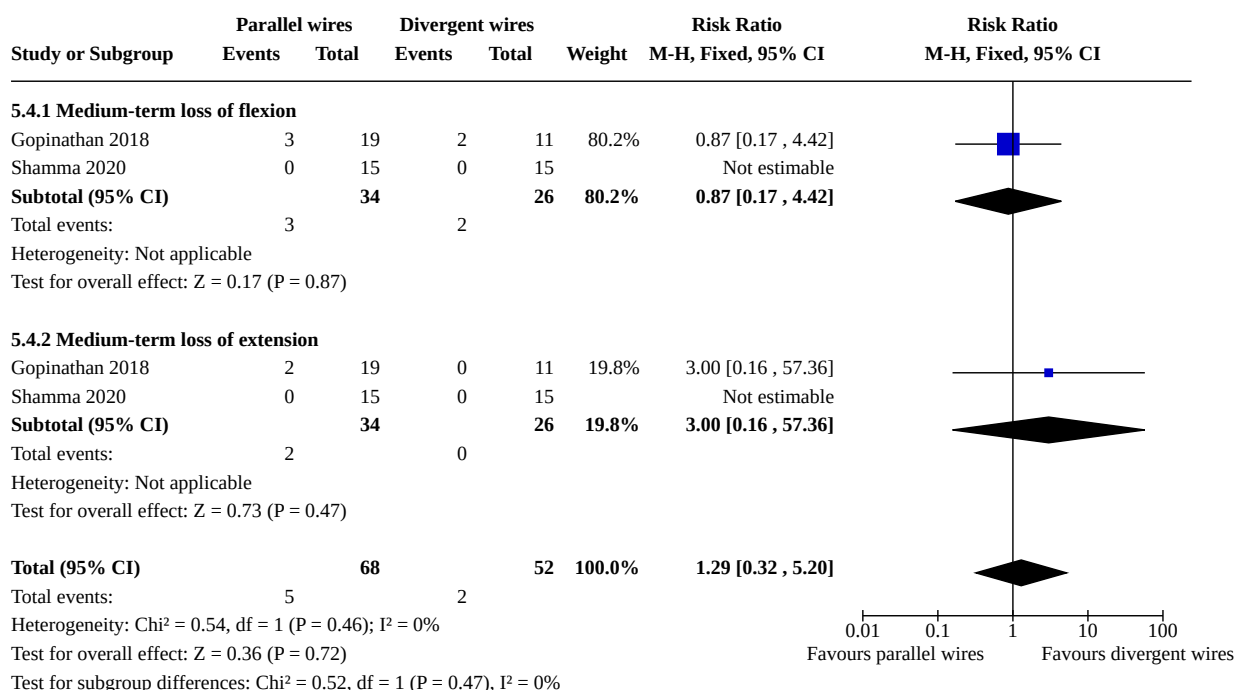
Analysis 5.2. Comparison 5: Different forms of surgical intervention: retrograde lateral wires in a parallel versus divergent configuration, Outcome 2: Range of movement: loss of movement



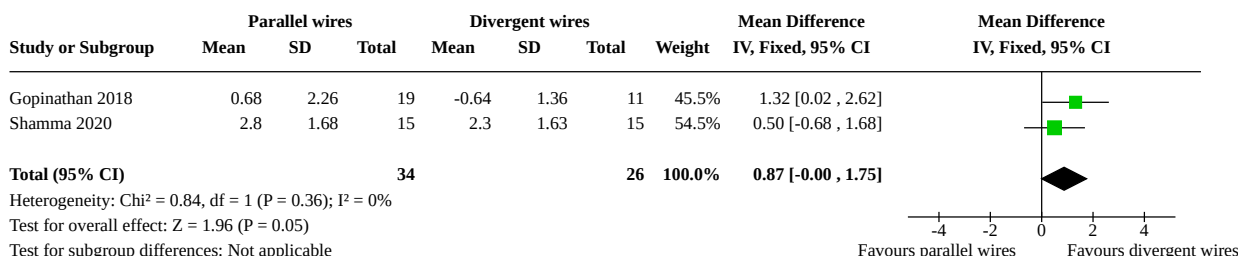
Analysis 5.3. Comparison 5: Different forms of surgical intervention: retrograde lateral wires in a parallel versus divergent configuration, Outcome 3: Cosmetic deformity: medium-term loss of carrying angle



Analysis 5.4. Comparison 5: Different forms of surgical intervention: retrograde lateral wires in a parallel versus divergent configuration, Outcome 4: Range of motion: medium-term loss of flexion and extension



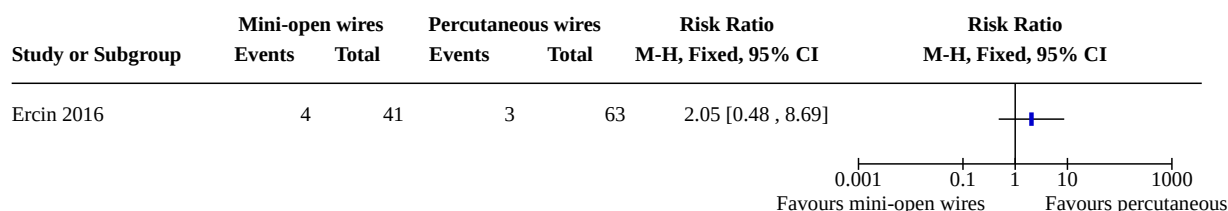
Analysis 5.5. Comparison 5: Different forms of surgical intervention: retrograde lateral wires in a parallel versus divergent configuration, Outcome 5: Radiographic deformity: medium-term loss of Baumann's angle



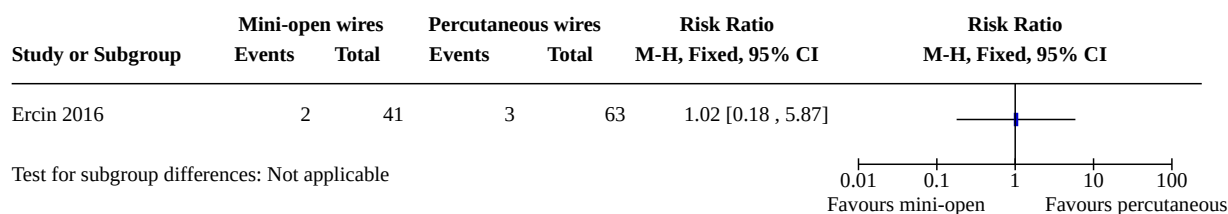
Comparison 6. Different forms of surgical intervention: mini-open crossed wires versus percutaneous crossed wires

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
6.1 Nerve injury	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
6.2 Major complications	1		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only
6.3 Resource use	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
6.3.1 Length of hospital stay (days)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
6.3.2 Anaesthesia time	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

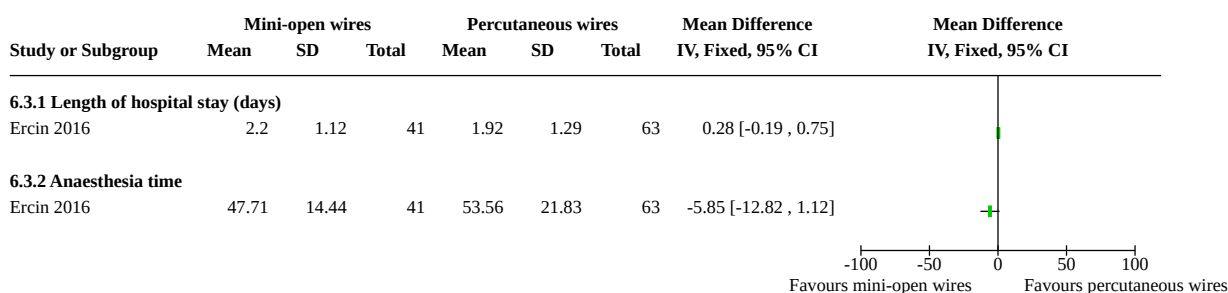
Analysis 6.1. Comparison 6: Different forms of surgical intervention: mini-open crossed wires versus percutaneous crossed wires, Outcome 1: Nerve injury



Analysis 6.2. Comparison 6: Different forms of surgical intervention: mini-open crossed wires versus percutaneous crossed wires, Outcome 2: Major complications



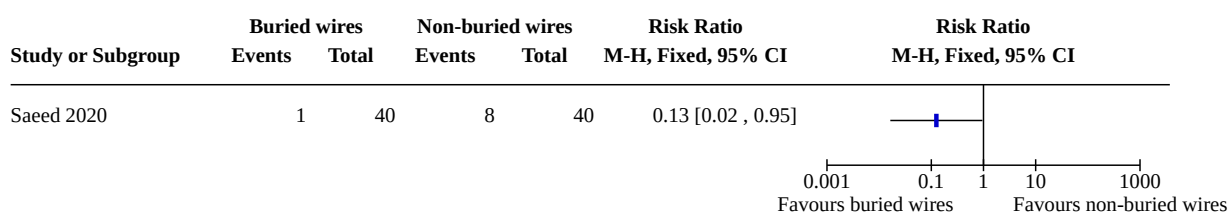
Analysis 6.3. Comparison 6: Different forms of surgical intervention: mini-open crossed wires versus percutaneous crossed wires, Outcome 3: Resource use



Comparison 7. Different forms of surgical intervention: buried versus non-buried wires

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
7.1 Major complications: pin site infections	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected

Analysis 7.1. Comparison 7: Different forms of surgical intervention: buried versus non-buried wires, Outcome 1: Major complications: pin site infections

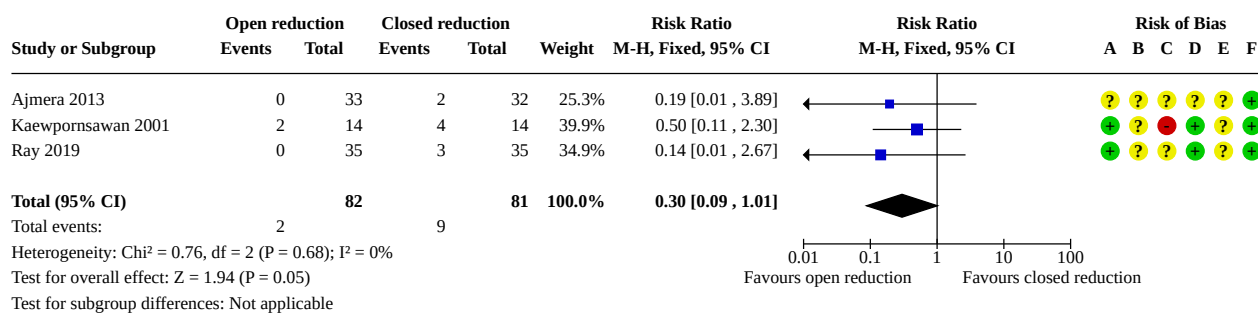


Comparison 8. Different forms of surgical intervention: open versus closed reduction of displaced fractures

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
8.1 Nerve injury	3	163	Risk Ratio (M-H, Fixed, 95% CI)	0.30 [0.09, 1.01]
8.2 Major complications: pin site infections	5		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only
8.2.1 Direct visualisation	4	253	Risk Ratio (M-H, Fixed, 95% CI)	4.15 [1.07, 16.20]
8.2.2 Joystick	1	59	Risk Ratio (M-H, Fixed, 95% CI)	1.10 [0.20, 6.12]
8.3 Cosmetic deformity: loss of carrying angle > 10 degrees or elbow deformity (medium- and long-term)	2		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
8.3.1 Medium-term cubitus varus	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
8.3.2 Medium-term loss of carrying angle	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
8.3.3 Long-term cubitus varus	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
8.4 Cosmetic deformity: loss of carrying angle in the long term (degrees of loss)	1		Mean Difference (IV, Fixed, 95% CI)	Subtotals only

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
8.5 Range of movement: loss of total range of movement > 10 degrees at medium term	2	93	Risk Ratio (M-H, Fixed, 95% CI)	3.20 [1.05, 9.77]
8.6 Range of movement: loss of range of movement at long-term follow-up	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8.7 Patient satisfaction with scar appearance (higher scores indicates more satisfaction)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8.7.1 Patient reported score	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8.7.2 Blinded assessor score	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8.8 Radiographic deformity: difference in Baumann's angle (medium and long term)	2		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8.8.1 Medium-term loss of Baumann's angle	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8.8.2 Long-term loss of Baumann's angle	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8.9 Radiographic deformity: capitellum posterior to anterior humeral line at late follow-up	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
8.10 Resource use	2		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8.10.1 Operative time (minutes); direct visualisation	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8.10.2 Length of hospital stay (days); direct visualisation	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8.10.3 Operative time (minutes); joystick technique	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8.10.4 Length of hospital stay (days); joystick technique	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

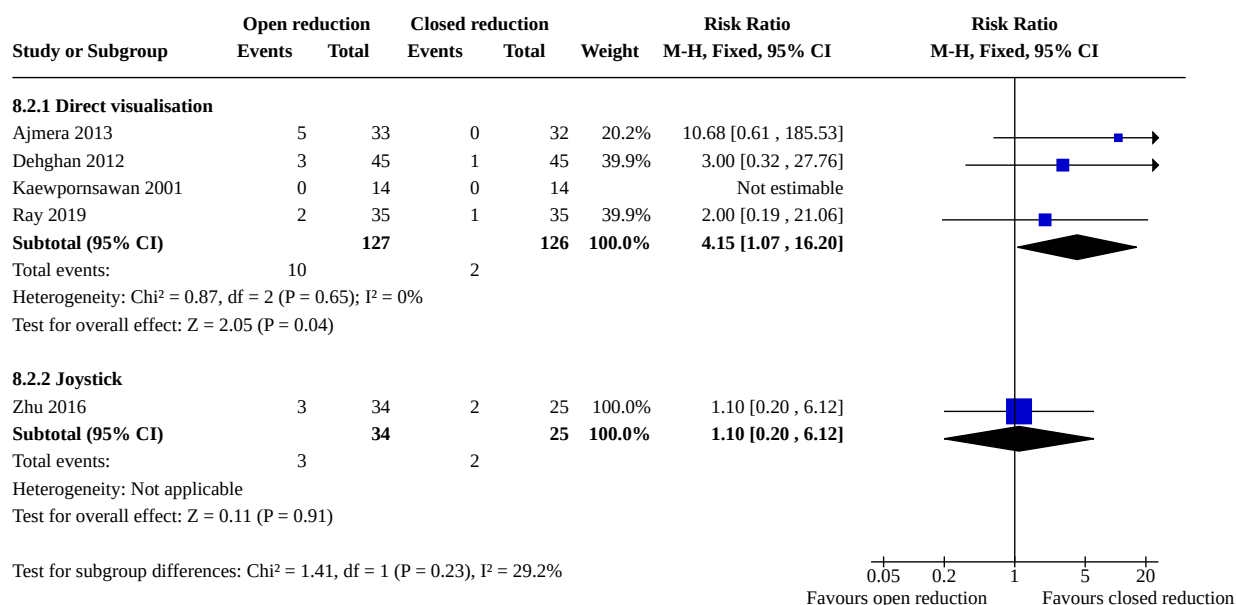
Analysis 8.1. Comparison 8: Different forms of surgical intervention: open versus closed reduction of displaced fractures, Outcome 1: Nerve injury



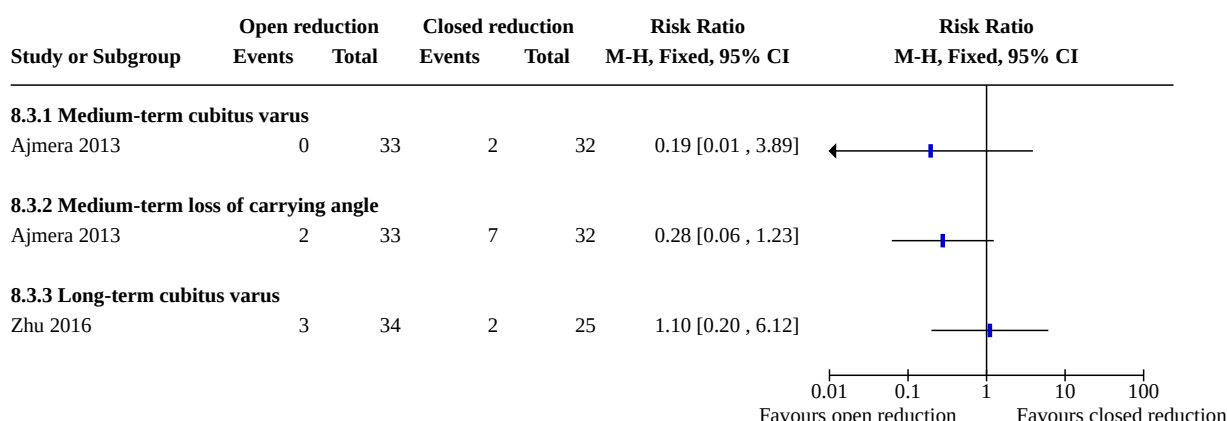
Risk of bias legend

- (A) Random sequence generation (selection bias)
- (B) Allocation concealment (selection bias)
- (C) Blinding of participants and personnel (performance bias)
- (D) Incomplete outcome data (attrition bias)
- (E) Selective reporting (reporting bias)
- (F) Other bias

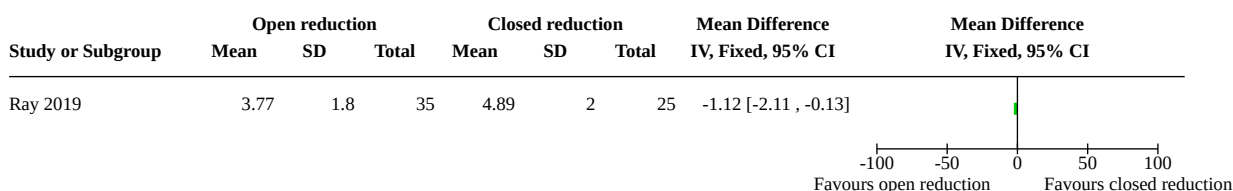
Analysis 8.2. Comparison 8: Different forms of surgical intervention: open versus closed reduction of displaced fractures, Outcome 2: Major complications: pin site infections



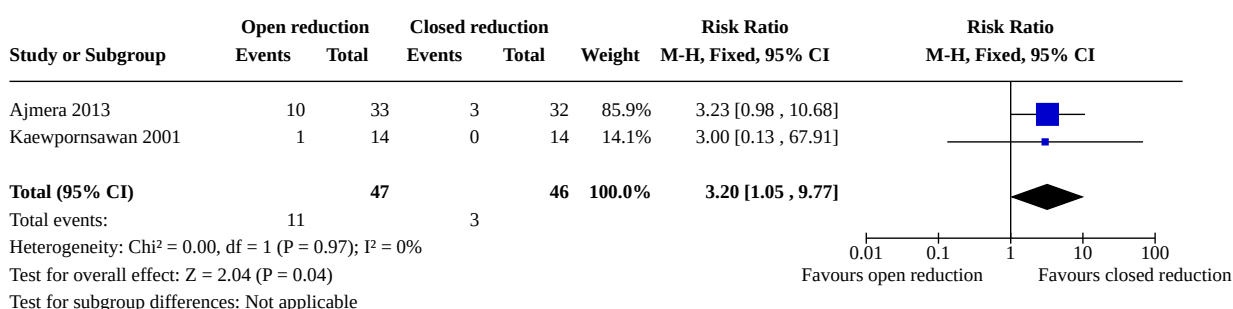
Analysis 8.3. Comparison 8: Different forms of surgical intervention: open versus closed reduction of displaced fractures, Outcome 3: Cosmetic deformity: loss of carrying angle > 10 degrees or elbow deformity (medium- and long-term)



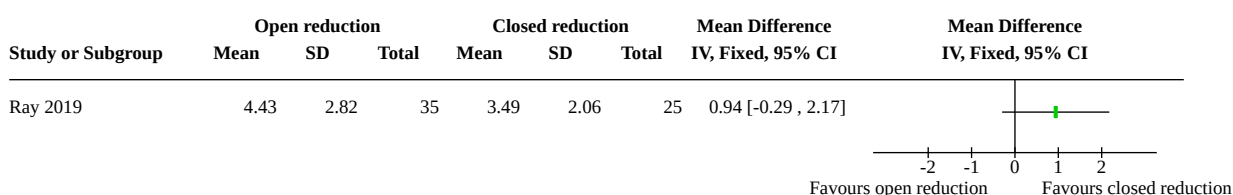
Analysis 8.4. Comparison 8: Different forms of surgical intervention: open versus closed reduction of displaced fractures, Outcome 4: Cosmetic deformity: loss of carrying angle in the long term (degrees of loss)

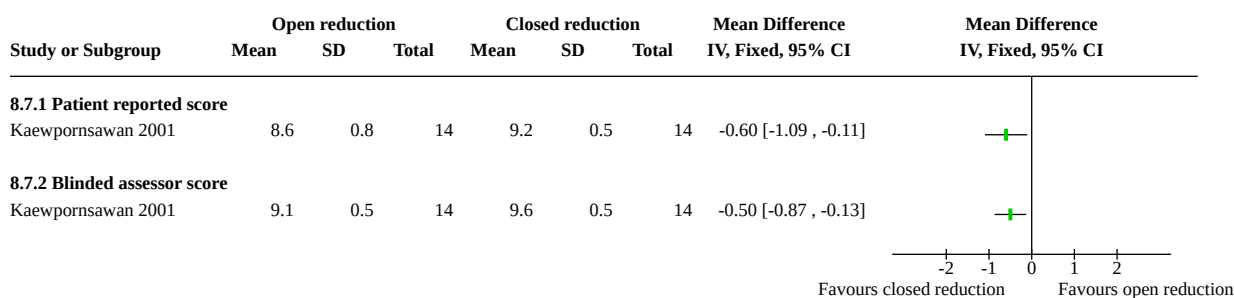
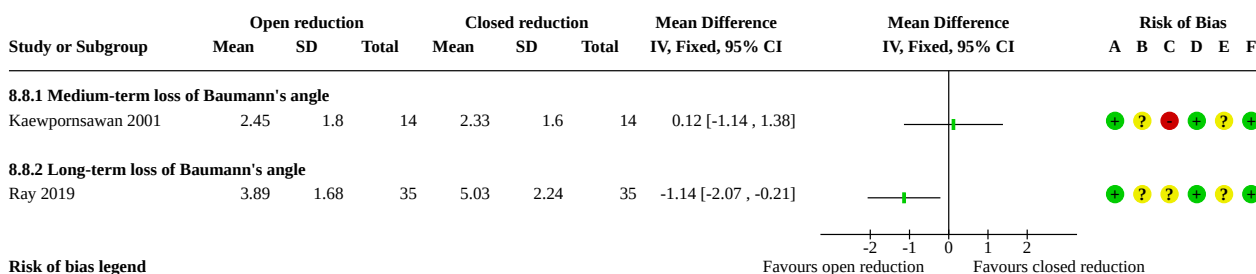


Analysis 8.5. Comparison 8: Different forms of surgical intervention: open versus closed reduction of displaced fractures, Outcome 5: Range of movement: loss of total range of movement > 10 degrees at medium term

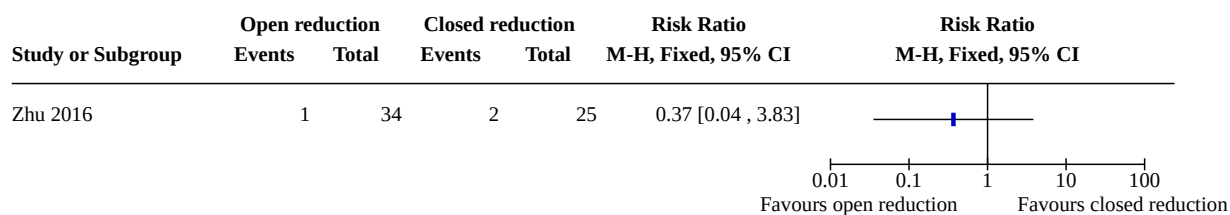


Analysis 8.6. Comparison 8: Different forms of surgical intervention: open versus closed reduction of displaced fractures, Outcome 6: Range of movement: loss of range of movement at long-term follow-up

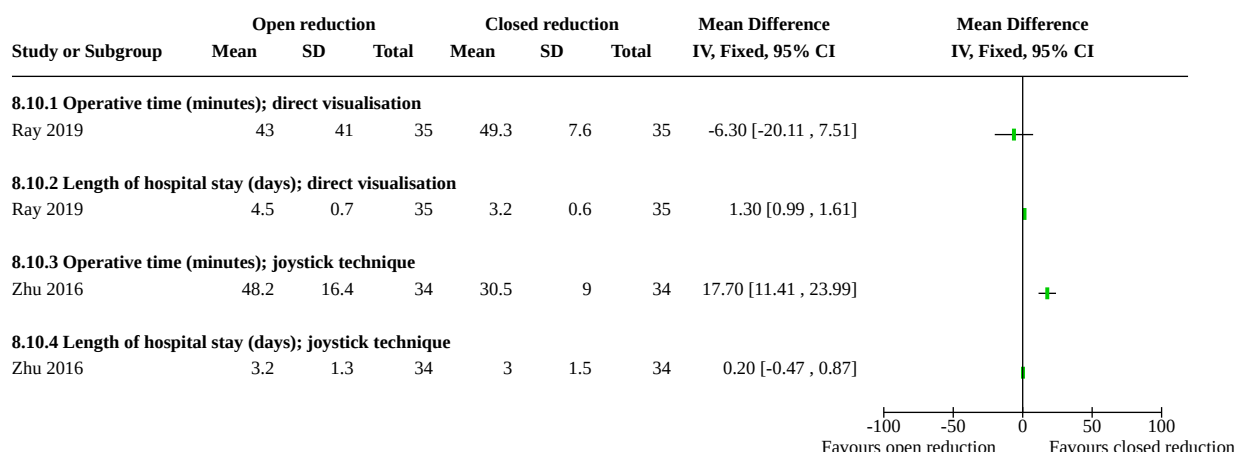


Analysis 8.7. Comparison 8: Different forms of surgical intervention: open versus closed reduction of displaced fractures, Outcome 7: Patient satisfaction with scar appearance (higher scores indicates more satisfaction)**Analysis 8.8. Comparison 8: Different forms of surgical intervention: open versus closed reduction of displaced fractures, Outcome 8: Radiographic deformity: difference in Baumann's angle (medium and long term)****Risk of bias legend**

- (A) Random sequence generation (selection bias)
- (B) Allocation concealment (selection bias)
- (C) Blinding of participants and personnel (performance bias)
- (D) Incomplete outcome data (attrition bias)
- (E) Selective reporting (reporting bias)
- (F) Other bias

Analysis 8.9. Comparison 8: Different forms of surgical intervention: open versus closed reduction of displaced fractures, Outcome 9: Radiographic deformity: capitellum posterior to anterior humeral line at late follow-up

Analysis 8.10. Comparison 8: Different forms of surgical intervention: open versus closed reduction of displaced fractures, Outcome 10: Resource use

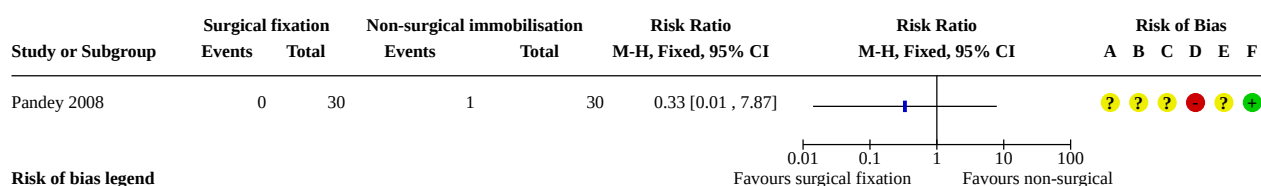


Comparison 9. Surgical versus non-surgical treatment: surgical fixation versus non-surgical immobilisation

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
9.1 Treatment failure	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
9.2 Nerve injury	3	140	Risk Ratio (M-H, Fixed, 95% CI)	2.50 [0.50, 12.46]
9.3 Major complications: pin site infections	3	126	Risk Ratio (M-H, Fixed, 95% CI)	4.00 [0.47, 34.11]
9.4 Cosmetic deformity: loss of carrying angle > 10 degrees or elbow deformity	3		Risk Ratio (M-H, Fixed, 95% CI)	Subtotals only
9.4.1 Long-term cubitus varus	2	80	Risk Ratio (M-H, Fixed, 95% CI)	0.20 [0.04, 1.09]
9.4.2 Long-term loss of carrying angle	2	66	Risk Ratio (M-H, Fixed, 95% CI)	0.29 [0.10, 0.81]
9.4.3 Long-term cubitus valgus	1	20	Risk Ratio (M-H, Fixed, 95% CI)	0.33 [0.02, 7.32]
9.5 Cosmetic deformity: degrees of loss of carrying angle at long-term follow-up	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
9.6 Range of movement: loss of > 10 degrees total movement at long-term follow-up	2	66	Risk Ratio (M-H, Fixed, 95% CI)	0.24 [0.06, 1.03]
9.7 Range of movement: degrees of loss of movement at long-term follow-up	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
9.7.1 Long-term loss of flexion	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
9.7.2 Long-term loss of extension	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

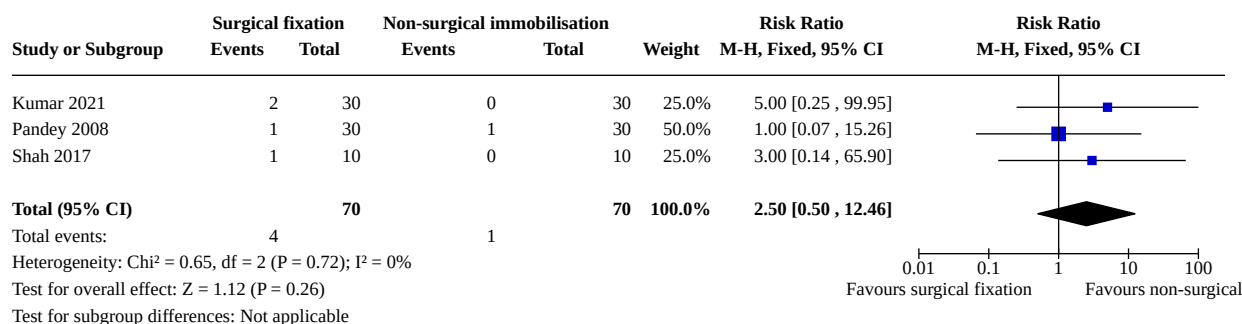
Analysis 9.1. Comparison 9: Surgical versus non-surgical treatment: surgical fixation versus non-surgical immobilisation, Outcome 1: Treatment failure



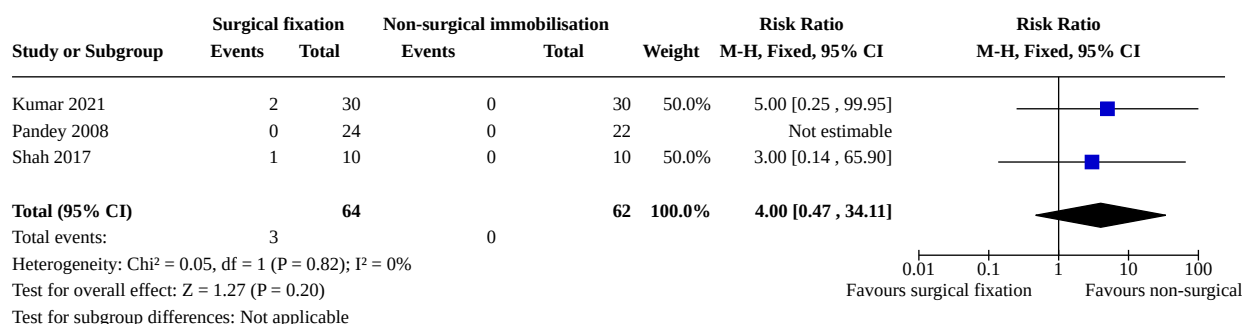
Risk of bias legend

- (A) Random sequence generation (selection bias)
- (B) Allocation concealment (selection bias)
- (C) Blinding of participants and personnel (performance bias)
- (D) Incomplete outcome data (attrition bias)
- (E) Selective reporting (reporting bias)
- (F) Other bias

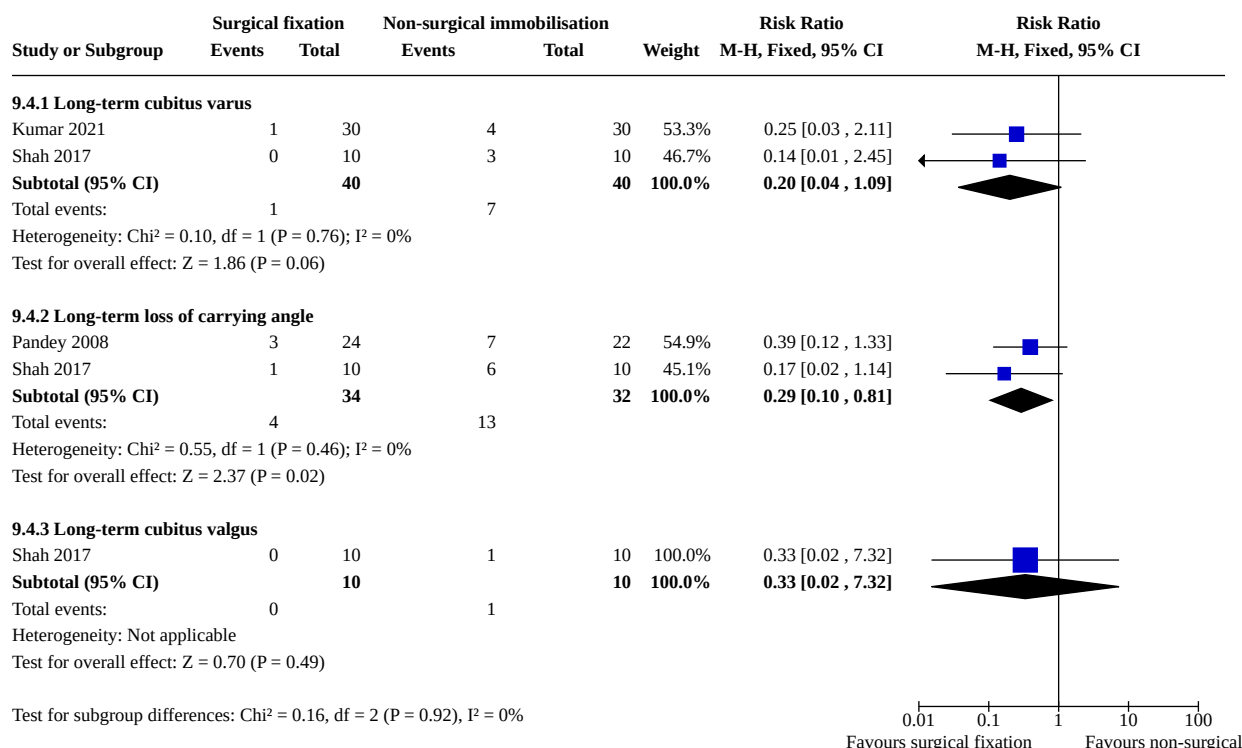
Analysis 9.2. Comparison 9: Surgical versus non-surgical treatment: surgical fixation versus non-surgical immobilisation, Outcome 2: Nerve injury



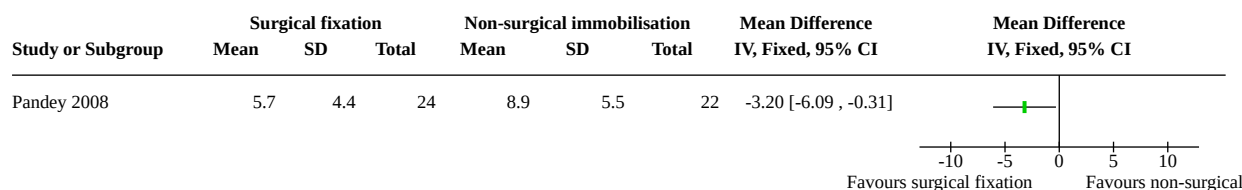
Analysis 9.3. Comparison 9: Surgical versus non-surgical treatment: surgical fixation versus non-surgical immobilisation, Outcome 3: Major complications: pin site infections

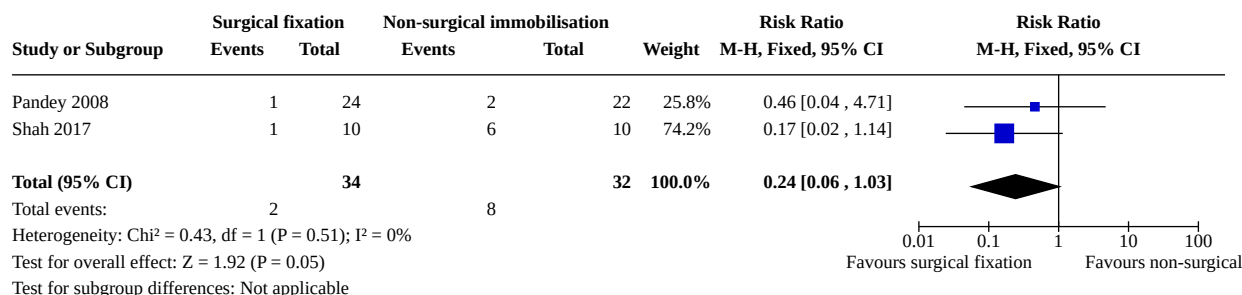
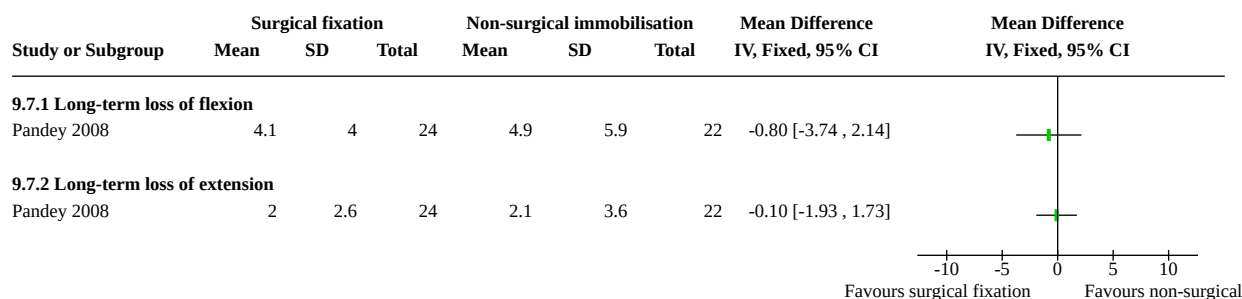


Analysis 9.4. Comparison 9: Surgical versus non-surgical treatment: surgical fixation versus non-surgical immobilisation, Outcome 4: Cosmetic deformity: loss of carrying angle > 10 degrees or elbow deformity



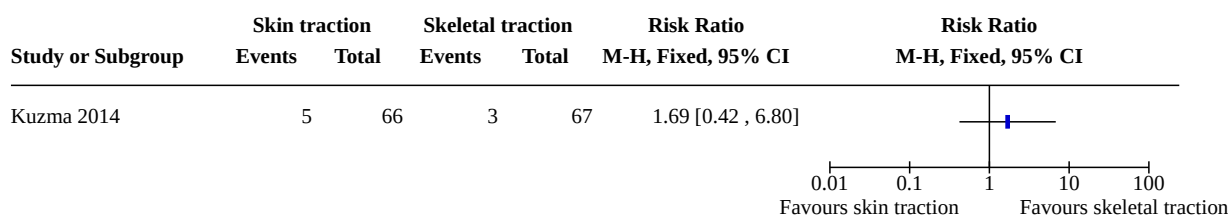
Analysis 9.5. Comparison 9: Surgical versus non-surgical treatment: surgical fixation versus non-surgical immobilisation, Outcome 5: Cosmetic deformity: degrees of loss of carrying angle at long-term follow-up



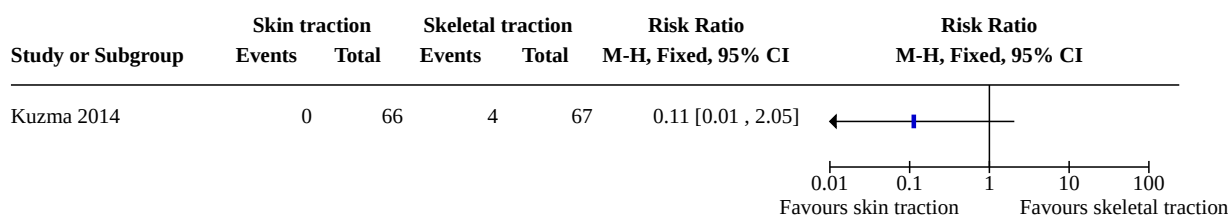
Analysis 9.6. Comparison 9: Surgical versus non-surgical treatment: surgical fixation versus non-surgical immobilisation, Outcome 6: Range of movement: loss of > 10 degrees total movement at long-term follow-up**Analysis 9.7. Comparison 9: Surgical versus non-surgical treatment: surgical fixation versus non-surgical immobilisation, Outcome 7: Range of movement: degrees of loss of movement at long-term follow-up****Comparison 10. Different forms of traction: skin traction versus olecranon skeletal traction**

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
10.1 Nerve injury	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
10.2 Major complications	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
10.3 Cosmetic deformity: cubitus varus	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
10.4 Range of movement (medium term)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
10.4.1 > 10° loss of flexion	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
10.4.2 > 5° of hyperextension	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
10.5 Resource use (duration of traction)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

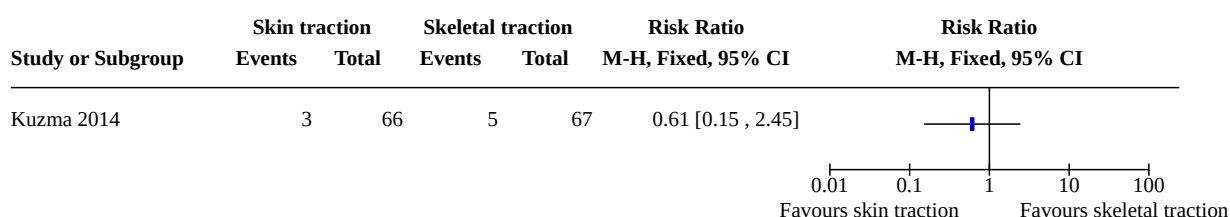
Analysis 10.1. Comparison 10: Different forms of traction: skin traction versus olecranon skeletal traction, Outcome 1: Nerve injury



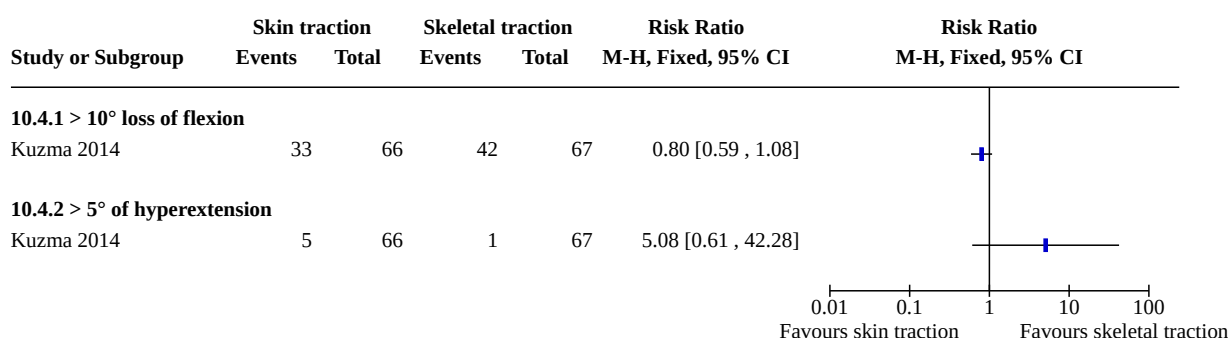
Analysis 10.2. Comparison 10: Different forms of traction: skin traction versus olecranon skeletal traction, Outcome 2: Major complications



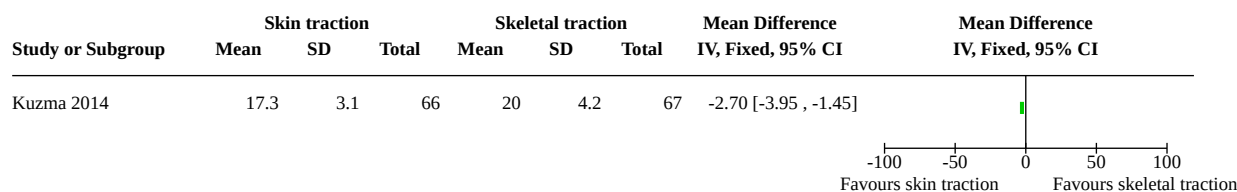
Analysis 10.3. Comparison 10: Different forms of traction: skin traction versus olecranon skeletal traction, Outcome 3: Cosmetic deformity: cubitus varus



Analysis 10.4. Comparison 10: Different forms of traction: skin traction versus olecranon skeletal traction, Outcome 4: Range of movement (medium term)



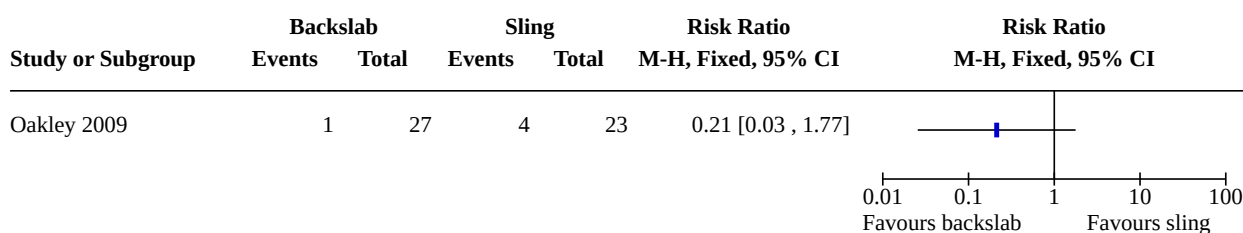
Analysis 10.5. Comparison 10: Different forms of traction: skin traction versus olecranon skeletal traction, Outcome 5: Resource use (duration of traction)



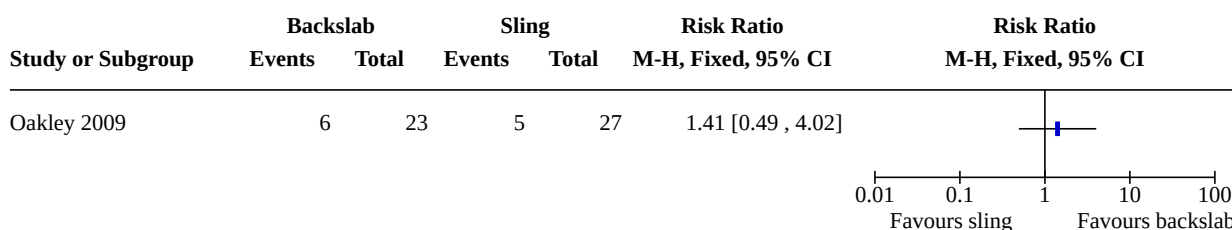
Comparison 11. Different forms of non-surgical intervention: backslab versus sling for undisplaced fractures

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
11.1 Parental satisfaction (unsure or unwilling to use same device again)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
11.2 Return to normal activities at 2 weeks	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected

Analysis 11.1. Comparison 11: Different forms of non-surgical intervention: backslab versus sling for undisplaced fractures, Outcome 1: Parental satisfaction (unsure or unwilling to use same device again)



Analysis 11.2. Comparison 11: Different forms of non-surgical intervention: backslab versus sling for undisplaced fractures, Outcome 2: Return to normal activities at 2 weeks



ADDITIONAL TABLES

Table 1. Modifications to the Gartland classification system

Type	Original Gartland Classification (Gartland 1959)	Wilkins modification (Wilkins 1996)	Leitch et al expansion (Leitch 2006)
1	Undisplaced or minimally displaced fracture	-	-
2	Displaced distal fragment with an intact posterior cortex	-	-
2a	-	Displaced distal fragment with an intact posterior cortex with angulation of the distal fragment	-
2b	-	Displaced distal fragment with an intact posterior cortex with angulation and rotation of the distal fragment	-
3	Completely displaced with no cortical contact	-	-
4	-	-	Displaced distal fragment with no intact periosteum and multi-directional instability

Table 2. Summary characteristics of included studies

Study	Country	Number of participants (mean age in years, % male)	Fracture type (numbers of fractures)	Reduction technique	Medial wire technique
Retrograde lateral wires versus retrograde crossed wires					
Abdel Karim 2016	Egypt	60 children: mean age 5.1, 70% male	Gartland 2 (7) and Gartland 3 (52)	Closed	Open (1.5 cm to 3.0 cm incision)
Abubeih 2019	Egypt	91 children: mean age for children who completed follow-up was 5.1, 67% male	Gartland 3 (91)	Closed	Open (1.5 cm to 3.0 cm incision)
Afaque 2020	Nepal	84 children: mean age for children who completed follow-up was 7.0, 62% male	Gartland 2, 3 or 4 (84)	Closed	Percutaneous
Aher 2018	India	60 children: mean age 7, 90% male	Gartland 3 (60)	Closed	Percutaneous
Ahmad 2020	Pakistan	70 children: mean age and gender distribution not specified	Gartland 1 and 2 (70)	Closed	Percutaneous
Anwar 2011	Pakistan	50 children: mean age 7, 33% male	Gartland 2 and 3 supracondylar fractures (50)	Closed	Not specified
Arun 2018	India	68 children: mean age 8.4, 68.7% male	Gartland 3 (68)	Closed	Percutaneous

Table 2. Summary characteristics of included studies *(Continued)*

Das 2019	India	50 children; mean age not reported, 56% male	Gartland 3 and 4 (50)	Closed	Not specified
Foad 2004	Malaysia	66 children: mean age 5.8, gender split not specified	Gartland 2 or 3 fractures (66)	Closed	Not specified
Gaston 2010	USA	104 children: mean age 6, 51% male	Gartland 3 (104)	Closed	Percutaneous
Gholap 2020	India	30 children: mean age 6.8, 70% male	Gartland 3 (30)	Closed	Open (incision length not specified)
Kocher 2007	USA	52 children: mean age 5.9, 44.2% male	Gartland 3 (52)	Closed	Open (1.5 cm to 3.0 cm incision)
Maity 2012	India	160 children: mean age 6.2, 61.9% male	Gartland 2 (71) and Gartland 3 (89)	Closed	Open (1 cm incision)
Majeed 2020	Pakistan	180 children: mean age 6.5, 63.9% male	Fracture classification not specified	Closed	Not specified
Mandal 2018	India	60 children: mean age 8.1, 68.3% male	Gartland 2 (7) and 33 Gartland 3 (33)	Closed	Not specified
Mulpuri 2016	Canada	52 children: mean age and gender split not specified	Gartland 3 (52)	Closed	Not specified
Naik 2017	India	57 children: mean age 6.7, 61.2% male	Gartland 3a (46) and Gartland 3b (9)	Closed	Open (small incision)
Naveen 2017	India	46 children: mean age 7.5, 63% male	Gartland 2 (15) and Gartland 3 (25)	Closed	Percutaneous
Othman 2017 ^a	Egypt	47 children: mean age 5.5, gender split not reported	Gartland (22) and Gartland 3 (25)	Closed	Percutaneous
Palange 2019	India	30 children: mean age 7, 63.3% male	Gartland 3 (30)	Closed	Open (small incision)
Patil 2017	India	30 children: mean age 8, 63.3% male	Gartland 3 (30)	Closed	Percutaneous
Pavone 2016	Italy	35 children: mean age 6, 72.4% male	Gartland 3 (35)	Closed	Not specified
Prashant 2016	India	76 children: mean age for children who completed follow-up was 8.4, 72.6% male	Gartland 3 (76)	Closed	Percutaneous
Raj 2018	India	20 children: mean age 8.4, 70% male	Gartland 3 (20)	Closed	Not specified
Said 2015	Egypt	44 children: mean age for children who completed follow-up was 5.8, 70.0% male	Gartland 3 (44)	Closed	Percutaneous
Shafi-Ur-Rehman 2013	Pakistan	200 children: mean age 6.2, 79.9% male	Gartland 3 (200)	Closed	Not specified

Table 2. Summary characteristics of included studies (Continued)

Subash 2020	India	66 children: mean age for children who completed follow-up was 6.1, 63.3% male	Fracture types not specified	Closed	Open
Tripuraneni 2009	USA	40 children: mean age 4.9, gender split not specified	Gartland 2 (5) and Gartland 3 (35)	Closed	Percutaneous
Vaidya 2009	Nepal	60 children: mean age 5.8, 66.3% male	Gartland 3 (60)	Closed	Open (2 cm to 3 cm incision)
Dawood 2011	Iraq	21 children: mean age 6.5, 61.9% male	Gartland 3 (21)	Open	Open
Sankar 2019	India	60 children: mean age 7.6, 70% male	Gartland 3 (60)	Open	Open
Lateral crossed (Dorgan) wires versus retrograde crossed wires					
Altay 2011	Turkey	29 children: mean age 7.8, 67.9% male	Gartland 3 (29)	Closed	Not specified
Ducic 2016a	Croatia	138 children: mean age 6.5, 65.2% male	Gartland 2a (12), Gartland 2b (35) and Gartland 3 (91)	Closed	Not specified
Kalia 2018	India	60 children: mean age 6.7, 63.3% male	Gartland 2 (19) and Gartland 3 (41)	Closed	Open (stab incision and direct visualisation)
Rizk 2019	Egypt	50 children: mean age 6.5, 64% male	Gartland 3 (50)	Closed	Percutaneous
Lateral crossed (Dorgan) wires versus retrograde lateral wires					
Sadek 2018	Egypt	40 children: mean age 6.2, 72.5% male	Gartland 2 or 3 (40)	Closed	N/A
Posterior intrafocal wire versus retrograde crossed wires					
Jain 2019	India	168 children: mean age 6.8, 70.2% male	Gartland 2 (58) and Gartland 3 (110)	Closed	N/A
Retrograde lateral wires in parallel versus divergent configuration					
Gopinathan 2018	India	30 children: mean age 7.6, 77% male	Gartland 3 (30)	Closed	N/A
Shamma 2020	Egypt	30 children: mean age 5.1, 70% male	Gartland 2 (3) and Gartland 3 (27)	Closed	N/A
Mini-open crossed wires versus percutaneous crossed wires					
Ercin 2016	Turkey	104 children: mean age 6.5, 60.6% male	Gartland 3 (104)	Closed	N/A
Buried versus non-buried wires					

Table 2. Summary characteristics of included studies (Continued)

Saeed 2020	Pakistan	80 children: mean age 7.5, 56.3% male	Fracture types not specified	Open	Open
Open reduction versus closed reduction					
Ajmera 2013	India	87 children: mean age for children who completed follow-up was 7, 52.3% male	Gartland 3 (87)	N/A	Percutaneous
Dehghan 2012	Iran	90 children: mean age 6.1, 55% male	Gartland 3 (90)	N/A	Not specified
Kaewporn-sawan 2001 ^c	Thailand	28 children: mean age 7.6, 67.9% male	Gartland 3 (28)	N/A	Percutaneous
Rakha 2020	Pakistan	130 children; mean age 7.3, 77.7% male	Garland 3 (130)	N/A	Not specified
Ray 2019	India	70 children: mean age 7, 64% male	Gartland 3 (70)	N/A	Not specified
Zhu 2016 ^b	China	68 children: mean age 7.8, 54.4% male	Gartland 2 (39) and Gartland 3 (29)	N/A	N/A
Surgical fixation versus non-surgical (immobilisation)					
Kumar 2021	India	60 children: mean age and gender split not specified	Fracture types not specified	Closed	Percutaneous
Pandey 2008	Nepal	60 children: mean age 7.7, 68.3% male	Gartland 2b or 3 supracondylar fractures (60)	Closed	Percutaneous
Shah 2017	India	20 children: mean age and gender split not specified	Gartland 3 (20)	Closed	Not specified
Skin traction versus olecranon skeletal traction					
Kuzma 2014	Papua New Guinea	133 children: mean age 7.5, 59.4% male	Gartland 2 (6) and Gartland 3 (127)	Closed	N/A
Backslab versus sling					
Oakley 2009	Australia	50 children: mean age 5.5, 62% male	Gartland 1 (50)	N/A	N/A

^aThree-arm study (retrograde crossed wires, retrograde lateral wires and lateral crossed (Dorgan) wires). Data are for all included participants

^bOpen reduction achieved using an indirect (joystick) technique so not included in meta-analysis as did not involve direct visualisation of the fracture

^cStudy compared open and closed reduction and retrograde crossed wires and lateral crossed (Dorgan) wires

N/A: not applicable

Table 3. Summary of wire configurations used in included studies

Group name	Typical wire entry points	Wire direction	Number of studies	Comments
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Table 3. Summary of wire configurations used in included studies (Continued)

Retrograde crossed wires	1) Lateral condyle 2) Medial epicondyle	All retrograde	35 RCTs	Typically avoid crossing at the fracture site Can use open technique or percutaneous technique to protect the ulnar nerve from the medial wire Open technique allows direct visualisation of the bone and retraction of the nerve. Percutaneous techniques usually extend the elbow after inserting the lateral wire and roll the nerve back before inserting a medial wire anterior to the ulnar groove.
Retrograde lateral wires	2 or 3 wires from lateral condyle	All retrograde	32 RCTs	Can be placed in a parallel or divergent configuration Can be supplemented by an additional medial wire if there are intra-operative concerns around stability
Lateral crossed (Dorgan) wires	1) Lateral condyle 2) Lateral metaphysis	1) Retrograde 2) Antegrade	7 RCTs	Antegrade wire advanced into medial epicondyle but not through cortex to avoid injury to ulnar nerve
Posterior intrafocal wire	1) Lateral condyle 2) Direct posterior	1) Retrograde 2) Into fracture site (intrafocal)	1 RCT	Posterior wire passed in the midline into the fracture site to aid reduction of the fracture

Table 4. Other important outcomes: retrograde lateral wires versus retrograde crossed wires

Other important outcomes: retrograde lateral wires versus retrograde crossed wires		
Outcome	Studies	Effect estimate
Range of movement at the elbow: loss of flexion Follow-up: medium term (range from 3 months to 4 months)	Abdel Karim 2016 ; Abubeih 2019 ; Dawood 2011	RR 1.24, 95% CI 0.37 to 4.16, favours crossed wires; $I^2 = 0\%$; 3 studies, 148 participants; Analysis 1.6
Range of movement at the elbow: loss of extension Follow-up: medium term (4 months)	Dawood 2011	RR 0.73, 95% CI 0.15 to 3.53, favours lateral wires; 1 study, 21 participants; Analysis 1.6
Range of movement at the elbow: loss of flexion Follow-up: long term (6 months)	Anwar 2011 ; Foad 2004	RR 1.41, 95% CI 0.84 to 2.35, favours crossed wires; $I^2 = 0\%$; 2 studies, 105 participants; Analysis 1.6
Range of movement at the elbow: loss of extension Follow-up: long term (6 months)	Anwar 2011 ; Foad 2004	RR 0.85, 95% CI 0.40 to 1.80, favours lateral wires; $I^2 = 0\%$; 2 studies, 105 participants; Analysis 1.6

Table 4. Other important outcomes: retrograde lateral wires versus retrograde crossed wires (Continued)

Range of movement at the elbow: loss of total range of movement Follow-up: long term (range from 6 months to 2 years)	Mandal 2018; Naik 2017; Othman 2017	RR 1.26, 95% CI 0.56 to 2.82, favours crossed wires; $I^2 = 0\%$; 3 studies, 148 participants; Analysis 1.6
Range of movement at the elbow: degrees of loss of elbow flexion? Follow-up: long term (6 months)	Foad 2004	MD 2.58, 95% CI -2.48 to 7.64, favours crossed wires; 1 study, 55 participants; Analysis 1.7
Range of movement at the elbow: degrees of loss of elbow extension? Follow-up: long term (6 months)	Foad 2004	MD -0.03, 95% CI -5.35 to 5.29, favours elbow extension; 1 study, 55 participants; Analysis 1.7
Range of movement at the elbow: degrees of loss of total range of movement Follow-up: long term (6 months)	Aher 2018; Gholap 2020; Prashant 2016	MD 0.71, 95% CI -0.52 to 1.95, favours crossed wires; 2 studies, 92 participants; Analysis 1.7 . This analysis does not include Aher 2018 , in which data were reported without distribution values (mean loss in lateral group was 3° , mean loss in crossed wires group was 2°).
Return to sport or normal activities Follow-up: medium term (range from 3 months to 4 months)	Kocher 2007; Mandal 2018; Said 2015	RR 1.23, 95% CI 0.31 to 4.83, favours crossed wires; $I^2 = 0\%$; 3 studies, 151 participants; Analysis 1.8
Return to sport or normal activities Follow-up: long term (range from 6 months to 4 years)	Pavone 2016; Vaidya 2009	RR 0.54, 95% CI 0.08 to 3.53, favours lateral wires; $I^2 = 0\%$; 2 studies, 95 participants; Analysis 1.8
Return to sport or normal activities: time taken to return to normal activities (in weeks)	Mandal 2018	MD 0.50 weeks, 95% CI -0.12 to 1.12, favours crossed wires; 1 study, 58 participants; Analysis 1.9
Radiographic deformity: loss of reduction (measured as number of events) Defined in the majority of studies as a loss of Baumann's angle greater than 6° Follow-up: early (3 weeks)	Shafi-Ur-Rehman 2013	RR 1.37, 95% CI 0.93 to 2.00, favours crossed wires; Analysis 1.10
Radiographic deformity: loss of reduction (measured as number of events) Defined in the majority of studies as a loss of Baumann's angle greater than 6° Follow-up: medium term (range from 3 to 4 months)	Abdel Karim 2016; Abubeih 2019; Aher 2018; Kocher 2007; Maity 2012; Said 2015; Vaidya 2009	RR 2.00, 95% CI 1.21 to 3.30, favours crossed wires; $I^2 = 14\%$; 7 studies, 469 participants; Analysis 1.10
Radiographic deformity: loss of reduction (measured as number of events) Defined in the majority of studies as a loss of Baumann's angle greater than 6° Follow-up: long-term (6 months)	Patil 2017; Prashant 2016	RR 4.00, 95% CI 0.46 to 34.45, favours crossed wires; $I^2 = 0\%$; 2 studies, 92 participants; Analysis 1.10

Table 4. Other important outcomes: retrograde lateral wires versus retrograde crossed wires (Continued)

Radiographic deformity: degrees of loss of Baumann's angle Follow-up: medium term (range from 3 months to 4 months)	Abubeih 2019 ; Afaque 2020 ; Dawood 2011 ; Kocher 2007 ; Maity 2012 ; Said 2015 ; Vaidya 2009	MD 0.06, 95% CI -0.22 to 0.33, favours crossed wires; $I^2 = 0\%$; 7 studies, 447 participants; Analysis 1.11
Radiographic deformity: degrees of loss of lateral humeral-capitellar angle Follow-up: medium term (3 months)	Vaidya 2009	MD -0.20, 95% CI -2.86 to 2.46, favours lateral wires; 1 study, 60 participants; Analysis 1.11
Radiographic deformity: degrees of loss of Baumann's angle Follow-up: long term (range from 6 months to 4 years)	Anwar 2011 ; Foead 2004 ; Othman 2017 ; Palange 2019 ; Pavone 2016 ; Prashant 2016 ; Raj 2018	MD 0.05, 95% CI -0.00 to 0.11, favours lateral wires; $I^2 = 0\%$; 7 studies, 283 participants; Analysis 1.11^a In addition, Subash 2020 reported data without distribution values (mean in lateral wires group: 5.5°; mean in crossed wires group: 5.24°).
Radiographic deformity: degrees of loss of lateral humeral-capitellar angle Follow-up: long term (range from 6 months to 7 months)	Othman 2017	MD 0.01, 95% CI -0.06 to 0.08, favours crossed wires; 1 study, 31 participants; Analysis 1.11 . In addition, Subash 2020 reported data without distribution values (mean in lateral wires group: 6.4°; mean in crossed wires group: 6.54°).
Radiographic deformity: degrees of loss of humeral diaphyseal-metaphyseal angle Follow-up: long term (6 months)	Anwar 2011 ; Prashant 2016	MD 0.10, 95% CI -0.18 to 0.39, favours crossed wires; $I^2 = 0\%$; 2 studies, 112 participants; Analysis 1.11
Radiographic deformity: degrees of loss of humeral medial epicondylar epiphyseal angle Follow-up: long term (6 months)	Foead 2004	MD 0.86, 95% CI -2.27 to 3.99, favours crossed wires; 1 study, 55 participants; Analysis 1.11
Resource use: operative time	Abubeih 2019 ; Naik 2017	We did not pool the data owing to substantial statistical heterogeneity ($I^2 = 92\%$). Data from individual studies are reported in Analysis 1.12 .
Resource use: length of hospital stay (days)	Prashant 2016	MD -0.19, 95% CI -0.48 to 0.10, favours lateral wires; 1 study, 62 participants; Analysis 1.12

^aWe noted that data in one of the included studies in this analysis was inconsistent with other studies, and we could not rule out the possibility of data error in the study report ([Othman 2017](#)).

CI: confidence interval; MD: mean difference; RR: risk ratio

Table 5. Different forms of surgical interventions: effects of critical and other important outcomes for other comparison groups

Lateral crossed (Dorgan) wires versus retrograde crossed wires		
Outcome	Studies	Effect estimate

Table 5. Different forms of surgical interventions: effects of critical and other important outcomes for other comparison groups (Continued)

Nerve injury	Altay 2011 ; Ducic 2016a ; Kalia 2018 ; Othman 2017 ; Rizk 2019	RR 0.26, 95% CI 0.09 to 0.76, favours Dorgan wires; $I^2 = 0\%$; 5 studies, 307 participants; Analysis 2.1
Major complications: all complications	Altay 2011 ; Ducic 2016a ; Kalia 2018 ; Othman 2017 ; Rizk 2019	RR 1.94, 95% CI 0.88 to 4.30, favours retrograde crossed wires; $I^2 = 0\%$; 5 studies, 307 participants; Analysis 2.2
Major complications: pin site infection	Altay 2011 ; Ducic 2016a ; Kalia 2018 ; Othman 2017 ; Rizk 2019	RR 2.51, 95% CI 0.92 to 6.82, favours retrograde crossed wires; $I^2 = 0\%$; 5 studies, 307 participants; Analysis 2.2
Major complications: vascular injuries	Ducic 2016a	RR 1.06, 95% CI 0.28 to 4.07, favours retrograde crossed wires; 1 study, 138 participants; Analysis 2.2
Cosmetic deformity: loss of carrying angle $> 10^\circ$ (long term)	Ducic 2016a ; Othman 2017 ; Rizk 2019	RR 1.35, 95% CI 0.37 to 4.85, favours retrograde crossed wires; $I^2 = 0\%$; 3 studies, 218 participants; Analysis 2.3
Cosmetic deformity: loss of carrying angle (degrees of loss)	Rizk 2019	MD 0.30°, 95% CI -2.20° to 2.80°, favours retrograde crossed wires; 1 study, 50 participants; Analysis 2.4
Range of motion: loss of total range of motion $> 10^\circ$ (long term)	Ducic 2016a ; Othman 2017 ; Rizk 2019	RR 1.14, 95% CI 0.08 to 16.63, favours retrograde crossed wires; $I^2 = 0\%$; 3 studies, 218 participants; Analysis 2.5
Radiographic deformity: loss of Baumann's angle (long term)	Othman 2017 ; Rizk 2019	MD 0.04°, 95% CI -0.01° to 0.09°, favours retrograde crossed wires; 2 studies, 80 participants; Analysis 2.6
Radiographic deformity: loss of lateral humeral-capitellar angle (long term)	Othman 2017 ; Rizk 2019	MD 0.08°, 95% CI 0.00° to 0.16°, favours retrograde crossed wires; $I^2 = 0\%$; 2 studies, 80 participants; Analysis 2.6 This difference is unlikely to be clinically important.
Resource use (operative time; minutes)	Ducic 2016a	MD 7.88, 95% CI 6.27 to 9.49; favours retrograde crossed wires; 1 study, 138 participants; Analysis 2.7
Resource use (radiographic exposure time; minutes)	Ducic 2016a	MD 2.65, 95% CI 1.90 to 3.40, favours retrograde crossed wires; 1 study, 138 participants; Analysis 2.7

Lateral crossed (Dorgan) wires versus retrograde lateral wires

Outcome	Studies	Effect estimate
Nerve injury	Othman 2017 ; Sadek 2018	RR 1.07, 95% CI 0.07 to 15.54, favours retrograde lateral wires; $I^2 = 0\%$; 2 studies, 69 participants; Analysis 3.1
Major complications: pin site infections	Othman 2017 ; Sadek 2018	RR 2.06, 95% CI 0.56 to 7.56, favours retrograde lateral wires; $I^2 = 0\%$; 2 studies, 69 participants; Analysis 3.2
Cosmetic deformity: loss of carrying angle $> 10^\circ$ (long-term)	Othman 2017 ; Sadek 2018	RR 0.68, 95% CI 0.21 to 2.15, favours Dorgan wires; $I^2 = 0\%$; 2 studies, 69 participants; Analysis 3.3
Range of motion: loss of total range of motion $> 10^\circ$ (long term)	Othman 2017 ; Sadek 2018	RR 0.72, 95% CI 0.26 to 2.00, favours Dorgan wires; $I^2 = 0\%$; 2 studies, 69 participants; Analysis 3.4

Table 5. Different forms of surgical interventions: effects of critical and other important outcomes for other comparison groups (Continued)

Radiographic deformity: degrees of loss of Baumann's angle (long term)	Othman 2017	MD -0.02°, 95% CI -0.08° to 0.04°, favours Dorgan wires; 1 study, 29 participants; Analysis 3.5
Radiographic deformity: degrees of loss of lateral humeral-capitellar angle - long term	Othman 2017	MD 0.07°, 95% CI -0.01° to 0.15°, favours Dorgan wires; 1 study, 29 participants; Analysis 3.6
Posterior intrafocal wire versus retrograde crossed wires		
Outcome	Studies	Effect estimate
Nerve injury	Jain 2019	RR 0.33, 95% CI 0.07 to 1.60, favours intrafocal; 1 study, 168 participants; Analysis 4.1
Major complications: pin site infections	Jain 2019	RR 0.71, 95% CI 0.24 to 2.16, favours intrafocal; 1 study, 168 participants; Analysis 4.2
Cosmetic deformity: loss of carrying angle (long term)	Jain 2019	RR 1.88, 95% CI 0.84 to 4.19, favours retrograde crossed wires; 1 study, 168 participants; Analysis 4.3
Cosmetic deformity: cubitus varus	Jain 2019	RR 1.25, 95% CI 0.35 to 4.49, favours retrograde crossed wires; 1 study, 168 participants; Analysis 4.3
Range of motion: loss of total range of motion > 10° (long term)	Jain 2019	RR 1.33, 95% CI 0.73 to 2.42, favours retrograde crossed wires; 1 study, 168 participants; Analysis 4.4
Radiographic deformity: loss of reduction (long term)	Jain 2019	RR 1.79, 95% CI 1.28 to 2.52, favours retrograde crossed wires; 1 study, 168 participants; Analysis 4.5
Retrograde lateral wires in a parallel versus divergent configuration		
Outcome	Studies	Effect estimate
Nerve injury	Gopinathan 2018 ; Shamma 2020	Not estimable (no events in either group)
Major complications: compartment syndrome	Gopinathan 2018	RR 1.80, 95% CI 0.08 to 40.75, favours divergent wires; 1 study, 30 participants; Analysis 5.1
Range of movement: loss of movement (medium term)	Shamma 2020	MD -0.10, 95% CI -1.32 to 1.12, favours parallel wires; 1 study, 30 participants; Analysis 5.2
Range of movement: loss of extension (medium term)	Shamma 2020	MD 0.40, 95% CI -0.42 to 1.22, favours divergent wires; 1 study, 30 participants; Analysis 5.2
Cosmetic deformity: loss of carrying angle > 10° (medium term)	Gopinathan 2018 ; Shamma 2020	Not estimable (no events in either group)
Cosmetic deformity: degrees of loss of carrying angle (medium term)	Gopinathan 2018 ; Shamma 2020	MD 0.02°, 95% CI -0.65° to 0.69°, favours divergent wires; 2 studies, 60 participants; Analysis 5.3
Range of motion: loss of flexion (medium term)	Gopinathan 2018 ; Shamma 2020	RR 0.87, 95% CI 0.17 to 4.42, favours parallel wires; 2 studies, 60 participants; Analysis 5.4

Table 5. Different forms of surgical interventions: effects of critical and other important outcomes for other comparison groups (Continued)

Range of motion: loss of extension (medium term)	Gopinathan 2018 ; Shamma 2020	RR 3.00, 95% CI 0.16 to 57.36, favours divergent wires; 2 studies, 60 participants; Analysis 5.4
Radiographic deformity: degrees of loss of Baumann's angle (medium term)	Gopinathan 2018 ; Shamma 2020	MD 0.87°, 95% CI -0.00° to 1.75°, favours divergent wires; 2 studies, 60 participants; Analysis 5.5 This difference is unlikely to be clinically important.
Mini-open crossed wires versus percutaneous crossed wires		
Outcome	Studies	Effect estimate
Nerve injury	Ercin 2016	RR 2.05, 95% CI 0.48 to 8.69, favours percutaneous wires; 1 study, 104 participants; Analysis 6.1
Major complications: pin site infections	Ercin 2016	RR 1.02, 95% CI 0.18 to 5.87, favours percutaneous wires; 1 study, 104 participants; Analysis 6.2
Resource use (length of hospital stay; days)	Ercin 2016	MD 0.28, 95% CI -0.19 to 0.75, favours percutaneous wires; 1 study, 104 participants; Analysis 6.3
Resource use (anaesthesia time)	Ercin 2016	MD -5.85, 95% CI -12.82 to 1.12, favours mini-open wires; 1 study, 104 participants; Analysis 6.3
Buried versus non-buried wires		
Outcome	Studies	Effect estimate
Major complications: pin site infections	Saeed 2020	RR 0.13, 95% CI 0.02 to 0.95, favours buried wires; 1 study, 80 participants; Analysis 7.1

CI: confidence interval; MD: mean difference; RR: risk ratio

Table 6. Other important outcomes: open reduction versus closed reduction

Other important outcomes: open reduction versus closed reduction			
Outcome	Studies (using direct visualisation)	Effect estimate (using direct visualisation)	Effect estimate using joystick technique (in Zhu 2016 only)
Range of movement at the elbow: loss of total range of movement > 10 degrees Follow-up: medium term (range from 3 months to 5 months)	Ajmera 2013 ; Kaewpornasawan 2001	RR 3.20, 95% CI 1.05 to 9.77, favours closed reduction; 2 studies, 93 participants; Analysis 8.5	Not estimable (no events in either group)
Range of movement at the elbow: degrees of loss of carrying angle Follow-up: long term (12 months)	Ray 2019	MD 0.94°, 95% CI -0.29° to 2.17°, favours closed reduction; 1 study, 60 participants; Analysis 8.6	-

Table 6. Other important outcomes: open reduction versus closed reduction (Continued)

Patient satisfaction Assessed using non-validated 10-point scoring system to evaluate scar appearance (higher scores indicating higher levels of satisfaction) Follow-up: 5 months	Kaewpornawan 2001	Participant-assessed: MD -0.60, 95% CI -1.09 to -0.11, favours closed reduction; 1 study, 28 participants; Analysis 8.7 Assessor blinded to treatment allocation: MD -0.50, 95% CI -0.87 to -0.13, favours closed reduction; 1 study, 28 participants; Analysis 8.7	-
Radiographic deformity: loss of Bau-mann's angle Follow-up: medium term (5 months)	Kaewpornawan 2001	MD 0.12°, 95% CI -1.14° to 1.38°, favours closed reduction; 1 study, 28 participants; Analysis 8.8	-
Radiographic deformity: loss of Bau-mann's angle Follow-up: long term (12 months)	Ray 2019	MD 1.14°, 95% CI 0.21° to 2.07°, favours open reduction; 1 study, 70 participants; Analysis 8.8	-
Radiographic deformity: capitulum lying posterior to the anterior humeral line Follow-up: long term (30 to 33 months)	-	-	RR 0.37, 95% CI 0.04 to 3.83, favours open reduction; 1 study, 59 participants; Analysis 8.9
Resource use (operative time in minutes)	Ray 2019	MD -6.30, 95% CI -20.11 to 7.51, favours open reduction; 1 study, 70 participants; Analysis 8.10	MD 17.7, 95% CI 11.41 to 23.99, favours closed reduction; 1 study, 68 participants; Analysis 8.10
Resource use (length of hospital stay in days)	Ray 2019	MD 1.30, 95% CI 0.99 to 1.61, favours closed reduction; 1 study, 70 participants; Analysis 8.10	MD 0.20, 95% CI -0.47 to 0.87, favours closed reduction; 1 study, 68 participants; Analysis 8.10

CI: confidence interval; MD: mean difference; RR: risk ratio

Table 7. Other important outcomes: surgical fixation versus non-surgical immobilisation

Other important outcomes: surgical fixation versus non-surgical immobilisation		
Outcome	Studies	Effect estimate
Range of movement at the elbow: loss of movement > 10° Follow-up: long term (6 to 12 months)	Pandey 2008 ; Shah 2017	RR 0.24, 95% CI 0.06 to 1.03, favours surgical fixation; $I^2 = 0\%$; 2 studies, 66 participants; Analysis 9.6
Range of movement at the elbow: degrees of loss of flexion Follow-up: long term (6 months)	Pandey 2008	MD -0.80°, 95% CI -3.74° to 2.14°, favours surgical fixation; 1 study, 46 participants; Analysis 9.7

Table 7. Other important outcomes: surgical fixation versus non-surgical immobilisation (Continued)

Range of movement at the elbow:degrees of loss of extension	Pandey 2008	MD -0.10°, 95% CI -1.93° to 1.73°, favours surgical fixation; 1 study, 46 participants; Analysis 9.7
Follow-up: long term (6 months)		
Range of movement at the elbow:degrees of loss of total range of movement	Shah 2017	Surgical fixation group: mean 8.8° (reported without SD)
Follow-up: long term (6 to 12 months)		
Non-surgical immobilisation group: mean 7.3° (reported without SD)		

CI: confidence interval; MD: mean difference; RR: risk ratio; SD: standard deviation

Table 8. Other important outcomes: backslab versus sling

Other important outcomes: backslab versus sling		
Outcome	Studies	Data as reported by study authors
Pain	Oakley 2009	Backslab group, median (IQR): 28 (20 to 40)
Assessed with 100-point VAS (lower scores indicate less pain)		Sling group, median (IQR): 33 (25 to 53)
		P = 0.21; 1 study, 48 participants
Pain	Oakley 2009	Backslab group, median (IQR): (1 to 8) days
Assessed as number of days experiencing pain		Sling group, median (IQR): 6 (5 to 9.5) days
		P = 0.07; 1 study, 48 participants
Pain	Oakley 2009	Backslab group, median (IQR): 2 (1 to 5) days
Assessed as days requiring analgesia		Sling group, median (IQR): 3 (2 to 4.5) days
		P value not reported; 1 study, 48 participants
Parent satisfaction	Oakley 2009	RR 0.21, 95% CI 0.03 to 1.77, favours backslab; 1 study, 50 participants; Analysis 11.1
Assessed by asking if parents would be prepared to use the same immobilisation device		
Follow-up: at time of removal		
Return to normal activities	Oakley 2009	RR 1.41, 95% CI 0.49 to 4.02, favours backslab; 1 study, 50 participants; Analysis 11.2
Follow-up: at 2 weeks		
Time to return to normal activities	Oakley 2009	Backslab group, median (IQR): 2 (1 to 3) days
		Sling group, median (IQR): 7 (3 to 13) days
		P = 0.01; 1 study, 48 participants

CI: confidence interval; IQR: interquartile range; MD: mean difference; RR: risk ratio; VAS: visual analogue scale

APPENDICES

Appendix 1. Search strategies

CENTRAL (CRS-WEB)

- 1 MESH DESCRIPTOR Humeral fractures AND CENTRAL:TARGET (151)
- 2 ((humer* or elbow* or supracondylar) NEAR3 fractur*):AB,EH,KW,KY,MC,MH,TI,TO AND CENTRAL:TARGET (771)
- 3 #1 OR #2 (771)
- 4 MESH DESCRIPTOR Infant EXPLODE ALL AND CENTRAL:TARGET (31895)
- 5 MESH DESCRIPTOR child EXPLODE ALL AND CENTRAL:TARGET (55482)
6. MESH DESCRIPTOR Adolescent AND CENTRAL:TARGET (103537)
7. MESH DESCRIPTOR Minors AND CENTRAL:TARGET (8)
- 8 MESH DESCRIPTOR Puberty EXPLODE ALL AND CENTRAL:TARGET (361)
9. MESH DESCRIPTOR Pediatrics EXPLODE ALL AND CENTRAL:TARGET (697)
- 10 MESH DESCRIPTOR Schools AND CENTRAL:TARGET (1896)
- 11 MESH DESCRIPTOR Schools, Nursery AND CENTRAL:TARGET (38)
- 12 (Infant* or Infancy or Newborn* or New born* or Baby* or Babies or Neonat* or Preterm* or Prematur* or Postmatur* or Child* or Schoolchild* or School age* or Preschool* or pre school* or Kid or kids or Toddler* or Adoles* or Teen* or Youth or Boy* or Girl* or Minors* or Pubert* or Pubescen* or Prepubescen* or Paediatric* or Paediatric* or Peadiatric* or Nursery school* or Kindergar* or Primary school* or Secondary school* or Elementary school* or High school* or Highschool*):AB,EH,KW,KY,MC,MH,TI,TO AND CENTRAL:TARGET (290823)
- 13 #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 (290961)
- 14 #3 AND #13 (173)

Medline (Ovid)

- 1 Humeral fractures/ (7480)
- 2 ((humer* or elbow* or supracondylar) adj3 fractur*).tw. (9450)
- 3 1 or 2 (12760)
- 4 exp infant/ (1128327)
- 5 exp child/ (1889823)
- 6 Adolescent/ (2004518)
- 7 Minors/ (2563)
- 8 exp puberty/ (17542)
- 9 exp Pediatrics/ (57450)
- 10 schools/ or schools, nursery/ (38732)
- 11 (Infant* or Infancy or Newborn* or New born* or Baby* or Babies or Neonat* or Preterm* or Prematur* or Postmatur* or Child* or Schoolchild* or School age* or Preschool* or pre school* or Kid or kids or Toddler* or Adoles* or Teen* or Youth or Boy* or Girl* or Minors* or Pubert* or Pubescen* or Prepubescen* or Paediatric* or Paediatric* or Peadiatric* or Nursery school* or Kindergar* or Primary school* or Secondary school* or Elementary school* or High school* or Highschool*).tw. (2371790)
- 12 or/4-11 (4301396)
- 13 3 and 12 (4856)
- 14 randomized controlled trial.pt. (504064)
- 15 controlled clinical trial.pt. (93621)
- 16 randomized.ab. (476541)
- 17 placebo.ab. (206951)
- 18 drug therapy.fs. (2196015)
- 19 randomly.ab. (331424)
- 20 trial.ab. (502119)
- 21 groups.ab. (2035564)
- 22 or/14-21 (4682772)
- 23 exp animals/ not humans.sh. (4691338)
- 24 22 not 23 (4059881)
- 25 13 and 24 (490)

Embase (Ovid)

- 1 humerus fracture/ (9134)
- 2 ((humer* or elbow* or supracondylar) adj3 fractur*).tw. (10525)
- 3 1 or 2 (14657)
- 4 exp infant/ (970229)
- 5 exp child/ (2571123)
- 6 adolescent/ (1497450)

7 "minor (person)"/ (608)
 8 exp puberty/ (40664)
 9 exp pediatrics/ (104698)
 10 school/ (61164)
 11 nursery school/ or nursery/ (4319)
 12 (Infant* or Infancy or Newborn* or New born* or Baby* or Babies or Neonat* or Preterm* or Prematur* or Postmatur* or Child* or Schoolchild* or School age* or Preschool* or pre school* or Kid or kids or Toddler* or Adoles* or Teen* or Youth or Boy* or Girl* or Minors* or Pubert* or Pubescen* or Prepubescen* or Paediatric* or Paediatric* or Peadiatric* or Nursery school* or Kindergar* or Primary school* or Secondary school* or Elementary school* or High school* or Highschool*).tw. (2902301)
 13 or/4-12 (4267623)
 14 3 and 13 (4501)
 15 Randomized controlled trial/ (598975)
 16 Controlled clinical study/ (464022)
 17 Random*.ti,ab. (1522606)
 18 randomization/ (86540)
 19 intermethod comparison/ (258958)
 20 placebo.ti,ab. (304061)
 21 (compare or compared or comparison).ti. (505574)
 22 ((evaluated or evaluate or evaluating or assessed or assess) and (compare or compared or comparing or comparison)).ab. (2087932)
 23 (open adj label).ti,ab. (78418)
 24 ((double or single or doubly or singly) adj (blind or blinded or blindly)).ti,ab. (230369)
 25 double blind procedure/ (171471)
 26 parallel group*1.ti,ab. (25256)
 27 (crossover or cross over).ti,ab. (104213)
 28 ((assign* or match or matched or allocation) adj5 (alternate or group*1 or intervention*1 or patient*1 or subject*1 or participant*1)).ti,ab. (326475)
 29 (assigned or allocated).ti,ab. (384325)
 30 (controlled adj7 (study or design or trial)).ti,ab. (344446)
 31 (volunteer or volunteers).ti,ab. (244931)
 32 trial.ti. (296562)
 33 or/15-32 (4626136)
 34 (exp animal/ or animal.hw. or nonhuman/) not (exp human/ or human cell/ or (human or humans).ti.) (6376913)
 35 33 not 34 (3993501)
 36 14 and 35 (593)

ClinicalTrials.gov

Humerus Fracture (139)
 Supracondylar Fracture (22)

Appendix 2. Review of previous systematic reviews

Our searches identified 21 relevant previous systematic reviews and two national treatment guidelines that have assessed elements of this comparison. The earliest review was published in 1990 ([Kurer 1990](#)), with eight reviews published between 1991 and 2011 ([Babal 2010](#); [Brauer 2007](#); [Loizou 2009](#); [Pretell 2010](#); [Pretell-Mazzini 2010a](#); [Pretell-Mazzini 2010b](#); [Slobogean 2010](#); [White 2010](#)). The American Academy of Orthopaedic Surgeons (AAOS) published its guideline in 2011 ([American Academy of Orthopaedic Surgeons 2011](#)), and the British Orthopaedic Association/British Society for Children's Orthopaedic Surgery (BOA/BSCOS) guideline was published in 2014 ([British Orthopaedic Association 2014](#)). The remaining 12 reviews were published between 2011 and 2021 ([Carrazzone 2021](#); [Catena 2019](#); [Dekker 2016](#); [Delniotis 2019](#); [De Pellegrin 2018](#); [Farrow 2018](#); [Lin-Guo 2018](#); [Na 2018](#); [Patriota 2017](#); [Woratanarat 2012](#); [Yeomans 2018](#); [Yousri 2012](#)).

The searches for the AAOS guideline included studies from January 1966 to July 2010. The guideline proposes four recommendations based on the literature and two consensus-based recommendations. They identified moderate-level evidence for non-surgical immobilisation of undisplaced fractures, and closed reduction and surgical fixation of displaced fractures. They found limited-quality evidence for the use of lateral pins to prevent harm to the patient, and for the use of open reduction for a fracture mal-reduced after closed reduction. The guideline included many prospective, non-randomised studies, and used the indirect evidence of [Oakley 2009](#) to infer that simple immobilisation is suitable for undisplaced fractures. The guideline included two RCTs to recommend the use of surgical fixation for displaced fractures ([Kaewpornsanwan 2001](#); [Pandey 2008](#)), augmented with nine other studies. The group found no difference in cosmetic deformity or radiographic loss of reduction between surgical fixation and non-surgical immobilisation, with one study demonstrating loss of range of movement with non-surgical immobilisation. The guideline did not use the GRADE approach, and rated the quality of evidence higher than we would have. We also did not find a significant difference in cosmetic deformity or loss of reduction, and also did not find an improvement in range of motion when surgery was performed. The limited recommendation to use lateral wires is based on three trials ([Foead 2004](#); [Kocher 2007](#); [Tripuraneni 2009](#)), and 12 other studies. A pooled re-operation odds ratio of 1.3 (95% CI 0.5 to 3.4) was found in favour of crossed wires with an odds ratio for ulnar nerve injury of 0.27 (95% CI 0.13 to 0.59). This is consistent with our findings, with

a greater effect size driven predominantly by the included non-randomised studies. The guideline did not find any RCTs to support the limited recommendation to perform an open reduction following varus malposition of a fracture following closed reduction.

The BOA/BSCOS guideline presents a professional consensus that children with displaced supracondylar fractures should have surgery on the day of admission, or the next morning if presenting overnight. Crossed wires are identified to have lower rates of loss of reduction whilst lateral wires reduce risk of nerve injury. A technique should be used to protect the ulnar nerve if a medial wire is used, though a specific technique is not recommended. These findings on wire technique correspond to the findings of this review, though we have only found one RCT that evaluated ulnar nerve protection techniques and assessed it to be of low quality. The guideline recommends the use of 2 mm wires to improve stability; a recommendation for which we have been unable to find supporting RCT evidence.

[Yeomans 2018](#) reviewed the literature for comparisons of non-surgical management of displaced supracondylar fractures, with a focus on resource-poor settings. The review identified 46 studies, of which none were RCTs. The authors concluded that the current evidence regarding the non-surgical management of supracondylar fractures (casting or traction) is inconclusive. [Kurer 1990](#) identified 27 observational studies evaluating closed reduction and casting or traction for displaced fractures, nine studies relating to closed reduction with wire fixation, and eight studies on open reduction and wire fixation. This review found casting to be associated with a 60% loss of reduction rate with good results from traction and closed or open reduction and fixation. This review concludes that reduction and cast immobilisation is inadequate for displaced fractures.

Nine previous reviews have compared the use of retrograde lateral and retrograde crossed wires; these are summarised in [Appendix 3](#). In the most recent review, [Carrazzone 2021](#) concluded that lateral wires are safer than crossed wires but are more prone to a loss of reduction.

The [Carrazzone 2021](#) review defined loss of reduction as a loss of Baumann's angle $> 6^\circ$, loss of $> 10^\circ$ of carrying angle, or loss of $> 10^\circ$ humeral-capitellar angle, and it was not clear how unit of analysis issues were resolved in this composite outcome. The authors used the Cochrane risk of bias tool and assigned the studies the same risk of bias for selection bias, were more likely to rate studies as at high risk of bias for blinding, and more conservative in rating other biases than our review. The pooled analysis identified a relative risk of 0.45 (95% CI 0.21 to 0.99) for nerve injury when lateral wires were used, in keeping with our findings. An increased rate of loss of reduction was also demonstrated, with a RR of 1.39 (95% CI 1.04 to 1.85).

[Na 2018](#) performed a systematic review of RCTs and observational studies for lateral entry and crossed wires that identified 24 studies, including nine RCTs. This total included two trials identified as awaiting classification due to the unavailability of the original manuscripts ([Bing 2017](#); [Vaidya 2013a](#)). [Na 2018](#) did not perform an evaluation of study quality. The pooled analysis of randomised trials showed no difference in the rates of children graded as 'excellent' using the Flynn score (RR 1.02, 95% CI 0.87 to 0.99). A reduction in the rate of nerve injury was demonstrated for lateral entry wires (RR 0.29, 95% CI 0.10 to 0.79). The rates of loss of reduction were not significant, though this included randomised and observational studies (RR 1.37, 95% CI 0.91 to 2.07). The authors concluded a wiring strategy of three divergent wires offered best stability, functional outcome, and nerve injury reduction, though this was not explicitly demonstrated from the data presented.

In contrast, [Patriota 2017](#) suggested a differential approach to fixation based on Gartland classification, based on a subgroup analysis that suggests Gartland 3-4 fractures are more likely to experience a loss of reduction ($P = 0.04$), and analysis of one RCT with 60 children showing a mini-open technique had no change in ulnar nerve injury rate compared to lateral wires (RR 0.14, 95% CI 0.01 to 2.79). [Dekker 2016](#) did not identify convincing evidence from seven RCTs and six observational studies that either approach was superior, with no significant difference in loss of reduction or rates of achieving a Flynn grade of excellent. The pooled ulnar nerve injury rate was a RR of 3.04 (95% CI 1.16 to 7.99). [Yousri 2012](#) undertook a systematic review and narrative synthesis of four RCTs, identifying limitations in study design for studies published before 2011; they could not draw any firm conclusions. [Woratanarat 2012](#) suggested using lateral wires for displaced fractures, based on pooling results from two RCTs and six observational studies, with a higher risk of nerve injury following crossed wires (RR 4.5, 95% CI 2.1 to 9.7) and lower risk of loss of reduction (RR 0.6, 95% CI 0.4 to 1.0). [Slobogean 2010](#) found a higher risk of ulnar nerve injury following crossed wires, but did not evaluate any other outcomes (pooled risk difference 0.035, 95% CI 0.014 to 0.045). In a review predominantly of observational studies, [Babal 2010](#) found a pooled nerve injury rate of 4.1% following retrograde crossed wires and 3.9% following lateral wires; and [Brauer 2007](#) found a modest difference in nerve injury rates between these two groups with a RR of 1.84 (95% CI 1.01 to 3.36).

Three systematic reviews have reviewed the use of an open or closed reduction ([Lin-Guo 2018](#); [Pretell-Mazzini 2010a](#); [Pretell-Mazzini 2010b](#); see [Appendix 4](#)). [Lin-Guo 2018](#) identified two RCTs ([Kaewpornsawan 2001](#); [Lu 2011](#)), of which one RCT was graded as low risk of bias for all domains ([Lu 2011](#)). Unfortunately, we have not been able to source this trial from the reference provided. The review authors concluded that stability and outcomes are similar between open and closed reduction, but the findings were limited by sample size and further study is necessary. A pair of reviews were published in 2010: evaluating the use of closed or open reduction ([Pretell-Mazzini 2010a](#)), and the surgical approach when undertaking an open reduction ([Pretell-Mazzini 2010b](#)), respectively. In these reviews, a single RCT was identified. The authors concluded that one to two attempts at closed reduction should be performed before progressing to an anterior-medial open reduction. The quality of the evidence supporting these conclusions is limited.

Two reviews of management of vascular injuries following supracondylar fracture have been published ([Delnietis 2019](#); [White 2010](#); see [Appendix 5](#)). In a review of grade 2 and 3 vascular injuries, [Delnietis 2019](#) identified 16 studies, none of which were randomised trials. The authors concluded that children with pulseless hands should have their fractures reduced urgently and fixed with percutaneous wires. Following reduction, if the hand becomes pink and perfused, the authors propose that observation is sufficient, with exploration of the

artery only indicated if the hand remains cold and white. [White 2010](#) performed a systematic review and expert survey, and concluded that the rate of vascular pathology following a grade 2 injury is 82% and therefore surgical exploration should be considered. This review was limited due to a lack of RCTs.

The timing of surgery for displaced fractures has been assessed through meta-analysis of retrospective cohorts, as no RCTs were identified ([Appendix 6](#)). The [Farrow 2018](#) review identified 12 cohorts. When these heterogeneous studies were pooled, there was no difference in the need for open reduction (RR 0.01, 95% CI -0.03 to 0.06; $I^2 = 75\%$), nerve injury, major complications, cosmetic deformity, or functional outcome (a Flynn grade of poor). The authors found the cutoff for early surgery to be variable: they included one study where the cutoff for early surgery was six hours; four studies with a cutoff of eight hours; five studies with a cutoff of 12 hours; and two studies where the cutoff was 24 hours. They concluded that surgery could be safely delayed overnight, but acknowledged that the strength of evidence was low to very low. In an earlier review, [Loizou 2009](#) found a higher rate of open reduction in delayed surgery from five observational studies (odds ratio (OR) 0.37, 95% CI 0.21 to 0.66). This review included three studies where the cutoff for early intervention was eight hours and two where the cutoff was 12 hours.

[De Pellegrin 2018](#) reviewed the role of patient positioning and the impact on nerve injury. Searches included studies published up to 31 December 2017 and identified two RCTs ([Tripuraneni 2009](#); [Venkatadass 2015](#)). The original objective of this review was to identify comparative studies of prone and supine closed reduction of fractures, but the authors were unable to identify sufficient numbers of studies to perform this comparison. Instead, the authors extracted nerve injury rates from observational studies in different populations, and concluded that nerve injuries only occurred following reduction in a supine position. However, a lack of comparative studies limits the strength of this finding. A similar review was published as [Catena 2019](#) with the same search date and included studies, and we presumed it to be a duplicate publication.

Appendix 3. Summary of systematic reviews comparing retrograde lateral wires with retrograde crossed wires

Review	Included studies	Main outcomes	Author conclusions
Carrazzone 2021	12 RCTs (Abdel Karim 2016 ; Afaq 2020 ; Anwar 2011 ; Foad 2004 ; Gaston 2010 ; Kocher 2007 ; Maity 2012 ; Naveen 2017 ; Prashant 2016 ; Shafi-Ur-Rehman 2013 ; Vaidya 2009 ; Venkatadass 2015)	Loss of reduction Nerve injury Functional outcome (Flynn grade satisfactory)	Low-quality evidence to show lateral wires are safer with fewer nerve injuries but crossed wires are more stable
Na 2018	9 RCTs (Anwar 2011 ; Foad 2004 ; Gaston 2010 ; Kocher 2007 ; Maity 2012 ; Prashant 2016 ; Tripuraneni 2009 ; Vaidya 2009 ; Bing 2017) 13 observational studies	Loss of reduction Nerve injury Functional outcome (Flynn grade excellent)	A wiring strategy of three divergent wires offered best stability, functional outcome, and nerve injury reduction
Patriota 2017 ,	8 RCTs (Anwar 2011 ; Foad 2004 ; Gaston 2010 ; Kocher 2007 ; Maity 2012 ; Mazda 2001* ; Tripuraneni 2009 ; Vaidya 2013a)	Ulnar nerve injury Loss of reduction Baumann's angle Carrying angle Loss of carrying angle	Gartland 2 fractures be fixed with lateral wires and Gartland 3-4 are fixed with crossed wires inserted with a mini-open technique
Dekker 2016	7 RCTs (Anwar 2011 ; Foad 2004 ; Gaston 2010 ; Kocher 2007 ; Maity 2012 ; Tripuraneni 2009 ; Vaidya 2009) 6 observational studies	Functional outcome (Flynn grade excellent) Loss of reduction Ulnar nerve injury	The available evidence does not support the use of either technique
Yousri 2012	4 RCTs (Foad 2004 ; Gaston 2010 ; Kocher 2007 ; Tripuraneni 2009)	Ulnar nerve injury Loss of reduction Loss of carrying angle	Cannot draw any firm conclusions based on the identified evidence

(Continued)

		Radiographic measures	
Woratanarat 2012	2 RCTs (Foead 2004; Kocher 2007)	Ulnar nerve injury	Fixation with crossed wires reduces the risk of loss of reduction but has higher nerve injuries. Fixation with lateral wires is the favoured procedure
	16 observational studies	Loss of reduction	
		Late deformity	
		Flynn grade poor or fair	
Slobogean 2010	2 RCTs (Foead 2004; Kocher 2007)	Ulnar nerve injury	Crossed wires have a higher risk of nerve injury
	30 observational studies		
Babal 2010	2 RCTs (Foead 2004; Kocher 2007)	Nerve injury	Crossed wires have a higher risk of nerve injury, but lateral wires also have a risk of ulnar nerve injury
	53 observational studies		
Brauer 2007	2 RCTs (Foead 2004; Kaewporn-sawan 2001)	Loss of reduction	Crossed wires seem to be the more stable construct
	33 observational studies	Nerve injury	

*Mazda 2001 was screened for inclusion in this Cochrane review but found to be a non-randomised study

Appendix 4. Summary of systematic reviews comparing closed with open reduction of displaced fractures

Review	Included studies	Main outcomes	Conclusions
Lin-Guo 2018	2 RCTs (Kaewporn-sawan 2001; Lu 2011)	Ulnar nerve injury Major complications Flynn grade	Similar outcomes from closed and open reduction
Pretell-Mazzini 2010b	1 RCT (Kaewporn-sawan 2001) 6 observational studies	Flynn grade excellent, good, fair or poor Cosmetic outcome Non-union Nerve injury Major complications	Anterior-medial approach may be associated with best functional and cosmetic outcomes
Pretell-Mazzini 2010a	1 RCT (Kaewporn-sawan 2001) 2 observational studies	Flynn grade excellent, good, fair or poor Cosmetic outcome Baumann's angle Time to union Major complications	Suggest starting with 1 or 2 attempts at closed reduction and proceed to open reduction if closed reduction fails

Appendix 5. Summary of systematic reviews comparing interventions for vascular injuries

Review	Included studies	Main outcomes	Conclusions
Delniotis 2019	0 RCTs 16 observational studies	Functional outcomes Major complications Vascular occlusion	Children with pulseless hands should have their fractures reduced urgently and fixed with percutaneous wires
White 2010	0 RCTs 17 observational studies 1 survey	Perfusion following reduction Major complications Vascular occlusion	Suggest low threshold for vascular exploration in grade 2 vascular injuries (pink, pulseless hands)

Appendix 6. Summary of systematic reviews comparing early and delayed surgery for displaced fractures

Review	Included studies	Main outcomes	Conclusions
Farrow 2018	0 RCTs 12 observational studies	Open reduction Nerve injury Major complications Functional outcome (Flynn grade of poor)	Surgery could be safely delayed overnight
Loizou 2009	0 RCTs 5 observational studies	Open reduction	Surgery should be performed within 12 hours of injury

HISTORY

Protocol first published: Issue 5, 2020

CONTRIBUTIONS OF AUTHORS

Ben Marson, Simon Craxford, Kathryn Price, and Benjamin Ollivere all conceived the review and designed the protocol. Ben Marson prepared the first draft. Ben Marson, Simon Craxford, and Adeel Ikram performed data extraction and risk of bias assessments. Benjamin Ollivere is the guarantor of the protocol.

DECLARATIONS OF INTEREST

Ben Marson: none known
Adeel Ikram: none known
Simon Craxford: none known
Kathryn Price: none known
Benjamin Ollivere: none known

SOURCES OF SUPPORT

Internal sources

- The University of Nottingham, UK

Host institution for Ben Marson, Simon Craxford and Benjamin Ollivere

- Nottingham University Hospitals NHS Trust, UK

Host institution for Kathryn Price

External sources

- National Institute for Health Research (NIHR), UK

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DIFFERENCES BETWEEN PROTOCOL AND REVIEW

Types of interventions: we changed the order of these interventions. During the review process, we noted a higher research interest in types of surgical interventions and judged that this should be given a higher priority in the review.

Types of outcomes: we had not explicitly specified measurements for cosmetic deformity (when measured as carrying angle), range of motion, and radiographic deformity through the measurement of angles. We included change scores for these three measurements rather than absolute values. This is because these three outcomes have a range of normal values that demonstrate considerable personal variation. We judged that differences in the loss of carrying angle, loss of range of motion, and loss of radiographic angle would be more valid than differences in mean absolute values. We also set a threshold for the dichotomising of loss of carrying angle and range of motion. For this, we set a threshold of 10° as a value that could be reliably measured using a goniometer and may have a bearing on outcome for children. We could not find any literature to identify a minimal clinically important difference for these outcomes in children, and would suggest clinical correlation of these outcomes is a priority for research. In addition, we reordered the 'other outcomes' according to interventions which we believed had more clinical relevance.

Subgroup analysis and investigation of heterogeneity: we conducted an additional subgroup analysis for the use of retrograde wires. We found a clinical heterogeneity in the technique used for the placement of the medial wire in a crossed K-wire configuration which, we felt, was important to explore and analyse as a potential contributor to nerve injury and rates of major complications.

Sensitivity analysis: we conducted two additional sensitivity analyses because we could not rule out the possibility of compromised data integrity: we found a large number of eligible studies that were published in journals not indexed in PubMed, and we found some studies that were published in duplicate by other author teams. We also clarified that sensitivity analyses were limited to the critical outcomes reported in the summary of findings tables.

Summary of findings and assessment of the certainty of the evidence: we provided additional information in this section of the Methods, including a decision to limit the summary of findings tables only to those that we judged to be most clinically relevant.

INDEX TERMS

Medical Subject Headings (MeSH)

Elbow; *Fracture Fixation [methods]; Fracture Fixation, Internal; *Fractures, Bone; Splints

MeSH check words

Child; Child, Preschool; Female; Humans; Male