Treatment of Pediatric Supracondylar Humerus Fractures

Evidence-Based Clinical Practice Guideline

Adopted by:
The American Academy of Orthopaedic Surgeons Board of Directors
September 24, 2011

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This Clinical Practice Guideline was developed by an AAOS physician volunteer Work Group based on a systematic review of the current scientific and clinical information and accepted approaches to treatment and/or diagnosis. This Clinical Practice Guideline is not intended to be a fixed protocol, as some patients may require more or less treatment or different means of diagnosis. Clinical patients may not necessarily be the same as those found in a clinical trial. Patient care and treatment should always be based on a clinician's independent medical judgment, given the individual patient's clinical circumstances.

Disclosure Requirement
In accordance with AAOS policy, all individuals whose names appear as authors or contributors to Clinical Practice Guideline filed a disclosure statement as part of the submission process. All panel members provided full disclosure of potential conflicts of interest prior to voting on the recommendations contained within this Clinical Practice Guidelines.

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FDA Clearance
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Summary of Recommendations

The following is a summary of the recommendations in the AAOS' clinical practice guideline, The Treatment of Pediatric Supracondylar Humerus Fractures. This summary does not contain rationales that explain how and why these recommendations were developed nor does it contain the evidence supporting these recommendations. All readers of this summary are strongly urged to consult the full guideline and evidence report for this information. We are confident that those who read the full guideline and evidence report will see that the recommendations were developed using systematic evidence-based processes designed to combat bias, enhance transparency, and promote reproducibility.

This summary of recommendations is not intended to stand alone. Treatment decisions should be made in light of all circumstances presented by the patient. Treatments and procedures applicable to the individual patient rely on mutual communication between guardian and physician as well as other healthcare practitioners.

1. We suggest nonsurgical immobilization of the injured limb for patients with acute (e.g. Gartland Type I) or non-displaced pediatric supracondylar fractures of the humerus or posterior fat pad sign

   Strength of Recommendation: Moderate

   Description: Evidence from two or more "Moderate" strength studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. A **Moderate** recommendation means that the benefits exceed the potential harm (or that the potential harm clearly exceeds the benefits in the case of a negative recommendation), but the strength of the supporting evidence is not as strong.

   Implications: Practitioners should generally follow a **Moderate** recommendation but remain alert to new information and be sensitive to patient preferences.

2. We suggest closed reduction with pin fixation for patients with displaced (Gartland Type II and III, and displaced flexion) pediatric supracondylar fractures of the humerus.

   Strength of Recommendation: Moderate

   Description: Evidence from two or more "Moderate" strength studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. A **Moderate** recommendation means that the benefits exceed the potential harm (or that the potential harm clearly exceeds the benefits in the case of a negative recommendation), but the strength of the supporting evidence is not as strong.

   Implications: Practitioners should generally follow a **Moderate** recommendation but remain alert to new information and be sensitive to patient preferences.

3. The practitioner might use two or three laterally introduced pins to stabilize the reduction of displaced pediatric supracondylar fractures of the humerus. Considerations of potential harm indicate that the physician might avoid the use of a medial pin.

   Strength of Recommendation: Limited

   Description: Evidence from two or more “Low” strength studies with consistent findings, or evidence from a single “Moderate” quality study recommending for or against the intervention or diagnostic. A **Limited** recommendation means the quality of the supporting evidence that exists is unconvincing, or that well-conducted studies show little clear advantage to one approach versus another.

   Implications: Practitioners should exercise clinical judgment when following a recommendation classified as **Limited**, and should be alert to emerging evidence that might negate the current findings. Patient preference should have a substantial influencing role.

4. We cannot recommend for or against using an open incision to introduce a medial pin to stabilize the reduction of displaced pediatric supracondylar fractures of the humerus.

   Strength of Recommendation: Inconclusive

   Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.

   Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

5. We are unable to recommend for or against a time threshold for reduction of displaced pediatric supracondylar fractures of the humerus without neurovascular injury.

   Strength of Recommendation: Inconclusive

   Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.

   Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

6. The practitioner might perform open reduction for displaced pediatric supracondylar fractures of the humerus with varus or other malposition after closed reduction.

   Strength of Recommendation: Limited

   Description: Evidence from two or more “Low” strength studies with consistent findings, or evidence from a single “Moderate” quality study recommending for or against the intervention or diagnostic. A **Limited** recommendation means the quality of the supporting evidence that exists is unconvincing, or that well-conducted studies show little clear advantage to one approach versus another.

   Implications: Practitioners should exercise clinical judgment when following a recommendation classified as **Limited**, and should be alert to emerging evidence that might negate the current findings. Patient preference should have a substantial influencing role.

7. In the absence of reliable evidence, the opinion of the work group is that emergent closed reduction of displaced pediatric supracondylar humerus fractures be performed in patients with decreased perfusion of the hand.

   Strength of Recommendation: Consensus

   Description: The supporting evidence is lacking and requires the work group to make a recommendation based on expert opinion by considering the known potential harm and benefits associated with the treatment. A **Consensus** recommendation means that expert opinion supports the guideline recommendation even though there is no available empirical evidence that meets the inclusion criteria of the guideline’s systematic review.

   Implications: Practitioners should be flexible in deciding whether to follow a recommendation classified as **Consensus,** although they may give it preference over alternatives. Patient preference should have a substantial influencing role.

8. In the absence of reliable evidence, the opinion of the work group is that open exploration of the antecubital fossa be performed in patients who have absent wrist pulses and are underperfused after reduction and pinning of displaced pediatric supracondylar humerus fractures.

   Strength of Recommendation: Consensus

   Description: The supporting evidence is lacking and requires the work group to make a recommendation based on expert opinion by considering the known potential harm and benefits associated with the treatment. A **Consensus** recommendation means that expert opinion supports the guideline recommendation even though there is no available empirical evidence that meets the inclusion criteria of the guideline’s systematic review.

   Implications: Practitioners should be flexible in deciding whether to follow a recommendation classified as **Consensus,** although they may give it preference over alternatives. Patient preference should have a substantial influencing role.

9. We cannot recommend for or against open exploration of the antecubital fossa in patients with absent wrist pulses but with a perfused hand after reduction of displaced pediatric supracondylar humerus fractures.

    Strength of Recommendation: Inconclusive

    Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.

    Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

10. We are unable to recommend an optimal time for removal of pins and mobilization in patients with displaced pediatric supracondylar fractures of the humerus.

    Strength of Recommendation: Inconclusive

    Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.

    Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

11. We are unable to recommend for or against routine supervised physical or occupational therapy for patients with pediatric supracondylar fractures of the humerus.

    Strength of Recommendation: Inconclusive

    Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.

    Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

12. We are unable to recommend an optimal time for allowing unrestricted activity after injury in patients with healed pediatric supracondylar fractures of the humerus.

    Strength of Recommendation: Inconclusive

    Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.

    Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

13. We are unable to recommend optimal timing of or indications for electrodiagnostic studies or nerve exploration in patients with nerve injuries associated with pediatric supracondylar fractures of the humerus.

    Strength of Recommendation: Inconclusive

    Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.

    Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

14. We are unable to recommend for or against open reduction and stable fixation for adolescent patients with supracondylar fractures of the humerus.

    Strength of Recommendation: Inconclusive

    Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.

    Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

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Peer Review

Participation in the AAOS peer review process does not constitute an endorsement of this guideline by the participating organization.

The following organizations participated in peer review of this clinical practice guideline and gave their explicit consent to have their names listed in this document:

American Society for Surgery of the Hand

American Association for Hand Surgery

Pediatric Orthopaedic Society of North America

American Pediatric Surgery Association

American Physical Therapy Association

American Academy of Pediatrics

American Academy of Pediatrics; Section on Administration and Practice Management

Participation in the AAOS peer review process does not constitute an endorsement of this guideline by the participating organization.

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I. INTRODUCTION

OVERVIEW

This clinical practice guideline is based on a systematic review of published studies on the treatment of supracondylar fractures of the humerus in children. In addition to providing practice recommendations, this guideline highlights gaps in the literature and areas that require future research.

This guideline is intended to be used by all appropriately trained surgeons and all qualified physicians managing the treatment supracondylar fractures of the humerus in children. It is also intended to serve as an information resource for decision makers and other developers of clinical practice guidelines.

GOALS AND RATIONALE

The purpose of this clinical practice guideline is to help improve treatment based on the current best evidence. Contemporary evidence-based medicine (EBM) standards demand that physicians use such evidence in their clinical decision making. To assist in this, this clinical practice guideline consists of a systematic review of the available literature regarding the treatment of supracondylar fractures of the humerus in children. The systematic review detailed herein was conducted between October 2009 and July 2010 and demonstrates where there is good evidence, where evidence is lacking, and what topics future research must target in order to improve the treatment of patients with supracondylar fractures of the humerus in children. AAOS staff and the physician work group systematically reviewed the available literature and subsequently wrote the following recommendations based on a rigorous, standardized process.

Musculoskeletal care is provided in many different settings by many different providers. We created this guideline as an educational tool to guide qualified physicians through a series of treatment decisions in an effort to improve the quality and efficiency of care. This guideline should not be construed as including all proper methods of care or excluding methods of care reasonably directed to obtaining the same results. The ultimate judgment regarding any specific procedure or treatment must be made in light of all circumstances presented by the patient and the needs and resources particular to the locality or institution.

INTENDED USERS

This guideline is intended to be used by orthopaedic surgeons and all physicians managing children with supracondylar fractures of the humerus. Typically, orthopaedic surgeons will have completed medical training, a qualified residency in orthopaedic surgery, and some may have completed additional sub-specialty training.

The guideline is intended to both guide clinical practice and to serve as an information resource for medical practitioners. An extensive literature base was considered during the development of this guideline. In general, practicing clinicians do not have the resources necessary for such a large project. The AAOS hopes that this guideline will assist practitioners not only in making clinical decisions about their patients, but also in describing, to patients and others, why the chosen treatment represents the best available course of action.

This guideline is not intended for use as a benefits determination document. Making these determinations involves many factors not considered in the present document, including available resources, business and ethical considerations, and need.

Users of this guideline may also want to consider any appropriate use criteria (AUC) that the AAOS has developed on the topic of this guideline. The focus of AAOS guidelines is on the question "Does it work?" When an AAOS guideline or an AAOS-endorsed guideline shows effectiveness, the AAOS may undertake development of AUC that ask the question "In whom does it work?" This dichotomy is necessary because the medical literature (both orthopaedic and otherwise) typically does not adequately address the latter question.

That having been said, evidence for the effectiveness of medical services is not always present. This is true throughout all areas of medicine. Accordingly, all users of this clinical practice guideline are cautioned that an absence of evidence is not evidence of ineffectiveness. An absence means just that; there are no data. It is the AAOS position that rigorously developed clinical practice guidelines should not seek to guide clinical practice when data are absent unless the disease, disorder, or condition in question can result in loss of life or limb. The AAOS incorporates expert opinion into a guideline under these circumstances, and only under these circumstances. Accordingly, when the AAOS states that it cannot recommend for or against a given intervention or service, it is stating that currently available data do not provide clear guidance on which course of action is best, and that it is therefore reluctant to make a recommendation that has potentially national ramifications. Although true in all circumstances, the AAOS believes that when evidence is absent, it is particularly important for the treatment for pediatric supracondylar fractures of the humerus in children to be based on the assumption that decisions are predicated on guardian and physician mutual communication with discussion of available treatments and procedures applicable to the individual patient. Once the patient's guardian has been informed of available therapies and has discussed these options with his/her child's physician, an informed decision can be made. Clinician input based on experience with conservative management and the clinician's surgical experience and skills increases the probability of identifying patients who will benefit from specific treatment options.

PATIENT POPULATION

This document addresses the treatment of isolated supracondylar fractures of the humerus in children who have not yet reached skeletal maturity (see Study Selection Criteria for specific age criteria of included studies). It provides information on pediatric patient management after diagnosis of a supracondylar fracture of the humerus. It is not intended for use in pediatric patients who present with additional coexisting injuries that require formal surgical intervention or other life-threatening conditions that take precedence over the treatment of the supracondylar fracture of the humerus.

ETIOLOGY

Supracondylar fractures of the humerus in children are the result of trauma to the elbow, most often a fall from height or related to sports or leisure activities.[1]

INCIDENCE

Supracondylar humerus fractures are widely considered the most common fracture of the elbow in children. The annual rate of children who present with supracondylar fractures has been estimated at 177.3 per 100,000.[1]

BURDEN OF DISEASE

There are many components to consider when calculating the overall cost of treatment for pediatric supracondylar fractures of the humerus.[2] The main considerations are the relative cost and effectiveness of each treatment option. However, hidden costs for pediatric patients must also be considered. These costs include the additional home care required for a patient, the costs of rehabilitation and of missed school for the patient, child care costs if both parents work, and time off of work required by one or both parents to care for the pediatric patient.

EMOTIONAL AND PHYSICAL IMPACT

The potential deformity of the arm at the elbow including varus deformity, prolonged loss of mobility, and absence from school often associated with the treatment of pediatric supracondylar fractures of the humerus can have adverse physical, social, and emotional consequences for the child as well as the child's family. Treatments that minimize these concerns are therefore desirable.

POTENTIAL BENEFITS, HARMS, AND CONTRAINDICATIONS

Most treatments are associated with some known risks, especially invasive and operative treatments. Contraindications vary widely based on the treatment administered. A particular concern when managing supracondylar humerus fractures is the potential for this fracture to cause vascular compromise of the limb, which can lead to long term loss of nerve and/or muscle function. Additional factors may affect the physician's choice of treatment including but not limited to associated injuries the patient may present with as well as the individual's co-morbidities, skeletal maturity, and/or specific patient characteristics including obesity. Clinician input based on experience increases the probability of identifying patients who will benefit from specific treatment options. The individual patient's family dynamic will also influence treatment decisions therefore, discussion of available treatments and procedures applicable to the individual patient rely on mutual communication between the patient's guardian and physician, weighing the potential risks and benefits for that patient. Once the patient's guardian has been informed of available therapies and has discussed these options with his/her child's physician, an informed decision can be made.

II. **METHODS**

This clinical practice guideline and the systematic review upon which it is based evaluate the effectiveness of treatments for supracondylar humerus fracture in children. This section describes the methods used to prepare this guideline and systematic review, including search strategies used to identify literature, criteria for selecting eligible articles, determining the strength of the evidence, data extraction, methods of statistical analysis, and the review and approval of the guideline. We employed these methods to minimize bias in the selection, appraisal, and analysis of the available evidence.[3, 4] These processes are vital to the development of reliable, transparent, and accurate clinical recommendations for treating supracondylar humerus fracture in children.

This guideline and systematic review were prepared by the AAOS Treatment of Pediatric Supracondylar Fracture of the Humerus guideline work group with the assistance of the AAOS Clinical Practice Guidelines Unit in the Department of Research and Scientific Affairs at the AAOS (Appendix I).

To develop this guideline, the work group held an introductory meeting on October 4, 2009 to establish the scope of the guideline and the systematic reviews. Upon completing the systematic reviews, the work group participated in a two-day recommendation meeting on October 2 and 3, 2010 at which the final recommendations and rationales were edited, written and voted on. An initial draft was completed and submitted for peer review November 15, 2010.

The resulting draft guidelines were then peer-reviewed, edited in response to that review, and subsequently sent for public commentary, whereafter additional edits are made. Thereafter, the draft guideline was sequentially sent for approval to the AAOS Evidence Based Practice Committee, AAOS Guidelines and Technology Oversight Committee, AAOS Council on Research, Quality Assessment, and Technology, and the AAOS Board of Directors (see Appendix II for a description of the AAOS bodies involved in the approval process). All AAOS guidelines are reviewed and updated or retired every five years in accordance with the criteria of the National Guideline Clearinghouse.

FORMULATING PRELIMINARY RECOMMENDATIONS

The work group began work on this guideline by constructing a set of preliminary recommendations. These recommendations specify [what] should be done in [whom], [when], [where], and [how often or how long]. They function as questions for the systematic review, not as final recommendations or conclusions. Preliminary recommendations are almost always modified on the basis of the results of the systematic review. Once established, these *a priori* preliminary recommendations cannot be modified until the final work group meeting, they must be addressed by the systematic review, and the relevant review results must be presented in the final guideline.

FULL DISCLOSURE INFORMATION

Each preliminary recommendation developed by the work group is addressed in this guideline. This is of critical importance because it ensures full disclosure of all the data the work group considered. It also prevents bias that could result from failure to make such disclosure.

STUDY SELECTION CRITERIA

We developed *a priori* article inclusion criteria for our review. These criteria are our "rules of evidence" and articles that did not meet them are, for the purposes of this guideline, not evidence.

To be included in our systematic reviews (and hence, in this guideline) an article had to be a report of a study that:

- Study must be of supracondylar humeral fracture
- Article must be a full article report of a clinical study
- Study must appear in a peer-reviewed publication
- Study must be published in English
- Study must be published in or after 1966
- Study must be of humans
- ≥80% of the enrolled study population must be < 12 years of age at the time of fracture (for all Recommendations except 14) For Recommendation 14, ≥80% of the enrolled study population must be >12 and <18.
- Study must not be an in vitro study
- Study must not be a biomechanical study
- Study must not have been performed on cadavers
- Study should have 10 or more patients per group
- All study follow up durations are included
- Study results must be quantitatively presented
- For any given follow-up time point in any included study, there must be ≥ 50% patient follow-up
- Retrospective non-comparative case series, medical records review, meeting abstracts, historical articles, editorials, letters, and commentaries are excluded
- Case series studies that give patients the treatment of interest AND another treatment are excluded
- Case series studies that have non-consecutive enrollment of patients are excluded
- All studies of "Very Low" strength of evidence are excluded

We did not include systematic reviews or meta-analyses compiled by others or guidelines developed by other organizations. These documents are developed using different inclusion criteria than those specified by the AAOS work group. Therefore they may include studies that do not meet our inclusion criteria. We recalled these documents, if the abstract suggested they might provide an answer to one of our recommendations, and searched their bibliographies for additional studies to supplement our systematic review.

BEST EVIDENCE SYNTHESIS

We included only the best available evidence for any given outcome addressing a recommendation. Accordingly, we first included the highest quality evidence for any given outcome if it was available. In the absence of two or more occurrences of an outcome at this quality, we considered outcomes of the next lowest quality until at least two or more occurrences of an outcome had been acquired. For example, if there were two 'moderate' quality occurrences of an outcome that addressed a recommendation, we did not include 'low' quality occurrences of this outcome.

OUTCOMES CONSIDERED

The work group identified the critical outcomes for each recommendation prior to conducting the literature searches. These outcomes are indicated in the table immediately following each recommendation. Non-critical outcomes reported by an author are reported as well.

We address a total of 60 unique outcomes in this guideline. The outcomes considered for each recommendation can be found in the summary table of results for each recommendation. Critical outcomes are listed at the beginning of these summary tables in bold text. All critical outcomes identified by the work group are listed and when no evidence was found for these critical outcomes this is reported.

Clinical studies often report many different outcomes. For this guideline, patient-oriented outcomes are included wherever possible. If patient-oriented outcomes were not available surrogate/intermediate outcomes were considered. Surrogate outcome measures are laboratory measurements or another physical sign used as substitutes for a clinically meaningful end point that measures directly how a patient feels, functions, or survives.[5] Radiographic results are an example of a surrogate outcome.

For outcomes measured using "paper and pencil" instruments (e.g. the visual analogue scale), the results using validated instruments are considered the best available evidence. In the absence of results using validated instruments, results using non-validated instruments are considered as the best available evidence and are subject to quality parameters reported below.

MINIMAL CLINICALLY IMPORTANT IMPROVEMENT

There were no occurrences of validated MCII outcomes in the studies included in this clinical practice guideline. The following information is included in all AAOS guidelines because the analysis of statistical importance is incomplete without consideration of the clinical importance.

Wherever possible, we consider the effects of treatments in terms of the minimal clinically important improvement (MCII) in addition to whether their effects are statistically significant. The MCII is the smallest clinical change that is important to patients, and recognizes the fact that there are some treatment-induced statistically significant improvements that are too small to matter to patients.

When possible we describe the results of studies using terminology based on Armitage, et al.[6] The associated descriptive terms in this guideline and the conditions for using each of these terms, are outlined in Table 1.

Table 1 Descriptive terms for results with MCII

Descriptive Term	Condition for Use
Clinically Important	Statistically significant and lower confidence limit > MCII
Possibly Clinically Important	Statistically significant and confidence intervals contain the MCII
Not Clinically Important	Statistically significant and upper confidence limit < MCII
Negative	Not statistically significant and upper confidence limit < MCII
Inconclusive	Not statistically significant but confidence intervals contain the MCII

When MCII values from the specific guideline patient population was not available, we used values from the most closely related population that has published data available. We acknowledge that there can be variance in the MCII from disease to disease as well as what individual patients consider improvement.

LITERATURE SEARCHES

We attempted to make our searches for articles comprehensive. Using comprehensive literature searches ensures that the evidence we considered for this guideline is not biased for (or against) any particular point of view.

We searched for articles published from January 1966 to July 29, 2010. We searched four electronic databases; PubMed, EMBASE, CINAHL, and The Cochrane Central Register of Controlled Trials. Strategies for searching electronic databases were constructed by the AAOS Medical Librarian using previously published search strategies to identify relevant studies.[7-12]

We supplemented searches of electronic databases with manual screening of the bibliographies of all retrieved publications. We also searched the bibliographies of recent systematic reviews and other review articles for potentially relevant citations. All articles identified were subject to the study selection criteria listed above.

The study attrition diagram in Appendix III provides details about the inclusion and exclusion of the studies considered for this guideline. The search strategies used to identify these studies are provided in Appendix IV.

METHODS FOR EVALUATING EVIDENCE

CLASSIFICATION OF THE FRACTURE

TIMING

Based on the evidence, acute fracture we defined patients with “acute” fractures as those patients who presented for treatment within fourteen days of injury. Please see the supporting evidence for Recommendation 1 for additional information.

SYSTEMS OF CLASSIFICATION

There are numerous fracture classification systems employed by surgeons to help evaluate, plan and standardize treatment. Classification systems communicate the displacement, comminution and rotation of the fracture being treated but no single classification system has perfect inter and intra observer reliability. Further, no classification system can precisely classify all fractures without consideration of additional clinical factors including the mechanism of injury, time and duration since injury, soft tissue damage and swelling and/or presence of neurovascular compromise. Hence, within the guideline we reference the Gartland classification system as a point of reference and not a standard for fracture classification.

The Gartland classification system also applies only to extension and not flexion fractures. However, within our guideline all recommendations that address a displaced fracture refer to both extension and flexion fractures. The ultimate goal of treatment is to achieve optimal outcomes for the patient. As stated throughout the guideline, treatments and procedures applicable to the individual patient rely on mutual communication between the patient’s guardian and physician, weighing the potential risks and benefits for that patient based on their individual circumstances, injury and presentation.

QUALITY

We evaluated the quality of the data on each outcome using a domain-based approach. Such an approach is used by the Cochrane Collaboration.[13] Unlike the Cochrane Collaboration’s scheme (which is for studies with parallel control groups), our scheme allows for evaluation of studies of all designs. The domains we used are whether:

- The study was prospective (with prospective studies, it is possible to have an a priori hypothesis to test; this is not possible with retrospective studies.)
- The study was of low statistical power
- The assignment of patients to groups was unbiased
- There was sufficient blinding to mitigate against a placebo effect
- The patient groups were comparable at the beginning of the study
- The treatment was delivered in such a way that any observed effects could reasonably be attributed to that treatment
- Whether the instruments used to measure outcomes were valid
- Whether there was evidence of investigator bias

Each quality domain is addressed by one or more questions. These questions are shown in Appendix V, Table 76.

To arrive at the quality of the evidence for a given outcome, every quality domain for that outcome reported in any given study is initially judged as not having any flaws and, therefore, the quality of evidence for the effect of that treatment on that outcome is taken as “High.” For all domains except the “Statistical Power” domain, if one or more questions addressing any given domain are answered “No” for a given outcome, that domain is said to have a flaw. A domain is also flawed if there are two or more “Unclear” answers to questions addressing that domain.

Our evaluation of the “Statistical Power” domain considers whether a study had high, moderate or low power. In doing so, we account for whether the results were statistically significant and for the number of patients in the statistical analysis performed on the outcome of interest. The details of these considerations are provided in Appendix V, Table 77.

Domain flaws lead to corresponding reductions in the quality of the evidence. The manner in which we conducted these reductions is shown in the table below (Table 2). For example, the evidence reported in a randomized controlled trial (RCT) for an outcome of interest begins as being rated as “High” quality. However, if more than one domain is flawed for the evidence addressing this outcome, the quality of evidence is reduced to “Moderate.” The quality remains “Moderate” even if another domain is flawed. However, if a fourth domain is flawed, the quality of evidence for that outcome is reduced to “Low.” The quality of evidence is reduced to “Very Low” if six or more domains are flawed.

Some flaws are so serious that we automatically term the evidence as being of “Very Low” quality if a study exhibits them. These serious design flaws are:

- Non-consecutive enrollment of patients in a case series
- Case series that gave patients the treatment of interest AND another treatment
- Measuring the outcome of interest one way in some patients and measuring it in another way in other patients
- Low Statistical Power

Table 2 Relationship between Quality and Domain Scores for Outcomes of Treatments

Number of Domains With No More Than One “Unclear” Answer*	Strength of Evidence
0	High
1-2	Moderate
3-4	Low
>5	Very Low

APPLICABILITY

The applicability (also called “generalizability” or “external validity”) of an outcome is one of the factors used to determine the strength of a recommendation. We categorize outcomes according to whether their applicability is “High”, “Moderate”, or “Low.” As with quality, we separately evaluate the applicability for each outcome a study reports.

The applicability of a study is evaluated using the PRECIS instrument.[14] The instrument was originally designed to evaluate the applicability of randomized controlled trials, but it can also be used for studies of other design. For example, the existence of an implicit control group in a case series (see above) make it useful for evaluating outcomes from these latter studies.

This instrument is comprised of the 10 questions that are briefly described in Table 3. All 10 questions are asked of all studies, regardless of design. The questions are divided into four domains. These domains and their corresponding questions are given in Table 3.

Table 3 Brief Description of the PRECIS Questions and Domains

Question	Domain
All Types of Patients Enrolled	Participants
Flexible Instructions to Practitioners	Interventions and Expertise
Full Range of Expt'l Practitioners	Interventions and Expertise
Usual Practice Control	Interventions and Expertise
Full Range of Control Practitioners	Interventions and Expertise
No Formal Follow-up	Interventions and Expertise
Usual and Meaningful Outcome	Interventions and Expertise
Compliance Not Measured	Compliance and Adherence
No Measure of Practitioner Adherence	Compliance and Adherence
All Patients in Analysis	Analysis

Each study is assumed to have “High” applicability at the start, and applicability is downgraded for flawed domains as summarized in Table 4.

Table 4 Relationship Between Applicability and Domain Scores for Studies of Treatments

Number. Of Flawed Domains	Applicability
0	High
1, 2, 3	Moderate
4	Low

A study’s applicability is “High” if there is only one “Unclear” answer in one domain and the answers to all of the questions for all other domains is “Yes.” A study’s applicability is low if there is one “Unclear” answer in one domain and the answers to all of the questions for all other domains is “No.” A study’s applicability is “Moderate” under all other conditions.

FINAL STRENGTH OF EVIDENCE

To determine the final strength of evidence for an outcome, the strength is initially taken to equal quality. An outcome's strength of evidence is increased by one category if its applicability is "High", and an outcome's strength of evidence is decreased by one category if its applicability is "Low." If an outcome's applicability is "Moderate", no adjustment is made to the strength of evidence derived from the quality evaluation.

DEFINING THE STRENGTH OF THE RECOMMENDATIONS

Judging the strength of evidence is only a stepping stone towards arriving at the strength of a guideline recommendation. The strength of recommendation also takes into account the quality, quantity, and the trade-off between the benefits and harms of a treatment, the magnitude of a treatment's effect, and whether there is data on critical outcomes.

Strength of recommendation expresses the degree of confidence one can have in a recommendation. As such, the strength expresses how possible it is that a recommendation will be overturned by future evidence. It is very difficult for future evidence to overturn a recommendation that is based on many high quality randomized controlled trials that show a large effect. It is much more likely that future evidence will overturn recommendations derived from a few small case series. Consequently, recommendations based on the former kind of evidence are given a high strength of recommendation and recommendations based on the latter kind of evidence are given a low strength.

To develop the strength of a recommendation, AAOS staff first assigned a preliminary strength for each recommendation that took only the final strength of evidence (including quality and applicability) and the quantity of evidence (see Table 5). Work group members then modified the preliminary strength of the recommendation using the 'Form for Assigning Strength of Recommendation (Interventions)' shown in Appendix VI.

Table 5 Strength of recommendation descriptions

Statement Rating	Description of Evidence Strength	Implication for Practice
Strong	Evidence is based on two or more “High” strength studies with consistent findings for recommending for or against the intervention. A **Strong** recommendation means that the benefits of the recommended approach clearly exceed the potential harm (or that the potential harm clearly exceeds the benefits in the case of a strong negative recommendation), and that the strength of the supporting evidence is high.	Practitioners should follow a **Strong** recommendation unless a clear and compelling rationale for an alternative approach is present.
Moderate	Evidence from two or more “Moderate” strength studies with consistent findings, or evidence from a single “High” quality study for recommending for or against the intervention. A **Moderate** recommendation means that the benefits exceed the potential harm (or that the potential harm clearly exceeds the benefits in the case of a negative recommendation), but the strength of the supporting evidence is not as strong.	Practitioners should generally follow a **Moderate** recommendation but remain alert to new information and be sensitive to patient preferences.
Limited	Evidence from two or more “Low” strength studies with consistent findings, or evidence from a single Moderate quality study recommending for or against the intervention or diagnostic. A **Limited** recommendation means the quality of the supporting evidence that exists is unconvincing, or that well-conducted studies show little clear advantage to one approach versus another.	Practitioners should be cautious in deciding whether to follow a recommendation classified as **Limited**, and should exercise judgment and be alert to emerging publications that report evidence. Patient preference should have a substantial influencing role.
Inconclusive	Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.	Practitioners should feel little constraint in deciding whether to follow a recommendation labeled as **Inconclusive** and should exercise judgment and be alert to future publications that clarify existing evidence for determining balance of benefits versus potential harm. Patient preference should have a substantial influencing role.
Consensus[1]	The supporting evidence is lacking and requires the work group to make a recommendation based on expert opinion by considering the known potential harm and benefits associated with the treatment. A **Consensus** recommendation means that expert opinion supports the guideline recommendation even though there is no available empirical evidence that meets the inclusion criteria.	Practitioners should be flexible in deciding whether to follow a recommendation classified as **Consensus,** although they may set boundaries on alternatives. Patient preference should have a substantial influencing role.

[1] The AAOS will issue a consensus-based recommendation only when the service in question has virtually no associated harm and is of low cost (e.g. a history and physical) or when not establishing a recommendation could have catastrophic consequences.

Each recommendation was written using language that accounts for the final strength of the recommendation. This language, and the corresponding strength, is shown in Table 6.

Table 6 AAOS guideline language

Guideline Language	Strength of Recommendation
We ***recommend***	Strong
We ***suggest***	Moderate
The Practitioner ***might***	Limited
We are ***unable to recommend for or against***	Inconclusive
In the absence of reliable evidence, the ***opinion*** of this work group is*	Consensus*

*Consensus based recommendations are made according to specific criteria. These criteria can be found in Appendix VII.

VOTING ON THE RECOMMENDATIONS

The recommendations and their strength were voted on using a structured voting technique known as the nominal group technique.[15] We present details of this technique in Appendix VII. Voting on guideline recommendations was conducted using a secret ballot and work group members were blinded to the responses of other members. If disagreement between work group members was significant, there was further discussion to see whether the disagreement(s) could be resolved. Up to three rounds of voting were held to attempt to resolve disagreements. If disagreements were not resolved following three voting rounds, no recommendation was adopted. Lack of agreement is a reason that the strength for some recommendations can be labeled "Inconclusive."

STATISTICAL METHODS

When possible, we recalculate the results reported in individual studies and compile them to answer the recommendations. The results of all statistical analysis conducted by the AAOS Clinical Practice Guidelines Unit is conducted using STATA 10.0[16]. STATA was used to determine the magnitude, direction, and/or 95% confidence intervals of the treatment effect. For data reported as means (and associated measures of dispersion) the mean difference between groups and the 95% confidence interval was calculated and a two-tailed t-test of independent groups was used to determine statistical significance. When published studies report measures of dispersion other than the standard deviation the value was estimated to facilitate calculation of the treatment effect. In studies that report standard errors or confidence intervals the standard deviation was back-calculated. In studies that only report the median, range, and/or size of the trial, we estimated the means and variances according to a published method.[17] In some circumstances statistical testing was conducted by the authors and measures of dispersion were not reported. In the absence of measures of dispersion, the results of the statistical analyses conducted by the authors (i.e. the p-value) are considered as evidence. For proportions, we report the proportion of patients that experienced an outcome along with the percentage of patients that experienced an outcome. The variance of the arcsine difference was used to determine statistical significance.[18] P-values < 0.05 were considered statistically significant.

We performed meta-analyses using the random effects method of DerSimonian and Laird.[19] A minimum of four studies was required for an outcome to be considered by meta-analysis. Heterogeneity was assessed with the I-squared statistic.[20] Meta-analyses with I-squared values less than 50% were considered as evidence. Those with I-squared larger than 50% were not considered as evidence for this guideline. All meta-analyses were performed using STATA 10.0 and the "metan" command. The arcsine difference was used in meta-analysis of proportions. In order to overcome the difficulty of interpreting the magnitude of the arcsine difference, a summary odds ratio is calculated based on random effects meta-analysis of proportions and the number needed to treat (or harm) is calculated. The standardized mean difference was used for meta-analysis of means and magnitude was interpreted using Cohen's definitions of small, medium, and large effect.[21]

In this guideline, we conduct meta-analysis on relatively low quality data. We do this to combat low power of individual studies, however readers should remember that the data are still low quality and our meta-analysis do not increase the quality of the this evidence.

PEER REVIEW

The draft of the guideline and evidence report was peer reviewed for content. The work group nominated external specialty societies *a priori* to the development of the guideline who then chose content experts to review the document on their behalf. The physician members of the AAOS Guidelines Oversight Committee and the Evidence Based Practice Committee also peer reviewed this document.

Peer review was accomplished using a structured peer review form (see Appendix VIII). The structured review form requires all peer reviewers to declare their conflicts of interest. Peer reviewers may request that their name and corresponding contact information remain anonymous when the final document is published, however, all comments, corresponding conflicts of interest and AAOS responses will be made public with the guidelines if the AAOS Board of Directors approves the document.

Some external specialty societies' will ask their evidence-based practice (EBP) committee to provide peer review comments of our guidelines. These comments must be compiled into one succinct document. We require that the Chair of the external specialty societies' EBP declare his/her conflict of interest and manage the conflicts of interest of the members of that organizations EBP committee.

The draft guideline was sent to eight review organizations of ten that were solicited. A total of thirty-seven reviewers including the members of the AAOS Guidelines Oversight Committee and Evidence-Based Practice Committee were forwarded the draft. Thirteen peer reviewers returned comments (see Appendix IX). The disposition of all non-editorial peer review comments was documented and accompanied this guideline through the public commentary and the AAOS guideline approval process.

PUBLIC COMMENTARY

After modifying the draft in response to peer review, the guideline was subjected to a thirty day period of "Public Commentary." Commentators consist of members of the AAOS Board of Directors (BOD), members of the Council on Research and Quality (CORQ), members of the Board of Councilors (BOC), and members of the Board of Specialty Societies (BOS). The guideline is automatically forwarded to the AAOS BOD and CORQAT so that they may review it and provide comment prior to being asked to approve the document. Members of the BOC and BOS are solicited for interest. If they request to see the document, it is forwarded to them for comment. Based on these bodies, over 200 commentators have the opportunity to provide input into this guideline. Of these, eighteen members received the document for review and four members returned public comments (see Appendix IX).

THE AAOS GUIDELINE APPROVAL PROCESS

Following public commentary, the draft is again modified by the AAOS Clinical Practice Guidelines Unit and work group members. If changes are made as a result of public comment, these changes are summarized and members providing commentary are notified that their input resulted in a change in the guideline.

This final guideline draft must be approved by the AAOS Evidence Based Practice Committee, the AAOS Guidelines Oversight Committee, the AAOS Council on Research and Quality, and the AAOS Board of Directors. Descriptions of these bodies are provided in Appendix II.

REVISION PLANS

This guideline represents a cross-sectional view of current treatment and may become outdated as new evidence becomes available. This guideline will be revised in accordance with new evidence, changing practice, rapidly emerging treatment options, and new technology. This guideline will be updated or withdrawn in five years in accordance with the standards of the National Guideline Clearinghouse.

GUIDELINE DISSEMINATION PLANS

The primary purpose of the present document is to provide interested readers with full documentation about not only our recommendations, but also about how we arrived at those recommendations. This document is also posted on the AAOS website at http://www.aaos.org/research/guidelines/guide.asp.

Shorter versions of the guideline are available in other venues. Publication of most guidelines is announced by an Academy press release, articles authored by the work group and published in the Journal of the American Academy of Orthopaedic Surgeons, and articles published in AAOS *Now*. Most guidelines are also distributed at the AAOS Annual Meeting in various venues such as on Academy Row and at Committee Scientific Exhibits.

Selected guidelines are disseminated by webinar, an Online Module for the Orthopaedic Knowledge Online website, Radio Media Tours, Media Briefings, and by distributing them at relevant Continuing Medical Education (CME) courses and at the AAOS Resource Center.

Other dissemination efforts outside of the AAOS will include submitting the guideline to the National Guideline Clearinghouse and distributing the guideline at other medical specialty societies' meetings.

III. RECOMMENDATIONS

RECOMMENDATION 1

We suggest nonsurgical immobilization of the injured limb for patients with acute (e.g. Gartland Type I) or non-displaced pediatric supracondylar fractures of the humerus or posterior fat pad sign.

Strength of Recommendation: Moderate

Description: Evidence from two or more "Moderate" strength studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. A **Moderate** recommendation means that the benefits exceed the potential harm (or that the potential harm clearly exceeds the benefits in the case of a negative recommendation), but the strength of the supporting evidence is not as strong.

Implications: Practitioners should generally follow a **Moderate** recommendation but remain alert to new information and be sensitive to patient preferences.

Included Studies	Number of Outcomes	Level of Evidence	Quality	Applicability	Critical Outcome(s) For this Recommendation	Benefits and Harms Adjustment
Oakley[22]	2	II	Moderate	Moderate	cubitus varus, hyperextension, loss of reduction, pain	None
Ballal[23]	3	II	Low	High		

RATIONALE

Gartland Type I or non-displaced pediatric supracondylar humeral fractures are fractures without significant distortion of anatomical bony landmarks of the supracondylar region and can be associated with posterior fat pad sign. Non-operative immobilization of these fractures is common practice.

This recommendation is based on two moderate quality studies that analyzed collar and cuff immobilization versus back-slab (posterior splint) immobilization for non-displaced pediatric supracondylar humeral fractures. Ballal, et al. was a prospective double-cohort study with a total of 40 patients and 20 in each group (collar and cuff versus back slab). Oakley, et al presented a randomized control trial with similar comparison groups and had a total of 50 patients (27 randomized to a posterior slab group and 23 to a collar and cuff). The randomized controlled trial was classified as moderate quality (see below for quality evaluation). Both of these prospective studies found better pain relief within the first two weeks of injury with the posterior splint/ back slab method of immobilization. The critical outcomes not reported include cubitus varus, hyperextension and loss of reduction.

SUPPORTING EVIDENCE

QUALITY

Relevant Tables: Table 7, Table 9

Data on 5 outcomes from two studies were found for this recommendation. Two outcomes were of moderate quality and three were of low quality (Table 7). Oakley, et al. was a randomized controlled trial and Ballal, et al. was a prospective controlled trial. Neither study blinded patients, caregivers, or assessors. The blinding domain was the only flawed quality domain for the randomized controlled trial. The other study assigned patients to a treatment group based on the preference of the treating physician and had statistically significant differences in the duration between injury and time of clinic review (i.e. group comparability). All other quality analysis domains were not flawed (Table 9).

APPLICABILITY

Relevant Tables: Table 7, Table 9

Outcomes from Ballall, et al. were assessed as likely to apply to usual clinical practice. Therefore, the applicability of results to results that would be obtained in a typical practice is high. Oakley, et al., a randomized controlled trial with a strict treatment protocol, has some uncertainty if the treatment was delivered similarly to the way it would be delivered in the typical practice and uncertainty if the practitioners who delivered the treatment did so in a way similar to the way it would be delivered in most practices. The applicability of these to results that would be obtained in a typical practice is moderate. Results of the applicability domains analysis are available in Table 9.

FINAL STRENGTH OF EVIDENCE

All ‘Low’ quality outcomes considered for this recommendation were upgraded because of ‘High’ applicability, resulting in a ‘Moderate’ final strength of evidence. The ‘Moderate’ quality outcomes remained at ‘Moderate’ strength of evidence based on their ‘Moderate’ applicability (Table 7).

Table 7 Quality and Applicability Summary - Treatment of Type I Fractures

Study	Outcome	Duration	Quality	Applicability	Strength of Evidence
Oakley	Days to resume normal activities	2 weeks	Moderate	Moderate	**Moderate**
Ballal	**Pain (Wong-Baker Faces)**	2-3 days	Low	High	**Moderate**
Oakley	**Pain (VAS)**	2 weeks	Moderate	Moderate	**Moderate**
Ballal	Regular use of analgesia	2-3 days	Low	High	**Moderate**
Ballal	Sleep interruption	2-3 days	Low	High	**Moderate**

Bold outcomes are identified as critical outcomes

RESULTS

Relevant Tables: Table 8, Table 10, Table 11

Both studies compared treatment with a backslab to treatment with cuff and collar. One study reported outcomes 2-3 days after treatment and the other reported outcomes 2 weeks after treatment. The results of statistical testing and the direction of treatment effect (i.e. the favored treatment) are summarized in the table below (Table 8).

In total, 5 of 5 outcomes had statistically significant differences based on analysis of mean differences and proportions (Table 8, Table 10, Table 11)

One (of 4) critical outcome identified by the work group was reported. Pain was reported by both studies, although at different durations and using different scales. The results were statistically significant in both studies when analyzing mean differences (Table 10). Oakley, et al. reported that 20 mm difference in pain on the visual analog scale (VAS) would be clinically important. The difference between the two treatment groups in this study, for pain on the VAS, was statistically significant with confidence intervals that did not include this clinically meaningful difference.

Table 8 Results Summary - Treatment of Type I Fractures

Outcome(s)	2-3 days	2 weeks
Cubitus varus	no evidence	
Hyperextension	no evidence	
Loss of Reduction	no evidence	
Pain	●	●
Number of days to resume normal activities		●
Regular use of analgesia	●	
Sleep interruption	●	

Bold outcomes are identified as critical outcomes, ●: statistically significant in favor of backslab, ○: no statistically significant difference, ♦: statistically significant in favor of cuff and collar

EVIDENCE TABLES AND FIGURES

QUALITY AND APPLICABILITY

Table 9 Quality and Applicability Domain Scores – Treatment of Type I Fractures

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Oakley	Days to resume normal activities	2 weeks	●	●	●	○	●	●	●	●	Moderate	●	○	●	●	Moderate
Ballal	Pain (Wong-Baker Faces)	2-3 days	●	●	○	○	○	●	●	●	Low	●	●	●	●	High
Oakley	Pain (VAS)	2 weeks	●	●	●	○	●	●	●	●	Moderate	●	○	●	●	Moderate
Ballal	Regular use of analgesia	2-3 days	●	●	○	○	○	●	●	●	Low	●	●	●	●	High
Ballal	Sleep interruption	2-3 days	●	●	○	○	○	●	●	●	Low	●	●	●	●	High

FINDINGS

Table 10 Analysis of Mean Differences – Treatment of Type I fractures

Study	n	Strength of Evidence	Outcome	Duration	Backslab (mean±SD)	Cuff/Collar (mean±SD)	Difference (95% CI)	Results
Oakley	39	Moderate	Days to resume normal activities	2 weeks	2.5 ± 1	7 ± 2.5	4.5 (3.3, 5.7)	Favors Backslab
Oakley	48	Moderate	**Pain (100mm VAS)**	2 weeks	28 ± 5	36 ± 7	8* (4.6, 11.4)	Favors Backslab
Ballal	50	Moderate	**Pain (Wong-Baker Faces scale)**	2-3 days	3.4 ± 1.58	7.2 ± 1.4	3.8 (2.8, 4.8)	Favors Backslab

* study authors use a clinically significant difference of 20mm in a priori power analysis.

Table 11 Analysis of Proportions – Treatment of Type I Fractures

Study	n	Strength of Evidence	Outcome	Duration	Backslab %, n/N	Cuff/Collar %, n/N	p-value	Results
Ballal	40	Moderate	Regular use of analgesia	2-3 days	20% , 4/20	70%, 14/20	0.00	Favors Backslab
Ballal	40	Moderate	Sleep interruption	2-3 days	45%, 9/20	85%, 17/20	0.01	Favors Backslab

RECOMMENDATION 2

We suggest closed reduction with pin fixation for patients with displaced (e.g. Gartland Type II and III, and displaced flexion) pediatric supracondylar fractures of the humerus.

Strength of Recommendation: Moderate

Description: Evidence from two or more "Moderate" strength studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. A **Moderate** recommendation means that the benefits exceed the potential harm (or that the potential harm clearly exceeds the benefits in the case of a negative recommendation), but the strength of the supporting evidence is not as strong.

Implications: Practitioners should generally follow a **Moderate** recommendation but remain alert to new information and be sensitive to patient preferences.

Included Studies	Number of Outcomes	Level of Evidence	Quality	Applicability	Critical Outcome(s)	Benefits and Harms Adjustment
Ababneh[24]	3	III	Low	Moderate	cubitus varus, hyperextension, loss of reduction, malunions, pain, stiff elbow	Upgrade
Almorhij[25]	2	III	Low	Moderate		
France[26]	2	III	Low	Moderate		
Kennedy[27]	4	III	Low	Moderate		
Khan[28]	4	III	Low	Moderate		
Padman[29]	1	III	Low	Moderate		
Pandey[30]	3	II	Low	Moderate		
Pirone[31]	7	III	Low	Moderate		
Ababneh[24]	3	III	Low	Moderate		
Kaewpor-nsawan[32]	1	II	Moderate	Moderate		
Ozkoc[33]	8	III	Low	Moderate		
France[26]	2	III	Low	Moderate		
Pirone[31]	7	III	Low	Moderate		
Sutton[2]	1	III	Low	Moderate		

RATIONALE

Data on 48 outcomes from 11 studies formed the basis of this recommendation. For this analysis, Gartland Type II and III fractures were analyzed in aggregate since many of the studies combined the results from the two types. Similarly, the less common flexion type pediatric supracondylar fracture was included in this group. [Please refer to line 732 of this guideline for additional information.] The quality, applicability, and the strength of the evidence generated a preliminary strength of recommendation of “limited”. The work group upgraded the recommendation to “moderate” based on the potential for harm from non-operative treatment of displaced pediatric supracondylar fractures. For example, casting the arm in hyperflexion may cause limb threatening ischemia.

The initial recommendation of “limited” was based on the lack of evidence addressing the six critical outcomes that the work group had identified. Pin fixation was shown to be statistically superior to non-operative treatment for two critical outcomes, prevention of cubitus varus and loss of motion.

Among the non-critical outcomes, pin fixation was statistically superior to non-operative treatment in a meta-analysis of Flynn’s Criteria. This outcome incorporates both range of motion and carrying angle. Two non-critical outcomes, infection and pin track infection, favored non-operative treatment because they can only occur in patients who receive operative treatment.

Although operative treatment introduces the risk of infection, the improved critical outcomes combined with the decreased risk of limb threatening ischemic injury outweigh these risks.

SUPPORTING EVIDENCE

QUALITY

Relevant Tables: Table 12-Table 14, Table 18-Table 20

Data on 48 outcomes from eleven studies were found for this recommendation. One outcome was of moderate quality and all remaining outcomes were of low quality (Table 52-Table 55). The single moderate strength outcome was from the randomized controlled trial by Kaewpornsawan. This outcome, patient satisfaction, had two flawed quality domains; blinding and measurement. The measurement domain is flawed, despite its obvious importance to patients, due to not being validated. Three outcomes from the second RCT, Pandey, et al., had an unflawed prospective quality domain but was flawed for group assignment, blinding, and measurement. Three outcomes measuring infection had unflawed measurement domains due to being directly observable without the need for testing and/or important to the patient. The remaining 41 outcomes from nine retrospective comparative studies had flawed prospective, group assignment, blinding and measurement domains. All other quality analysis domains were not flawed (Table 18-Table 20).

APPLICABILITY

Relevant Tables: Table 12-Table 14, Table 18-Table 20

For all eleven studies there is some uncertainty if the practitioners who delivered the treatment did so in a way similar to the way it would be delivered in most practices due to the low number of surgeons performing the operations in each study. Except for the patients enrolled in the two randomized controlled trials (Pandey, et al. and Kaewpornsawan), the patients investigated in these studies are thought to be similar to those seen in actual clinical practice. The compliance and adherence to treatment in all of the studies is believed to be similar to that seen in actual clinical practice. The applicability of the included outcomes to results that would be obtained in a typical practice is moderate. Results of the applicability domains analysis are available in Table 18-Table 20.

FINAL STRENGTH OF EVIDENCE

All 'Low' quality outcomes remained at 'Low' strength of evidence based on their 'Moderate' applicability. The single 'Moderate' quality outcome remained at 'Moderate' strength of evidence based on it's 'Moderate' applicability (Table 12-Table 14).

Table 12 Quality and Applicability Summary - Closed Reduction with Pin Fixation vs. Non-operative Treatment

Study	Outcome	Duration	Quality	Applicability	Strength of Evidence
France	Baumann's angle	Union	Low	Moderate	**Low**
Pirone	Carrying angle	Final follow-up	Low	Moderate	**Low**
Ababneh	**Cubitus varus**	n/a	Low	Moderate	**Low**
Almohrij	**Cubitus varus**	n/a	Low	Moderate	**Low**
Kennedy	**Cubitus varus**	n/a	Low	Moderate	**Low**
Khan	**Cubitus varus**	n/a	Low	Moderate	**Low**
Pirone	**Cubitus varus**	n/a	Low	Moderate	**Low**
Pirone	Elbow extension	Final follow-up	Low	Moderate	**Low**
Pirone	Elbow flexion	Final follow-up	Low	Moderate	**Low**
Ababneh	Flynn's criteria - satisfactory	Final follow-up	Low	Moderate	**Low**
Khan	Flynn's criteria - satisfactory	1 year	Low	Moderate	**Low**
Pandey	Flynn's criteria - satisfactory	6 months	Low	Moderate	**Low**
Pirone	Flynn's criteria - satisfactory	Final follow-up	Low	Moderate	**Low**

Table 12 Quality and Applicability Summary - Closed Reduction with Pin Fixation vs. Non-operative Treatment

Study	Outcome	Duration	Quality	Applicability	Strength of Evidence
Padman	Good outcome/uneventful recovery	Final follow-up	Low	Moderate	**Low**
France	Humerocapitellar angle	Union	Low	Moderate	**Low**
Pandey	Iatrogenic ulnar nerve injuries	n/a	Low	Moderate	**Low**
Pirone	Iatrogenic ulnar nerve injuries	n/a	Low	Moderate	**Low**
Kennedy	Iatrogenic ulnar nerve injury	n/a	Low	Moderate	**Low**
Khan	Iatrogenic ulnar nerve injury	n/a	Low	Moderate	**Low**
Pirone	Infection	n/a	Low	Moderate	**Low**
Almohrij	Infection – pin track	n/a	Low	Moderate	**Low**
Kennedy	Infection – pin track	n/a	Low	Moderate	**Low**
Khan	Infection – pin track	n/a	Low	Moderate	**Low**
Pandey	Infection – pin track	n/a	Low	Moderate	**Low**
Ababneh	**Loss of motion**	n/a	Low	Moderate	**Low**
Kennedy	**Loss of reduction**	n/a	Low	Moderate	**Low**

Bold outcomes are identified as critical outcomes

Bold outcomes are identified as critical outcomes

Table 13 Quality and Applicability Summary - Closed Reduction with Pin Fixation vs. Open Reduction with Pin Fixation

Study	Outcome	Duration	Quality	Applicability	Strength of Evidence
Ababneh	**Cubitus varus**	n/a	Low	Moderate	**Low**
Ozkoc	Extension lag	Final follow-up	Low	Moderate	**Low**
Ozkoc	Flexion deficiency	Final follow-up	Low	Moderate	**Low**
Ozkoc	Flynn’s cosmetic criteria - satisfactory	Final follow-up	Low	Moderate	**Low**

Table 13 Quality and Applicability Summary - Closed Reduction with Pin Fixation vs. Open Reduction with Pin Fixation

Study	Outcome	Duration	Quality	Applicability	Strength of Evidence
Ababneh	Flynn's criteria - satisfactory	Final follow-up	Low	Moderate	**Low**
Ozkoc	Flynn's functional criteria - satisfactory	Final follow-up	Low	Moderate	**Low**
Ozkoc	Fracture healing time	n/a	Low	Moderate	**Low**
Ozkoc	Humeral-ulnar angle difference	Final follow-up	Low	Moderate	**Low**

Bold outcomes are identified as critical outcomes

Study	Outcome	Duration	Quality	Applicability	Strength of Evidence
Ozkoc	Iatrogenic ulnar nerve injury	n/a	Low	Moderate	**Low**
Ozkoc	Infection – pin track	n/a	Low	Moderate	**Low**
Ababneh	**Loss of motion**	n/a	Low	Moderate	**Low**
Kaewpornsawan	Patient satisfaction score (VAS)	Final follow-up	Moderate	Moderate	**Moderate**

Bold outcomes are identified as critical outcomes

Table 14 Quality and Applicability Summary - Closed Reduction with Pin Fixation vs. Traction

Study	Outcome	Duration	Quality	Applicability	Strength of Evidence
France	Baumann's angle	Union	Low	Moderate	**Low**
Pirone	Carrying angle	Final follow-up	Low	Moderate	**Low**
Pirone	**Cubitus varus**	n/a	Low	Moderate	**Low**
Pirone	Elbow extension	Final follow-up	Low	Moderate	**Low**
Pirone	Elbow flexion	Final follow-up	Low	Moderate	**Low**
Pirone	Flynn's criteria - satisfactory	Final follow-up	Low	Moderate	**Low**
France	Humerocapitellar angle	Union	Low	Moderate	**Low**
Pirone	Iatrogenic ulnar nerve injuries	n/a	Low	Moderate	**Low**
Pirone	Infection	n/a	Low	Moderate	**Low**
Sutton	Volkmann's ischemia	n/a	Low	Moderate	**Low**

Bold outcomes are identified as critical outcomes

RESULTS

Relevant Tables and Figures: Table 15-Table 17, Table 21-Table 26, Figure 1- Figure 4

Eight of the studies compared closed reduction with pin fixation to closed reduction and non-operative immobilization. Two of the eight studies investigated only Type III fracture (or otherwise described as displaced with posterior cortex not intact) and the remaining six investigated Type II or III fractures (or otherwise described as displaced with posterior cortex not intact or simply described as displaced). Three of the studies compared closed reduction with pin fixation to closed reduction and traction. Two of these studies investigated Type III fractures only and one investigated Type II or III fractures. Three of the studies compared closed reduction with pin fixation to open reduction with pin fixation. The patients that received open reduction in the final group of studies did not undergo closed reduction attempts and received open reduction as the primary reduction (due to lack of technology to attempt closed reduction). Two of these studies investigated Type III fractures only and one investigated Type II or III fractures. These characteristics are summarized in Table 16.

The results of statistical testing and the direction of treatment effect (i.e. the favored treatment) are summarized in Table 17 according to the fracture types. In total 19 of 39 outcomes had statistically significant differences in favor of closed reduction with pin fixation, 2 of 39 had statistically significant differences in favor of non-operative treatment, and 17 did not have statistically significant differences (Table 17). 9 outcomes in the comparison of closed reduction with pin fixation to closed reduction with non-operative treatment were only considered for meta-analysis because of low power. The results of all meta-analysis for these four outcomes (cubitus varus, Flynn's criteria, iatrogenic ulnar nerve injury, and infection) are summarized in Table 17.

Three (of 6) critical outcomes; cubitus varus, loss of reduction, and stiff elbow, identified by the work group were reported in the included studies for the comparison of closed reduction with pin fixation to closed reduction with non-operative treatment. Cubitus varus was evaluated with meta-analysis of five studies and showed no statistically significant difference between closed reduction with pin fixation and closed reduction with non-operative treatment (Figure 1). Loss of reduction was evaluated in one study of Type II and III fractures and was not statistically significant. Loss of motion (i.e. stiff elbow) was evaluated in one study of Type II and III fractures and was statistically significant in favor of closed reduction and pin fixation. The meta-analysis of Flynn's criteria was statistically significant in favor of closed reduction with pin fixation, the meta-analysis of iatrogenic ulnar nerve injury was not statistically significant, and the meta-analysis of infection was statistically significant in favor of closed reduction with non-operative treatment (Figure 2-Figure 4)

Two (of 6) critical outcomes, cubitus varus and stiff elbow, identified by the work group were reported in the included studies for the comparison of closed reduction with pin fixation to closed reduction with open reduction and pin fixation. There was no statistically significant difference between the treatment groups for cubitus varus and a statistically significant difference in favor of closed reduction with pin fixation for loss of motion (i.e. stiff elbow).

One (of 6) critical outcome, cubitus varus, identified by the work group was reported in the included studies for the comparison of closed reduction with pin fixation to traction. This result was not statistically significant.

Table 15 Treatments Compared to Closed Reduction with Pin Fixation

Treatment compared to Closed reduction with Pin fixation	Number of Studies
Closed reduction and non-operative immobilization	8
Closed reduction and traction	3
Open reduction (without closed reduction attempt) and pin fixation	3
Open reduction and internal fixation	0
External fixation	0

Table 16 Fracture Type and Treatment Comparisons to Closed Reduction with Pin Fixation

Study	Fracture Types Studied	Treatment Compared to Closed Reduction with Pin Fixation
Khan[28]	II, III	cast immobilization
Ababneh[24]	II, III	cast immobilization in flexion
Almohrij[25]	III	cast immobilization in flexion
Padman[29]	II, III	cast immobilization in flexion
Pandey[30]	II, III	cast immobilization in flexion
Pirone[31]	II, III	cast immobilization in flexion
Kennedy[27]	II, III	collar and cuff immobilization
France[26]	III	splint immobilization in flexion
Ababneh[24]	II, III	open reduction with crossed pin fixation
Ozkoc[33]	III	open reduction with crossed pin fixation
Kaewpornsawan[32]	III	open reduction with crossed lateral pin fixation
France[26]	III	traction/ormandy screw or ulna wire

Table 16 Fracture Type and Treatment Comparisons to Closed Reduction with Pin Fixation

Study	Fracture Types Studied	Treatment Compared to Closed Reduction with Pin Fixation
Pirone[31]	II, III	skeletal traction/olecranon screw
Sutton[2]	III	skeletal traction/olecranon wire

Table 17 Results Summary - Closed Reduction with Pin Fixation vs. Non-operative, Open Reduction with Pin Fixation, or Traction

Closed Reduction/Pin	vs. Non-operative			vs. Open Reduction/Pin		vs. Traction	
Outcome(s)	**Type II and III**	**Type III**	**Meta-Analysis**	**Type II and III**	**Type III**	**Type II and III**	**Type III**
Cubitus Varus	● ● ○		○	○		○	
Hyperextension		no evidence		no evidence		no evidence	
Loss of reduction	○			no evidence		no evidence	
Malunion		no evidence		no evidence		no evidence	
Pain		no evidence		no evidence		no evidence	
Stiff elbow (Loss of motion)	●			●		no evidence	
Baumann's angle		●					●
Carrying angle	●					○	
Elbow extension	○					●	
Elbow flexion	●					○	
Extension lag					●		
Flexion deficiency					●		
Flynn's cosmetic criteria					○		
Flynn's criteria	● ●		●	○		○	
Flynn's functional criteria					●		
Fracture healing time					●		
Good outcome/uneventful recovery	○						
Humeral-ulnar angle difference					●		
Humerocapitellar angle		●					●

Bold outcomes are identified as critical outcomes, ●: statistically significant in favor of closed reduction with pin fixation, ○: no statistically significant difference, ♦: statistically significant in favor of non-operative, open reduction with pin fixation, or traction

Table 17 Results Summary - Closed Reduction with Pin Fixation vs. Non-operative, Open Reduction with Pin Fixation, or Traction

Closed Reduction/Pin	vs. Non-operative			vs. Open Reduction/Pin		vs. Traction	
Outcome(s)	**Type II and III**	**Type III**	**Meta-Analysis**	**Type II and III**	**Type III**	**Type II and III**	**Type III**
Iatrogenic ulnar nerve injury	○ ○		○		○	○	
Infection	♦		♦			○	
Infection - pin track	♦				○		
Patient satisfaction score					●		
Volkmann’s ischemia							○

Bold outcomes are identified as critical outcomes, ●: statistically significant in favor of closed reduction with pin fixation, ○: no statistically significant difference, ♦: statistically significant in favor of non-operative, open reduction with pin fixation, or traction

EVIDENCE TABLES AND FIGURES

QUALITY AND APPLICABILITY-CLOSED REDUCTION WITH PIN FIXATION VS. NON-OPERATIVE TREATMENTS

Table 18 Quality and Applicability Domain Scores – Treatment of Type II and III Fractures, Closed Reduction with Pin Fixation vs. Non-operative Treatments

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
France	Baumann's angle	Union	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Pirone	Carrying angle	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Ababneh	Cubitus varus	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Almohrij	Cubitus varus	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Kennedy	Cubitus varus	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Khan	Cubitus varus	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Pirone	Cubitus varus	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate

Table 18 Quality and Applicability Domain Scores – Treatment of Type II and III Fractures, Closed Reduction with Pin Fixation vs. Non-operative Treatments

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Pirone	Elbow extension	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Pirone	Elbow flexion	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Ababneh	Flynn's criteria - satisfactory	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Khan	Flynn's criteria - satisfactory	1 year	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Pandey	Flynn's criteria - satisfactory	6 months	●	●	●	○	○	●	○	●	Low	○	○	●	●	Moderate
Pirone	Flynn's criteria - satisfactory	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Padman	Good outcome/uneventful recovery	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
France	Humerocapitellar angle	Union	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate

Table 18 Quality and Applicability Domain Scores – Treatment of Type II and III Fractures, Closed Reduction with Pin Fixation vs. Non-operative Treatments

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Pandey	Iatrogenic ulnar nerve injury	n/a	●	●	●	○	○	●	○	●	Low	○	○	●	●	Moderate
Pirone	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Kennedy	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Khan	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Pirone	Infection	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	●	Moderate
Almohrij	Infection – pin track	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Kennedy	Infection – pin track	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Khan	Infection – pin track	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	●	Moderate

Table 18 Quality and Applicability Domain Scores – Treatment of Type II and III Fractures, Closed Reduction with Pin Fixation vs. Non-operative Treatments

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Pandey	Infection – pin track	n/a	●	●	●	○	○	●	●	●	Low	○	○	●	●	Moderate
Ababneh	Loss of motion	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Kennedy	Loss of reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate

QUALITY AND APPLICABILITY-CLOSED VS. OPEN REDUCTION WITH PIN FIXATION

Table 19 Quality and Applicability Domain Scores – Treatment of Type II and III Fractures, Closed vs. Open Reduction with Pin Fixation

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Ababneh	Cubitus varus	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Ozkoc	Extension lag	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Ozkoc	Flexion deficiency	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Ozkoc	Flynn's cosmetic criteria - satisfactory	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Ozkoc	Flynn's cosmetic criteria - satisfactory	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Ababneh	Flynn's criteria - satisfactory	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Ozkoc	Fracture healing time	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Ozkoc	Humeral-ulnar angle difference	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate

Table 19 Quality and Applicability Domain Scores – Treatment of Type II and III Fractures, Closed vs. Open Reduction with Pin Fixation

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Ozkoc	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Ozkoc	Infection – pin track	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	●	Moderate
Ababneh	Loss of motion	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Kaewpor-nsawan	Patient satisfaction score (VAS)	Final follow-up	●	●	●	○	●	●	○	●	Moderate	○	○	●	●	Moderate

QUALITY AND APPLICABILITY-CLOSED REDUCTION WITH PIN FIXATION VS. TRACTION

Table 20 Quality and Applicability Domain Scores – Treatment of Type II and III Fractures, Closed Reduction with Pin Fixation vs. Traction

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
France	Baumann's angle	Union	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Pirone	Carrying angle	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Pirone	Cubitus varus	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Pirone	Elbow extension	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Pirone	Elbow flexion	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Pirone	Flynn's criteria - satisfactory	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
France	Humerocapitellar angle	Union	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Pirone	Iatrogenic ulnar nerve injuries	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate

Table 20 Quality and Applicability Domain Scores – Treatment of Type II and III Fractures, Closed Reduction with Pin Fixation vs. Traction

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Pirone	Infection	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	●	Moderate
Sutton	Volkmann's ischemia	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate

FINDINGS-CLOSED REDUCTION WITH PIN FIXATION VS. NON-OPERATIVE TREATMENTS

Table 21 Analysis of Mean Differences – Treatment of Type II and III Fractures, Closed Reduction with Pin Fixation vs. Non-operative Treatments

Study	n	Strength of Evidence	Outcome	Duration	Closed/ Pin (mean±SD)	Non-op (mean±SD)	Difference (95% CI)	Results
France	99	Low	Baumann's angle	Union	18 ± 2.8	12 ± 2.9	6 (4.8, 7.2)	Favors Closed
Pirone	197	Low	Carrying angle	Final follow-up	7.8 ± 4.6	6.2 ± 6.1	1.6 (0.08, 3.12)	Favors Closed
Pirone	197	Low	Elbow extension	Final follow-up	-11.2 ± 6.2	-10.2 ± 7.6	1 (-0.95, 2.95)	No difference
Pirone	197	Low	Elbow flexion	Final follow-up	139.1 ± 5.1	137.0 ± 7.3	2.1 (0.3, 3.9)	Favors Closed
France	99	Low	Humerocapitellar angle	Union	39 ± 3.3	18 ± 4.2	21 (19.5, 22.5)	Favors Closed

Table 22 Analysis of Proportions – Treatment of Type II and III Fractures, Closed Reduction with Pin Fixation vs. Non-operative Treatments

Study	n	Strength of Evidence	Outcome	Duration	Closed/Pin %, n/N	Non-op %, n/N	p-value	Results
Ababneh	82	Low	Cubitus varus	n/a	5%, 2/37	20%, 9/45	0.04	Favors Closed
Almohrij	50	Low	Cubitus varus	n/a	4%, 1/24	4%, 1/26	underpowered, retained for meta-analysis	
Kennedy	85	Low	Cubitus varus	n/a	9%, 3/35	4%, 2/50	0.39	No difference

Table 22 Analysis of Proportions – Treatment of Type II and III Fractures, Closed Reduction with Pin Fixation vs. Non-operative Treatments

Study	n	Strength of Evidence	Outcome	Duration	Closed/Pin %, n/N	Non-op %, n/N	p-value	Results
Khan	40	Low	Cubitus varus	n/a	10%, 2/20	30%, 6/20	underpowered, retained for meta-analysis	
Pirone	197	Low	Cubitus varus	n/a	1%, 1/96	8%, 8/101	0.01	Favors Closed
Ababneh	82	Low	Flynn's criteria - satisfactory	Final follow-up	92%, 34/37	69%, 31/45	0.00	Favors Closed
Khan	40	Low	Flynn's criteria - satisfactory	1 year	85%, 17/20	70%, 14/20	underpowered, retained for meta-analysis	
Pandey	46	Low	Flynn's criteria - satisfactory	Final follow-up	100%, 24/24	86%, 19/22	underpowered, retained for meta-analysis	
Pirone	197	Low	Flynn's criteria - satisfactory	Final follow-up	95%, 91/96	80%, 81/101	0.00	Favors Closed
Padman	66	Low	Good outcome/uneventful recovery	Final follow-up	90%, 44/49	88%, 15/17	0.86	No difference
Pandey	46	Moderate	Iatrogenic ulnar nerve injury	n/a	4%, 1/24	0%, 0/22	underpowered, retained for meta-analysis	
Pirone	197	Low	Iatrogenic ulnar nerve injury	n/a	0%, 0/96	0%, 0/101	1.00	No difference

Table 22 Analysis of Proportions – Treatment of Type II and III Fractures, Closed Reduction with Pin Fixation vs. Non-operative Treatments

Study	n	Strength of Evidence	Outcome	Duration	Closed/Pin %, n/N	Non-op %, n/N	p-value	Results
Kennedy	85	Low	Iatrogenic ulnar nerve injury	n/a	3%, 1/35	0%, 0/50	0.12	No difference
Khan	40	Low	Iatrogenic ulnar nerve injury	n/a	5%, 1/20	0%, 0/20	underpowered, retained for meta-analysis	
Pirone	197	Low	Infection	n/a	2%, 2/96	0%, 0/101	0.04	Favors Non-op
Almohrij	50	Low	Infection – pin track	n/a	4%, 1/24	0%, 0/26	underpowered, retained for meta-analysis	
Kennedy	85	Low	Infection – pin track	n/a	17%, 6/35	0%, 0/50	0.00	Favors Non-op
Khan	40	Low	Infection – pin track	n/a	10%, 2/20	0%, 0/20	underpowered, retained for meta-analysis	
Pandey	46	Low	Infection – pin track	n/a	0%, 0/24	0%, 0/22	underpowered, retained for meta-analysis	
Ababneh	82	Low	Loss of motion	n/a	0%, 0/37	11%, 5/45	0.00	Favors Closed
Kennedy	85	Low	Loss of reduction	n/a	3%, 1/35	10%, 5/50	0.16	No difference

FINDINGS-CLOSED VS. OPEN REDUCTION WITH PIN FIXATION

Table 23 Analysis of Means – Treatment of Type II and III Fractures, Closed vs. Open Reduction with Pin Fixation

Study	n	Strength of Evidence	Outcome	Duration	Closed/ Pin (mean±SD)	Open/ Pin (mean±SD)	Difference (95% CI)	Results
Ozkoc	99	Low	Extension lag	Final follow-up	0.6 ± 1.7	6.23 ± 2.3	5.63 (4.8, 6.4)	Favors Closed
Ozkoc	99	Low	Flexion deficiency	Final follow-up	5.25 ± 1.9	8.61 ± 2.2	3.36 (2.5, 4.2)	Favors Closed
Ozkoc	99	Low	Fracture healing time	n/a	4.8 ± 0.7	5.3 ± 0.7	0.5 (0.2, 0.8)	Favors Closed
Ozkoc	99	Low	Humeral-ulnar angle difference	Final follow-up	3.6 ± 2.4	5.1 ± 2.2	1.5 (0.6, 2.4)	Favors Closed
Kaewpor-nsawan	28	Moderate	Patient satisfaction score (VAS)	Final follow-up	9.2 ± 0.5	8.6 ± 0.8	0.6 (0.08, 1.12)	Favors Closed

Table 24 Analysis of Proportions – Treatment of Type II and III Fractures, Closed vs. Open Reduction with Pin Fixation

Study	n	Strength of Evidence	Outcome	Duration	Closed/Pin %, n/N	Open/Pin %, n/N	p-value	Results
Ababneh	135	Low	Cubitus varus	n/a	5%, 2/37	13%, 7/53	0.20	No difference
Ozkoc	99	Low	Flynn’s cosmetic criteria - satisfactory	Final follow-up	95%, 52/55	95%, 42/44	0.84	No difference
Ababneh	135	Low	Flynn’s criteria - satisfactory	Final follow-up	8%, 3/37	23%, 12/53	0.05	No difference

Table 24 Analysis of Proportions – Treatment of Type II and III Fractures, Closed vs. Open Reduction with Pin Fixation

Study	n	Strength of Evidence	Outcome	Duration	Closed/Pin %, n/N	Open/Pin %, n/N	p-value	Results
Ozkoc	99	Low	Flynn's functional criteria - satisfactory	Final follow-up	93%, 51/55	70%, 31/44	0.00	Favors Closed
Ozkoc	99	Low	Iatrogenic ulnar nerve injury	n/a	4%, 2/55	5%, 2/44	0.82	No difference
Ozkoc	99	Low	Infection – pin track	n/a	4%, 2/55	7%, 3/44	0.48	No difference
Ababneh	135	Low	Loss of motion	n/a	0%, 0/37	9%, 5/53	0.00	Favors Closed

FINDINGS-CLOSED REDUCTION WITH PIN FIXATION VS. TRACTION

Table 25 Analysis of Means – Treatment of Type II and III Fractures, Closed Reduction with Pin Fixation vs. Traction

Study	n	Strength of Evidence	Outcome	Duration	Closed/ Pin (mean±SD)	Traction (mean±SD)	Difference (95% CI)	Results
France	99	Low	Baumann's angle	Union	18 ± 2.8	16 ± 2.9	2 (0.9, 3.1)	Favors Closed
Pirone	120	Low	Carrying angle	Final follow-up	7.8 ± 4.6	7.4 ± 5.1	0.4 (-1.7, 2.52)	No difference
Pirone	120	Low	Elbow extension	Final follow-up	-11.2 ± 6.2	-15.1 ± 7.4	3.9 (1, 6.8)	Favors Closed
Pirone	120	Low	Elbow flexion	Final follow-up	139.1 ± 5.1	138.1 ± 7.9	1 (-1.6, 3.6)	No difference
France	99	Low	Humerocapitellar angle	Union	39 ± 3.3	24 ± 4.2	15 (13.5, 16.5)	Favors Closed

Table 26 Analysis of Proportions – Treatment of Type II and III Fractures, Closed Reduction with Pin Fixation vs. Traction

Study	n	Strength of Evidence	Outcome	Duration	Closed/Pin %, n/N	Traction %, n/N	p-value	Results
Pirone	120	Low	Cubitus varus	n/a	1%, 1/96	0%, 0/24	0.37	No difference
Pirone	120	Low	Flynn's criteria - satisfactory	Final follow-up	95%, 91/96	92%, 22/24	0.58	No difference
Pirone	120	Low	Iatrogenic ulnar nerve injuries	n/a	0%, 0/96	0%, 0/24	1.00	No difference
Pirone	120	Low	Infection	n/a	2%, 2/96	0%, 0/24	0.20	No difference

Table 26 Analysis of Proportions – Treatment of Type II and III Fractures, Closed Reduction with Pin Fixation vs. Traction

Study	n	Strength of Evidence	Outcome	Duration	Closed/Pin %, n/N	Traction %, n/N	p-value	Results
Sutton	65	Low	Volkmann's ischemia	n/a	0%, 0/48	0%, 0/17	1.00	No difference

FIGURES-CLOSED REDUCTION WITH PIN FIXATION VS. NON-OPERATIVE TREATMENTS

Figure 1 Cubitus Varus Meta-Analysis - Closed Reduction with Pin Fixation vs. Non-operative Treatments

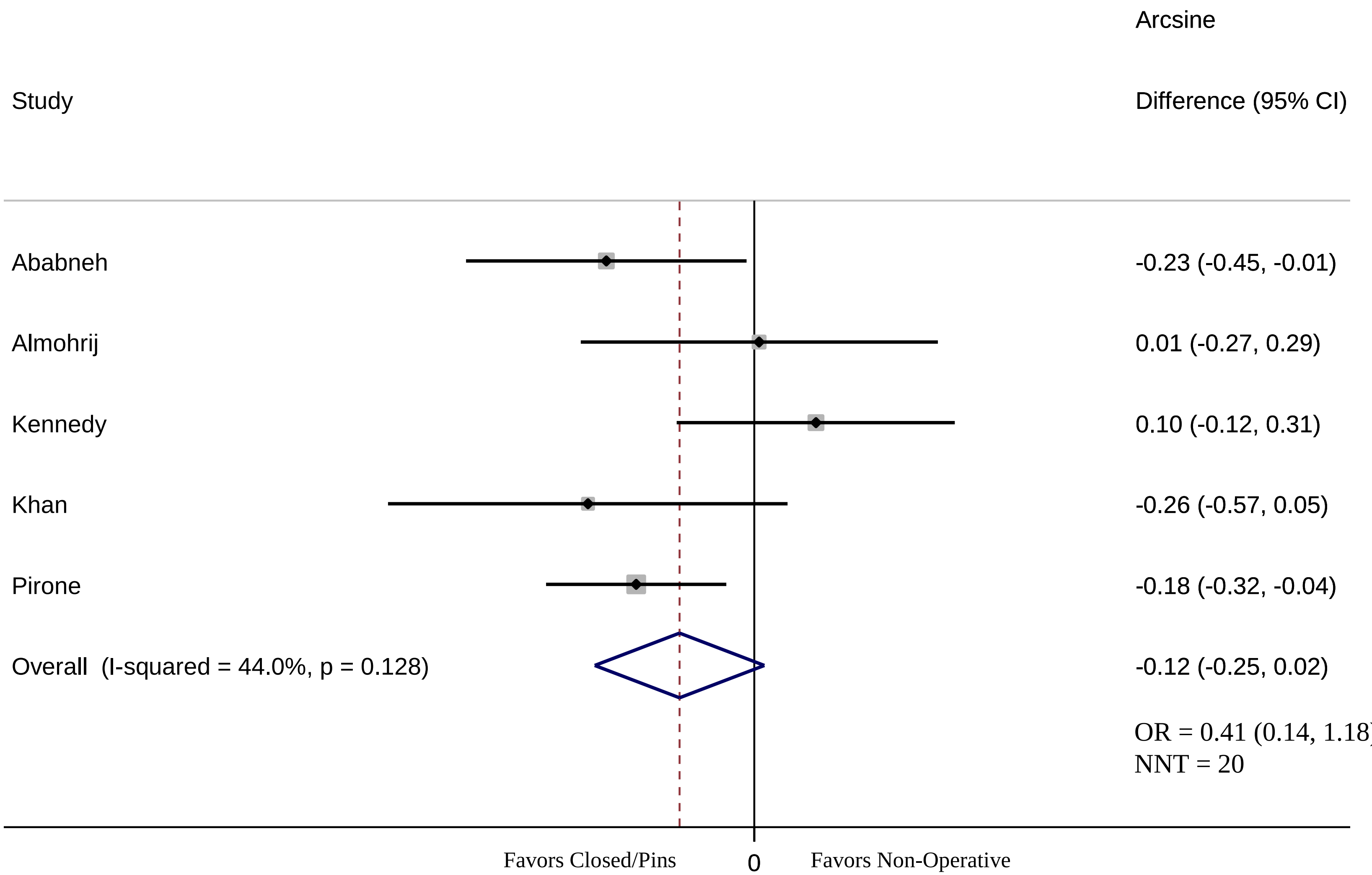


Figure 2 Flynn's Criteria Meta-Analysis - Closed Reduction with Pin Fixation vs. Non-operative Treatments

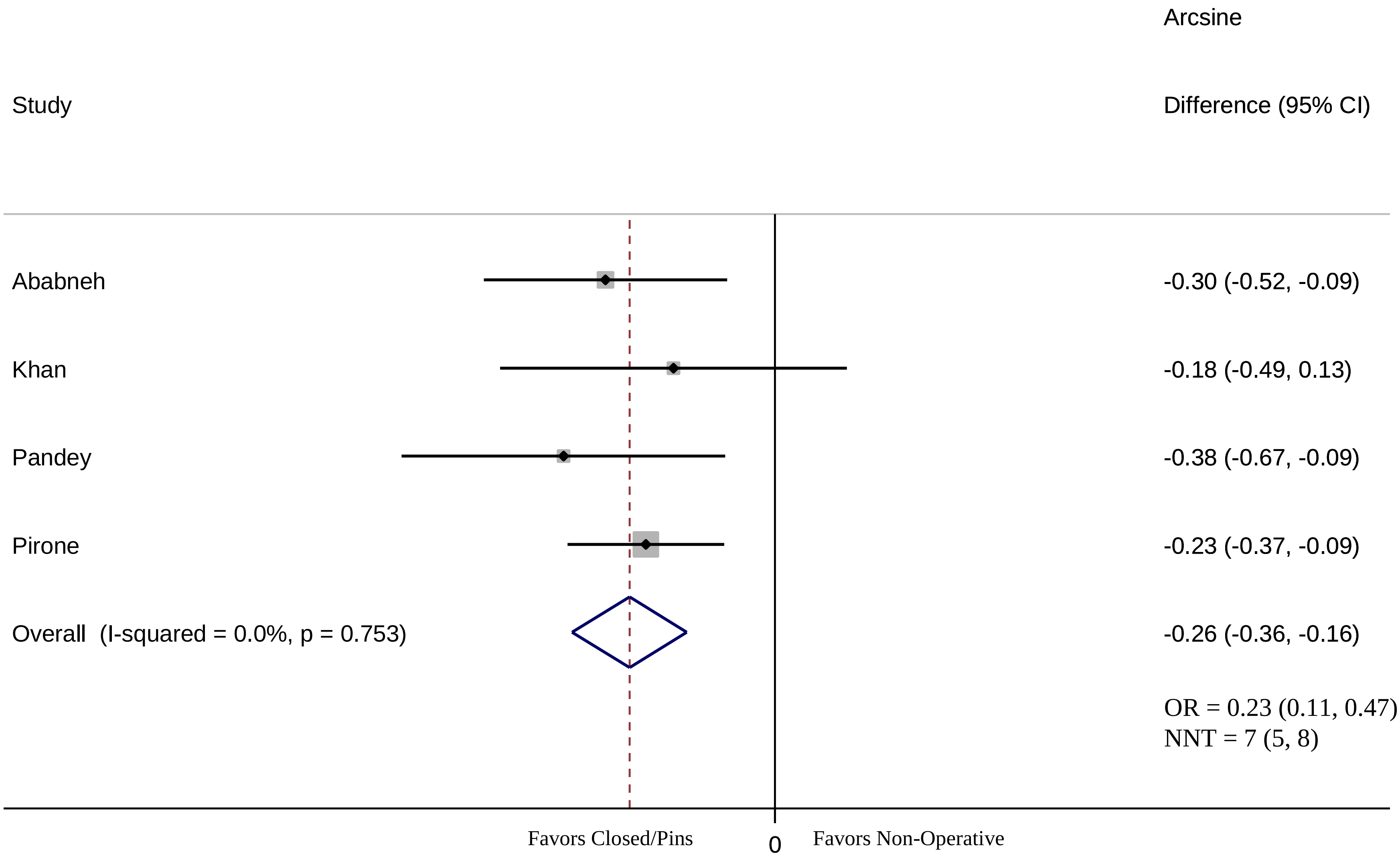


Figure 3 Iatrogenic Ulnar Nerve Injury Meta-Analysis - Closed Reduction with Pin Fixation vs. Non-operative Treatments

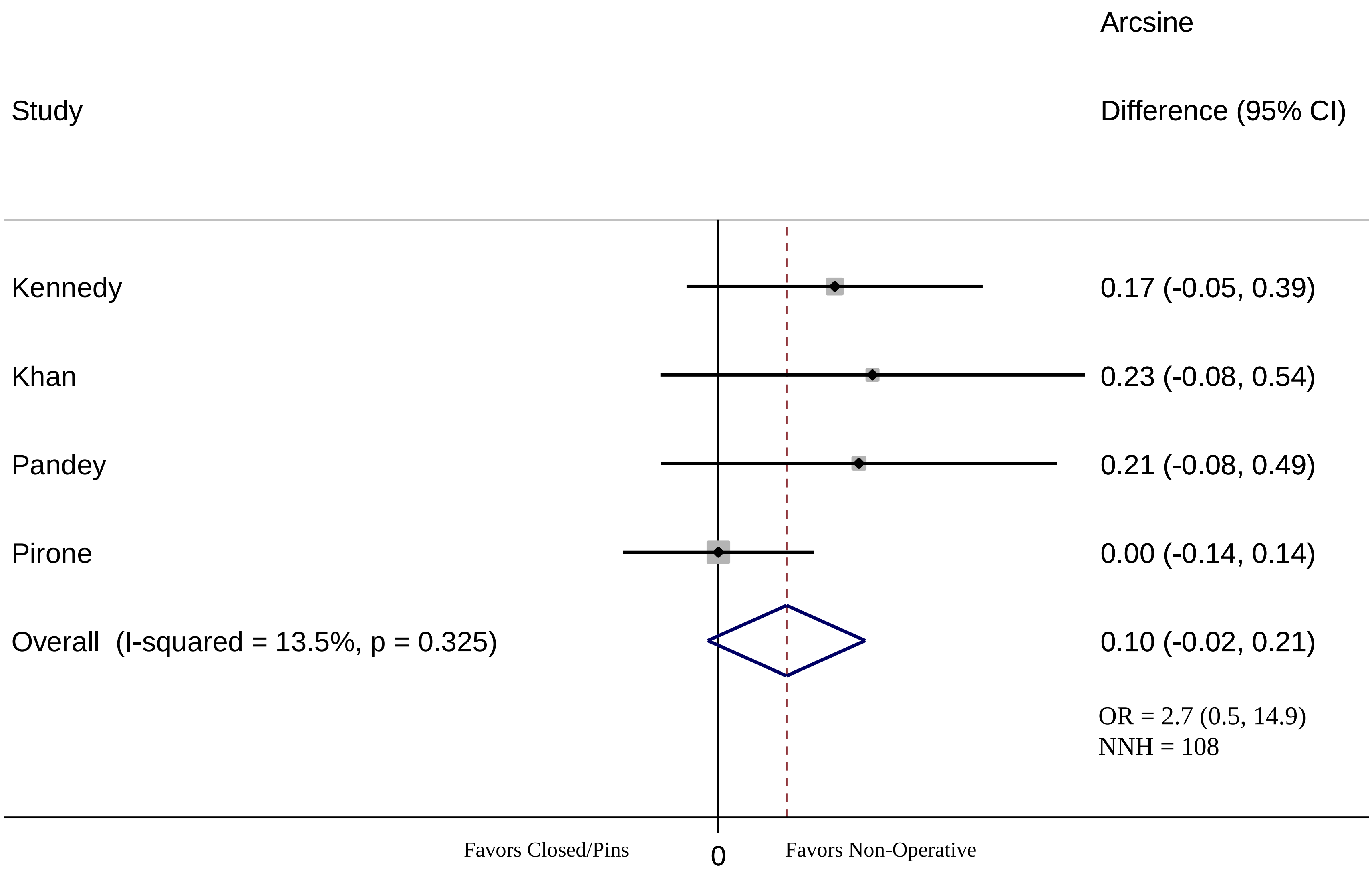
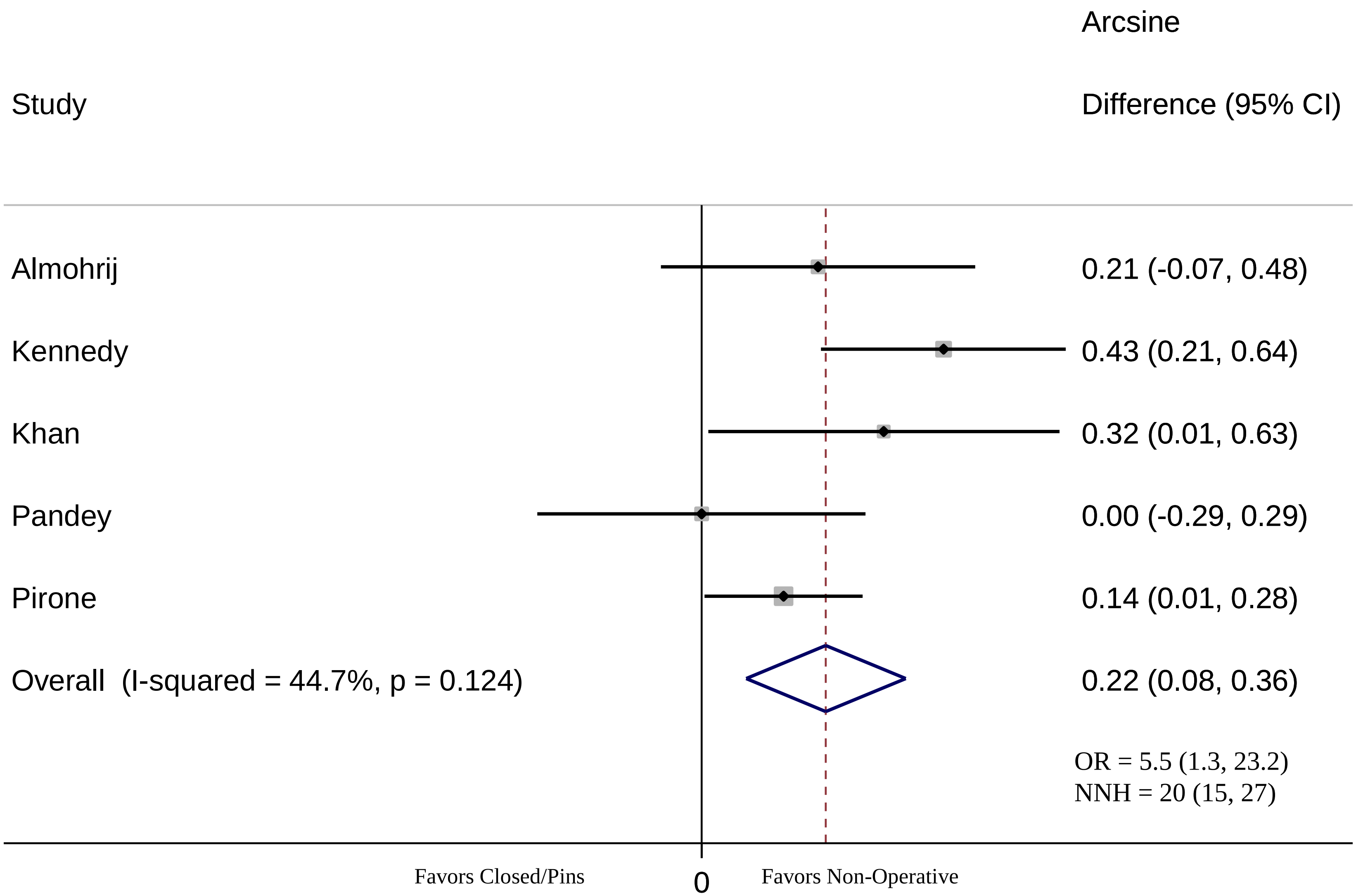


Figure 4 Infection Meta-Analysis - Closed Reduction with Pin Fixation vs. Non-operative Treatments



EXCLUDED STUDIES

Table 27 Excluded Studies Considered for Recommendation 2

Study	Year	Title	Reason for Exclusion
Fu D;Xiao B;Yang S;Li J;	2010	Open reduction and bioabsorbable pin fixation for late presenting irreducible supracondylar humeral fracture in children	Not best available evidence (case series)
Kinkpe CV;Dansokho AV;Niane MM;Chau E;Sales de GJ;Clement JL;Seye SI;	2010	Children distal humerus supracondylar fractures: the Blount Method experience	Not best available evidence (case series)
Randsborg PH;Sivertsen EA;Skramm I;Saltyt BJ;Gulbrandsen P;	2010	The need for better analysis of observational studies in orthopedics. A retrospective study of elbow fractures in children	Not best available evidence (case series)
Spencer HT;Wong M;Fong YJ;Penman A;Silva M;	2010	Prospective longitudinal evaluation of elbow motion following pediatric supracondylar humeral fractures	Less than 50% patient follow-up
Ersan O;Gonen E;Arik A;Dasar U;Ates Y;	2009	Treatment of supracondylar fractures of the humerus in children through an anterior approach is a safe and effective method	Not best available evidence (case series)
Ismatullah LAK;	2009	Results of conservative treatment of displaced extension - Type supracondylar fractures of humerus in children	Not best available evidence (case series)
Kazimoglu C;Cetin M;Sener M;Agus H;Kalanderer O;	2009	Operative management of type III extension supracondylar fractures in children	Not best available evidence, very low quality, low power
Parmaksizoglu AS;Ozkaya U;Bilgili F;Sayin E;Kabukcuoglu Y;	2009	Closed reduction of the pediatric supracondylar humerus fractures: the 'joystick' method	Not best available evidence (case series)
Queally JM;Paramanathan N;Walsh JC;Moran CJ;Shannon FJ;D'Souza LG;	2009	Dorgan's lateral cross-wiring of supracondylar fractures of the humerus in children: A retrospective review	Not best available evidence (case series)

Table 27 Excluded Studies Considered for Recommendation 2

Study	Year	Title	Reason for Exclusion
Bamrungthin N;	2008	Comparison of posterior and lateral surgical approach in management of type III supracondylar fractures of the humerus among the children	Comparison not considered for this guideline
Colaris JW;Horn TM;van den Ende ED;Allema JH;Merkus JW;	2008	Supracondylar fractures of the humerus in children. Comparison of results in two treatment periods	Not best available evidence, very low quality
Kalenderer O;Reisoglu A;Surer L;Agus H;	2008	How should one treat iatrogenic ulnar injury after closed reduction and percutaneous pinning of paediatric supracondylar humeral fractures?	Not best available evidence (case series)
Khan AQ;Goel S;Abbas M;Sherwani MK;	2007	Percutaneous K-wiring for Gartland type III supracondylar humerus fractures in children	Not best available evidence (case series)
Kraus R;Joeris A;Castellani C;Weinberg A;Slongo T;Schnettler R;	2007	Intraoperative radiation exposure in displaced supracondylar humeral fractures: a comparison of surgical methods	Not best available evidence, very low quality
Rijal KP;Pandey BK;	2006	Supracondylar extension type III fracture of the humerus in children: percutaneous cross-pinning	Not best available evidence (case series)
Barlas K;Baga T;	2005	Medial approach for fixation of displaced supracondylar fractures of the humerus in children	Not best available evidence (case series)
Gadgil A;Hayhurst C;Maffulli N;Dwyer JS;	2005	Elevated, straight-arm traction for supracondylar fractures of the humerus in children	Not best available evidence (case series)
Suh SW;Oh CW;Shingade VU;Swapnil MK;Park BC;Lee SH;Song HR;	2005	Minimally invasive surgical techniques for irreducible supracondylar fractures of the humerus in children	Comparison not considered for this guideline
Arora RK;	2004	A different method of pinning of displaced extension type supracondylar fracture of humerus in children	Not best available evidence (case series)
Griffet J;Abou-Daher A;Breaud J;El HT;Rubio A;El MW;	2004	Systematic percutaneous pinning of displaced extension-type supra-condylar fractures of the humerus in children: A prospective study of 67 patients	Not best available evidence (case series)

Table 27 Excluded Studies Considered for Recommendation 2

Study	Year	Title	Reason for Exclusion
Gris M;Van NO;Gehanne C;Quintin J;Burny F;	2004	Treatment of supracondylar humeral fractures in children using external fixation	Not best available evidence (case series)
Shannon FJ;Mohan P;Chacko J;D'Souza LG;	2004	'Dorgan's' percutaneous lateral cross-wiring of supracondylar fractures of the humerus in children	Not best available evidence (case series)
Shoaib M;Sultan S;Sahibzada SA;Ali A;	2004	Percutaneous pinning in displaced supracondylar fracture of humerus in children	Not best available evidence (case series)
Shoaib M;Hussain A;Kamran H;Ali J;	2003	Outcome of closed reduction and casting in displaced supracondylar fracture of humerus in children	Not best available evidence (case series)
Koudstaal MJ;De Ridder VA;De LS;Ulrich C;	2002	Pediatric supracondylar humerus fractures: the anterior approach	Comparison not considered for this guideline
Chen RS;Liu CB;Lin XS;Feng XM;Zhu JM;Ye FQ;	2001	Supracondylar extension fracture of the humerus in children. Manipulative reduction, immobilisation and fixation using a U-shaped plaster slab with the elbow in full extension	Comparison not considered for this guideline
Vuckov S;Kvesic A;Rebac Z;Cuculic D;Lovasic F;Bukvic N;	2001	Treatment of supracondylar humerus fractures in children: minimal possible duration of immobilization	Less than 50% patient follow-up
Davis RT;Gorczyca JT;Pugh K;	2000	Supracondylar humerus fractures in children. Comparison of operative treatment methods	Not best available evidence (case series)
Mulhall KJ;Abuzakuk T;Curtin W;O'Sullivan M;	2000	Displaced supracondylar fractures of the humerus in children	Not best available evidence (case series)
The RM;Severijnen RS;	1999	Neurological complications in children with supracondylar fractures of the humerus	Not best available evidence, very low quality, low power
Fleuriau-Chateau P;McIntyre W;Letts M;	1998	An analysis of open reduction of irreducible supracondylar fractures of the humerus in children	Not best available evidence (case series)
Gennari JM;Merrot T;Piclet B;Bergoin M;	1998	Anterior approach versus posterior approach to surgical treatment of children's supracondylar fractures: comparative study of thirty cases in each series	Comparison not considered for this guideline

Table 27 Excluded Studies Considered for Recommendation 2

Study	Year	Title	Reason for Exclusion
Yusof A;Razak M;Lim A;	1998	Displaced supracondylar fracture of humerus in children--comparative study of the result of closed and open reduction	Comparison not considered for this guideline, <10 patients in valid comparison group
Hadlow AT;Devane P;Nicol RO;	1996	A selective treatment approach to supracondylar fracture of the humerus in children	Comparison not considered for this guideline, <10 patients in valid comparison group
Ong TG;Low BY;	1996	Supracondylar humeral fractures--a review of the outcome of treatment	Comparison not considered for this guideline, <10 patients in valid comparison group
Turra S;Santini S;Zandonadi A;Jacobellis C;	1995	Supracondylar fractures of the humerus in children. A comparison between non-surgical treatment and minimum synthesis	Not best available evidence, very low quality
Paradis G;Lavallee P;Gagnon N;Lemire L;	1993	Supracondylar fractures of the humerus in children. Technique and results of crossed percutaneous K-wire fixation	Not best available evidence (case series)
Boyd DW;Aronson DD;	1992	Supracondylar fractures of the humerus: a prospective study of percutaneous pinning	Not best available evidence (case series)
Rodriguez Merchan EC;	1992	Supracondylar fractures of the humerus in children: treatment by overhead skeletal traction	Not best available evidence (case series)
Arnala I;Paananen H;Lindell-Iwan L;	1991	Supracondylar fractures of the humerus in children	Not best available evidence, very low quality, low power
Urlus M;Kestelijn P;Vanlommel E;Demuynck M;Vanden Berghe L;	1991	Conservative treatment of displaced supracondylar humerus fractures of the extension type in children	Not best available evidence (case series)
Kotwal PP;Mani GV;Dave PK;	1989	Open reduction and internal fixation of displaced supracondylar fractures of the humerus	Not best available evidence (case series)
Aronson DD;Prager BI;	1987	Supracondylar fractures of the humerus in children. A modified technique for closed pinning	Not best available evidence (case series)

Table 27 Excluded Studies Considered for Recommendation 2

Study	Year	Title	Reason for Exclusion
Millis MB;Singer IJ;Hall JE;	1984	Supracondylar fracture of the humerus in children. Further experience with a study in orthopaedic decision-making	Not best available evidence (case series)
Bongers KJ;Ponsen RJ;	1979	Use of Kirschner wires for percutaneous stabilization of supracondylar fractures of the humerus in children	Not best available evidence (case series)
Prietto CA;	1979	Supracondylar fractures of the humerus. A comparative study of Dunlop's traction versus percutaneous pinning	Not best available evidence, very low quality
Bender J;Busch CA;	1978	Results of treatment of supracondylar fractures of the humerus in children with special reference to the cause and prevention of cubitus varus	Comparison not considered for this guideline, <10 patients in valid comparison group
Alcott WH;Bowden BW;Miller PR;	1977	Displaced supracondylar fractures of the humerus in children: long-term follow-up of 69 patients	Comparison not considered for this guideline
Lund-Kristensen J;Vibild O;	1976	Supracondylar fractures of the humerus in children. A follow-up with particular reference to late results after severely displaced fractures	Comparison not considered for this guideline, <10 patients in valid comparison group

RECOMMENDATION 3

The practitioner might use two or three laterally introduced pins to stabilize the reduction of displaced pediatric supracondylar fractures of the humerus. Considerations of potential harm indicate that the physician might avoid the use of a medial pin.

Strength of Recommendation: Limited

Description: Evidence from two or more “Low” strength studies with consistent findings, or evidence from a single “Moderate” quality study recommending for or against the intervention or diagnostic. A **Limited** recommendation means the quality of the supporting evidence that exists is unconvincing, or that well-conducted studies show little clear advantage to one approach versus another.

Implications: Practitioners should exercise clinical judgment when following a recommendation classified as **Limited**, and should be alert to emerging evidence that might negate the current findings. Patient preference should have a substantial influencing role.

Included Studies	Number of Outcomes	Level of Evidence	Quality	Applicability	Critical Outcome(s)	Benefits and Harms Adjustment
Altay[34]	1	III	Low	Moderate	iatrogenic ulnar nerve injury. loss of reduction, malunion, reoperation rate	None
Bombaci[35]	3	III	Low	Moderate		
Devkota[36]	3	II	Low	Moderate		
Foead[37]	9	II	Low/ Moderate	Moderate		
France[26]	1	III	Low	Moderate		
Gordon[38]	2	III	Low	Moderate		
Kocher[39]	14	II	Moderate	Moderate		
Memisoglu[40]	5	III	Low	Moderate		
Shamsuddin[41]	7	III	Low	Moderate		
Sibinski[42]	4	III	Low	Moderate		
Skaggs[43]	3	III	Low	Moderate		
Solak[44]	3	III	Low	Moderate		
Topping[45]	3	III	Low	Moderate		
Tripuraneni[46]	4	II	Low/ Moderate	Moderate		
Zamzam[47]	3	III	Low	Moderate		

Fahmy[48] *	3	III	Low	Moderate
Lee[49] **	6	III	Low	Moderate

*Intrafocal pinning techniques compared, **Divergent vs. parallel configurations

RATIONALE

Pin configuration and the potential complications related to instability and iatrogenic ulnar nerve injury are recognized concerns in this population. Therefore the work group deemed it important to examine the technique of pin stabilization.

Critical outcomes investigated were iatrogenic ulnar nerve injury, loss of reduction, malunion, and reoperation rate. This recommendation is based on data on 65 outcomes from 15 studies comparing pinning technique using lateral only pin entry to lateral and medial crossed pin technique.

Two of the six studies that were sufficiently powered for loss of reduction were statistically significant in favor of medial pins. The remaining four studies reported no statistically significant difference between lateral and medial pins.

One randomized, prospective study by Kocher, et al., examined loss of reduction and found a loss of reduction rate of 21% (6/28) in lateral only pins. Medial and lateral pins had a statistically significant lower loss of reduction rate of 4% (1/24). This loss of reduction was not clinically significant enough to warrant re-operation in either group. Meta-analysis of low and moderate quality studies found no statistically significant difference between lateral and medial pin configurations with respect to Baumann's angle, Baumann's angle change, Flynn's Criteria and infection.

The ulnar nerve was injured in 3 of 557 (0.53%) cases with laterally introduced pins. Medially introduced pins resulted in 49 of 808 (6%) cases of ulnar nerve injury. Iatrogenic ulnar nerve injury was noted to be statistically significant in favor of lateral pinning in 6 of 11 studies. A meta-analysis of these studies and three additional underpowered studies (1 moderate quality and 13 low quality) also demonstrated a statistically significant effect in favor of lateral pinning (Number Needed to Harm = 22, Odds ratio = 0.27). This suggests a 1 in 22 chance of harm resulting from the medial pinning techniques used in these studies. Based on limited evidence, the practitioner might use two or three laterally introduced pins to stabilize the reduction of displaced pediatric supracondylar fractures of the humerus. The risk of potential harm from a medial pin must be weighed against the potential advantages.

SUPPORTING EVIDENCE

QUALITY

Relevant Tables: Table 28 - Table 30, Table 35 - Table 37

Data on 65 outcomes from 15 studies comparing pinning techniques using lateral pins only to a single lateral pin with a medial cross pin were found for this recommendation. Sixteen outcomes were of moderate quality and the remaining 49 were of low quality

(Table 28). Three of the studies were randomized controlled trials. Kocher, et al. had flawed blinding and measurement domains (except for the outcomes infection and return to function which have unflawed measurement domains because the outcome is directly observable and is important to the patient). All 14 outcomes from Kocher, et al. were of moderate quality. Foaed, et al al. and Tripuranenei, et al. did not use stochastic methods to randomize patients to treatment groups, flawing the group assignment domain in addition to flawed blinding and measurement domains (except for the outcome infection which has an unflawed measurement domain because the outcome is directly observable and is important to the patient). Only the outcome infection from Foead, et al. and Tripuraneni, et al. was of moderate quality, the other 11 outcomes from these RCT's were of low quality. All other quality analysis domains were not flawed (Table 35)

Eleven of the remaining twelve comparing pinning techniques using lateral pins only to a single lateral pin with a medial cross pin were retrospective comparative studies which resulted in flawed prospective, group assignment, and blinding domains. Devkota, et al. was a prospective cohort study with flawed group assignment and blinding domains. All 38 outcomes from these 12 non-randomized comparative studies were of low quality (Table 28). The outcome infection had an unflawed measurement domain. The remaining 34 outcomes had flawed measurement domains because of the need for testing. All other quality analysis domains were not flawed (Table 35).

Two additional studies making different comparison from the studies described above were found for this recommendation. Fahmy, et al. was a retrospective comparison of posterior intrafocal pinning to posterior intrafocal pinning with an additional lateral pin. The 3 outcomes reported by this study were of low quality (Table 29). This study had flawed prospective, group assignment, and blinding domains. The measurement domain was flawed for 2 of the 3 outcomes reported but unflawed for the outcome, infection. All other quality analysis domains were not flawed (Table 36).

Lee, et al. was a retrospective comparison of divergent lateral pinning to parallel lateral pinning. All 6 outcomes from this study had flawed prospective, group assignment, blinding and measurement domains and were of low quality (Table 30). All other quality analysis domains were not flawed (Table 37)

APPLICABILITY

Relevant Tables: Table 28 - Table 30, Table 35 - Table 37

For all fifteen studies there is some uncertainty if the practitioners who delivered the treatment did so in a way similar to the way it would be delivered in most practices due to the low number of surgeons performing the operations in each study. Only Tripuraneni, et al. took measures to ensure that all potential patients were included in the analysis. Only Kocher, et al. enrolled patients that might be different from those seen in actual clinical practice. None of the studies have compliance and adherence that is different from that seen in actual clinical practice. The applicability of the included outcomes to results that would be obtained in a typical practice is moderate. Results of the applicability domains analysis are available in Table 35 - Table 37.

FINAL STRENGTH OF EVIDENCE

All 'Low' quality outcomes remained at 'Low' strength of evidence based on their 'Moderate' applicability. All 'Moderate' quality outcomes remained at 'Moderate' strength of evidence based on their 'Moderate' applicability (Table 28-Table 30).

Table 28 Quality and Applicability Summary – Lateral vs. Medial Pinning

Study	Outcome	Quality	Applicability	Strength of Evidence
Kocher	Baumann's angle	Moderate	Moderate	**Moderate**
Bombaci	Baumann's angle†	Low	Moderate	**Low**
Shamsuddin	Baumann's angle	Low	Moderate	**Low**
Tripuraneni	Baumann's angle†	Low	Moderate	**Low**
Kocher	Baumann's angle change	Moderate	Moderate	**Moderate**
Foead	Baumann's angle change	Low	Moderate	**Low**
Shamsuddin	Baumann's angle change	Low	Moderate	**Low**
Topping†	Baumann's angle change†	Low	Moderate	**Low**
Skaggs	Baumann's angle change	Low	Moderate	**Low**
Kocher	Carrying angle	Moderate	Moderate	**Moderate**
Foead	Carrying angle change	Low	Moderate	**Low**
Zamzam	Cubitus varus	Low	Moderate	**Low**
Kocher	Elbow extension	Moderate	Moderate	**Moderate**
Shamsuddin	Elbow extension	Low	Moderate	**Low**
Foead	Elbow extension loss	Low	Moderate	**Low**
Kocher	Elbow flexion	Moderate	Moderate	**Moderate**
Shamsuddin	Elbow flexion	Low	Moderate	**Low**
Foead	Elbow flexion loss	Low	Moderate	**Low**
Kocher	Elbow motion - total	Moderate	Moderate	**Moderate**
Memisoglu	Flynn's cosmetic result	Low	Moderate	**Low**
Foead	Flynn's cosmetic result	Low	Moderate	**Low**
Devkota	Flynn's criteria	Low	Moderate	**Low**
Solak	Flynn's criteria	Low	Moderate	**Low**
France†	Flynn's criteria†	Low	Moderate	**Low**
Kocher	Flynn's criteria	Moderate	Moderate	**Moderate**
Sibinski	Flynn's criteria	Low	Moderate	**Low**

Table 28 Quality and Applicability Summary – Lateral vs. Medial Pinning

Study	Outcome	Quality	Applicability	Strength of Evidence
Memisoglu	Flynn's functional result	Low	Moderate	**Low**

Bold outcomes are identified as critical outcomes, † underpowered outcome, only considered in meta-analysis

Kocher	Humerocapitellar angle	Moderate	Moderate	**Moderate**
Shamsuddin	Humerocapitellar angle	Low	Moderate	**Low**
Kocher	Humerocapitellar angle change	Moderate	Moderate	**Moderate**
Shamsuddin	Humerocapitellar angle change	Low	Moderate	**Low**
Foead	Iatrogenic radial nerve injury	Low	Moderate	**Low**
Altay	**Iatrogenic ulnar nerve injury**	Low	Moderate	**Low**
Bombaci	**Iatrogenic ulnar nerve injury**†	Low	Moderate	**Low**
Devkota	**Iatrogenic ulnar nerve injury**	Low	Moderate	**Low**
Foead	**Iatrogenic ulnar nerve injury**	Low	Moderate	**Low**
Gordon	**Iatrogenic ulnar nerve injury**	Low	Moderate	**Low**
Kocher	**Iatrogenic ulnar nerve injury**	Moderate	Moderate	**Moderate**
Memisoglu	**Iatrogenic ulnar nerve injury**	Low	Moderate	**Low**
Shamsuddin	**Iatrogenic ulnar nerve injury**	Low	Moderate	**Low**
Sibinski	**Iatrogenic ulnar nerve injury**	Low	Moderate	**Low**
Skaggs	**Iatrogenic ulnar nerve injury**	Low	Moderate	**Low**
Solak	**Iatrogenic ulnar nerve injury**	Low	Moderate	**Low**
Topping	**Iatrogenic ulnar nerve injury**†	Low	Moderate	**Low**
Tripuraneni	**Iatrogenic ulnar nerve injury**†	Low	Moderate	**Low**
Zamzam	**Iatrogenic ulnar nerve injury**	Low	Moderate	**Low**
Bombaci	Infection†	Low	Moderate	**Low**
Tripuraneni	Infection†	Moderate	Moderate	**Moderate**
Foead	Infection - pin	Moderate	Moderate	**Moderate**
Memisoglu	Infection - pin	Low	Moderate	**Low**
Sibinski	Infection - pin	Low	Moderate	**Low**
Topping	Infection - pin†	Low	Moderate	**Low**
Kocher	Infection – superficial	Moderate	Moderate	**Moderate**

Table 28 Quality and Applicability Summary – Lateral vs. Medial Pinning

Study	Outcome	Quality	Applicability	Strength of Evidence
Kocher	**Loss of reduction**	Moderate	Moderate	**Moderate**

Bold outcomes are identified as critical outcomes, † underpowered outcome, only considered in meta-analysis

Sibinski	**Loss of reduction**	Low	Moderate	**Low**
Skaggs	**Loss of reduction**	Low	Moderate	**Low**
Tripuraneni	**Loss of reduction**†	Low	Moderate	**Low**
Zamzam	**Loss of reduction**	Low	Moderate	**Low**
Foead	MEE angle loss	Low	Moderate	**Low**
Gordon	Reoperation	Low	Moderate	**Low**
Kocher	Reoperation	Moderate	Moderate	**Moderate**
Memisoglu	**Reoperation/loss of reduction**	Low	Moderate	**Low**
Solak	**Reoperation/loss of reduction**	Low	Moderate	**Low**
Kocher	Return to full function	Moderate	Moderate	**Moderate**

Bold outcomes are identified as critical outcomes, † underpowered outcome, only considered in meta-analysis

Table 29 Quality and Applicability Summary – Intrafocal Pinning

Study	Outcome	Quality	Applicability	Strength of Evidence
Fahmy	Flynn's criteria - satisfactory	Low	Moderate	**Low**
Fahmy	Infection – pin track	Low	Moderate	**Low**
Fahmy	Posterior wire migration	Low	Moderate	**Low**

Bold outcomes are identified as critical outcomes.

Table 30 Quality and Applicability Summary – Divergent Lateral vs. Parallel Lateral Pinning

Study	Outcome	Quality	Applicability	Strength of Evidence
Lee	Cubitus varus	Low	Moderate	**Low**
Lee	Epiphyseal injury	Low	Moderate	**Low**
Lee	Hyperextension of elbow	Low	Moderate	**Low**
Lee	Iatrogenic nerve injuries	Low	Moderate	**Low**
Lee	Loss of motion	Low	Moderate	**Low**

Table 30 Quality and Applicability Summary – Divergent Lateral vs. Parallel Lateral Pinning

Study	Outcome	Quality	Applicability	Strength of Evidence
Lee	Reoperation	Low	Moderate	**Low**

Bold outcomes are identified as critical outcomes.

RESULTS

Relevant Tables and Figures: Table 31-Table 34, Table 38-Table 41, Figure 5-Figure 11

Fifteen of the studies compared pinning techniques using lateral pins only to a single lateral pin with a medial cross pin. The pinning technique and the fracture types studied from these 15 included studies are listed in Table 31. Six of the studies enrolled only patients with Type III fractures (or otherwise described as displaced with posterior cortex not intact). The other 9 studies enrolled patients with Type II or III fracture (or otherwise described as displaced with posterior cortex not intact or simply described as displaced). The remaining two studies considered for this recommendation did not compare lateral pinning techniques to a medial pinning technique. Fahmy, et al. compared posterior intrafocal pinning to posterior intrafocal pinning with an additional lateral pin in patients with Type II or III fractures. Lee, et al. compared lateral divergent pinning to lateral parallel pinning in patients with Type II or III fractures.

The results of statistical testing and the direction of treatment effect (i.e. the favored treatment) for the comparison of pinning techniques using lateral pins only to a single lateral pin with a medial cross pin are summarized in Table 32-Table 34 according to the fracture types. In total 9 of 54 outcomes had statistically significant differences and 45 did not have statistically significant based on analysis of mean differences and proportions. Eleven outcomes were considered for meta-analysis. The results of meta-analysis for seven outcomes (Baumann's angle, Baumann's angle change, Flynn's criteria, Iatrogenic ulnar nerve injury, Infection, Loss of reduction and Reoperation) are summarized in Table 32.

Three (of 4) critical outcomes; loss of reduction, reoperation rate, and iatrogenic ulnar nerve injury, identified by the work group were reported in the included studies for the comparison of pinning techniques using lateral pins only to a single lateral pin with a medial cross pin. All three outcomes were evaluated with meta-analysis. Meta-analysis of the outcome, loss of reduction, is not considered for this recommendation because of high heterogeneity ($I^2 = 74.6\%$, $p = 0.03$). Two of the six studies that were sufficiently powered for loss of reduction were statistically significant in favor of medial pins (i.e. significantly less patients lost their reduction in the medial pinning groups). The remaining four studies reported no statistically significant difference in loss of reduction. Meta-analysis of reoperation rates in four studies found no statistically significant difference between lateral and medial pinning (Figure 5). Meta-analysis of iatrogenic ulnar nerve injuries in 14 studies found a statistically significant difference in favor of lateral pinning (Figure 6). Meta-analysis of Baumann's angle, Baumann's angle change, Flynn's criteria, and Infection found no statistically significant differences between lateral and medial pins (Figure 8-Figure 11).

Only one outcome for the comparison of pinning techniques using lateral pins only to a single lateral pin with a medial cross pin that did not undergo meta-analysis. Cubitus varus, was statistically significant in favor of medial pinning (i.e. fewer patients with medial pins had cubitus varus). Only one study reported this significant difference. The remaining outcomes for the comparison of pinning techniques using lateral pins only to a single lateral pin with a medial cross pin had no statistically significant differences.

There were no statistically significant differences for the comparison of intrafocal pinning techniques (Table 40). There were no statistically significant differences for the comparison of lateral divergent pinning to lateral parallel pinning (Table 41)

Table 31 Lateral Pinning Techniques and Fracture Type

Study	Fracture Types Studied	Lateral Pinning Technique
Altay[34]	II, III	Crossed
Bombaci[35]	II, III	Crossed
Foead[37]	II, III	Crossed or Parallel
Shamsuddin[41]	II, III	Divergent
Tripuraneni[46]	II, III	Divergent
Gordon[38]	II, III	Parallel
Sibinski[42]	II, III	Parallel
Zamzam[47]	II, III	Parallel
Skaggs[43]	II, III	technique not reported
Memisoglu[40]	III	Crossed
Kocher[39]	III	Divergent or Parallel
Devkota[36]	III	Parallel
Topping[45]	III	Parallel
France[26]	III	technique not reported
Solak[44]	III	technique not reported

Table 32 Results Summary - Lateral vs. Medial Pinning - ALL Fracture Types

Outcome(s)	Post-operative period			Meta-Analysis
Iatrogenic ulnar nerve injury	○○○○○●●●●●●			●
Loss of reduction	○○○○♦♦			?
Malunion	no evidence			
Reoperation	○○○○			○
Cubitus varus	♦			n/a
Iatrogenic radial nerve injury	○			n/a
Infection	no sufficiently powered studies			
Infection - pin	○○○			○
Infection – superficial	○			
	Final follow-up	**0-6 Months**	**2+ Years**	**Meta-Analysis**
Baumann's angle	○	○		○
Baumann's angle change	○○	○○		○
Carrying angle		○		n/a
Carrying angle change	○			n/a
Elbow extension	○	○		n/a
Elbow extension loss	○			n/a
Elbow flexion	○	○		n/a
Elbow flexion loss	○			n/a
Elbow motion - total		○		n/a
Flynn's criteria	○	○○○	○	○
Flynn's cosmetic result	○		○	n/a
Flynn's functional result			○	n/a
Humerocapitellar angle	○	○		n/a
Humerocapitellar angle change	○	○		n/a
MEE angle loss	○			n/a
Return to full function		○		n/a

●: statistically significant in favor of lateral pinning, ○: no statistically significant difference,
♦: statistically significant in favor of medial pinning, ? cannot interpret due to heterogeneity

Table 33 Results Summary - Lateral vs. Medial Pinning - Type II or III Fractures

Outcome(s)	Post-operative period		
Iatrogenic ulnar nerve injury	○ ● ○ ● ● ● ○		
Loss of reduction	○ ○ ♦		
Malunion	no evidence		
Reoperation	○		
Cubitus varus	♦		
Iatrogenic radial nerve injury	○		
Infection			
Infection - pin	○ ○		
Infection – superficial			
	Final follow-up	**0-6 Months**	**2+ Years**
Baumann's angle	○		
Baumann's angle change	○ ○ ○		
Carrying angle			
Carrying angle change	○		
Elbow extension	○		
Elbow extension loss	○		
Elbow flexion	○		
Elbow flexion loss	○		
Elbow motion - total			
Flynn's criteria	○		
Flynn's cosmetic result	○		
Flynn's functional result			
Humerocapitellar angle	○		
Humerocapitellar angle change	○		
MEE angle loss	○		
Return to full function			

●: statistically significant in favor of lateral pinning, ○: no statistically significant difference,
♦: statistically significant in favor of medial pinning

Table 34 Results Summary - Lateral vs. Medial Pinning - Type III Fractures

Outcome(s)	Post-operative period
Iatrogenic ulnar nerve injury	● ○ ● ○
Loss of reduction	○ ○ ♦
Malunion	no evidence
Reoperation	○ ○ ○
Cubitus varus	
Iatrogenic radial nerve injury	
Infection	
Infection - pin	○
Infection – superficial	○

	Final follow-up	0-6 Months	2+ Years
Baumann’s angle		○	
Baumann’s angle change		○	
Carrying angle		○	
Carrying angle change			
Elbow extension		○	
Elbow extension loss			
Elbow flexion		○	
Elbow flexion loss			
Elbow motion - total		○	
Flynn’s criteria		○ ○ ○	○
Flynn’s cosmetic result			○
Flynn’s functional result			○
Humerocapitellar angle		○	
Humerocapitellar angle change		○	
MEE angle loss			
Return to full function		○	

●: statistically significant in favor of lateral pinning, ○: no statistically significant difference,
♦: statistically significant in favor of medial pinning

EVIDENCE TABLES AND FIGURES

QUALITY AND APPLICABILITY-LATERAL VS. MEDIAL PINNING

Table 35 Quality and Applicability Domain Scores – Lateral vs. Medial Pinning

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Kocher	Baumann's angle	3 months	●	●	●	○	●	●	○	●	Moderate	○	○	●	○	Moderate
Bombaci	Baumann's angle	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Shamsuddin	Baumann's angle	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Tripuraneni	Baumann's angle	Final follow-up	●	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Skaggs	Baumann's angle change	Union	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Kocher	Baumann's angle change	3 months	●	●	●	○	●	●	○	●	Moderate	○	○	●	○	Moderate
Foead	Baumann's angle change	Final follow-up	●	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Shamsuddin	Baumann's angle change	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate

Table 35 Quality and Applicability Domain Scores – Lateral vs. Medial Pinning

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Topping	Baumann's angle change	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Kocher	Carrying angle	3 months	●	●	●	○	●	●	○	●	Moderate	○	○	●	○	Moderate
Foead	Carrying angle change	n/a	●	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Zamzam	Cubitus varus	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Kocher	Elbow extension	3 months	●	●	●	○	●	●	○	●	Moderate	○	○	●	○	Moderate
Shamsuddin	Elbow extension	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Foead	Elbow extension loss	Final follow-up	●	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Kocher	Elbow flexion	3 months	●	●	●	○	●	●	○	●	Moderate	○	○	●	○	Moderate
Shamsuddin	Elbow flexion	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate

Table 35 Quality and Applicability Domain Scores – Lateral vs. Medial Pinning

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Foead	Elbow flexion loss	Final follow-up	●	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Kocher	Elbow motion - total	3 months	●	●	●	○	●	●	○	●	Moderate	○	○	●	○	Moderate
Foead	Flynn's cosmetic result – satisfactory	Final follow-up	●	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Memisoglu	Flynn's cosmetic result – satisfactory	2-6 years	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Devkota	Flynn's criteria - satisfactory	8 weeks	●	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Kocher	Flynn's criteria - satisfactory	3 months	●	●	●	○	●	●	○	●	Moderate	○	○	●	○	Moderate
Devkota	Flynn's criteria - satisfactory	14 weeks	●	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Sibinski	Flynn's criteria - satisfactory	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
France	Flynn's criteria - satisfactory	2-3 years	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate

Table 35 Quality and Applicability Domain Scores – Lateral vs. Medial Pinning

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Solak	Flynn's criteria - satisfactory	2-5 years	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Memisoglu	Flynn's functional result – satisfactory	2-6 years	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Kocher	Humerocapitellar angle	3 months	●	●	●	○	●	●	○	●	Moderate	○	○	●	○	Moderate
Shamsuddin	Humerocapitellar angle	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Kocher	Humerocapitellar angle change	3 months	●	●	●	○	●	●	○	●	Moderate	○	○	●	○	Moderate
Shamsuddin	Humerocapitellar angle change	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Foead	Iatrogenic radial nerve injury	n/a	●	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Altay	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Bombaci	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate

Table 35 Quality and Applicability Domain Scores – Lateral vs. Medial Pinning

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Devkota	Iatrogenic ulnar nerve injury	n/a	●	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Foead	Iatrogenic ulnar nerve injury	n/a	●	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Gordon	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Kocher	Iatrogenic ulnar nerve injury	n/a	●	●	●	○	●	●	○	●	Moderate	○	○	●	○	Moderate
Memisoglu	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Shamsuddin	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Sibinski	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Skaggs	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Solak	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate

Table 35 Quality and Applicability Domain Scores – Lateral vs. Medial Pinning

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Topping	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Tripuraneni	Iatrogenic ulnar nerve injury	n/a	●	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Zamzam	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Bombaci	Infection	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	○	Moderate
Tripuraneni	Infection	n/a	●	●	○	○	●	●	●	●	Moderate	●	○	●	●	Moderate
Foead	Infection - pin	n/a	●	●	○	○	●	●	●	●	Moderate	●	○	●	○	Moderate
Memisoglu	Infection - pin	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	○	Moderate
Sibinski	Infection - pin	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	○	Moderate
Topping	Infection - pin	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate

Table 35 Quality and Applicability Domain Scores – Lateral vs. Medial Pinning

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Kocher	Infection – superficial	n/a	●	●	●	○	●	●	●	●	Moderate	○	○	●	○	Moderate
Kocher	Loss of reduction	n/a	●	●	●	○	●	●	○	●	Moderate	○	○	●	○	Moderate
Sibinski	Loss of reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Skaggs	Loss of reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Tripuraneni	Loss of reduction	n/a	●	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Zamzam	Loss of reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Foead	MEE angle loss	n/a	●	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Gordon	Reoperation	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Kocher	Reoperation	n/a	●	●	●	○	●	●	○	●	Moderate	○	○	●	○	Moderate

Table 35 Quality and Applicability Domain Scores – Lateral vs. Medial Pinning

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Memisoglu	Reoperation/loss of reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Solak	Reoperation/loss of reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Kocher	Return to full function	3 months	●	●	●	○	●	●	●	●	Moderate	○	○	●	○	Moderate

QUALITY AND APPLICABILITY-INTRAFOCAL PINNING

Table 36 Quality and Applicability Domain Scores – Intrafocal Pinning

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Fahmy	Flynn’s criteria - Satisfactory	21-30 months	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Fahmy	Infection – pin track	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	○	Moderate
Fahmy	Posterior wire migration	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate

QUALITY AND APPLICABILITY-DIVERGENT LATERAL VS. PARALLEL LATERAL PINNING

Table 37 Quality and Applicability Domain Scores – Divergent Lateral vs. Parallel Lateral Pinning

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Lee	Cubitus varus	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Lee	Epiphyseal injury	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Lee	Hyperextension of elbow	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Lee	Iatrogenic nerve injuries	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Lee	Loss of motion	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Lee	Reoperation	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate

FINDINGS-LATERAL VS. MEDIAL PINNING

Table 38 Analysis of Mean Differences - Lateral vs. Medial Pinning

Study	n	Strength of Evidence	Outcome	Duration	Lateral (mean±SD)	Medial (mean±SD)	Difference (95% CI)	Results
Kocher	52	Moderate	Baumann’s angle	3 months	73.7 ± 8.4	75.8 ± 7.3	2.1 (-2.3, 6.5)	No difference
Bombaci	45	Low	Baumann’s angle	Final follow-up	74.46 ± 5.13	76.88 ± 4.61	underpowered, retained for meta-analysis	
Shamsuddin	56	Low	Baumann’s angle	Final follow-up	77.82 ± 5.51	79.04 ± 5.01	1.22 (-1.6, 4.0)	No difference
Tripuraneni	40	Low	Baumann’s angle	Final follow-up	70.7 ± 5.2	70.7 ± 6.3	underpowered, retained for meta-analysis	
Skaggs	281	Low	Baumann’s angle change	Union	0.06 ± 6.31	0.25 ± 6.19	0.19 (-1.3, 1.7)	No difference
Kocher	52	Moderate	Baumann’s angle change	3 months	5.8 ± 3.5	5.4 ± 3.1	0.4 (-1.5, 2.3)	No difference
Foead	55	Low	Baumann’s angle change	Final follow-up	5.30 ± 5.0	5.96 ± 5.6	0.66 (-2.2, 3.5)	No difference
Shamsuddin	56	Low	Baumann’s angle change	Final follow-up	3.75 ± 2.77	3.04 ± 2.83	0.71 (-0.8, 2.2)	No difference
Topping	47	Low	Baumann’s angle change	Final follow-up	4.7 ± 3.2	6.4 ± 4.8	underpowered, retained for meta-analysis	

Table 38 Analysis of Mean Differences - Lateral vs. Medial Pinning

Study	n	Strength of Evidence	Outcome	Duration	Lateral (mean±SD)	Medial (mean±SD)	Difference (95% CI)	Results
Kocher	52	Moderate	Carrying angle	3 months	7.3 ± 1.7	7.2 ± 1.9	0.1 (-0.9, 1.1)	No difference
Foead	55	Low	Carrying angle change	Final follow-up	3.70 ± 4.24	3.57 ± 4.67	0.13 (-2.5, 2.3)	No difference
Kocher	52	Moderate	Elbow extension	3 months	-3 ± NR	-4 ± NR	p > 0.05	No difference
Shamsuddin	56	Low	Elbow extension	Final follow-up	8.46 ± 11.62	7.08 ± 10.1	1.38 (-4.5, 7.2)	No difference
Foead	55	Low	Elbow extension loss	Final follow-up	7.11 ± 10.8	7.14 ± 9.25	0.03 (-5.4, 5.4)	No difference
Kocher	52	Moderate	Elbow flexion	3 months	132 ± NR	128 ± NR	p > 0.05	No difference
Shamsuddin	56	Low	Elbow flexion	Final follow-up	130 ± 21.11	119 ± 20.12	11 (-0.05, 22.1)	No difference
Foead	55	Low	Elbow flexion loss	Final follow-up	11.26 ± 10.4	8.68 ± 8.64	2.6 (-2.6, 7.7)	No difference
Kocher	52	Moderate	Elbow motion - total	3 months	129 ± NR	124 ± NR	p > 0.05	No difference
Kocher	52	Moderate	Humerocapitellar angle	3 months	36.5 ± 4.1	38.5 ± 4.5	2 (-0.4, 4.4)	No difference

Table 38 Analysis of Mean Differences - Lateral vs. Medial Pinning

Study	n	Strength of Evidence	Outcome	Duration	Lateral (mean±SD)	Medial (mean±SD)	Difference (95% CI)	Results
Shamsuddin	56	Low	Humerocapitellar angle	Final follow-up	39.86 ± 5.87	38.86 ± 6.72	1 (-2.4, 4.4)	No difference
Kocher	52	Moderate	Humerocapitellar angle change	3 months	6.2 ± 5.1	6.5 ± 5.4	0.3 (-2.6, 3.2)	No difference
Shamsuddin	56	Low	Humerocapitellar angle change	Final follow-up	4.39 ± 3.45	3.79 ± 3.00	0.6 (-1.1, 2.3)	No difference
Foead	55	Low	MEE angle loss	Final follow-up	6.93 ± 6.6	6.07 ± 5.1	0.86 (-2.3, 4.0)	No difference

Table 39 Analysis of Proportions – Lateral vs. Medial Pinning

Study	n	Strength of Evidence	Outcome	Duration	Lateral %, n/N	Medial %, n/N	p-value	Results
Zamzam	108	Low	Cubitus varus	n/a	8%, 3/37	0%, 0/71	0.00	Favors Medial
Foead	55	Low	Flynn's cosmetic result – satisfactory	Final follow-up	93%, 25/27	96%, 27/28	0.53	No difference
Memisoglu	139	Low	Flynn's cosmetic result – satisfactory	2-6 years	92%, 69/75	91%, 58/64	0.77	No difference
Devkota	102	Low	Flynn's criteria - satisfactory	8 weeks	96%, 22/23	97%, 77/79	0.67	No difference

Table 39 Analysis of Proportions – Lateral vs. Medial Pinning

Study	n	Strength of Evidence	Outcome	Duration	Lateral %, n/N	Medial %, n/N	p-value	Results
Kocher	52	Moderate	Flynn's criteria - satisfactory	3 months	100%, 28/28	100%, 24/24	1.00	No difference
Devkota	102	Low	Flynn's criteria - satisfactory	14 weeks	100%, 23/23	99%, 78/79	0.34	No difference
Sibinski	131	Low	Flynn's criteria - satisfactory	Final follow-up	86%, 57/66	75%, 49/65	0.11	No difference
France	46	Low	Flynn's criteria - satisfactory	2-3 years	91%, 29/32	93%, 13/14	underpowered, retained for meta-analysis	
Solak	59	Low	Flynn's criteria - satisfactory	2-5 years	83%, 20/24	83%, 29/35	0.96	No difference
Memisoglu	139	Low	Flynn's functional result – satisfactory	2-6 years	92%, 69/75	94%, 60/64	0.69	No difference
Foead	55	Low	Iatrogenic radial nerve injury	n/a	4%, 1/27	0%, 0/28	0.15	No difference
Altay	50	Low	Iatrogenic ulnar nerve injury	n/s	0%, 0/25	8%, 2/25	0.04	Favors Lateral
Bombaci	45	Low	Iatrogenic ulnar nerve injury	n/a	0%, 0/17	4%, 1/28	underpowered, retained for meta-analysis	

Table 39 Analysis of Proportions – Lateral vs. Medial Pinning

Study	n	Strength of Evidence	Outcome	Duration	Lateral %, n/N	Medial %, n/N	p-value	Results
Devkota	102	Low	Iatrogenic ulnar nerve injury	n/a	0%, 0/23	9%, 7/79	0.01	Favors Lateral
Foead	55	Low	Iatrogenic ulnar nerve injury	n/a	7%, 2/27	18%, 5/28	0.23	No difference
Gordon	138	Low	Iatrogenic ulnar nerve injury	n/a	0%, 0/42	0%, 0/94	1.00	No difference
Kocher	52	Moderate	Iatrogenic ulnar nerve injury	n/a	0%, 0/28	0%, 0/24	1.00	No difference
Memisoglu	139	Low	Iatrogenic ulnar nerve injury	n/a	0%, 0/75	9%, 6/64	0.00	Favors Lateral
Shamsuddin	56	Low	Iatrogenic ulnar nerve injury	n/a	0%, 0/28	11%, 3/28	0.01	Favors Lateral
Sibinski	131	Low	Iatrogenic ulnar nerve injury	n/a	0%, 0/66	6%, 4/65	0.00	Favors Lateral
Skaggs	345	Low	Iatrogenic ulnar nerve injury	n/a	0%, 0/125	8%, 17/220	0.00	Favors Lateral
Solak	59	Low	Iatrogenic ulnar nerve injury	n/a	4%, 1/24	3%, 1/35	0.79	No difference

Table 39 Analysis of Proportions – Lateral vs. Medial Pinning

Study	n	Strength of Evidence	Outcome	Duration	Lateral %, n/N	Medial %, n/N	p-value	Results
Topping	47	Low	Iatrogenic ulnar nerve injury	n/a	0%, 0/20	4%, 1/27	underpowered, retained for meta-analysis	
Tripuraneni	40	Low	Iatrogenic ulnar nerve injury	n/a	0%, 0/20	5%, 1/20	underpowered, retained for meta-analysis	
Zamzam	108	Low	Iatrogenic ulnar nerve injury	n/a	0%, 0/37	3%, 2/71	0.10	No difference
Bombaci	45	Low	Infection	n/a	6%, 1/17	0%, 0/28	underpowered, retained for meta-analysis	
Tripuraneni	40	Moderate	Infection	n/a	0%, 0/20	0%, 0/20	underpowered, retained for meta-analysis	
Foead	55	Moderate	Infection – pin track	n/a	4%, 1/27	7%, 2/28	0.57	No difference
Memisoglu	139	Low	Infection – pin track	n/a	9%, 14/150 (pins)	9%, 11/128 (pins)	0.83	No difference
Sibinski	131	Low	Infection – pin track	n/a	2%, 1/66	2%, 1/65	0.99	No difference
Topping	47	Low	Infection – pin track	n/a	0%, 0/20	0%, 0/27	underpowered, retained for meta-analysis	

Table 39 Analysis of Proportions – Lateral vs. Medial Pinning

Study	n	Strength of Evidence	Outcome	Duration	Lateral %, n/N	Medial %, n/N	p-value	Results
Kocher	52	Moderate	Infection - superficial	n/a	0%, 0/28	4%, 1/24	0.14	No difference
Kocher	52	Moderate	Loss of reduction	n/a	21%, 6/28	4%, 1/24	0.04	Favors Medial
Sibinski	131	Low	Loss of reduction	n/a	3%, 2/66	5%, 3/65	0.63	No difference
Skaggs	281	Low	Loss of reduction	n/a	4%, 4/103	3%, 5/178	0.63	No difference
Tripuraneni	40	Low	Loss of reduction	n/a	5%, 1/20	0%, 0/20	underpowered, retained for meta-analysis	
Zamzam	108	Low	Loss of reduction	n/a	24%, 9/37	0%, 0/71	0.00	Favors Medial
Memisoglu	139	Low	Reoperation/loss of reduction	n/a	3%, 2/75	2%, 1/64	0.65	No difference
Solak	59	Low	Reoperation/loss of reduction	n/a	29%, 7/24	26%, 9/35	0.77	No difference
Gordon	138	Low	Reoperation	n/a	0%, 0/42	0%, 0/94	1.00	No difference
Kocher	52	Moderate	Reoperation	n/a	0%, 0/28	0%, 0/24	1.00	No difference
Kocher	52	Moderate	Return to full function	3 months	93%, 26/28	96%, 23/24	0.64	No difference

FINDINGS-INTRAFOCAL PINNING

Table 40 Analysis of Proportions – Intrafocal Pinning

Study	n	Strength of Evidence	Outcome	Duration	Lateral %, n/N	Medial %, n/N	p-value	Results
Fahmy	64	Low	Flynn's criteria - satisfactory	21-30 months	8%, 3/37	4%, 1/27	0.45	No difference
Fahmy	64	Low	Infection – pin track	n/a	5%, 2/37	0%, 0/27	0.06	No difference
Fahmy	64	Low	Posterior wire migration	n/a	5%, 2/37	7%, 2/27	0.75	No difference

FINDINGS-DIVERGENT LATERAL PINNING VS. PARALLEL LATERAL PINNING

Table 41 Analysis of Proportions – Divergent Lateral vs. Parallel Lateral Pinning

Study	n	Strength of Evidence	Outcome	Duration	Divergent %, n/N	Parallel %, n/N	p-value	Results
Lee	61	Low	Cubitus varus	n/a	0%, 0/41	0%, 0/20	1.00	No difference
Lee	61	Low	Epiphyseal injury	Final follow-up	0%, 0/41	0%, 0/20	1.00	No difference
Lee	61	Low	Hyperextension of elbow	Final follow-up	0%, 0/41	0%, 0/20	1.00	No difference
Lee	61	Low	Iatrogenic nerve injuries	n/a	0%, 0/41	0%, 0/20	1.00	No difference
Lee	61	Low	Loss of motion	Final follow-up	0%, 0/41	0%, 0/20	1.00	No difference
Lee	61	Low	Reoperation	n/a	0%, 0/41	0%, 0/20	1.00	No difference

FIGURES-LATERAL VS. MEDIAL PINNING

Figure 5 Reoperation Meta-Analysis - Lateral vs. Medial Pinning

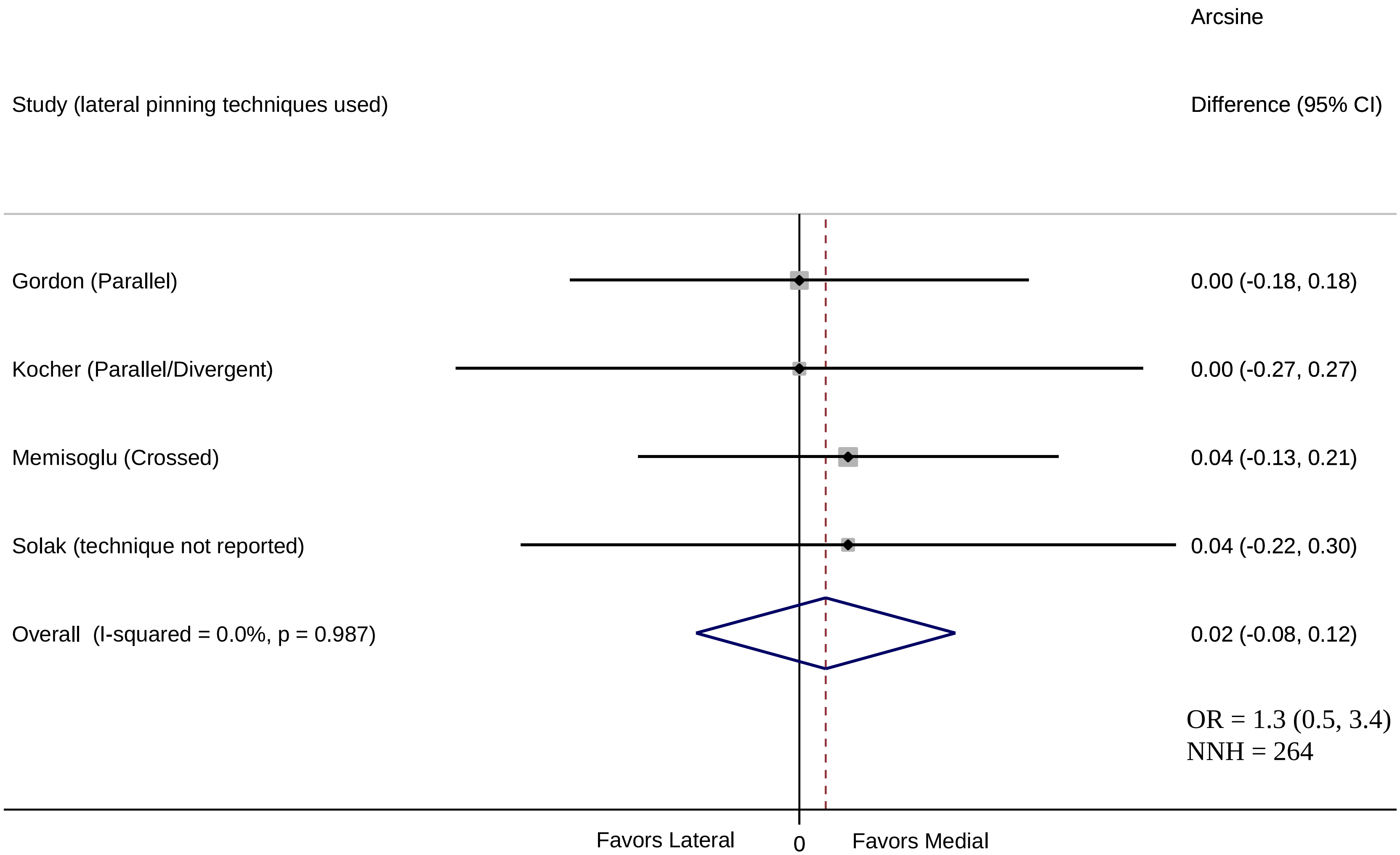


Figure 6 Iatrogenic Ulnar Nerve Injury Meta-Analysis - Lateral vs. Medial Pinning (stratified by study design)

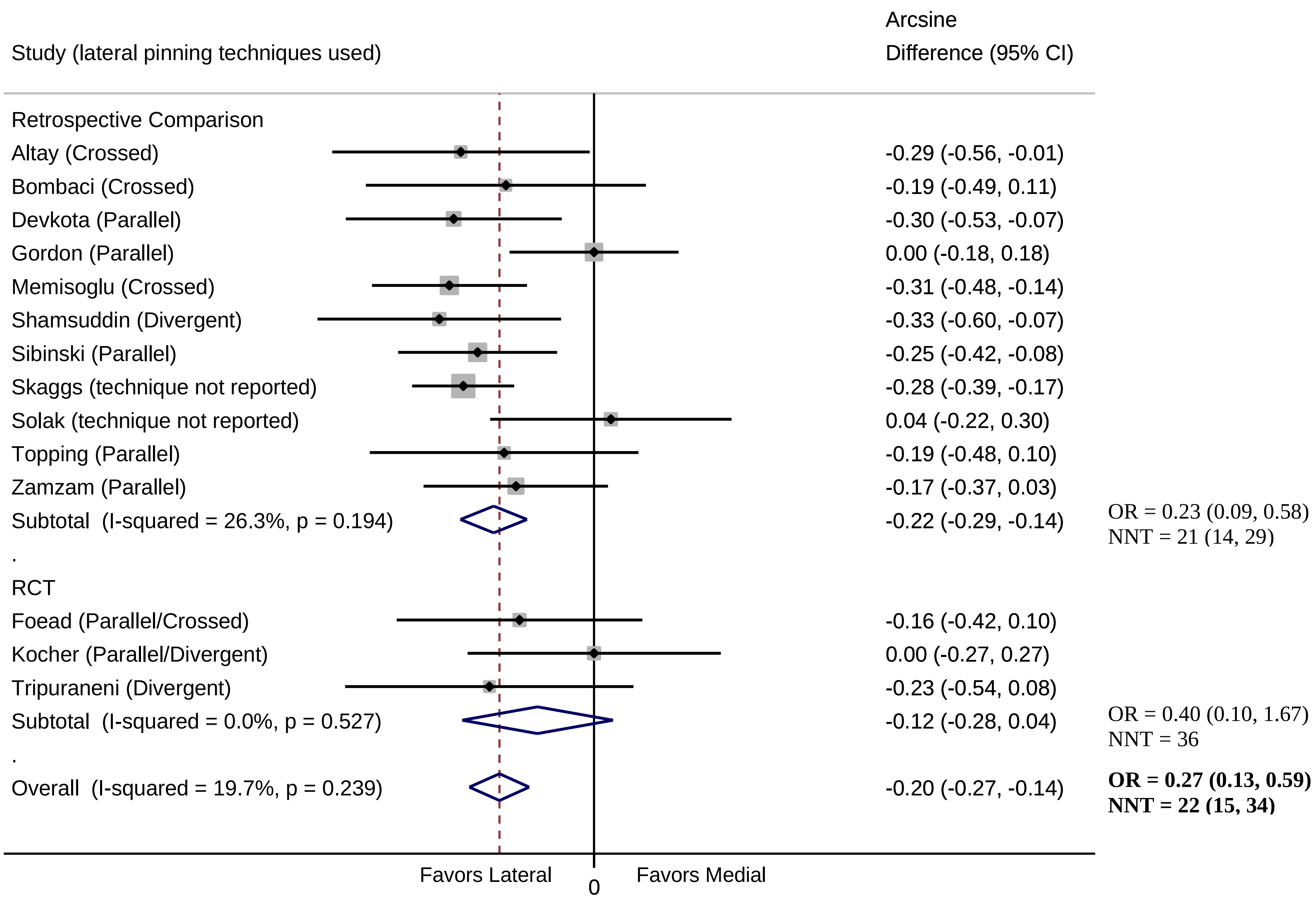


Figure 7 Iatrogenic Ulnar Nerve Injury Meta-Analysis - Lateral vs. Medial Pinning (stratified by quality)

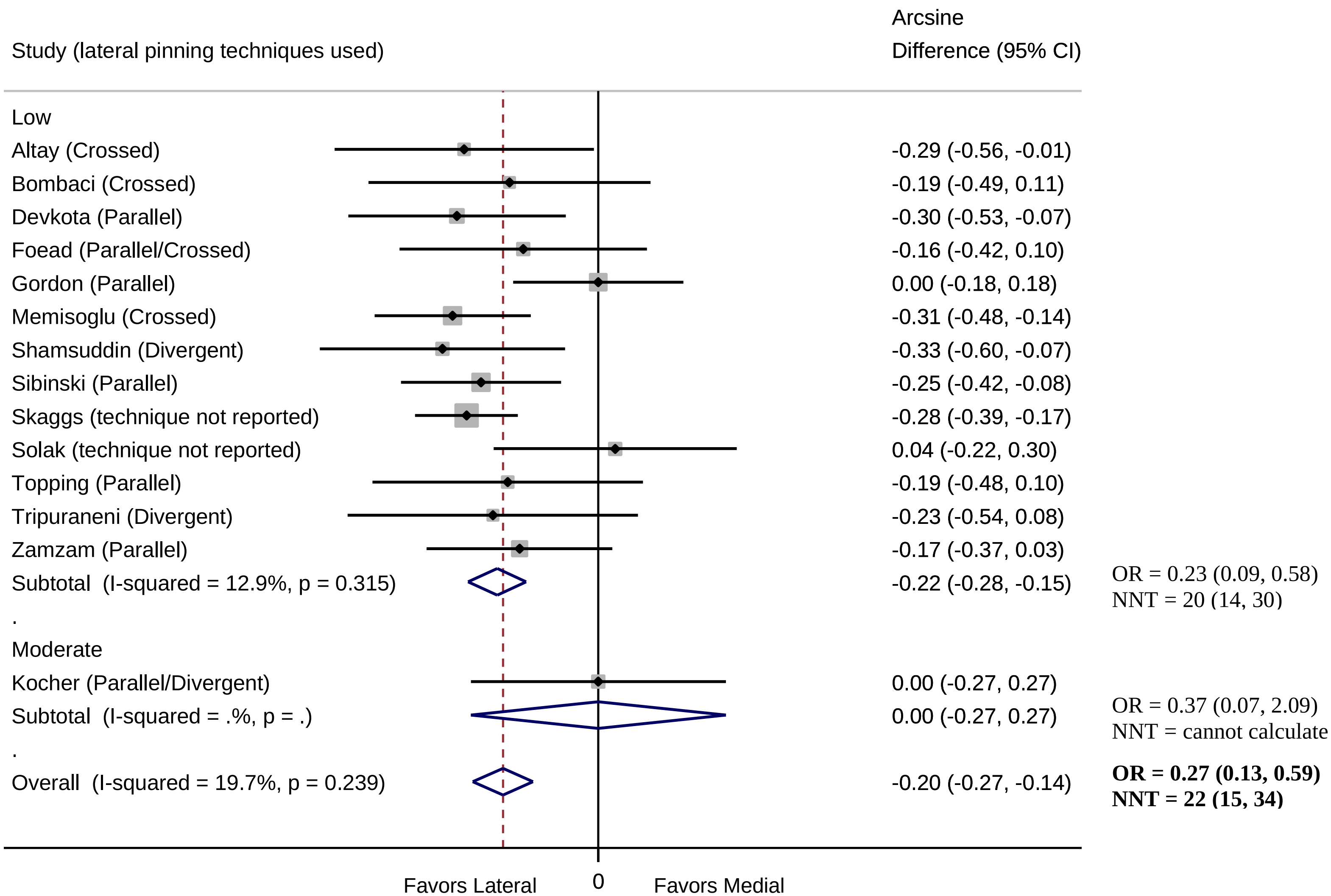


Figure 8 Baumann's Angle Meta-Analysis - Lateral vs. Medial Pinning

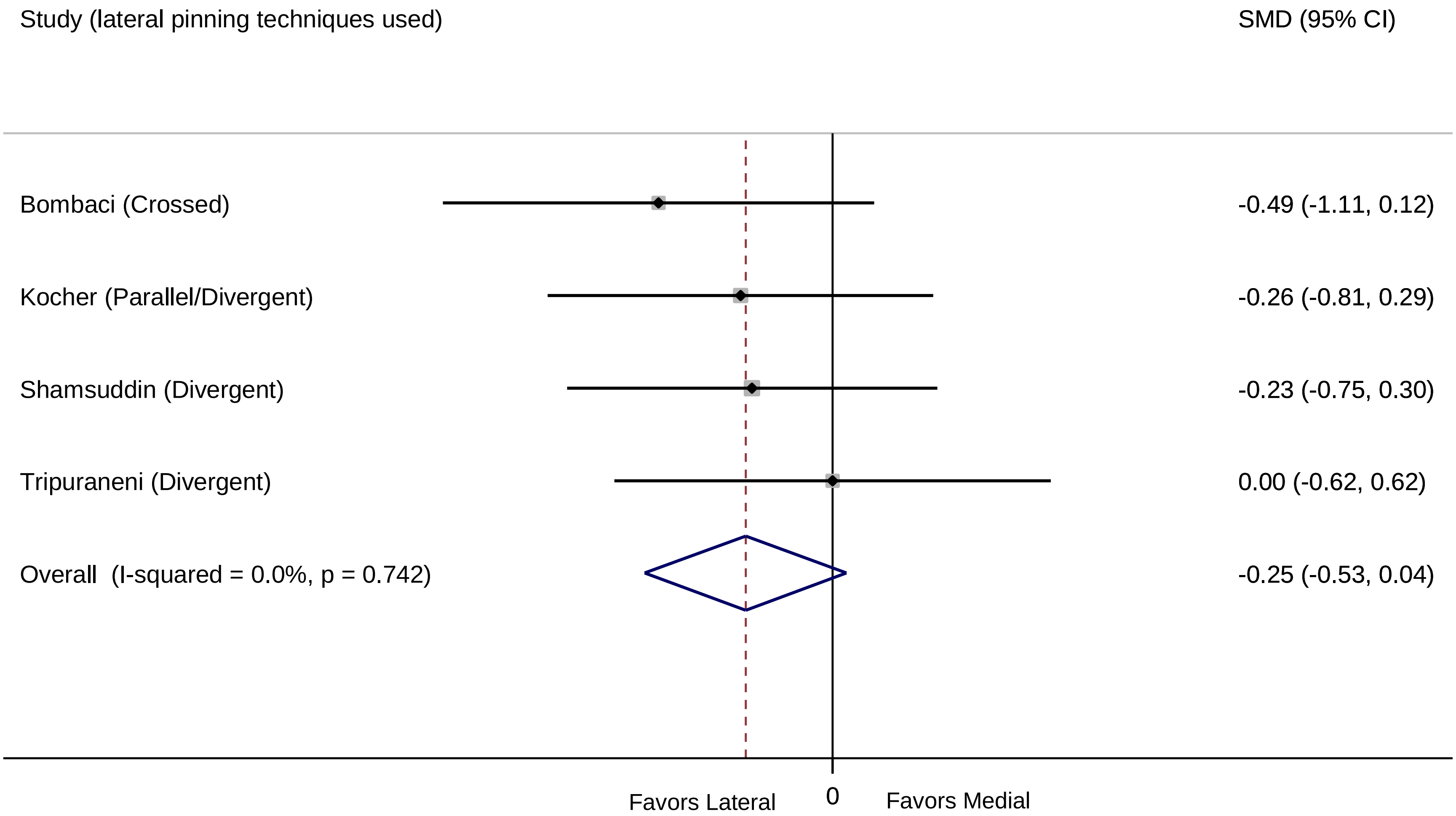


Figure 9 Baumann's Angle Change Meta-Analysis - Lateral vs. Medial Pinning

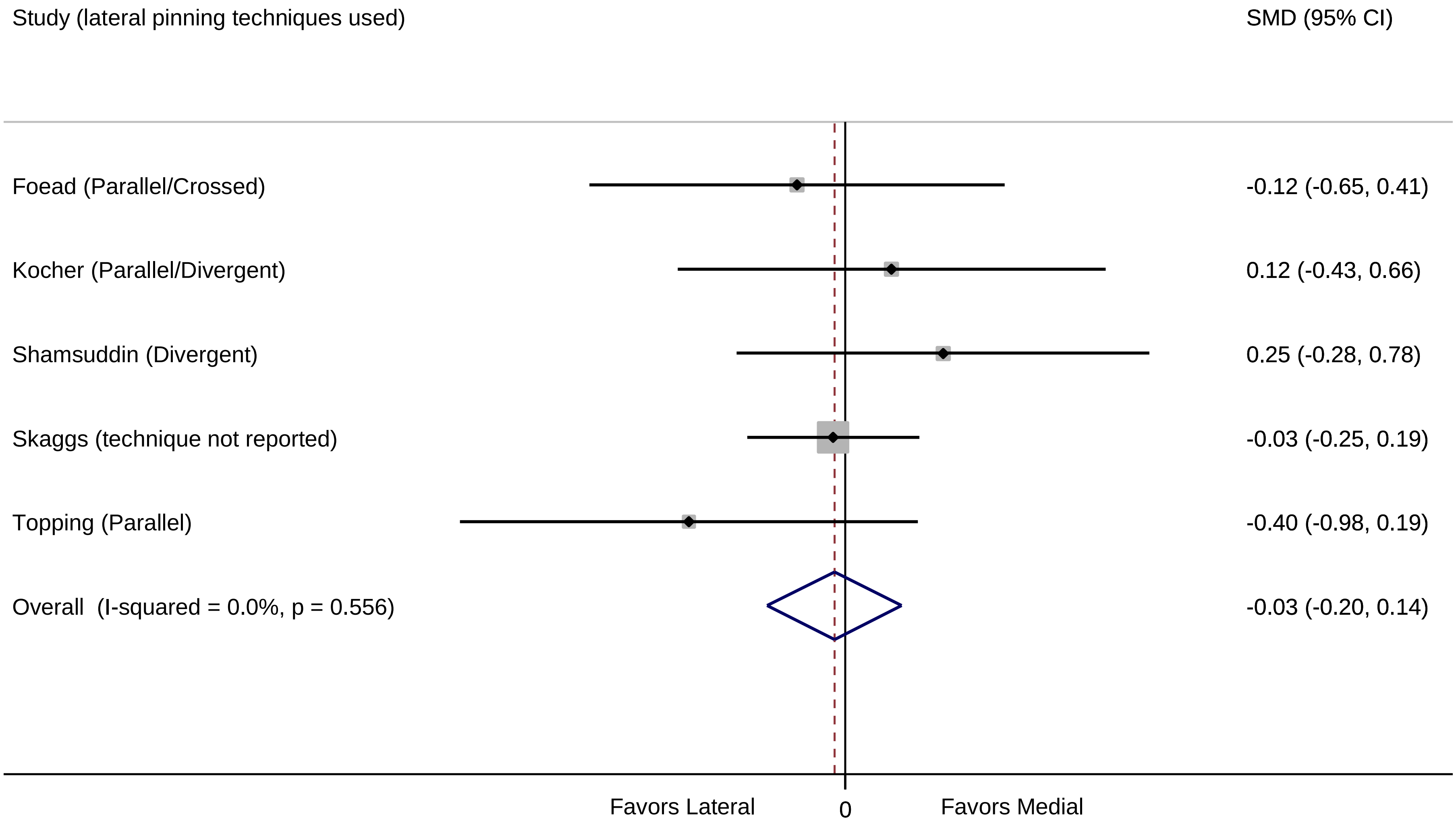


Figure 10 Flynn's Criteria Satisfactory Meta-Analysis - Lateral vs. Medial Pinning

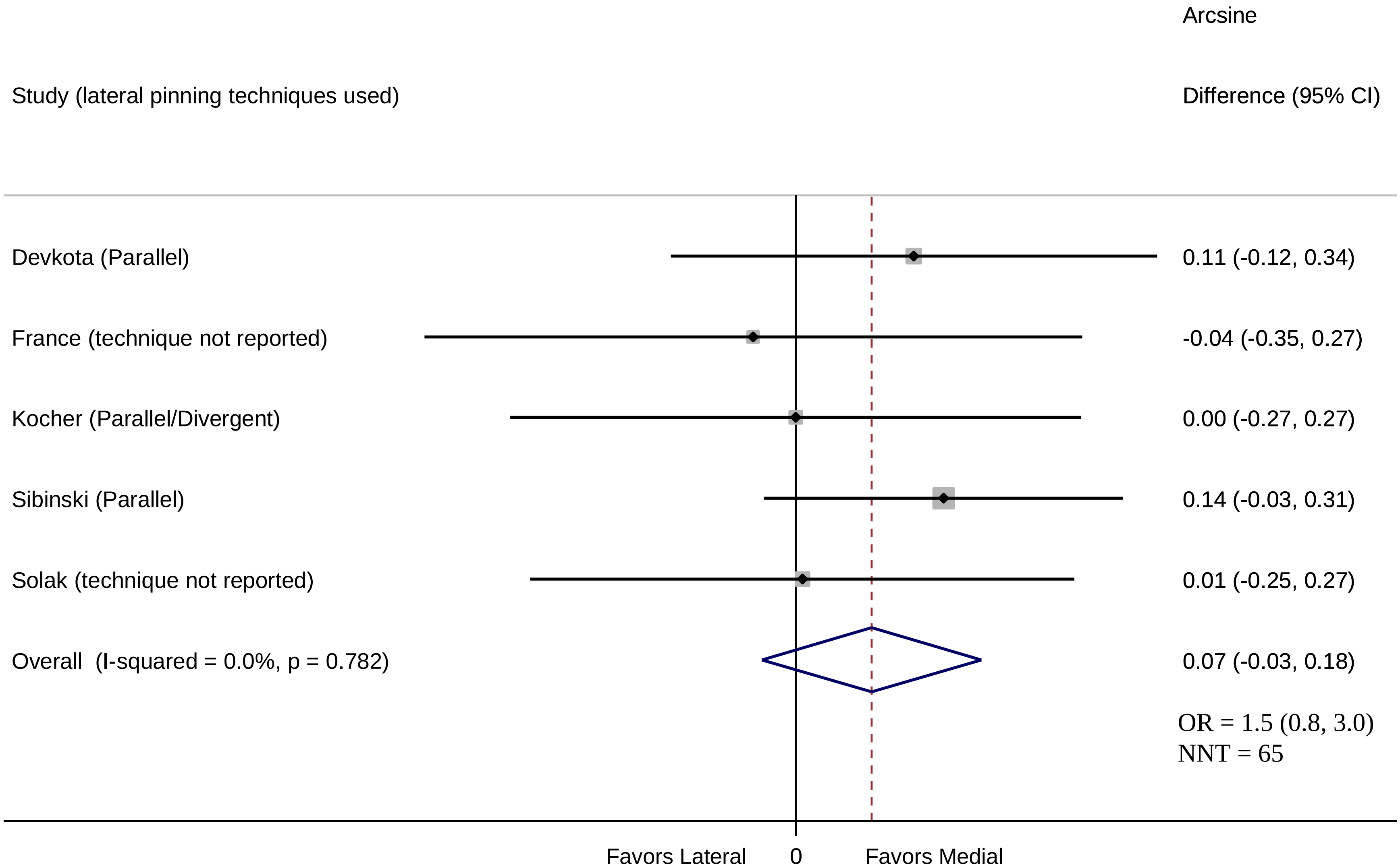
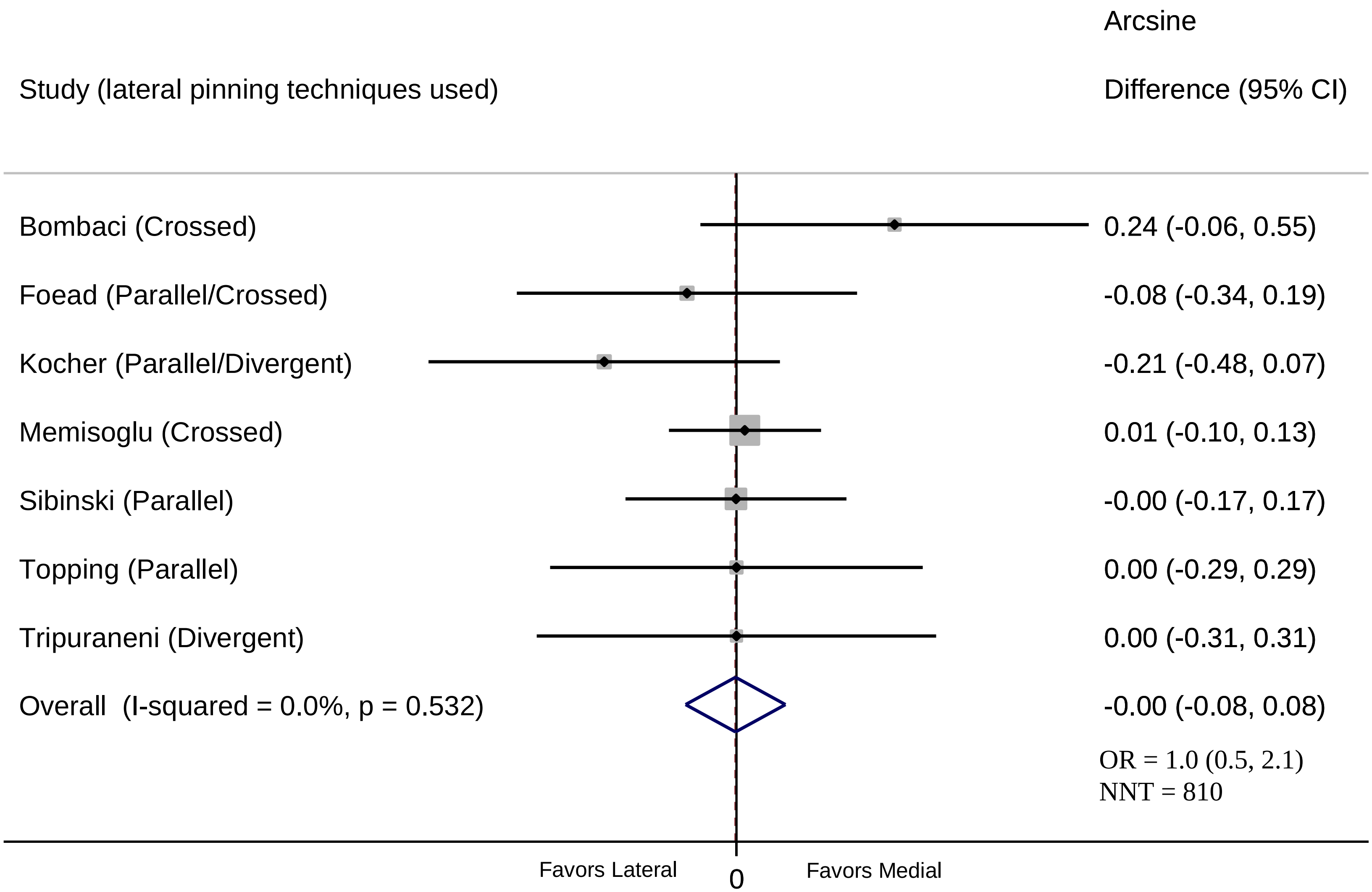


Figure 11 Infection Meta-Analysis - Lateral vs. Medial Pinning



EXCLUDED STUDIES

Table 42 Excluded Studies Considered for Recommendation 3

Study	Year	Title	Reason for Exclusion
Belhan O; Karakurt L; Ozdemir H; Yilmaz E; Kaya M; Serin E; Inci M;	2009	Dynamics of the ulnar nerve after percutaneous pinning of supracondylar humeral fractures in children	Not best available evidence, very low quality
Zenios M; Ramachandran M; Milne B; Little D; Smith N;	2007	Intraoperative stability testing of lateral-entry pin fixation of pediatric supracondylar humeral fractures	Not best available evidence, very low quality
Onwuanyi ON; Nwobi DG;	1998	Evaluation of the stability of pin configuration in K-wire fixation of displaced supracondylar fractures in children	Not best available evidence, very low quality

RECOMMENDATION 4

We cannot recommend for or against using an open incision as a means of increasing the safety of introduction of a medial pin.

Strength of Recommendation: Inconclusive

> Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.
>
> Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

RATIONALE

Pin configuration and the potential complications related to iatrogenic ulnar nerve injury are recognized concerns in this population. Therefore the group deemed it important to examine the technique of medial pin placement; specifically if there was a difference in ulnar nerve injury rates related to percutaneous vs. open medial pin placement. There was no existing adequate data to address the technique of medial pin placement.

SUPPORTING EVIDENCE

No studies that met the selection criteria addressed this recommendation.

RECOMMENDATION 5

We are unable to recommend for or against a time threshold for reduction of displaced pediatric supracondylar fractures of the humerus without neurovascular injury.

Strength of Recommendation: Inconclusive

Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.

Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

Included Studies	Number of Outcomes	Level of Evidence	Quality	Applicability	Critical Outcome(s)	Benefits and Harms Adjustment
Carmichael[50]	1	III	Low	Moderate	baumann's angle, cubitus varus, compartment syndrome, malunion, operative time, quality of reduction, reoperation	None
Gupta[51]	10	III	Low	Moderate		
Iyengar[52]	1	III	Low	Moderate		
Mehlman[53]	4	III	Low	Moderate		
Sibinski[54]	6	III	Low	Moderate		
Walmsley[55]	8	III	Low	Moderate		

RATIONALE

The timing of treatment of displaced pediatric supracondylar humerus fractures is an important practical concern. The advisability of urgent/emergent treatment is often weighed against the availability of a surgeon, access to an operating room, and the relative safety of anesthesia. Six low quality studies with moderate applicability were identified.

All studies took a continuous variable (time to treatment) and defined early versus late treatment. Early treatment was described as being within eight hours of injury in four studies and two used a twelve-hour cut-off (Table 44). While the time of an individual's presentation to the hospital is often well documented in the medical record, the time of injury is often estimated. Such uncertainties may affect the quality of conclusions in these studies.

Five of seven critical outcomes identified by the work group were reported in the studies. Four outcomes (compartment syndrome, cubitus varus, operative time, and need for reoperation) were not reported to be significantly different between early and late treatment groups in any of the studies.

One outcome, the need for open reduction, was reported in all six studies. Carmichael and Joyner, Iyengar, et al. and Sibinski, et al. reported no difference between early and late treatment groups. Gupta, et al. and Walmsley, et al. indicated an *increased* rate for open reduction in the delayed group, while Mehlman, et al. showed a *decreased* rate for open reduction with later treatment. The indication for open reduction is subjective and may therefore vary considerably. Without consistent, objective criteria for the requirement for open treatment, it is difficult to assess the results of the studies. Furthermore, these non-randomized retrospective studies are prone to selection bias. More severe injuries may have been selected for earlier treatment, potentially confounding the comparative data.

SUPPORTING EVIDENCE

QUALITY

Relevant Tables: Table 43, Table 46, Table 47

Data on 30 outcomes from six studies were found for this recommendation. All outcomes were of low quality (Table 43). All six studies were retrospective comparative studies which resulted in flawed prospective, group assignment, and blinding domains. Five outcomes had unflawed measurement domains (infections, hospital stay, operation time). These outcomes are directly observable without the need for testing and/or important to the patient. The remaining 25 outcomes had flawed measurement domains because of the need for testing. All other quality analysis domains were not flawed (Table 46, Table 47).

APPLICABILITY

Relevant Tables: Table 43, Table 46, Table 47

For all six studies there is some uncertainty if the practitioners who delivered the treatment did so in a way similar to the way it would be delivered in most practices due to the low number of surgeons performing the operations in each study. Only Iyengar, et al. and Mehlman, et al. took measures to ensure that all potential patients were included in the analysis, resulting in an unflawed analysis domain. Due to the retrospective review nature of the included studies the patients are thought to be similar to those seen in actual clinical practice and the compliance and adherence to treatment is believed to be similar to that seen in actual clinical practice. The applicability of the included outcomes to results that would be obtained in a typical practice is moderate. Results of the applicability domains analysis are available in Table 46 and Table 47.

FINAL STRENGTH OF EVIDENCE

All ‘Low’ quality outcomes remained at ‘Low’ strength of evidence based on their ‘Moderate’ applicability (Table 43).

Table 43 Quality and Applicability Summary – Timing of Operation

Study	Outcome	Quality	Applicability	Strength of Evidence
Walmsley	Anterior interosseous nerve palsy	Low	Moderate	**Low**
Sibinski	Avascular necrosis	Low	Moderate	**Low**
Gupta*	**Compartment syndrome**	Low	Moderate	**Low**

Bold outcomes are identified as critical outcomes, * also performed analysis of Type III fractures only, † underpowered outcome, only considered in meta-analysis

Mehlman	**Compartment syndrome**	Low	Moderate	**Low**
Sibinski	**Cubitus varus**	Low	Moderate	**Low**
Walmsley	**Cubitus varus**	Low	Moderate	**Low**
Sibinski	Flynn's criteria - Satisfactory	Low	Moderate	**Low**
Sibinski	Hospital stay	Low	Moderate	**Low**
Gupta*	Iatrogenic nerve injury	Low	Moderate	**Low**
Mehlman	Iatrogenic nerve injury	Low	Moderate	**Low**
Gupta*	Infection - pin track	Low	Moderate	**Low**
Mehlman	Infection - pin track	Low	Moderate	**Low**
Walmsley	Median nerve palsy	Low	Moderate	**Low**
Gupta*	**Need for open reduction**	Low	Moderate	**Low**
Iyengar	**Need for open reduction**	Low	Moderate	**Low**
Mehlman	**Need for open reduction**	Low	Moderate	**Low**
Sibinski	**Need for open reduction**	Low	Moderate	**Low**
Walmsley	**Need for open reduction**	Low	Moderate	**Low**
Carmichael	**Need for open reduction**†	Low	Moderate	**Low**
Sibinski	**Operative time**	Low	Moderate	**Low**
Walmsley	Radial nerve palsy	Low	Moderate	**Low**
Walmsley	**Reoperation/loss of reduction**	Low	Moderate	**Low**
Walmsley	Ulnar nerve palsy	Low	Moderate	**Low**
Gupta*	Vascular damage	Low	Moderate	**Low**
Walmsley	Wound infection	Low	Moderate	**Low**

Bold outcomes are identified as critical outcomes, * also performed analysis of Type III fractures only, † underpowered outcome, only considered in meta-analysis

RESULTS

Relevant Tables: Table 44, Table 45, Table 48-Table 50

Four of the studies retrospectively compared patients receiving operative treatment before or after an 8 hour cutoff and two of the studies retrospectively compared patients receiving operative treatment before or after a 12 hour cutoff (Table 44). Additionally, two of the studies investigated Gartland Type II or III fractures retrospectively. Gupta, et al. investigated both types of fractures and performed an analysis of only the Type III fractures identified by their retrospective review. This is in addition to the remaining three studies which investigated only Type III fractures retrospectively (Table 44).

The results of statistical testing and the direction of treatment effect (i.e. the favored treatment) are summarized in the table below according to the early/delayed cutoff assigned by study authors and the types of fractures enrolled/analyzed by the study authors (Table 45).

In total, 3 of 29 outcomes had statistically significant differences and 26 were did not have statistically significant differences based on analysis of mean differences and proportions. One outcome was only considered for meta-analysis because of low power. This outcome does not appear in the summary of results (Table 45).

Five (of 7) critical outcomes identified by the work group were reported in the included studies. Four of these, compartment syndrome, cubitus varus, operative time, and reoperation were not statistically significant in any study at any early/delayed cutoff time.

The final critical outcome, need for open reduction (i.e. quality of reduction), was reported by all six studies. Carmichael and Joyner, Iyengar, et al., and Sibinski, et al reported no statistically significant differences although the study by Carmichale and Joyner was not powered to detect a large effect. Gupta, et al. and Walmsley, et al. reported statistically significant differences in favor of early treatment . However, Gupta, et al. reported statistically significant differences in favor of early treatment for Type III fractures only. When Type II and III fractures were considered together, the results were not statistically significant. Mehlman, et al. reported statistically significant differences in favor of delayed treatment. A meta-analysis of the outcome, need for open reduction, from all six studies, comparing early to delayed surgery, was performed but is not considered for this recommendation due to statistically significant heterogeneity ($I^2 = 70.5\%$, $p = 0.005$).

Table 44 Timing Cutoff and Fracture Types

Study	Early/Delayed Cutoff Time	Fracture types - Early	Fracture types - Delayed
Carmichael	8 hours	64% Type III, 36% Type II	29% Type III, 71% Type II
Iyengar	8 hours	100% Type III	100% Type III
Mehlman	8 hours	94% Type III, 6% Type II	70% Type III, 30% Type II
Walmsley	8 hours	100% Type III	100% Type III
Gupta*	12 hours	70% Type III, 30% Type II	34% Type III, 66% Type II
Sibinski	12 hours	100% Type III	100% Type III

*also performed analysis of Type III fractures only

Table 45 Results Summary - Timing of Operation

Outcome(s)	8 hour cutoff: Type II and III	8 hour cutoff: Type III	12 hour cutoff: Type II and III	12 hour cutoff: Type III
Baumann's angle	no evidence		no evidence	
Cubitus varus		○		○
Compartment syndrome	○		○	○
Malunion	no evidence		no evidence	
Need for open reduction†	♦	○ ●	○ ○	●
Operative time	no evidence			○
Reoperation/loss of reduction		○	no evidence	
Anterior interosseous nerve palsy		○		
Avascular necrosis				○
Flynn's criteria - Satisfactory				○
Hospital stay				○
Iatrogenic nerve injury	○		○	○
Infection - pin track	○		○	○
Median nerve palsy		○		
Radial nerve palsy		○		
Ulnar nerve palsy		○		
Vascular damage			○	○
Wound infection	○			

Bold outcomes are identified as critical outcomes, ●: statistically significant in favor of early, ○: no statistically significant difference, ♦: statistically significant in favor of delayed, † meta-analysis of need for open reduction I^2=70.5%

EVIDENCE TABLES AND FIGURES

QUALITY AND APPLICABILITY

Table 46 Quality and Applicability Domain Scores – Timing of Operation (8 hour cutoff)

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Walmsley	Anterior interosseous nerve palsy	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Mehlman	Compartment syndrome	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Walmsley	Cubitus varus	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Mehlman	Iatrogenic nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Mehlman	Infection - pin track	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	●	Moderate
Walmsley	Median nerve palsy	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Carmichael	Need for open reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Iyengar	Need for open reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate

Table 46 Quality and Applicability Domain Scores – Timing of Operation (8 hour cutoff)

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Mehlman	Need for open reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Walmsley	Need for open reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Walmsley	Reoperation/loss of reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Walmsley	Radial nerve palsy	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Walmsley	Ulnar nerve palsy	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Walmsley	Wound infection	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	○	Moderate

Table 47 Quality and Applicability Domain Scores – Timing of Operation (12 hour cutoff)

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Sibinski	Avascular necrosis	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Gupta	Compartment syndrome	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Sibinski	Cubitus varus	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Sibinski	Flynn’s criteria	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Sibinski	Hospital stay	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	○	Moderate
Gupta	Iatrogenic nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Gupta	Infection - pin track	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	○	Moderate
Sibinski	Need for open reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate
Gupta	Need for open reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate

Table 47 Quality and Applicability Domain Scores – Timing of Operation (12 hour cutoff)

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Sibinski	Operative time	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	○	Moderate
Gupta	Vascular damage	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	○	Moderate

FINDINGS

Table 48 Analysis of Proportions – Timing of Operation (8 hour cutoff)

Study	n	Strength of Evidence	Outcome	Duration	<8 hours %, n/N	>8 hours %, n/N	p-value	Results
Walmsley	171	Low	Anterior interosseous nerve palsy	n/a	8%, 10/126	9%, 4/45	0.84	No difference
Mehlman	198	Low	Compartment syndrome	n/a	0%, 0/52	0%, 0/146	1.00	No difference
Walmsley	171	Low	Cubitus varus	n/a	4%, 5/126	7%, 3/45	0.49	No difference
Mehlman	198	Low	Iatrogenic nerve injury	n/a	4%, 2/52	2%, 3/146	0.51	No difference
Mehlman	198	Low	Infection - pin track	n/a	4%, 2/52	2%, 3/146	0.51	No difference
Walmsley	171	Low	Median nerve palsy	n/a	10%, 13/126	13%, 6/45	0.59	No difference
Carmichael	42	Low	Need for open reduction	n/a	4%, 1/25	6%, 1/17	underpowered, retained for meta-analysis	
Iyengar	58	Low	Need for open reduction	n/a	13%, 3/23	17%, 6/35	0.67	No difference
Mehlman	198	Low	Need for open reduction	n/a	13%, 7/52	3%, 5/146	0.02	Favors >8 hours

Table 48 Analysis of Proportions – Timing of Operation (8 hour cutoff)

Study	n	Strength of Evidence	Outcome	Duration	<8 hours %, n/N	>8 hours %, n/N	p-value	Results
Walmsley	171	Low	Need for open reduction	n/a	11%, 14/126	33%, 15/45	0.00	Favors <8 hours
Walmsley	171	Low	Reoperation/ loss of reduction	n/a	2%, 3/126	0%, 0/45	0.07	No difference
Walmsley	171	Low	Radial nerve palsy	n/a	4%, 5/126	4%, 2/45	0.89	No difference
Walmsley	171	Low	Ulnar nerve palsy	n/a	3%, 4/126	2%, 1/45	0.73	No difference
Walmsley	171	Low	Wound infection	n/a	1%, 1/126	2%, 1/45	0.49	No difference

Table 49 Analysis of Mean Differences - Timing of Operation (12 hour cutoff)

Study	n	Strength of Evidence	Outcome	Duration	<12 hours (mean)	>12 hours (mean)	p-value	Results
Sibinski	77	Low	Hospital stay	n/a	37.7	46.5	0.1	No difference
Sibinski	77	Low	Operative time	n/a	1.05	1.00	0.65	No difference

Table 50 Analysis of Proportions – Timing of Operation (12 hour cutoff)

Study	n	Strength of Evidence	Outcome	Duration	<12 hours %, n/N	>12 hours %, n/N	p-value	Results
Sibinski	77	Low	Avascular necrosis	n/a	0%, 0/43	0%, 0/34	1.00	No difference
Gupta	150	Low	Compartment syndrome	n/a	0%, 0/50	0%, 0/100	1.00	No difference
Gupta	69	Low	Compartment syndrome	n/a	0%, 0/35	0%, 0/34	1.00	No difference
Sibinski	77	Low	Cubitus varus	n/a	0%, 0/43	0%, 0/34	1.00	No difference
Sibinski	77	Low	Flynn's criteria - Satisfactory	n/a	72%, 31/43	85%, 29/34	0.16	No difference
Gupta	150	Low	Iatrogenic nerve injury	n/a	0%, 0/50	0%, 0/100	1.00	No difference
Gupta	69	Low	Iatrogenic nerve injury	n/a	0%, 0/35	0%, 0/34	1.00	No difference
Gupta	150	Low	Infection - pin track	n/a	0%, 0/50	1%, 1/100	0.25	No difference
Gupta	69	Low	Infection - pin track	n/a	0%, 0/35	3%, 1/34	0.15	No difference
Sibinski	77	Low	Need for open reduction	n/a	21%, 9/43	32%, 11/34	0.26	No difference

Table 50 Analysis of Proportions – Timing of Operation (12 hour cutoff)

Study	n	Strength of Evidence	Outcome	Duration	<12 hours %, n/N	>12 hours %, n/N	p-value	Results
Gupta	150	Low	Need for open reduction	n/a	0%, 0/50	2%, 2/100	0.10	No difference
Gupta	69	Low	Need for open reduction	n/a	0%, 0/35	6%, 2/34	0.04	Favors <12 hours
Gupta	150	Low	Vascular damage	n/a	2%, 1/50	0%, 0/100	0.10	No difference
Gupta	69	Low	Vascular damage	n/a	3%, 1/35	0%, 0/34	0.16	No difference

EXCLUDED STUDIES

Table 51 Excluded Studies Considered for Recommendation 5

Study	Year	Title	Reason for Exclusion
Yildirim AO;Unal VS;Oken OF;Gulcek M;Ozsular M;Ucaner A;	2009	Timing of surgical treatment for type III supracondylar humerus fractures in pediatric patients	Not best available evidence, very low quality
Devnani AS;	2005	Late presentation of supracondylar fracture of the humerus in children	Not best available evidence, very low quality
Ponce BA;Hedequist DJ;Zurakowski D;Atkinson CC;Waters PM;	2004	Complications and timing of follow-up after closed reduction and percutaneous pinning of supracondylar humerus fractures: follow-up after percutaneous pinning of supracondylar humerus fractures	Not relevant, comparison of follow-up time
Leet AI;Frisancho J;Ebramzadeh E;	2002	Delayed treatment of type 3 supracondylar humerus fractures in children	Not best available evidence, very low quality
Devnani AS;	2000	Gradual reduction of supracondylar fracture of the humerus in children reporting late with a swollen elbow	Less than 10 patients per group
Khan T;Hussain FN;Ahmed A;Jokhio W;	2000	Management of delayed supracondylar fracture of humerus	Not best available evidence, very low quality

RECOMMENDATION 6

The practitioner might perform open reduction for displaced pediatric supracondylar fractures of the humerus following closed reduction if varus or other malposition of the bone occurs.

Strength of Recommendation: Limited

Description: Evidence from two or more "Low" strength studies with consistent findings, or evidence from a single "Moderate" quality study recommending for or against the intervention or diagnostic. A **Limited** recommendation means the quality of the supporting evidence that exists is unconvincing, or that well-conducted studies show little clear advantage to one approach versus another.

Implications: Practitioners should exercise clinical judgment when following a recommendation classified as **Limited**, and should be alert to emerging evidence that might negate the current findings. Patient preference should have a substantial influencing role.

Included Studies	Number of Outcomes	Level of Evidence	Quality	Applicability	Critical Outcome(s)	Benefits and Harms Adjustment
Aktekin[56]	11	III	Low	Moderate	cubitus varus, hyperextension, loss of reduction, malunions, pain, stiff elbow	None
Cramer[57]	1	III	Low	Moderate		
Mazda[58]	3	III	Low	Moderate		
Turhan[59]	2	III	Low	Moderate		
Sibly[60]	4	III	Low	Moderate		
Lee[61]	4	III	Low	Moderate		
Li[62]	2	III	Low	Moderate		
Kekomaki[63]	1	III	Low	Moderate		

RATIONALE

The work group recognizes that a percentage of pediatric supracondylar fractures of the humerus cannot be reduced using a closed technique. Fracture pattern, soft-tissue interposition, patient characteristics, and surgeon experience may contribute individually or in combination. In these more challenging cases the surgeon may need to perform an open reduction. The studies included in the guideline only provide limited support this recommendation.

Data on 28 outcomes from 8 studies were analyzed. Significant flaws in study design limited the strength of all the studies. The critical outcomes studied were cubitus varus, hyperextension, loss of reduction, malunion, pain, and elbow stiffness. Statistically significant data was found for only two of these outcomes. Aktekin, et al. report stiffness was greater in the patients treated with open reduction compared to patients treated with a closed reduction and pinning. Li, et al. reported that the fractures treated open had a lower incidence of loss of reduction compared to displaced fractures that could be managed successfully with closed reduction and pinning. Sibly, et al. found no statistically significant difference between groups for cubitus varus or elbow stiffness.

These non-randomized retrospective studies are prone to selection bias. More severe injuries may have been selected for open reduction, potentially confounding the comparative data. We could not determine if adverse outcomes in the open reduction group were due to the severity of injury or to the intervention. Furthermore, the literature lacks clear definitions for an acceptable reduction.

SUPPORTING EVIDENCE

QUALITY

Relevant Tables: Table 52-Table 55, Table 58-Table 61

Data on 28 outcomes from eight studies [were found for this recommendation. All outcomes were of low quality (Table 52-Table 55). Seven of the studies were retrospective comparative studies which resulted in flawed prospective, group assignment, and blinding domains. The remaining study was a prospective comparative study with flawed group assignment and blinding domains. All but four outcomes had flawed measurement domains (infections, operation time). The four outcomes, infection and operation time, are directly observable without the need for testing and/or are important to the patient resulting in an unflawed measurement domain. The remaining 25 outcomes had flawed measurement domains because of the need for testing. All other quality analysis domains were not flawed (Table 58-Table 61).

APPLICABILITY

Relevant Tables: Table 52-Table 55, Table 58-Table 61

For all eight studies there is some uncertainty if the practitioners who delivered the treatment did so in a way similar to the way it would be delivered in most practices due to the low number of surgeons performing the operations in each study. The patients investigated in these studies are thought to be similar to those seen in actual clinical practice and the compliance and adherence to treatment is believed to be similar to that seen in actual clinical practice. The applicability of the included outcomes to results that would be obtained in a typical practice is moderate. Results of the applicability domains analysis are available in Table 58-Table 61.

FINAL STRENGTH OF EVIDENCE

All ‘Low’ quality outcomes remained at ‘Low’ strength of evidence based on their ‘Moderate’ applicability (Table 52-Table 55).

Table 52 Quality and Applicability Summary - Failed Closed Reduction with Open Reduction and Pins compared to Successful Closed Reduction and Pins

Study	Outcome	Duration	Quality	Applicability	Strength of Evidence
Aktekin	Avascular necrosis of trochlea	n/a	Low	Moderate	**Low**
Aktekin	Baumann's angle	Final follow-up	Low	Moderate	**Low**
Aktekin	Carrying angle	Final follow-up	Low	Moderate	**Low**
Cramer	Carrying angle difference > 15°	18 months	Low	Moderate	**Low**
Aktekin	Flynn's cosmetic criteria - satisfactory	Final follow-up	Low	Moderate	**Low**
Mazda	Flynn's cosmetic criteria - satisfactory	Final follow-up	Low	Moderate	**Low**
Mazda	Flynn's criteria - satisfactory	Final follow-up	Low	Moderate	**Low**
Aktekin	Flynn's functional criteria - satisfactory	Final follow-up	Low	Moderate	**Low**
Mazda	Flynn's functional criteria - satisfactory	Final follow-up	Low	Moderate	**Low**
Turhan	Humerocapitellar angle	Post-op	Low	Moderate	**Low**
Aktekin	Iatrogenic ulnar nerve injury	n/a	Low	Moderate	**Low**
Aktekin	Infection - pin track	n/a	Low	Moderate	**Low**
Aktekin	Myositis ossificans	n/a	Low	Moderate	**Low**
Turhan	Poor reduction quality	Post-op	Low	Moderate	**Low**
Aktekin	**Range of motion restriction**	Final follow-up	Low	Moderate	**Low**
Aktekin	Time to union	n/a	Low	Moderate	**Low**
Aktekin	Wound dehiscence	n/a	Low	Moderate	**Low**

Bold outcomes are identified as critical outcomes

Table 53 Quality and Applicability Summary - Failed Closed Reduction with Open Reduction and Pins compared to Successful Closed Reduction and Non-operative Treatment

Study	Outcome	Duration	Quality	Applicability	Strength of Evidence
Sibly	**Cubitus varus**	n/a	Low	Moderate	**Low**
Sibly	Iatrogenic ulnar nerve injury	n/a	Low	Moderate	**Low**
Sibly	Ischemic contracture	n/a	Low	Moderate	**Low**
Sibly	**Loss of motion > 5°**	Final follow-up	Low	Moderate	**Low**

Bold outcomes are identified as critical outcomes

Table 54 Quality and Applicability Summary - Failed Closed Reduction with Instrument Reduction and Pins compared to Successful Closed Reduction and Pins

Study	Outcome	Duration	Quality	Applicability	Strength of Evidence
Lee	Flynn's criteria - satisfactory	n/a	Low	Moderate	**Low**
Lee	Iatrogenic ulnar nerve injury	n/a	Low	Moderate	**Low**
Lee	Infection - pin track	n/a	Low	Moderate	**Low**
Li	**Loss of reduction**	n/a	Low	Moderate	**Low**
Lee	Operation time	n/a	Low	Moderate	**Low**
Li	Operation time	n/a	Low	Moderate	**Low**

Bold outcomes are identified as critical outcomes

Table 55 Quality and Applicability Summary - Failed Closed Reduction with Open Reduction and Pins vs. Failed Closed Reduction with Traction

Study	Outcome	Duration	Quality	Applicability	Strength of Evidence
Kekomaki	Satisfactory Outcome	n/a	Low	Moderate	**Low**

Bold outcomes are identified as critical outcomes

RESULTS

Relevant Tables and Figures: Table 56, Table 57, Table 62-Table 67

Five of the studies retrospectively compared patients that underwent sequential treatment by closed reduction, which failed, followed by an open reduction with pin fixation. These patients were compared to patients that had successful closed reduction followed by pin fixation in four studies and cuff and collar treatment in one study. Two additional studies compared the successful closed reduction and pin fixation patients with reduction techniques using instrumentation followed by pin fixation. The final study investigated patients that had failure of closed reduction followed by open reduction and pin fixation compared to patients with a failed closed reduction treated by traction. Table 56 summarizes these comparisons in addition to the types of fractures investigated in each study. Four studies investigated patients with Type II or III fractures (or otherwise described as displaced with posterior cortex not intact or simply described as displaced) and three of the studies enrolled only patients with Type III fractures (or otherwise described as displaced with posterior cortex not intact).

The results of statistical testing and the direction of treatment effect (i.e. the favored treatment) are summarized in Table 57 according to the fracture types.

In total, 8 of 27 outcomes had statistically significant differences. Seven were in favor of the successful closed reduction group and 1 was in favor of instrumentation reduction with pin fixation after a failed closed reduction. 19 outcomes did not have statistically significant differences based on analysis of mean differences and proportions (Table 62-Table 66).

Three (of 6) critical outcomes; cubitus varus, loss of reduction, and stiff elbow, identified by the work group were reported in the included studies for the comparison of patients with successful closed reduction and pin fixation to patients treated with open or instrument reduction with pin fixation after a failed closed reduction. Cubitus varus was not statistically significant. Stiff elbow (i.e. loss of motion > 5°, range of motion restriction) was statistically significant in one study and not statistically significant in another. The measurements used in the two studies were not on the same scale but both studies did investigate only Type III fractures. Loss of reduction was statistically significant in favor of instrumentation reduction in a study of only Type III fractures.

Only one result, satisfactory outcome, was considered for this recommendation in the study comparing traction vs. open reduction in patients with a failed closed reduction. This result was not statistically significant (Table 67).

Table 56 Fracture Types and Treatment Comparisons

Study	Fracture Types Studied	Treatment After Successful Closed Reduction	Treatment After Failed Closed Reduction
Cramer[57]	II, III	Pin fixation	Open reduction with pin fixation
Mazda[58]	II, III	Pin fixation	Open reduction with pin fixation
Turhan[59]	II, III	Pin fixation	Open reduction with pin fixation
Aktekin[56]	III	Pin fixation	Open reduction with pin fixation
Sibly[60]	III	Cuff and Collar	Open reduction with pin fixation
Lee[61]	III	Pin fixation	Pin Leverage reduction with pin fixation
Li[62]	III	Pin fixation	Forceps reduction with pin fixation
Kekomaki[63]	II, III	None*	Open reduction with pin fixation or Traction

*No patients had successful closed reduction

Table 57 Results Summary - Failed Closed Reduction with Open/Instrument Reduction and Pins compared to Successful Closed Reduction and Pins

Successful Closed Reduction	vs. Failed Closed Reduction with Open Reduction and Pin Fixation		vs. Failed Closed Reduction with Instrument Reduction and Pin Fixation	
Outcome(s)	**Type II and III**	**Type III**	**Type II and III**	**Type III**
Cubitus varus		○	no evidence	
Hyperextension	no evidence		no evidence	
Loss of reduction	no evidence			♦
Malunion	no evidence		no evidence	
Pain	no evidence		no evidence	
Stiff Elbow		○ ●	no evidence	
Avascular necrosis of trochlea		●		
Baumann's angle		○		
Carrying angle		○		
Carrying angle difference >15°	●			
Flynn's cosmetic result	○	○		
Flynn's criteria	○			○
Flynn's functional result	○	●		
Humerocapitellar angle	○			
Iatrogenic ulnar nerve injury		○ ○		○
Infection - pin track		○		○
Ischemic contracture		○		
Myositis ossificans		○		
Operative time				● ●
Poor reduction quality	○			
Time to union		●		
Wound dehiscence		●		

Bold outcomes are identified as critical outcomes, ●: statistically significant in favor of successful closed reduction, ○: no statistically significant difference, ♦: statistically significant in favor of open reduction with pin fixation or instrument reduction with pin fixation

EVIDENCE TABLES AND FIGURES

QUALITY AND APPLICABILITY-FAILED CLOSED REDUCTION WITH OPEN REDUCTION AND PINS COMPARED TO SUCCESSFUL CLOSED REDUCTION AND PINS

Table 58 Quality and Applicability Domain Scores – Failed Closed Reduction with Open Reduction and Pins compared to Successful Closed Reduction and Pins

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Aktekin	Avascular necrosis of trochlea	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Aktekin	Baumann's angle	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Aktekin	Carrying angle	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Cramer	Carrying angle difference > 15°	18 months	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Aktekin	Flynn's cosmetic criteria - satisfactory	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Mazda	Flynn's cosmetic criteria - satisfactory	Final follow-up	●	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Mazda	Flynn's criteria - satisfactory	Final follow-up	●	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate

Table 58 Quality and Applicability Domain Scores – Failed Closed Reduction with Open Reduction and Pins compared to Successful Closed Reduction and Pins

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Aktekin	Flynn's functional criteria - satisfactory	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Mazda	Flynn's functional criteria - satisfactory	Final follow-up	●	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Turhan	Humerocapitellar angle	Post-op	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Aktekin	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Aktekin	Infection - pin track	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	●	Moderate
Aktekin	Myositis ossificans	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Turhan	Poor reduction quality	Post-op	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Aktekin	Range of motion restriction	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate

Table 58 Quality and Applicability Domain Scores – Failed Closed Reduction with Open Reduction and Pins compared to Successful Closed Reduction and Pins

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Aktekin	Time to union	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Aktekin	Wound dehiscence	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate

QUALITY AND APPLICABILITY-FAILED CLOSED REDUCTION WITH OPEN REDUCTION AND PINS COMPARED TO SUCCESSFUL CLOSED REDUCTION AND NON-OPERATIVE TREATMENT

Table 59 Quality and Applicability Domain Scores – Failed Closed Reduction with Open Reduction and Pins compared to Successful Closed Reduction and Non-operative Treatment

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Sibly	Cubitus varus	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Sibly	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Sibly	Ischemic contracture	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Sibly	Loss of motion > 5°	Final follow-up	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate

QUALITY AND APPLICABILITY-FAILED CLOSED REDUCTION WITH INSTRUMENT REDUCTION AND PINS COMPARED TO SUCCESSFUL CLOSED REDUCTION AND PINS

Table 60 Quality and Applicability Domain Scores – Failed Closed Reduction with Instrument Reduction and Pins compared to Successful Closed Reduction and Pins

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Lee	Flynn's criteria - satisfactory	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Lee	Iatrogenic ulnar nerve injury	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Lee	Infection - pin track	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	●	Moderate
Li	Loss of reduction	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate
Lee	Operation time	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	●	Moderate
Li	Operation time	n/a	○	●	○	○	●	●	●	●	Low	●	○	●	●	Moderate

QUALITY AND APPLICABILITY-FAILED CLOSED REDUCTION WITH OPEN REDUCTION AND PINS VS. FAILED CLOSED REDUCTION WITH TRACTION

Table 61 Quality and Applicability Domain Scores – Failed Closed Reduction with Open Reduction and Pins vs. Failed Closed Reduction with Traction

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Kekomaki	Satisfactory Outcome	n/a	○	●	○	○	●	●	○	●	Low	●	○	●	●	Moderate

FINDINGS-FAILED CLOSED REDUCTION WITH OPEN REDUCTION AND PINS COMPARED TO SUCCESSFUL CLOSED REDUCTION AND PINS

Table 62 Analysis of Mean Differences – Failed Closed Reduction with Open Reduction and Pins compared to Successful Closed Reduction and Pins

Study	n	Strength of Evidence	Outcome	Duration	Closed/ Pin (mean±SD)	Open/ Pin (mean±SD)	Difference (95% CI)	Results
Aktekin	55	Low	Baumann's angle	Final follow-up	3.7 ± NR	9 ± NR	p > 0.05	No difference
Aktekin	55	Low	Carrying angle	Final follow-up	3.6 ± NR	5.9 ± NR	p > 0.05	No difference
Turhan	144	Low	Humerocapitellar angle	Post-op	7.64 ± 2.69	7.33 ± 2.85	0.31 (-0.6, 1.2)	No difference
Aktekin	55	Low	Range of motion restriction	Final follow-up	3.8 ± NR	12.3 ± NR	p = 0.03	Favors closed
Aktekin	55	Low	Time to union	n/a	5.8 ± NR	7 ± NR	p = 0.01	Favors closed

Table 63 Analysis of Proportions – Failed Closed Reduction with Open Reduction and Pins compared to Successful Closed Reduction and Pins

Study	n	Strength of Evidence	Outcome	Duration	Closed/Pin %, n/N	Open/Pin %, n/N	p-value	Results
Aktekin	55	Low	Avascular necrosis of trochlea	n/a	0%, 0/32	9%, 2/23	0.03	Favors closed
Cramer	29	Low	Carrying angle difference > 15°	18 months	0/0%, 15	14%, 2/14	0.04	Favors closed

Table 63 Analysis of Proportions – Failed Closed Reduction with Open Reduction and Pins compared to Successful Closed Reduction and Pins

Study	n	Strength of Evidence	Outcome	Duration	Closed/Pin %, n/N	Open/Pin %, n/N	p-value	Results
Aktekin	55	Low	Flynn's cosmetic criteria - satisfactory	Final follow-up	97%, 31/32	83%, 19/23	0.07	No difference
Mazda	108	Low	Flynn's cosmetic criteria - satisfactory	Final follow-up	96%, 79/82	96%, 25/26	0.97	No difference
Mazda	108	Low	Flynn's criteria - satisfactory	Final follow-up	96%, 79/82	96%, 25/26	0.97	No difference
Aktekin	55	Low	Flynn's functional criteria - satisfactory	Final follow-up	94%, 30/32	74%, 17/23	0.04	Favors closed
Mazda	108	Low	Flynn's functional criteria - satisfactory	Final follow-up	0%, 0/82	0%, 0/26	1.00	No difference
Aktekin	55	Low	Iatrogenic ulnar nerve injury	n/a	6%, 2/32	0%, 0/23	0.07	No difference
Aktekin	55	Low	Infection - pin track	n/a	13%, 4/32	9%, 2/23	0.65	No difference
Aktekin	55	Low	Myositis ossificans	n/a	0%, 0/32	0%, 0/23	1.00	No difference

Table 63 Analysis of Proportions – Failed Closed Reduction with Open Reduction and Pins compared to Successful Closed Reduction and Pins

Study	n	Strength of Evidence	Outcome	Duration	Closed/Pin %, n/N	Open/Pin %, n/N	p-value	Results
Turhan	144	Low	Poor reduction quality	Post-op	0%, 0/76	0%, 0/68	1.00	No difference
Aktekin	55	Low	Wound dehiscence	n/a	0%, 0/32	9%, 2/23	0.03	Favors closed

FINDINGS-FAILED CLOSED REDUCTION WITH OPEN REDUCTION AND PINS COMPARED TO SUCCESSFUL CLOSED REDUCTION AND NON-OPERATIVE TREATMENT

Table 64 Analysis of Proportions – Failed Closed Reduction with Open Reduction and Pins compared to Successful Closed Reduction and Non-operative Treatment

Study	n	Strength of Evidence	Outcome	Duration	Closed/non-op %, n/N	Open/Pin %, n/N	p-value	Results
Sibly	55	Low	Cubitus varus	n/a	19%, 5/26	24%, 7/29	0.66	No difference
Sibly	55	Low	Iatrogenic ulnar nerve injury	n/a	0%, 0/26	3%, 1/29	0.17	No difference
Sibly	55	Low	Ischemic contracture	n/a	0%, 0/26	3%, 1/29	0.17	No difference
Sibly	55	Low	Loss of motion > 5°	Final follow-up	42%, 11/26	19%, 19/29	0.08	No difference

FINDINGS-FAILED CLOSED REDUCTION WITH INSTRUMENT REDUCTION AND PINS COMPARED TO SUCCESSFUL CLOSED REDUCTION AND PINS

Table 65 Analysis of Mean Differences – Failed Closed Reduction with Instrument Reduction and Pins compared to Successful Closed Reduction and Pins

Study	n	Strength of Evidence	Outcome	Duration	Closed / Pin (mean±SD)	Instrument/ Pin (mean±SD)	Difference (95% CI)	Results
Lee	79	Low	Operation time	n/a	57 ± 4.7	68 ± 3.9	11 (8.7, 13.3)	Favors Closed
Li	42	Low	Operation time	n/a	46.17 ± 13.86	79.69 ± 24.7	33.52 (20.1, 46.9)	Favors Closed

Table 66 Analysis of Proportions – Failed Closed Reduction with Instrument Reduction and Pins compared to Successful Closed Reduction and Pins

Study	n	Strength of Evidence	Outcome	Duration	Closed/Pin %, n/N	Instrument /Pin %, n/N	p-value	Results
Lee	79	Low	Flynn's criteria - satisfactory	n/a	100%, 58/58	100%, 21/21	1.00	No difference
Lee	79	Low	Iatrogenic ulnar nerve injury	n/a	2%, 1/58	0%, 0/21	0.30	No difference
Lee	79	Low	Infection - pin track	n/a	5%, 3/58	0%, 0/21	0.07	No difference
Li	42	Low	Loss of reduction	n/a	12%, 2/17	0%, 0/25	0.03	Favors Instrument

FINDINGS-FAILED CLOSED REDUCTION WITH OPEN REDUCTION AND PINS VS. FAILED CLOSED REDUCTION WITH TRACTION

Table 67 Analysis of Proportions – Failed Closed Reduction with Open Reduction and Pins vs. Failed Closed Reduction with Traction

Study	n	Strength of Evidence	Outcome	Duration	Traction %, n/N	Open/Pin %, n/N	p-value	Results
Kekomaki	45	Low	Satisfactory Outcome	n/a	54%, 7/13	97%, 31/32	0.00	Favors Open

EXCLUDED STUDIES

Table 68 Excluded Studies Considered for Recommendation 6

Study	Year	Title	Reason for Exclusion
Aronson DC;van VE;Meeuwis JD;	1993	K-wire fixation of supracondylar humeral fractures in children: results of open reduction via a ventral approach in comparison with closed treatment	Not best available evidence, very low quality, low power
Oh CW;Park BC;Kim PT;Park IH;Kyung HS;Ihn JC;	2003	Completely displaced supracondylar humerus fractures in children: results of open reduction versus closed reduction	Not best available evidence, very low quality, low power

RECOMMENDATION 7

In the absence of reliable evidence, the opinion of the work group is that emergent closed reduction of displaced pediatric supracondylar humerus fractures be performed in patients with decreased perfusion of the hand.

Strength of Recommendation: Consensus

> Description: The supporting evidence is lacking and requires the work group to make a recommendation based on expert opinion by considering the known potential harm and benefits associated with the treatment. A **Consensus** recommendation means that expert opinion supports the guideline recommendation even though there is no available empirical evidence that meets the inclusion criteria of the guideline's systematic review.
>
> Implications: Practitioners should be flexible in deciding whether to follow a recommendation classified as **Consensus,** although they may give it preference over alternatives. Patient preference should have a substantial influencing role.

RATIONALE

Ischemic injury with contracture and/or permanent muscle and nerve damage is a disastrous outcome of the displaced pediatric supracondylar fracture with vascular compromise. The precise incidence of these complications is not accurately reported but they do occur. Only 7 studies related to the recommendation were found and all were excluded based on their poor quality. This recommendation is based on expert opinion because the displaced pediatric supracondylar fracture with reduced perfusion jeopardizes the function and viability of the limb.

Several factors may impact decisions in this clinical scenario. The degree of vascular compromise can vary from absent pulses at the wrist with some perfusion to the hand, to a completely pale hand with concomitant nerve deficits. Additional factors include the skill level of the practitioners, the time from injury, and the availability of consultants such as vascular surgeons. In the absence of high level evidence related to these factors, the practitioner's judgment will be important. In the case of a pale hand without wrist pulses, the potential benefit of manipulating the fracture may be greater than splinting and sending the patient to a center that is hours away. Conversely, if an unsuccessful reduction fails to improve blood flow, there may be trade-offs including worsening the condition by delaying access to specialized centers. This consensus recommendation allows for the discretion and judgment of the practitioner to determine who does the emergent reduction, where it is done, and what technique (open versus closed) is used. This recommendation is consistent with common medical practice.

SUPPORTING EVIDENCE

No studies that met the selection criteria addressed this recommendation.

EXCLUDED STUDIES

Table 69 Excluded Studies Considered for Recommendation 7

Study	Year	Title	Reason for Exclusion
Choi PD;Melikian R;Skaggs DL;	2010	Risk factors for vascular repair and compartment syndrome in the pulseless supracondylar humerus fracture in children	Very Low Quality, Low Power, <10 patients in comparison
Blakey CM;Biant LC;Birch R;	2009	Ischaemia and the pink, pulseless hand complicating supracondylar fractures of the humerus in childhood: long-term follow-up	Very Low Quality, Low Power
Mangat KS;Martin AG;Bache CE;	2009	The 'pulseless pink' hand after supracondylar fracture of the humerus in children: the predictive value of nerve palsy	Very Low Quality, Low Power, <10 per group in comparison
Noaman HH;	2006	Microsurgical reconstruction of brachial artery injuries in displaced supracondylar fracture humerus in children	Very Low Quality, Low Power
Ghasemzadeh F;Ahadi K;Rahjoo A;Habibollahzadeh P;	2002	Absence of radial pulse in displaced supracondylar fracture of humerus in children	Very Low Quality, Low Power
Sabharwal S;Tredwell SJ;Beauchamp RD;MacKenzie WG;Jakubec DM;Cairns R;LeBlanc JG;	1997	Management of pulseless pink hand in pediatric supracondylar fractures of humerus	Very Low Quality, Low Power
Copley LA;Dormans JP;Davidson RS;	1996	Vascular injuries and their sequelae in pediatric supracondylar humeral fractures: toward a goal of prevention	Very Low Quality, Low Power

RECOMMENDATION 8

In the absence of reliable evidence, the opinion of the work group is that open exploration of the antecubital fossa be performed in patients who have absent wrist pulses and underperfusion after reduction and pinning of displaced pediatric supracondylar humerus fractures.

Strength of Recommendation: Consensus

> Description: The supporting evidence is lacking and requires the work group to make a recommendation based on expert opinion by considering the known potential harm and benefits associated with the treatment. A **Consensus** recommendation means that expert opinion supports the guideline recommendation even though there is no available empirical evidence that meets the inclusion criteria of the guideline's systematic review.
>
> Implications: Practitioners should be flexible in deciding whether to follow a recommendation classified as **Consensus,** although they may give it preference over alternatives. Patient preference should have a substantial influencing role.

RATIONALE

In a majority of patients with displaced fractures and vascular compromise, limb perfusion improves after reduction. In the absence of improvement, surgical exploration of the antecubital fossa is indicated for patients with absent wrist pulses and a cold, pale hand. The work group issued this consensus recommendation, despite the paucity of evidence and the rarity of this occurrence, because of the risk of limb loss.

Benefits of immediate exploration outweigh the potential harms. The catastrophic risks of persistent inadequate perfusion include loss of limb, ischemic muscle contracture, nerve injury, and functional deficit. Risks of exploratory surgery include infection, neurovascular injury, and stiffness.

The orthopaedic surgeon will need to use clinical judgment. Consultation regarding vascular injury may be necessary. Treatment decisions should be made in light of all circumstances presented by the patient. This recommendation is consistent with common medical practice.

SUPPORTING EVIDENCE

No studies that met the selection criteria addressed this recommendation.

EXCLUDED STUDIES

Table 70 Excluded Studies Considered for Recommendation 8

Study	Year	Title	Reason for Exclusion
Choi PD;Melikian R;Skaggs DL;	2010	Risk factors for vascular repair and compartment syndrome in the pulseless supracondylar humerus fracture in children	Very Low Quality, Low Power, <10 patients in comparison
Blakey CM;Biant LC;Birch R;	2009	Ischaemia and the pink, pulseless hand complicating supracondylar fractures of the humerus in childhood: long-term follow-up	Very Low Quality, Low Power
Mangat KS;Martin AG;Bache CE;	2009	The 'pulseless pink' hand after supracondylar fracture of the humerus in children: the predictive value of nerve palsy	Very Low Quality, Low Power, <10 per group in comparison
Noaman HH;	2006	Microsurgical reconstruction of brachial artery injuries in displaced supracondylar fracture humerus in children	Very Low Quality, Low Power
Ghasemzadeh F;Ahadi K;Rahjoo A;Habibollahzadeh P;	2002	Absence of radial pulse in displaced supracondylar fracture of humerus in children	Very Low Quality, Low Power
Sabharwal S;Tredwell SJ;Beauchamp RD;MacKenzie WG;Jakubec DM;Cairns R;LeBlanc JG;	1997	Management of pulseless pink hand in pediatric supracondylar fractures of humerus	Very Low Quality, Low Power
Copley LA;Dormans JP;Davidson RS;	1996	Vascular injuries and their sequelae in pediatric supracondylar humeral fractures: toward a goal of prevention	Very Low Quality, Low Power

RECOMMENDATION 9

We cannot recommend for or against open exploration of the antecubital fossa in patients with absent wrist pulses but with a perfused hand after reduction of displaced pediatric supracondylar humerus fractures.

Strength of Recommendation: Inconclusive

Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.

Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

RATIONALE

There are no data to address the incidence and the impact of the clinical circumstance of a reduced pediatric supracondylar fracture with a perfused hand but absent wrist pulse, nor can the likelihood of avoiding adverse outcomes from this circumstance by open exploration of the antecubital fossa.

SUPPORTING EVIDENCE

No studies that met the selection criteria addressed this recommendation.

EXCLUDED STUDIES

Table 71 Excluded Studies Considered for Recommendation 9

Study	Year	Title	Reason for Exclusion
Choi PD;Melikian R;Skaggs DL;	2010	Risk factors for vascular repair and compartment syndrome in the pulseless supracondylar humerus fracture in children	Very Low Quality, Low Power, <10 patients in comparison
Blakey CM;Biant LC;Birch R;	2009	Ischaemia and the pink, pulseless hand complicating supracondylar fractures of the humerus in childhood: long-term follow-up	Very Low Quality, Low Power
Mangat KS;Martin AG;Bache CE;	2009	The 'pulseless pink' hand after supracondylar fracture of the humerus in children: the predictive value of nerve palsy	Very Low Quality, Low Power, <10 per group in comparison
Noaman HH;	2006	Microsurgical reconstruction of brachial artery injuries in displaced supracondylar fracture humerus in children	Very Low Quality, Low Power
Ghasemzadeh F;Ahadi K;Rahjoo A;Habibollahzadeh P;	2002	Absence of radial pulse in displaced supracondylar fracture of humerus in children	Very Low Quality, Low Power
Sabharwal S;Tredwell SJ;Beauchamp RD;MacKenzie WG;Jakubec DM;Cairns R;LeBlanc JG;	1997	Management of pulseless pink hand in pediatric supracondylar fractures of humerus	Very Low Quality, Low Power
Copley LA;Dormans JP;Davidson RS;	1996	Vascular injuries and their sequelae in pediatric supracondylar humeral fractures: toward a goal of prevention	Very Low Quality, Low Power

RECOMMENDATION 10

We are unable to recommend an optimal time for removal of pins and mobilization in patients with displaced pediatric supracondylar fractures of the humerus.

Strength of Recommendation: Inconclusive

Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.

Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

RATIONALE

Prolonged pinning and immobilization might cause pin track infection or elbow stiffness. Early removal of pins may increase the risk of redisplacement or refracture. There were no studies where the duration of pinning or of immobilization was explicitly linked to any outcome of interest.

SUPPORTING EVIDENCE

No studies that met the selection criteria addressed this recommendation.

RECOMMENDATION 11

We are unable to recommend for or against routine supervised physical or occupational therapy for patients with pediatric supracondylar fractures of the humerus.

Strength of Recommendation: Inconclusive

Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.

Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

Included Studies	Number of Outcomes	Level of Evidence	Quality	Applicability	Critical Outcome(s)	Benefits and Harms Adjustment
Keppler[64]	2	II	Moderate	Low	range of motion after 1 year, stiffness, function, pain, return to activity	None

RATIONALE

We addressed this topic because of concerns regarding range of motion after healing of the fracture. Critical outcomes sought included range of motion after one year, stiffness, function, pain, and return to activity. A single study was found. It prospectively compared patients who received physical therapy with patients who did not. The study was randomized but not blinded and included only patients who were treated by open reduction. The study was underpowered so we could not include the one year endpoint. However, statistically significant results were seen at earlier endpoints. Patients in the physical therapy group had better range of motion at both 12-13 weeks and 18-19 weeks.

The recommendation is inconclusive since a single study of limited applicability (restricted to open reductions) with flawed design (underpowered, not blinded) was the only evidence available.

SUPPORTING EVIDENCE

QUALITY

Relevant Tables: Table 72, Table 74

Data on 2 outcomes from one study was found for this recommendation. Both outcomes were of low quality (Table 72). Keppler, et al. was a randomized controlled trial in which the blinding domain and the measurement domain were flawed. The use of a surrogate measure (range of motion) flawed the measurement domain. All other quality analysis domains were not flawed.

APPLICABILITY

Relevant Tables: Table 72, Table 74

The included study has uncertain applicability. Specifically, if the treatment was delivered similarly to the way it would be delivered in the typical practice. There is also uncertainty if the patients enrolled in this study are like those seen in actual clinical practice, since only patients undergoing open reduction of the pediatric supracondylar fracture were enrolled. The strict compliance and adherence monitoring and subsequent exclusion of noncompliant patients from the analysis in this trial adds further uncertainty to the applicability of patients in this trial to those typically seen in clinical practice. Therefore, the applicability of this study's results to results that would be obtained in a typical practice is low. Results of the applicability domains analysis are available in Table 74.

FINAL STRENGTH OF EVIDENCE

All 'Moderate' quality outcomes were downgraded because of 'Low' applicability, resulting in a 'Low' final strength of evidence (Table 72).

Table 72 Quality and Applicability Summary – Physical Therapy

Study	Outcome	Duration	Quality	Applicability	Strength of Evidence
Keppler	Limitation of ROM	12-13 weeks	Moderate	Low	**Low**
Keppler	Limitation of ROM	18-19 weeks	Moderate	Low	**Low**

RESULTS

Relevant Tables: Table 73, Table 75

The included study compared patients receiving supervised physical therapy to patients that did not undergo any physical therapy. Outcomes were assessed at 6 weeks to 1 year after injury (1 week to 1 year after cast removal). The only outcomes considered for this recommendation were limitation in range of motion at 12-13 weeks and at 18-19 weeks. This study was not powered to find large effects for all other follow-up durations of range of motion reported, therefore they are not considered for this recommendation. The results of statistical testing and the direction of treatment effect (i.e. the favored treatment) are summarized in Table 73.

In total, 2 of 2 outcomes had statistically significant differences (Table 75). No critical outcomes identified by the work group were found.

Table 73 Results Summary - Treatment of Type I Fractures

Outcome(s)	12-13 weeks*	18-19 weeks*
Limitation of ROM	●	●

●: statistically significant in favor of physical therapy, ○: no statistically significant difference,
♦: statistically significant in favor of no physical therapy, * from time of injury

EVIDENCE TABLES AND FIGURES

QUALITY AND APPLICABILITY

Table 74 Quality and Applicability Domain Scores – Physical Therapy

●: Domain free of flaws

○: Domain flaws present

Study	Outcome	Duration	Prospective	Power	Group Assignment	Blinding	Group Comparability	Treatment Integrity	Measurement	Investigator Bias	*Quality*	Participants	Interventions & Expertise	Compliance & Adherence	Analysis	*Applicability*
Keppler	Limitation of ROM	12-13 weeks	●	●	●	○	●	●	○	●	Moderate	○	○	○	○	Low
Keppler	Limitation of ROM	18-19 weeks	●	●	●	○	●	●	○	●	Moderate	○	○	○	○	Low

FINDINGS

Table 75 Analysis of Mean Differences – Physical Therapy

Study	n	Strength of Evidence	Outcome	Duration	PT (mean±SD)	No PT (mean±SD)	Difference (95% CI)	Results
Keppler	43	Low	Limitation of ROM	12-13 weeks	20 ± 19	35 ± 13	15 (4.9, 25.1)	Favors PT
Keppler	43	Low	Limitation of ROM	18-19 weeks	9 ± 5	20 ± 7	11 (7.3, 14.7)	Favors PT

RECOMMENDATION 12

We are unable to recommend an optimal time for allowing unrestricted activity after injury in patients with healed pediatric supracondylar fractures of the humerus.

Strength of Recommendation: Inconclusive

> Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.
>
> Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

RATIONALE

We addressed this topic because unnecessary restriction of activity contributes to the morbidity of a fracture from the patient and parent perspective, but this must be balanced against the risk of a refracture if activity is resumed too early. There were no studies addressing the question. Two critical outcomes were searched to answer this recommendation, incidence of refracture and timing of refracture.

SUPPORTING EVIDENCE

No studies that met the selection criteria addressed this recommendation.

RECOMMENDATION 13

We are unable to recommend optimal timing of or indications for electrodiagnostic studies or nerve exploration in patients with nerve injuries associated with pediatric supracondylar fractures of the humerus.

Strength of Recommendation: Inconclusive

Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.

Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

RATIONALE

Nerve injuries can occur with pediatric supracondylar fractures. We addressed this topic because electrodiagnostic studies might supplement a repeated physical examination in the monitoring of nerve recovery. We were also interested in the role of nerve exploration. There were no data to determine if or when electrodiagnostic studies and/or nerve exploration are useful.

SUPPORTING EVIDENCE

No studies that met the selection criteria addressed this recommendation.

RECOMMENDATION 14

We are unable to recommend for or against open reduction and stable fixation for adolescent patients with supracondylar fractures of the humerus.

Strength of Recommendation: Inconclusive

> Description: Evidence from a single low quality study or conflicting findings that do not allow a recommendation for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence resulting in an unclear balance between benefits and potential harm.
>
> Implications: Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive,** exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm. Patient preference should have a substantial influencing role.

RATIONALE

We addressed this topic because adolescent patients have different fracture patterns and mechanisms of injury. We addressed the role of stable fixation because adolescents have the potential for slower healing than juveniles. There were no data available reporting on outcomes of interest in adolescent patients.

SUPPORTING EVIDENCE

No studies that met the selection criteria addressed this recommendation.

FUTURE RESEARCH

Despite being the most common fracture of the elbow in children, high quality scientific data regarding the treatment of pediatric supracondylar humerus fractures is lacking. Of the 44 included studies in this clinical practice guideline, only 7 were randomized controlled trials. None of these RCT's had strong scientific evidence due to methodological shortcomings and surrogate/intermediate outcome measures. Besides three additional prospective studies the remainder of the evidence for pediatric supracondylar fractures of the humerus is from retrospective comparisons. The methodological flaws of retrospective study design are the primary reason so few recommendations in this guideline can achieve a strength of evidence greater than "limited."

Clearly, controversy exists regarding the best treatments for pediatric supracondylar humerus fractures. Properly designed randomized controlled trials comparing treatment options are necessary to determine optimal treatments. These trials should focus on patient oriented outcomes using psychometrically validated instruments and also consider adverse events that commonly occur during treatment of these fractures. They should be subject to a priori power analysis to ensure clinically important improvements (improvements that matter to the patients). Consideration may also be given to validated family based outcomes since their inclusion may improve recommendations for younger patients. Future studies would also benefit from attempts to increase the applicability of study results (i.e. generalizability) as described by the PRECIS instrument.[14]

Specific trials which would be helpful to improve recommendations include:

- Prospective investigation of the adequacy of the initial reduction against outcome, with a focus on establishing criteria for accepting a closed reduction

- Prospective randomized studies comparing medial with lateral entry pin fixation focusing on patient centered outcomes and adverse events (e.g. iatrogenic ulnar nerve injuries) along with maintenance and quality of reduction quality

- Prospective investigation of the treatment options for fractures that cannot be reduced by closed reduction.

- Prospective investigation of the patient centered outcomes and adverse events of treatment of vascular compromise.

- Prospective randomized studies investigating the long term (e.g. up to one year) patient centered outcomes of simplified treatments for nondisplaced pediatric supracondylar humerus fractures

- Prospective cohort investigation of the optimal time threshold for surgery

- Prospective investigation comparing timing for removal of pins, timing for resumption of activities and results of physical therapy.

- Prospective randomized studies comparing treatments for adolescent supracondylar fractures
- Prospective investigation for treating versus transferring, with a focus on how to optimize outcomes in a geographically dispersed area

IV. **APPENDIXES**

APPENDIX I
WORK GROUP

AAOS POSNA Collaboration
Treatment of Supracondylar Fractures Work Group Roster 2009-2010

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APPENDIX II
AAOS BODIES THAT APPROVED THIS CLINICAL PRACTICE GUIDELINE

Guidelines Oversight Committee

The AAOS Guidelines Oversight Committee (GOC) consists of sixteen AAOS members. The overall purpose of this Committee is to oversee the development of the clinical practice guidelines, performance measures, health technology assessments and utilization guidelines.

Evidence Based Practice Committee

The AAOS Evidence Based Practice Committee (EBPC) consists of ten AAOS members. This Committee provides review, planning and oversight for all activities related to quality improvement in orthopaedic practice, including, but not limited to evidence-based guidelines, performance measures, and outcomes.

Council on Research and Quality

To enhance the mission of the AAOS, the Council on Research and Quality promotes the most ethically and scientifically sound basic, clinical, and translational research possible to ensure the future care for patients with musculoskeletal disorders. The Council also serves as the primary resource to educate its members, the public, and public policy makers regarding evidenced-based medical practice, orthopaedic devices and biologics, regulatory pathways and standards development, patient safety, occupational health, technology assessment, and other related areas of importance.

The Council is comprised of the chairs of the AAOS Biological Implants, Biomedical Engineering, Evidence Based Practice, Guidelines and Technology Oversight, Occupational Health and Workers' Compensation, Patient Safety, Research Development, and US Bone and Joint Decade committees. Also on the Council are the AAOS second vice-president, representatives of the Diversity Advisory Board, the Women's Health Issues Advisory Board, the Board of Specialty Societies (BOS), the Board of Councilors (BOC), the Communications Cabinet, the Orthopaedic Research Society (ORS), the Orthopedic Research and Education Foundation (OREF), and three members at large.

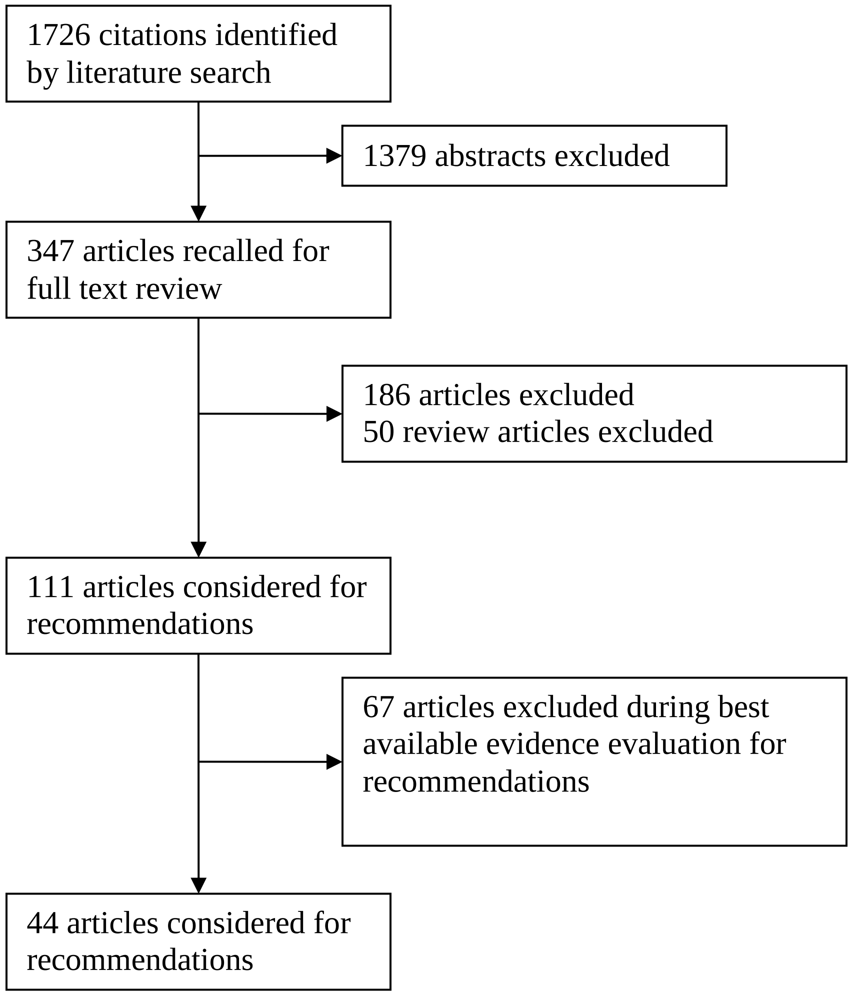
Board of Directors

The 17 member AAOS Board of Directors manages the affairs of the AAOS, sets policy, and determines and continually reassesses the Strategic Plan.

DOCUMENTATION OF APPROVAL

AAOS Work Group Draft Completed	November 15, 2010
Peer Review Completed	January 5, 2011
Public Commentary Completed	May 15, 2011
AAOS Guidelines Oversight Committee	September 7, 2011
AAOS Evidence Based Practice Committee	September 7, 2011
AAOS Council on Research and Quality	September 14, 2011
AAOS Board of Directors	September 23, 2011

APPENDIX III
STUDY ATTRITION FLOWCHART



APPENDIX IV
LITERATURE SEARCH STRATEGIES
MEDLINE

#1: supracondylar[tiab] OR distal[tiab] OR epiphys*[tiab] OR condyl*[tiab] OR "elbow joint"[mh] OR elbow[mh]

#2: humeral fractures[mh] OR (fracture*[tiab] AND humer*[tiab])

#3: "1966"[PDat]:"2010"[PDat] AND English[lang] AND 2010/07/29[edat]

#4: (animal[mh] NOT human[mh]) OR ((aged[mh] OR middle aged[mh] OR adult[mh] OR elderly[titl]) NOT (child*[tw] OR adolescent[tw] OR infan*[tw] OR osteotom*[tw])) OR cadaver[mh] OR cadaver*[titl] OR comment[pt] OR editorial[pt] OR letter[pt] OR addresses[pt] OR news[pt] OR "newspaper article"[pt] OR "historical article"[pt] OR "case report"[title]

#5 (#1 AND #2 AND #3) NOT #4

Search Notes:	[PDat]	= journal publication date
	[CDAT]	= creation date; date the record was added to the PubMed database (helps to ensure reproducibility of search results for reviewers)
	[tw]	= keyword, in title/abstract/subject headings
	[tiab]	= keyword in title/abstract
	[mh]	= Medical Subject Heading (MeSH term)
	[mh:noexp]	= MeSH term, not exploded to include additional (more specific) terms below that term in the MeSH tree
	[sh]	= subheading
	[pt]	= publication (study) type

EMBASE

#1: 'humerus supracondylar fracture'/de

#2: supracondylar OR distal or epiphys* OR condyl* OR 'elbow fracture'/de OR 'elbow injury'/de OR elbow/de

#3: fracture* AND humer*

#4: #1 OR (#2 AND #3)

#5: [english]/lim AND [humans]/lim AND [embase]/lim AND

#6: cadaver/de OR 'in vitro study'/exp OR ‘case report’:ti OR 'abstract report'/de OR book/de OR editorial/de OR letter/de OR note/de OR ((aged/de/exp OR 'middle aged'/de OR adult/de OR elderly:ti) NOT (child* OR child/de/exp OR adolescen* OR infan* OR osteotom*))

#7: #4 AND #5 NOT #6

Search Notes: Database subscription covers 1974-present.
/de = descriptor, EMTREE thesaurus subject heading
/sd = publications added to the database (or not) since a certain date (helps to ensure reproducibility of search results for reviewers)
/lim = limit

COCHRANE LIBRARY

(supracondylar OR distal OR elbow) AND fractur* AND humer*

CINAHL

S1: MH "Elbow Fractures"

S2: Supracondylar

S3: distal

S4: fracture*

S5: humer*

S6: S1 and (S2 or S5)

S7: S4 and (S2 or S3) and S5

S8: S6 OR S7

S9: LA English

S10: PT "editorial" or PT "letter" or PT "case study" or TI "case report" OR ((MH adult+ OR TI elderly) NOT (child* OR MH child+ OR adolescen* OR infan* OR osteotom*))

S11: S8 AND S9 NOT S10

Search notes: MH = subject heading
PT = publication type
TI = title word

APPENDIX V

EVALUATION OF QUALITY

Table 76 Quality Questions and Domains for Each of Four Study Designs

Domain	Question:	Study: / Outcome:	Parallel, Contemporary Controls / Any	Crossover Trials / Any	Historically Controlled Studies / Any	Case Series / Any
Group Assignment	Stochastic		Yes	Yes	No	No
Group Assignment	Quasi-random Assignment		No	No	No	n/a*
Group Assignment	Matched Groups		No	No	Yes	No
Group Assignment	Consecutive Enrollment		n/a	n/a	n/a	Yes
Prospective	Prospective		Yes	Yes	Yes	Yes
Blinding	Blinded Patients		Yes	Yes	No	No
Blinding	Blinded Assessors		Yes	Yes	No	No
Blinding	Blinding Verified**		Yes	Yes	No	No
Group Comparability	Allocation Concealment**		Yes	Yes	No	No
Group Comparability	>80% Follow-up		Yes	Yes	No	Yes
Group Comparability	<20% Completion Difference		Yes	Yes	No	No
Group Comparability	Similar Baseline Outcome Values		Yes	n/a	Yes	No
Group Comparability	Comparable Pt. Characteristics		Yes	n/a	Yes	No
Group Comparability	Same Control Group Results (cross-over only)		n/a	Yes	n/a	n/a
Group Comparability	Same Experimental Group Results (cross-over only)		n/a	Yes	n/a	n/a
Treatment Integrity	Same Centers		Yes	Yes	Yes	No
Treatment Integrity	Same Treatment Duration in and across All Groups		Yes	Yes	Yes	No
Treatment Integrity	Same Concomitant Treatment to All Groups (controlled studies only)		Yes	Yes	Yes	n/a
Treatment Integrity	No Confounding Treatment (case series only)		n/a	n/a	n/a	Yes
Measurement	Same Instruments		Yes	Yes	Yes	Yes
Measurement	Valid Instrument		Yes	Yes	Yes	Yes
Bias	Article & Abstract Agree		Yes	Yes	Yes	Yes
Bias	All Outcomes Reported		Yes	Yes	Yes	Yes
Bias	No Primary Subgroup Analysis		Yes	Yes	Yes	Yes
Statistical Power	Statistically Significant		High	High	High	High
Statistical Power	Number of Patients in Analysis		See statistical power section			

* “n/a” refers to “not applicable”. Cells in which non-applicable questions appear are shaded in grey. **Studies are not penalized for not concealing allocation or not verifying the integrity of blinding. Rather, the answers to these questions act to preserve the quality of outcomes for which the answers to certain questions were “No” or “Unclear”.

Some questions about studies that are not RCT's are automatically answered "No." This is shown in Table 76, which illustrates the scoring for a perfect RCT, a perfect crossover trial, a perfect historically controlled trial, and a perfect case series. The fact that some questions about non-RCTs are automatically answered "No" ensures that historically controlled studies and case series always initially provide evidence that is weaker than the evidence from well-designed RCTs.

Table 77 Statistical Power Evaluation

Power Rating	Condition
High	***ANY OF THE FOLLOWING IS TRUE***: • The results of a statistical test were statistically significant • The results were not statistically significant (or it was unclear whether they were significant), and the study was either an uncontrolled study with 34 or more patients in the statistical analysis OR a controlled study in with 128 or more patients in the analysis. • The results will be used in a meta-analysis.*
Moderate	***ALL OF THE FOLLOWING ARE TRUE:*** • The results of a statistical test were either not statistically significant or it was unclear whether the results of statistical test were statistically significant. • The study was an uncontrolled study in which data from between 15 and 33 patients were included in the analysis OR the study was a controlled study in which data from between 52 and 127 patients were in the analysis. • No meta-analysis of the relevant data will be performed.
Low	***ALL OF THE FOLLOWING ARE TRUE:*** • The results of a statistical test were either not statistically significant or it was unclear whether the results of statistical test were statistically significant. • The study was an uncontrolled study in which data from fewer than 15 patients were included in the analysis OR the study was a controlled study in which data from fewer than 52 patients were in the analysis. • No meta-analysis of the relevant data will be performed.

*We make this assumption because one reason for performing a meta-analysis is to compensate for the low statistical power of individual studies. Implicit in this assumption is that the power of the meta-analysis that will be conducted is sufficient to detect an effect as statistically significant.

APPENDIX VI
FORM FOR ASSIGNING STRENGTH OF RECOMMENDATION

GUIDELINE RECOMMENDATION___________________________________

PRELIMINARY STRENGTH OF RECOMMENDATION: ________________

STEP 1: LIST BENEFITS AND HARMS

Please list the benefits (as demonstrated by the systematic review) of the intervention.

Please list the harms (as demonstrated by the systematic review) of the intervention.

Please list the benefits for which the systematic review is not definitive.

Please list the harms for which the systematic review is not definitive.

STEP 2: IDENTIFY CRITICAL OUTCOMES

Please circle the above outcomes that are critical for determining whether the intervention is beneficial and whether it is harmful.

Are data about critical outcomes lacking to such a degree that you would lower the preliminary strength of the recommendation?

What is the resulting strength of recommendation?

STEP 3: EVALUATE APPLICABILITY OF THE EVIDENCE

Is the applicability of the evidence for any of the critical outcomes so low that substantially worse results are likely to be obtained in actual clinical practice?

Please list the critical outcomes backed by evidence of doubtful applicability.

Should the strength of recommendation be lowered because of low applicability?

What is the resulting strength of recommendation?

STEP 4: BALANCE BENEFITS AND HARMS

Are there trade-offs between benefits and harms that alter the strength of recommendation obtained in STEP 3?

What is the resulting strength of recommendation?

STEP 5 CONSIDER STRENGTH OF EVIDENCE

Does the strength of the existing evidence alter the strength of recommendation obtained in STEP 4?

What is the resulting strength of recommendation?

NOTE: Because we are not performing a formal cost analyses, you should only consider costs if their impact is substantial.

APPENDIX VII
OPINION BASED RECOMMENDATIONS

A guideline can contain recommendations that are backed by little or no data. Under such circumstances, work groups often issue opinion-based recommendations. Although doing so is sometimes acceptable in an evidence-based guideline (expert opinion is a form of evidence), it is also important to avoid constructing a guideline that liberally uses expert opinion; research shows that expert opinion is often incorrect.

Opinion-based recommendations are developed only if they address a vitally important aspect of patient care. For example, constructing an opinion-based recommendation in favor of taking a history and physical is warranted. Constructing an opinion-based recommendation in favor of a specific modification of a surgical technique is seldom warranted. To ensure that an opinion-based recommendation is absolutely necessary, the AAOS has adopted rules to guide the content of the rationales that underpin such recommendations. These rules are based on those outlined by the US Preventive Services Task Force (USPSTF).[65] Specifically, rationales based on expert opinion must:

- Not contain references to or citations from articles not included in the systematic review that underpins the recommendation.

- Not contain the AAOS guideline language “We Recommend”, “We suggest” or “The practitioner might”.

- Contain an explanation of the potential preventable burden of disease. This involves considering both the incidence and/or prevalence of the disease, disorder, or condition and considering the associated burden of suffering. To paraphrase the USPSTF, when evidence is insufficient, provision of a treatment (or diagnostic) for a serious condition might be viewed more favorably than provision of a treatment (or diagnostic) for a condition that does not cause as much suffering. The AAOS (like the USPSTF) understand that evaluating the “burden of suffering” is subjective and involves judgment. This evaluation should be informed by patient values and concerns. The considerations outlined in this bullet make it difficult to recommend new technologies. It is not appropriate for a guideline to recommend widespread use of a technology backed by little data and for which there is limited experience. Such technologies are addressed in the AAOS’ Technology Overviews.

- Address potential harms. In general, “When the evidence is insufficient, an intervention with a large potential for harm (such as major surgery) might be viewed less favorably than an intervention with a small potential for harm (such as advice to watch less television).”[65]

- Address apparent discrepancies in the logic of different recommendations. Accordingly, if there are no relevant data for several recommendations and the work group chooses to issue an opinion-based recommendation in some cases but chooses not to make a recommendation in other cases, the rationales for the opinion-based recommendations must explain why this difference exists. Information garnered from the previous bullet points will be helpful in this regard.

- Consider current practice. The USPSTF specifically states that clinicians justifiably fear that not doing something that is done on a widespread basis will lead to litigation.[65] The consequences of not providing a service that is neither widely available nor widely used are less serious than the consequences of not providing a treatment accepted by the medical profession and thus expected by patients. Discussions of available treatments and procedures rely on mutual communication between the patient's guardian and physician, and on weighing the potential risks and benefits for a given patient. The patient's "expectation of treatment" must be tempered by the treating physician's guidance about the reasonable outcomes that the patient can expect.

- Justify, why a more costly device, drug, or procedure is being recommended over a less costly one whenever such an opinion-based recommendation is made.

Work group members write the rationales for opinion based recommendations on the first day of the final work group meeting. When the work group re-convenes on the second day of its meeting, it will vote on the rationales. The typical voting rules will apply. If the work group cannot adopt a rationale after three votes, the rationale and the opinion-based recommendation will be withdrawn, and a "recommendation" stating that the group can neither recommend for or against the recommendation in question will appear in the guideline.

Discussions of opinion-based rationales may cause some members to change their minds about whether to issue an opinion-based recommendation. Accordingly, at any time during the discussion of the rationale for an opinion-based recommendation, any member of the work group can make a motion to withdraw that recommendation and have the guideline state that the work group can neither recommend for or against the recommendation in question.

CHECKLIST FOR VOTING ON OPINION BASED RECOMMENDATIONS

When voting on the rationale, please consider the following:

1. Does the recommendation affect a substantial number of patients or address treatment (or diagnosis) of a condition that causes death and/or considerable suffering?

2. Does the recommendation address the potential harms that will be incurred if it is implemented and, if these harms are serious, does the recommendation justify;

    a. why the potential benefits outweigh the potential harms and/or

    b. why an alternative course of treatment (or diagnostic workup) that involves less serious or fewer harms is not being recommended?

3. Does the rationale explain why the work group chose to make a recommendation in the face of minimal evidence while, in other instances, it chose to make no recommendation in the face of a similar amount of evidence?

4. Does the rationale explain that the recommendation is consistent with current practice?

5. If relevant, does the rationale justify why a more costly device, drug, or procedure is being recommended over a less costly one?

VOTING BY THE NOMINAL GROUP TECHNIQUE

Voting on guideline recommendations will be conducted using a modification of the nominal group technique (NGT), a method previously used in guideline development.71 Briefly each member of the guideline work group ranks his or her agreement with a guideline recommendation on a scale ranging from 1 to 9 (where 1 is "extremely inappropriate" and 9 is "extremely appropriate"). Consensus is obtained if the number of individuals who do not rate a measure as 7, 8, or 9 is statistically non-significant (as determined using the binomial distribution). Because the number of work group members who are allowed to dissent with the recommendation depends on statistical significance, the number of permissible dissenters varies with the size of the work group. The number of permissible dissenters for several work group sizes is given in the table below:

Work Group Size	Number of Permissible Dissenter
≤3	Not allowed, statistical significance cannot be obtained
4-5	0
6-8	1
9	1 or 2

The NGT is conducted by first having members vote on a given recommendation without discussion. If the number of dissenters is "permissible", the recommendation is adopted without further discussion. If the number of dissenters is not permissible, there is further discussion to see whether the disagreement(s) can be resolved. Three rounds of voting are held to attempt to resolve disagreements. If disagreements are not resolved after three voting rounds, no recommendation is adopted.

APPENDIX VIII
STRUCTURED PEER REVIEW FORM

Review of any AAOS confidential draft allows us to improve the overall guideline but does not imply endorsement by any given individual or any specialty society who participates in our review processes. The AAOS review process may result in changes to the documents; therefore, endorsement cannot be solicited until the AAOS Board of Directors officially approves the final guideline.

Reviewer Information:

Name of Reviewer____

Address____

City________________________ State_________________ Zip Code___________

Phone ___________________________Fax ___________________E-mail_______________________

Specialty Area/Discipline: _______________________________________

Work setting: _______________________Credentials: ______________________

May we list you as a Peer Reviewer in the final Guidelines (GL)? ☐ Yes ☐ No
If you do not wish to be listed, your name will be removed for identification purposes. However, your COI will still be available for review with the comments you have made.

Are you reviewing this guideline as a representative of a professional society? ☐ Yes ☐ No

If yes, may we list your society as a reviewer of this guideline? ☐ Yes ☐ No

Society Name: ____
(Listing the specialty society as a reviewing society does not imply or otherwise indicate endorsement of this guideline.)

Conflicts of Interest (COI): All Reviewers must declare their conflicts of interest.

If the boxes below are not checked and/or the reviewer does not attach his/her conflicts of interest, the reviewer's comments will not be addressed by the AAOS nor will the reviewer's name or society be listed as a reviewer of this GL. If a committee reviews the guideline, only the chairperson/or lead of the review must declare their relevant COI.

☐ **I have declared my conflicts of interest on page 2 of this form.**

☐ **I have declared my conflicts of interest in the AAOS database; my customer # is __________**

☐ **I understand that the AAOS will post my declared conflicts of interest with my comments concerning review of this guideline or technology overview on the AAOS website.**

REVIEWER CONFLICT OF INTEREST - The Orthopaedic Disclosure Program

Each item below requires an answer. Please report information for the last 12-months as required by the Accreditation Council for Continuing Medical Education (ACCME) guidelines.

Do you or a member of your immediate family receive royalties for any pharmaceutical, biomaterial or orthopaedic product or device? If YES, please identify product or device:	☐ Yes ☐ No
Within the past twelve months, have you or a member of your immediate family served on the speakers bureau or have you been paid an honorarium to present by any pharmaceutical, biomaterial or orthopaedic product or device company? If YES, please identify company:	☐ Yes ☐ No
Are you or a member of your immediate family a PAID EMPLOYEE for any pharmaceutical, biomaterial or orthopaedic device or equipment company, or supplier? If YES, please identify company or supplier:	☐ Yes ☐ No
Are you or a member of your immediate family a PAID CONSULTANT for any pharmaceutical, biomaterial or orthopaedic device or equipment company, or supplier? If YES, please identify company or supplier:	☐ Yes ☐ No
Are you or a member of your immediate family an UNPAID CONSULTANT for any pharmaceutical, biomaterial or orthopaedic device or equipment company, or supplier? If YES, please identify company or supplier:	☐ Yes ☐ No
Do you or a member of your immediate family own stock or stock options in any pharmaceutical, biomaterial or orthopaedic device or equipment company, or supplier (excluding mutual funds) If YES, please identify company or supplier:	☐ Yes ☐ No
Do you or a member of your immediate family receive research or institutional support as a principal investigator from any pharmaceutical, biomaterial or orthopaedic device or equipment company, or supplier? If YES, please identify company or supplier:	☐ Yes ☐ No
Do you or a member of your immediate family receive any other financial or material support from any pharmaceutical, biomaterial or orthopaedic device and equipment company or supplier? If YES, please identify company or supplier:	☐ Yes ☐ No
Do you or a member of your immediate family receive any royalties, financial or material support from any medical and/or orthopaedic publishers? If YES, please identify publisher:	☐ Yes ☐ No
Do you or a member of your immediate family serve on the editorial or governing board of any medical and/or orthopaedic publication? If YES, please identify:	☐ Yes ☐ No
Do you or a member of your immediate family serve on the Board of Directors or a committee of any medical and/or orthopaedic professional society? If YES, please identify:	☐ Yes ☐ No

Reviewer Instructions

Please read and review this Draft Clinical Practice Guideline and its associated Technical Report with particular focus on your area of expertise. Your responses are confidential and will be used only to assess the validity, clarity and accuracy of the interpretation of the evidence. If applicable, please specify the draft page and line numbers in your comments. Please feel free to also comment on the overall structure and content of the guideline and Technical Report. If you need more space than is provided, please attach additional pages.

Please complete and return this form electronically to wies@aaos.org or fax the form back to Jan Wies at (847) 823-9769. Thank you in advance for your time in completing this form and giving us your feedback. We value your input and greatly appreciate your efforts. Please send the completed form and comments by end of day **DATE**.

Please indicate your level of agreement with each of the following statements by placing an "X" in the appropriate box.

	Disagree	Somewhat Disagree	Somewhat Agree	Agree
1. The recommendations are clearly stated	☐	☐	☐	☐
2. There is an explicit link between the recommendations and the supporting evidence	☐	☐	☐	☐
3. Given the nature of the topic and the data, all clinically important outcomes are considered	☐	☐	☐	☐
4. The guideline's target audience is clearly described	☐	☐	☐	☐
5. The patients to whom this guideline is meant to apply are specifically described	☐	☐	☐	☐
6. The criteria used to select articles for inclusion are appropriate	☐	☐	☐	☐
7. The reasons why some studies were excluded are clearly described	☐	☐	☐	☐
8. All important studies that met the article inclusion criteria are included	☐	☐	☐	☐
9. The validity of the studies is appropriately appraised	☐	☐	☐	☐
10. The methods are described in such a way as to be reproducible.	☐	☐	☐	☐
11. The statistical methods are appropriate to the material and the objectives of this guideline	☐	☐	☐	☐
12. Important parameters (e.g., setting, study population, study design) that could affect study results are systematically addressed	☐	☐	☐	☐
13. Health benefits, side effects, and risks are adequately addressed	☐	☐	☐	☐
14. The writing style is appropriate for health care professionals.	☐	☐	☐	☐
15. The grades assigned to each recommendation are appropriate	☐	☐	☐	☐

COMMENTS

Please provide a brief explanation of both your positive and negative answers in the preceding section. If applicable, please specify the draft page and line numbers in your comments. Please feel free to also comment on the overall structure and content of the guideline and Technical Report

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OVERALL ASSESSMENT

Would you recommend these guidelines for use in practice? (check one)

☐ Strongly recommend

☐ Recommend (with provisions or alterations)

☐ Would not recommend

☐ Unsure

APPENDIX IX
PEER REVIEW PANEL

Participation in the AAOS peer review process does not constitute an endorsement of this guideline by the participating organization.

Peer review of the draft guideline is completed by an outside Peer Review Panel. Outside peer reviewers are solicited for each AAOS guideline and consist of experts in the guideline's topic area. These experts represent professional societies other than AAOS and are nominated by the guideline work group prior to beginning work on the guideline. For this guideline, ten outside peer review organizations were invited to review the draft guideline and all supporting documentation. Seven societies participated in the review of the Treatment of Pediatric Supracondylar Humerus Fractures guideline draft and those below explicitly consented to be listed as a peer review organization in this appendix.

The organizations that reviewed the document and consented to be listed as a peer review organization are listed below:

American Society for Surgery of the Hand (ASSH)

American Association for Hand Surgery (AAHS)

Pediatric Orthopaedic Society of North America (POSNA)

American Pediatric Surgery Association (APSA)

American Physical Therapy Association (APTA)

American Academy of Pediatrics (AAP)

American Academy of Pediatrics Section on Administration and Practice Management (AAP)

Individuals who participated in the peer review of this document and gave their explicit consent to be listed as reviewers of this document are:

Joshua M. Abzug, MD

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David Ring MD PhD, Chair, The ASSH Evidence Based Practice Committee

Charles T. Price, M.D

Participation in the AAOS guideline peer review process does not constitute an endorsement of the guideline by the participating organizations or the individuals listed above nor does it is any way imply the reviewer supports this document.

PUBLIC COMMENTARY

A period of public commentary follows the peer review of the draft guideline. If significant non-editorial changes are made to the document as a result of public commentary, these changes are also documented and forwarded to the AAOS bodies that approve the final guideline.

Public commentators who gave explicit consent to be listed in this document include the following:

Peter L. Gambacorta DO

William Herndon

Kevin Klingele, MD

Arabella Leet MD

Amy L. McIntosh MD

J. Andy Sullivan, M.D.

Charles T. Price, M.D

Participation in the AAOS guideline public commentary review process does not constitute an endorsement of the guideline by the participating organizations or the individual listed nor does it in any way imply the reviewer supports this document.

APPENDIX X
INTERPRETING THE FOREST PLOTS

We use descriptive diagrams known as forest plots to present data from studies comparing the differences in outcomes between two treatment groups when a meta-analysis has been performed (combining results of multiple studies into a single estimate of overall effect). The estimate of overall effect is presented at the bottom of the graph using a diamond to illustrate the confidence intervals of the estimated overall effect. The arcsine difference or the standardized mean difference is the effect measures used to depict differences in outcomes between the two treatment groups of a study. The horizontal line running through each point represents the 95% confidence interval for that point. The solid vertical line represents “no effect” where the arcsine difference or the standardized mean difference is equal to zero.

APPENDIX XI
CONFLICT OF INTEREST

All members of the AAOS work group disclosed any conflicts of interest prior to the development of the recommendations for this guideline. Conflicts of interest are disclosed in writing with the American Academy of Orthopaedic Surgeons via a private on-line reporting database and also verbally at the recommendation approval meeting.

Disclosure Items: (n) = Respondent answered 'No' to all items indicating no conflicts. 1=Board member/owner/officer/committee appointments; 2= Medical/Orthopaedic Publications; 3= Royalties; 4= Speakers bureau/paid presentations;5A= Paid consultant; 5B= Unpaid consultant; 6= Research or institutional support from a publisher; 7= Research or institutional support from a company or supplier; 8= Stock or Stock Options; 9= Other financial/material support from a publisher; 10= Other financial/material support from a company or supplier.

APPENDIX XII
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ARTICLES EXCLUDED FROM THE AAOS SYSTEMATIC REVIEW(S) & REASONS FOR EXCLUSION

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Abe 1995	Tardy ulnar nerve palsy caused by cubitus varus deformity	Not specific to supracondylar fractures
Abraham 2005	Management of supracondylar fractures of humerus with condylar involvement in children	Retrospective case series (medical records review)
Agus 2002	Skeletal traction and delayed percutaneous fixation of complicated supracondylar humerus fractures due to delayed or unsuccessful reductions and extensive swelling in children	Retrospective case series
Alcott 1977	Displaced supracondylar fractures of the humerus in children: long-term follow-up of 69 patients	Comparison not considered for this guideline
Alonso-Llames 1972	Bilaterotricipital approach to the elbow. Its application in the osteosynthesis of supracondylar fractures of the humerus in children	Retrospective case series (medical records review)
Arino 1977	Percutaneous fixation of supracondylar fractures of the humerus in children	Retrospective case series
Arnala 1991	Supracondylar fractures of the humerus in children	Not best available evidence, very low quality, low power
Aronson 1987	Supracondylar fractures of the humerus in children. A modified technique for closed pinning	Not best available evidence (case series)
Aronson 1993	K-wire fixation of supracondylar humeral fractures in children: results of open reduction via a ventral approach in comparison with closed treatment	Not best available evidence, very low quality, low power
Arora 2004	A different method of pinning of displaced extension type supracondylar fracture of humerus in children	Not best available evidence (case series)
Aufranc 1969	Open supracondylar fracture of the humerus	Case report

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Austin 1995	Supracondylar fractures of the distal humerus in children	Narrative review, bibliography screened
Ay 2006	The anterior cubital approach for displaced pediatric supracondylar humeral fractures	Surgical Technique
Ba 1991	Malunited supracondylar fracture of humerus (Cubitus varus) treated by lateral closing wedged osteotomy and immobilized by above elbow p.o.p. with extended elbow and supinated forearm	Osteotomy study
Babal 2010	Nerve injuries associated with pediatric supracondylar humeral fractures: a meta-analysis	Systematic review, bibliography screened
Badhe 1998	Olecranon screw traction for displaced supracondylar fractures of the humerus in children	Retrospective case series (medical records review)
Bakalim 1972	Supracondylar humeral fractures in children. Causes of changes in the carrying angle of the elbow	Combines treatment results for fractures of more than one type (authors classification)
Bamrungthin 2008	Comparison of posterior and lateral surgical approach in management of type III supracondylar fractures of the humerus among the children	Comparison not considered for this guideline
Baratz 2006	Pediatric supracondylar humerus fractures	Narrative review, bibliography screened
Barlas 2005	Medial approach for fixation of displaced supracondylar fractures of the humerus in children	Not best available evidence (case series)
Barlas 2006	Open medial placement of Kirschner wires for supracondylar humeral fractures in children	Retrospective case series (medical records review)
Barrett 1998	Cosmetic results of supracondylar osteotomy for correction of cubitus varus	Osteotomy study

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Bashyal 2009	Complications after pinning of supracondylar distal humerus fractures	Not relevant, comparison of antibiotic use (not addressed by this guideline)
Bates 1971	Supracondylar fractures of the humerus in children	Narrative review, bibliography screened
Beaty 1992	Fractures and dislocations about the elbow in children	Narrative review, bibliography screened
Belhan 2009	Dynamics of the ulnar nerve after percutaneous pinning of supracondylar humeral fractures in children	Not best available evidence, very low quality
Bender 1978	Results of treatment of supracondylar fractures of the humerus in children with special reference to the cause and prevention of cubitus varus	Comparison not considered for this guideline, <10 patients in valid comparison group
Bennet 2002	Supracondylar fractures of the humerus in children	Narrative review, bibliography screened
Beslikas 1999	Supracondylar humeral osteotomy in children with severe posttraumatic cubitus varus deformity	Osteotomy study
Best 1989	An aid to the treatment of supracondylar fracture of the humerus: brief report	Case report
Bewes 1989	Supracondylar fractures in children	Narrative review, bibliography screened
Bhatnagar 2006	Diagnosis and treatment of common fractures in children: femoral shaft fractures and supracondylar humeral fractures	Narrative review, bibliography screened
Bhende 1994	Clinical measurement of varus-valgus deformity after supracondylar fracture of the humerus	Not relevant, does not investigate treatment

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Bialik 1983	Scoring system for assessing the treatment of supracondylar fractures of the humerus	Combines treatment results for fractures of more than one type (authors classification)
Blakey 2009	Ischaemia and the pink, pulseless hand complicating supracondylar fractures of the humerus in childhood: long-term follow-up	Very Low Quality, Low Power
Bohrer 1970	The fat pad sign following elbow trauma. Its usefulness and reliability in suspecting 'invisible' fractures	Diagnostic study
Bongers 1979	Use of Kirschner wires for percutaneous stabilization of supracondylar fractures of the humerus in children	Not best available evidence (case series)
Botchu 2006	Displaced supracondylar fractures of humerus in children - to pin or not to?	Abstract
Boyd 1992	Supracondylar fractures of the humerus: a prospective study of percutaneous pinning	Not best available evidence (case series)
Brauer 2007	A systematic review of medial and lateral entry pinning versus lateral entry pinning for supracondylar fractures of the humerus	Systematic review, bibliography screened
Brubacher 2008	Pediatric supracondylar fractures of the distal humerus	Narrative review, bibliography screened
Buhl 1982	Displaced supracondylar fractures of the humerus in children	Combines treatment results for fractures of more than one type (Holmberg classification)
Bullen 2004	Pediatric supracondylar humerus fractures	Case report
Campbell 1995	Neurovascular injury and displacement in type III supracondylar humerus fractures	Retrospective case series (medical records review)

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Carbonell 2004	Monitoring antebrachial compartmental pressure in displaced supracondylar elbow fractures in children	Not relevant, study does not report outcomes of interest
Carcassonne 1972	Results of operative treatment of severe supracondylar fractures of the elbow in children	Retrospective case series
Carlson 1982	Cubitus varus: a new and simple technique for correction	Not relevant, non-acute fracture treatment
Cashman 2010	Effect of deferred treatment of supracondylar humeral fractures	Retrospective case series
Celiker 1990	Supracondylar fractures of the humerus in children: analysis of the results in 142 patients	Fracture type is not reported
Chen 2001	Supracondylar extension fracture of the humerus in children. Manipulative reduction, immobilisation and fixation using a U-shaped plaster slab with the elbow in full extension	Comparison not considered for this guideline
Cheng 1995	Closed reduction and percutaneous pinning for type III displaced supracondylar fractures of the humerus in children	Retrospective case series (medical records review)
Choi 2010	Risk factors for vascular repair and compartment syndrome in the pulseless supracondylar humerus fracture in children	Very Low Quality, Low Power, <10 patients in comparison
Clement 1990	Assessment of a treatment plan for managing acute vascular complications associated with supracondylar fractures of the humerus in children	Less than 10 patients per group
Colaris 2008	Supracondylar fractures of the humerus in children. Comparison of results in two treatment periods	Not best available evidence, very low quality
Copley 1996	Vascular injuries and their sequelae in pediatric supracondylar humeral fractures: toward a goal of prevention	Very Low Quality, Low Power

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Crawley 1972	Supracondylar fracture of the humerus in children	Retrospective case series
Crombie 2004	Closed reduction and percutaneous fixation of displaced paediatric supracondylar fractures of the elbow	Narrative review, bibliography screened
D'Ambrosia 1972	Supracondylar fractures of humerus--prevention of cubitus varus	Fracture type is not reported
Danielsson 1980	Open reduction and pin fixation of severely displaced supracondylar fractures of the humerus in children	Retrospective case series
Davis 2000	Supracondylar humerus fractures in children. Comparison of operative treatment methods	Not best available evidence (case series)
deBoeck 1997	Valgus deformity following supracondylar elbow fractures in children	Retrospective case series (medical records review)
deBoeck 2001	Flexion-type supracondylar elbow fractures in children	Retrospective case series (medical records review)
deBuys 2003	Open or closed pinning for distal humerus fractures in children?	Fracture type is not reported
deCoulon 2005	Nonoperative treatment of displaced supracondylar fractures in children: Rigault type 2 fractures	Retrospective case series (medical records review)
deGheldre 2010	Outcome of Gartland type II and type III supracondylar fractures treated by Blount's technique	Retrospective case series (medical records review)
Devnani 2000	Gradual reduction of supracondylar fracture of the humerus in children reporting late with a swollen elbow	Less than 10 patients per group
Devnani 2005	Late presentation of supracondylar fracture of the humerus in children	Not best available evidence, very low quality
Dodge 1972	Displaced supracondylar fractures of the humerus in children--treatment by Dunlop's traction	Retrospective case series (medical records review)

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Dormans 1995	Acute neurovascular complications with supracondylar humerus fractures in children	Retrospective case series (medical records review)
Dowd 1979	Varus deformity in supracondylar fractures of the humerus in children	Combines treatment results for fractures of more than one type (authors classification)
Eidelman 2007	Prevention of ulnar nerve injury during fixation of supracondylar fractures in children by 'flexion-extension cross-pinning' technique	Retrospective case series
el-Adl 2007	The equal limbs lateral closing wedge osteotomy for correction of cubitus varus in children	Osteotomy study
el-Adl 2008	Results of treatment of displaced supracondylar humeral fractures in children by percutaneous lateral cross-wiring technique	Retrospective case series
el-Ahwany 1974	Supracondylar fractures of the humerus in children with a note on the surgical correction of late cubitus varus	Retrospective case series
Eren 2008	Correlation between posteromedial or posterolateral displacement and cubitus varus deformity in supracondylar humerus fractures in children	Osteotomy study
Eren 2008	Delayed surgical treatment of supracondylar humerus fractures in children using a medial approach	Retrospective case series
Ersan 2009	Treatment of supracondylar fractures of the humerus in children through an anterior approach is a safe and effective method	Not best available evidence (case series)
Fama 1987	Supraintercondylar fractures of the humerus--treatment by the Vigliani osteosynthesis	Not specific to children
Farley 2008	Pediatric supracondylar humerus fractures: treatment by type of orthopedic surgeon	Retrospective case series (medical records review)

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Fatemi 2009	Delayed radial nerve laceration by the sharp blade of a medially inserted Kirschner-wire pin: a rare complication of supracondylar humerus fracture	Narrative review, bibliography screened
Fleuriau-Chateau 1998	An analysis of open reduction of irreducible supracondylar fractures of the humerus in children	Not best available evidence (case series)
Flynn 1974	Blind pinning of displaced supracondylar fractures of the humerus in children. Sixteen years' experience with long-term follow-up	Retrospective case series
Flynn 2002	The operative management of pediatric fractures of the upper extremity	Narrative review, bibliography screened
Fowler 2006	Reduction and pinning of pediatric supracondylar humerus fractures in the prone position	Retrospective case series (medical records review)
Fowles 1974	Displaced supracondylar fractures of the elbow in children. A report on the fixation of extension and flexion fractures by two lateral percutaneous pins	Retrospective case series
Fu 2010	Open reduction and bioabsorbable pin fixation for late presenting irreducible supracondylar humeral fracture in children	Not best available evidence (case series)
Furrer 1991	Management of displaced supracondylar fractures of the humerus in children	Retrospective case series
Gaddy 1994	Distal humeral osteotomy for correction of posttraumatic cubitus varus	Osteotomy study
Gadgil 2005	Elevated, straight-arm traction for supracondylar fractures of the humerus in children	Not best available evidence (case series)
Garbuz 1996	The treatment of supracondylar fractures in children with an absent radial pulse	Retrospective case series (medical records review)
Garg 2007	Treatment of flexion-type supracondylar humeral fracture in children	Retrospective case series

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Gennari 1998	Anterior approach versus posterior approach to surgical treatment of children's supracondylar fractures: comparative study of thirty cases in each series	Comparison not considered for this guideline
Gerardi 1989	Pediatric update #10. Treatment of displaced supracondylar fractures of the humerus in children by closed reduction and percutaneous pinning	Retrospective case series
Geutjens 1995	Ischaemic anterior interosseus nerve injuries following supracondylar fractures of the humerus in children	Case report
Ghasemzadeh 2002	Absence of radial pulse in displaced supracondylar fracture of humerus in children	Very Low Quality, Low Power
Giannini 1983	The treatment of supracondylar fractures of the humerus in children by closed reduction and fixation with percutaneous Kirschner wires	Retrospective case series
Gillingham 1995	Advances in children's elbow fractures	Narrative review, bibliography screened
Gong 2008	Oblique closing wedge osteotomy and lateral plating for cubitus varus in adults	Osteotomy study
Gosens 2003	Neurovascular complications and functional outcome in displaced supracondylar fractures of the humerus in children	Retrospective case series
Graham 1967	Supracondylar fractures of the elbow in children. 1	Narrative review, bibliography screened
Graham 1967	Supracondylar fractures of the elbow in children. 2	Narrative review, bibliography screened
Green 2005	Low incidence of ulnar nerve injury with crossed pin placement for pediatric supracondylar humerus fractures using a mini-open technique	Retrospective case series (medical records review)

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Griffet 2004	Systematic percutaneous pinning of displaced extension-type supra-condylar fractures of the humerus in children: A prospective study of 67 patients	Not best available evidence (case series)
Griffin 1975	Supracondylar fractures of the humerus. Treatment and complications	Narrative review, bibliography screened
Gris 2004	Treatment of supracondylar humeral fractures in children using external fixation	Not best available evidence (case series)
Haddad 1970	Percutaneous pinning of displaced supracondylar fractures of the elbow in children	Case report
Hadlow 1996	A selective treatment approach to supracondylar fracture of the humerus in children	Comparison not considered for this guideline, <10 patients in valid comparison group
Hamad 2003	Humeral supracondylar fractures in children - The role of closed reduction and percutaneous K-wire fixation in the displaced fracture	Retrospective case series
Hamdy 2009	Supracondylar fractures require treatment on the same day	Narrative review, bibliography screened
Hammond 1998	Supracondylar humerus fractures in children	Narrative review, bibliography screened
Harrington 2000	Management of the floating elbow injury in children. Simultaneous ipsilateral fractures of the elbow and forearm	Not specific to supracondylar fractures
Hart 1977	The operative management of the difficult supracondylar fracture of the humerus in the child	Combines treatment results for fractures of more than one type (Holmberg classification)

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Hart 2006	Broken bones: common pediatric upper extremity fractures--part II	Narrative review, bibliography screened
Hasler 2001	Supracondylar fractures of the humerus in children	Narrative review, bibliography screened
Hasler 2003	Correction of Malunion after Pediatric Supracondylar Elbow Fractures: Closing Wedge Osteotomy and External Fixation	Osteotomy study
Havlas 2008	Manipulation of pediatric supracondylar fractures of humerus in prone position under general anesthesia	Retrospective case series (medical records review)
Havranek 1989	Peripheral paresis of upper extremity nerves following supracondylar fracture of the humerus in children	Retrospective case series
Henderson 2007	Calculation of rotational deformity in pediatric supracondylar humerus fractures	Biomechanical study
Hernandez 1994	Corrective osteotomy for cubitus varus deformity	Osteotomy study
Hope 1991	Biodegradable pin fixation of elbow fractures in children. A randomised trial	Not specific to supracondylar fractures
Iobst 2007	Percutaneous pinning of pediatric supracondylar humerus fractures with the semisterile technique: the Miami experience	Retrospective case series (medical records review)
Ippolito 1996	Fracture of the humeral condyles in children: 49 cases evaluated after 18-45 years	Not specific to supracondylar fractures
Ismatullah 2009	Results of conservative treatment of displaced extension - Type supracondylar fractures of humerus in children	Not best available evidence (case series)
Jacobs 1967	Supracondylar fracture of the humerus in children	Narrative review, bibliography screened

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Jain 2000	Cubitus varus: problem and solution	Osteotomy study
Jarvis 1984	The pediatric T-supracondylar fracture	Retrospective case series
Jefferiss 1977	'Straight lateral traction' in selected supracondylar fractures of the humerus in children	Retrospective case series
Joist 1999	Anterior interosseous nerve compression after supracondylar fracture of the humerus: a metaanalysis	Narrative review, bibliography screened
Jun 1982	Close percutaneous pinning in treatment of displaced supracondylar fracture of humerus in children	Retrospective case series (medical records review)
Kalenderer 2008	How should one treat iatrogenic ulnar injury after closed reduction and percutaneous pinning of paediatric supracondylar humeral fractures?	Not best available evidence (case series)
Kanaujia 1988	Dome osteotomy for cubitus varus in children	Osteotomy study
Karakurt 2005	Morphology and dynamics of the ulnar nerve in the cubital tunnel after percutaneous cross-pinning of supracondylar fractures in children's elbows: an ultrasonographic study	Retrospective case series
Kasser 1992	Percutaneous pinning of supracondylar fractures of the humerus	Narrative review, bibliography screened
Kazimoglu 2009	Operative management of type III extension supracondylar fractures in children	Not best available evidence, very low quality, low power
Keppler 2002	Effectiveness of physiotherapy after surgically treated supracondylar humeral fractures in children	Foreign language
Khan 2000	Management of delayed supracondylar fracture of humerus	Not best available evidence, very low quality

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Khan 2007	Percutaneous K-wiring for Gartland type III supracondylar humerus fractures in children	Not best available evidence (case series)
Khare 2010	Anteriorly displaced supracondylar fractures of the humerus are caused by lateral rotation injury and posteriorly displaced by medial rotation injury: a new hypothesis	Combines treatment results for fractures of more than one type (Gartland classification)
Kinkpe 2010	Children distal humerus supracondylar fractures: the Blount Method experience	Not best available evidence (case series)
Kiyoshige 1999	Critical displacement of neural injuries in supracondylar humeral fractures in children	Retrospective case series
Knorr 2005	The use of ESIN in humerus fractures : Shaft seldom, subcapital sometimes, supracondylar often	Not specific to supracondylar fractures
Korompilias 2009	Treatment of pink pulseless hand following supracondylar fractures of the humerus in children	Retrospective case series
Kotwal 1989	Open reduction and internal fixation of displaced supracondylar fractures of the humerus	Not best available evidence (case series)
Koudstaal 2002	Pediatric supracondylar humerus fractures: the anterior approach	Comparison not considered for this guideline
Kraus 2007	Intraoperative radiation exposure in displaced supracondylar humeral fractures: a comparison of surgical methods	Not best available evidence, very low quality
Kumar 2000	Correction of cubitus varus by French or dome osteotomy: a comparative study	Osteotomy study
Kumar 2001	A study of vascular injuries in pediatric supracondylar humeral fractures	Less than 10 patients per group
Kuo 2004	Reduction and percutaneous pin fixation of displaced supracondylar elbow fractures in children	Narrative review, bibliography screened

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Kurbanov 2006	Reconstruction of the brachial artery in supracondylar humerus fractures and forearm dislocations	Retrospective case series
Kurer 1990	Completely displaced supracondylar fracture of the humerus in children. A review of 1708 comparable cases	Systematic review, bibliography screened
Lal 1991	Delayed open reduction for supracondylar fractures of the humerus	Retrospective case series
Lawrence 1993	Supracondylar fractures of the humerus in children	Case report
Leet 2002	Delayed treatment of type 3 supracondylar humerus fractures in children	Not best available evidence, very low quality
Leksan 2007	Supracondylar fractures of the humerus in children caused by traffic	Combines treatment results for fractures of more than one type (Gartland classification)
Lewis 2003	Arterial reconstruction using the basilic vein from the zone of injury in pediatric supracondylar humeral fractures: a clinical and radiological series	Less than 10 patients per group
Lim 2003	Displaced paediatric supracondylar fractures of the humerus - a sticky solution	Surgical Technique
Liyang 1999	Radiographic evaluation of Baumann angle in Chinese children and its clinical relevance	Radiological study
Loizou 2009	A systematic review of early versus delayed treatment for type III supracondylar humeral fractures in children	Systematic review, bibliography screened
Loomes 2005	Removing k-wires: an audit of practice	Narrative review, bibliography screened
Louahem 2006	Neurovascular complications and severe displacement in supracondylar humerus fractures in children: defensive or offensive strategy?	Retrospective case series (medical records review)

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Lund-Kristensen 1976	Supracondylar fractures of the humerus in children. A follow-up with particular reference to late results after severely displaced fractures	Comparison not considered for this guideline, <10 patients in valid comparison group
Luria 2007	Vascular complications of supracondylar humeral fractures in children	Retrospective case series (medical records review)
Lyons 1998	Ulnar nerve palsies after percutaneous cross-pinning of supracondylar fractures in children's elbows	Retrospective case series (medical records review)
Lyons 2000	Neurovascular injuries in type III humeral supracondylar fractures in children	Retrospective case series (medical records review)
Macafee 1967	Infantile supracondylar fracture	Case report
Mahaisavariya 1993	Supracondylar fracture of the humerus: malrotation versus cubitus varus deformity	Osteotomy study
Mahaisavariya 1996	Osteotomy for cubitus varus: a simple technique in 10 children	Osteotomy study
Mahan 2007	Operative management of displaced flexion supracondylar humerus fractures in children	Not relevant, does not investigate treatment outcomes
Malviya 2006	Pink pulseless hand following supra-condylar fractures: an audit of British practice	Not relevant, opinion survey
Mangat 2009	The 'pulseless pink' hand after supracondylar fracture of the humerus in children: the predictive value of nerve palsy	Very Low Quality, Low Power, <10 per group in comparison
Mangwani 2006	Supracondylar humeral fractures in children: ten years' experience in a teaching hospital	Retrospective case series (medical records review)

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Mapes 1998	The effect of elbow position on the radial pulse measured by Doppler ultrasonography after surgical treatment of supracondylar elbow fractures in children	Not relevant, biomechanic study
Marsh 1966	The fractured elbow. Supracondylar fractures of the humerus in children	Combines treatment results for fractures of more than one type (Holmberg classification)
Matsuzaki 2004	Treatment of supracondylar fracture of the humerus in children by skeletal traction in a brace	Retrospective case series
McCoy 1988	Supracondylar osteotomy for cubitus varus. The value of the straight arm position	Osteotomy study
McKee 2000	Functional outcome after open supracondylar fractures of the humerus. The effect of the surgical approach	Not specific to children
McLauchlan 1999	Extension of the elbow and supracondylar fractures in children	Not relevant, does not investigate treatment
McLennan 1997	Radiology rounds. Supracondylar fracture of the distal humerus	Narrative review, bibliography screened
Michael 1996	Localization of the ulnar nerve during percutaneous wiring of supracondylar fractures in children	Surgical Technique
Middleton 2006	k-Wiring of supracondylar humeral fractures	Surgical Technique
Millis 1984	Supracondylar fracture of the humerus in children. Further experience with a study in orthopaedic decision-making	Not best available evidence (case series)
Minkowitz 1994	Supracondylar humerus fractures. Current trends and controversies	Narrative review, bibliography screened
Mohammed 1995	Supracondylar fractures of the distal humerus in children	Less than 10 patients per group

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Mohan 2000	The posterolateral approach to the distal humerus for open reduction and internal fixation of fractures of the lateral condyle in children	Not specific to supracondylar fractures
Mostafavi 2000	Crossed pin fixation of displaced supracondylar humerus fractures in children	Retrospective case series (medical records review)
Mulhall 2000	Displaced supracondylar fractures of the humerus in children	Not best available evidence (case series)
Nacht 1983	Supracondylar fractures of the humerus in children treated by closed reduction and percutaneous pinning	Retrospective case series
Nand 1972	Management of supracondylar fracture of the humerus in children	Retrospective case series (medical records review)
Nelson 1977	Radiologic seminar CLXVI: positive posterior fat pad sign of the elbow indicating significant elbow injury even in the face of no visible fracture	Commentary
Newman 1969	The supracondylar process and its fracture	Narrative review, bibliography screened
Noaman 2006	Microsurgical reconstruction of brachial artery injuries in displaced supracondylar fracture humerus in children	Very Low Quality, Low Power
O'Driscoll 2001	Tardy posterolateral rotatory instability of the elbow due to cubitus varus	Osteotomy study
Ogunlade 2004	The surgical management of severely displaced supracondylar fracture of the humerus in childhood	Retrospective case series
Oh 2003	Completely displaced supracondylar humerus fractures in children: results of open reduction versus closed reduction	Not best available evidence, very low quality, low power
O'Hara 2000	Displaced supracondylar fractures of the humerus in children. Audit changes practice	Does not compare outcomes between treatments

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Omid 2008	Supracondylar humeral fractures in children	Narrative review, bibliography screened
Ong 1996	Supracondylar humeral fractures--a review of the outcome of treatment	Comparison not considered for this guideline, <10 patients in valid comparison group
Onwuanyi 1998	Evaluation of the stability of pin configuration in K-wire fixation of displaced supracondylar fractures in children	Not best available evidence, very low quality
Ostojic 2010	Results of treatment of displaced supracondylar humeral fractures in children by K-wiring	Retrospective case series
Otsuka 1997	Supracondylar Fractures of the Humerus in Children	Narrative review, bibliography screened
Palmer 1978	Supracondylar fracture of the humerus in children	Fracture type is not reported
Pankaj 2006	Dome osteotomy for posttraumatic cubitus varus: a surgical technique to avoid lateral condylar prominence	Osteotomy study
Paradis 1993	Supracondylar fractures of the humerus in children. Technique and results of crossed percutaneous K-wire fixation	Not best available evidence (case series)
Parikh 2004	Displaced type II extension supracondylar humerus fractures: do they all need pinning?	Retrospective case series (medical records review)
Parmaksizoglu 2009	Closed reduction of the pediatric supracondylar humerus fractures: the 'joystick' method	Not best available evidence (case series)
Pierz 2009	Fractures in children and adolescents: Distal humerus supracondylar fractures	Narrative review, bibliography screened

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Piggot 1986	Supracondylar fractures of the humerus in children. Treatment by straight lateral traction	Combines treatment results for fractures of more than one type (Holmberg classification)
Platt 2004	Supracondylar fracture of the humerus	Narrative review, bibliography screened
Pollock 1970	Early reconstruction of the elbow following severe trauma	Not specific to supracondylar fractures
Ponce 2004	Complications and timing of follow-up after closed reduction and percutaneous pinning of supracondylar humerus fractures: follow-up after percutaneous pinning of supracondylar humerus fractures	Not relevant, comparison of follow-up time
Postacchini 1988	Fractures of the humerus associated with paralysis of the radial nerve	Not specific to supracondylar fractures
Powell 1973	Dunlop traction in supracondylar fractures of the humerus	Case report
Prichasuk 1992	Late ulnar nerve injury following Kirschner wires fixation of the supracondylar fracture of the humerus	Case report
Prietto 1979	Supracondylar fractures of the humerus. A comparative study of Dunlop's traction versus percutaneous pinning	Not best available evidence, very low quality
Prins 1974	Extension therapy with Von Ekesparre darts of supracondylar fractures of the humerus in children	Narrative review, bibliography screened
Queally 2009	Dorgan's lateral cross-wiring of supracondylar fractures of the humerus in children: A retrospective review	Not best available evidence (case series)
Rabee 2001	Vascular compromise associated with supracondylar fractures in children	Retrospective case series (medical records review)

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Ramachandran 2008	Delaying treatment of supracondylar fractures in children: has the pendulum swung too far?	Retrospective case series (medical records review)
Ramsey 1973	Immediate open reduction and internal fixation of severely displaced supracondylar fractures of the humerus in children	Retrospective case series
Randsborg 2010	The need for better analysis of observational studies in orthopedics. A retrospective study of elbow fractures in children	Not best available evidence (case series)
Rasool 1999	Supracondylar fractures: posterolateral type with brachialis muscle penetration and neurovascular injury	Retrospective case series
Reinaerts 1979	Assessment of dislocation in the supracondylar fracture of the humerus, treated by overhead traction	Retrospective case series
Reitman 2001	Open reduction and internal fixation for supracondylar humerus fractures in children	Retrospective case series
Rejholec 1999	Supracondylar fracture of the humerus in children--closed pinning	Retrospective case series (medical records review)
Reynolds 2000	A technique to determine proper pin placement of crossed pins in supracondylar fractures of the elbow	Retrospective case series
Reynolds 2005	Concept of treatment in supracondylar humeral fractures	Surgical Technique
Rijal 2006	Supracondylar extension type III fracture of the humerus in children: percutaneous cross-pinning	Not best available evidence (case series)
Robb 2009	The pink, pulseless hand after supracondylar fracture of the humerus in children	Narrative review, bibliography screened
Rodriguez 1992	Supracondylar fractures of the humerus in children: treatment by overhead skeletal traction	Not best available evidence (case series)

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Sabharwal 1997	Management of pulseless pink hand in pediatric supracondylar fractures of humerus	Very Low Quality, Low Power
Sadiq 2007	Management of grade III supracondylar fracture of the humerus by straight-arm lateral traction	Retrospective case series
Sankar 2007	Loss of pin fixation in displaced supracondylar humeral fractures in children: causes and prevention	Retrospective case series (medical records review)
Sawaizumi 2003	Surgical technique for supracondylar fracture of the humerus with percutaneous leverage pinning	Retrospective case series
Sawaqed 2005	Correction of cubitus varus by supracondylar lateral closing wedge osteotomy	Osteotomy study
Schmittenbecher 2004	Analysis of Reinterventions in Children's Fractures - An Aspect of Quality Control	Not specific to supracondylar fractures
Schoenecker 1996	Pulseless arm in association with totally displaced supracondylar fracture	Less than 10 patients per group
Shannon 2004	'Dorgan's' percutaneous lateral cross-wiring of supracondylar fractures of the humerus in children	Not best available evidence (case series)
Shapiro 1995	Elbow fractures: Treating to avoid complications	Commentary
Shaw 1990	Management of vascular injuries in displaced supracondylar humerus fractures without arteriography	Retrospective case series
Sherr 2001	Fractures of the elbow in children	Narrative review, bibliography screened
Shifrin 1972	Open reduction and internal fixation of displaced supracondylar fractures of the humerus in children	Narrative review, bibliography screened

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Shifrin 1976	Open reduction and internal fixation of displaced supracondylar fractures of the humerus in children	Narrative review, bibliography screened
Shim 2002	Treatment of completely displaced supracondylar fracture of the humerus in children by cross-fixation with three Kirschner wires	Retrospective case series
Shin 2007	The ulnar nerve in elbow trauma	Narrative review, bibliography screened
Shoaib 2003	Outcome of closed reduction and casting in displaced supracondylar fracture of humerus in children	Not best available evidence (case series)
Shoaib 2004	Percutaneous pinning in displaced supracondylar fracture of humerus in children	Not best available evidence (case series)
Singh 2006	Analytical study of the management of supracondylar fracture of children in our setup	Combines treatment results for fractures of more than one type (Gartland classification)
Skaggs 1999	The posterior fat pad sign in association with occult fracture of the elbow in children	Diagnostic study
Skaggs 2004	Lateral-entry pin fixation in the management of supracondylar fractures in children	Retrospective case series (medical records review)
Slobogean 2010	Iatrogenic ulnar nerve injury after the surgical treatment of displaced supracondylar fractures of the humerus: number needed to harm, a systematic review	Systematic review, bibliography screened
Slongo 2008	Lateral external fixation--a new surgical technique for displaced unreducible supracondylar humeral fractures in children	Retrospective case series (medical records review)
Smith 1967	Supracondylar fractures of the humerus treated by direct observation	Narrative review, bibliography screened

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Song 1997	Supracondylar osteotomy with Ilizarov fixation for elbow deformities in adults	Osteotomy study
Spencer 2010	Prospective longitudinal evaluation of elbow motion following pediatric supracondylar humeral fractures	Less than 50% patient follow-up
Spinner 1969	Anterior interosseous-nerve paralysis as a complication of supracondylar fractures of the humerus in children	Case report
Srivastava 2008	Lateral closed wedge osteotomy for cubitus varus deformity	Osteotomy study
Steenbrugge 2001	Guidelines and pitfalls in the management of supracondylar humerus fractures in children	Narrative review, bibliography screened
Suh 2005	Minimally invasive surgical techniques for irreducible supracondylar fractures of the humerus in children	Comparison not considered for this guideline
Tabak 2003	Closed reduction and percutaneous fixation of supracondylar fracture of the humerus and ipsilateral fracture of the forearm in children	Not specific to supracondylar fractures
Taniguchi 2000	Iatrogenic ulnar nerve injury after percutaneous cross-pinning of supracondylar fracture in a child	Case report
Teklali 2004	Stiffness after neglected elbow trauma in children: A report of 57 cases	Not specific to supracondylar fractures
Tellisi 2004	Management of Gartland's type III supracondylar fractures of the humerus in children: the role audit and practice guidelines	Retrospective case series (medical records review)
The 1999	Neurological complications in children with supracondylar fractures of the humerus	Not best available evidence, very low quality, low power
Thomas 1987	Outcome of supracondylar fractures of the humerus in children	Combines treatment results for fractures of more than one type (Holmberg classification)

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Thomas 2001	Three weeks of Kirschner wire fixation for displaced lateral condylar fractures of the humerus in children	Not specific to supracondylar fractures
Thompson 1984	Internal fixation of fractures in children and adolescents. A comparative analysis	Not specific to supracondylar fractures
Tien 2000	Dome corrective osteotomy for cubitus varus deformity	Osteotomy study
Tien 2006	Supracondylar dome osteotomy for cubitus valgus deformity associated with a lateral condylar nonunion in children. Surgical technique	Surgical Technique
Tiwari 2007	Surgical management for late presentation of supracondylar humeral fracture in children	Retrospective case series
Turra 1995	Supracondylar fractures of the humerus in children. A comparison between non-surgical treatment and minimum synthesis	Not best available evidence, very low quality
Uchida 1991	A new three-dimensional osteotomy for cubitus varus deformity after supracondylar fracture of the humerus in children	Osteotomy study
Urlus 1991	Conservative treatment of displaced supracondylar humerus fractures of the extension type in children	Not best available evidence (case series)
Usui 1995	Three-dimensional corrective osteotomy for treatment of cubitus varus after supracondylar fracture of the humerus in children	Less than 10 patients per group
Van 1990	Operative treatment of supracondylar fractures of the humerus in children	Narrative review, bibliography screened
vanEgmond 1985	Anatomical and functional results after treatment of dislocated supracondylar fractures of the humerus in children	Retrospective case series (medical records review)
Vishwanath 1999	Olecranon traction using a recycled plate: a new technique for supracondylar humeral fractures	Surgical Technique

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Voss 1994	Uniplanar supracondylar humeral osteotomy with preset Kirschner wires for posttraumatic cubitus varus	Osteotomy study
Vuckov 2001	Treatment of supracondylar humerus fractures in children: minimal possible duration of immobilization	Less than 50% patient follow-up
Waddell 1988	Supracondylar fractures of the humerus - results of surgical treatment	Not specific to children
Waldron 1990	Tips of the trade #24. Supracondylar elbow fracture in the growing child	Surgical Technique
Walloe 1985	Supracondylar fracture of the humerus in children: review of closed and open reduction leading to a proposal for treatment	Combines treatment results for fractures of more than one type (authors classification)
Wang 2009	The recovery of elbow range of motion after treatment of supracondylar and lateral condylar fractures of the distal humerus in children	Combines treatment results for fractures of more than one type (Gartland classification)
Webb 1989	Supracondylar fractures of the humerus in children	Combines treatment results for fractures of more than one type (authors classification)
Weiland 1978	Surgical treatment of displaced supracondylar fractures of the humerus in children. Analysis of fifty-two cases followed for five to fifteen years	Retrospective case series
Weinberg 1995	Ulnar nerve injuries from percutaneous pinning of supracondylar fractures of the humerus in children	Case report
Weiss 2005	Lateral entry pinning of supracondylar humerus fractures	Narrative review, bibliography screened
Weiss 2010	Distal humerus osteotomy for supracondylar fracture malunion in children: a study of perioperative complications	Osteotomy study

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
White 2010	Perfused, pulseless, and puzzling: a systematic review of vascular injuries in pediatric supracondylar humerus fractures and results of a POSNA questionnaire	Systematic review, bibliography screened
Wilkins 1989	The management of severely displaced supracondylar fractures of the humerus	Narrative review, bibliography screened
Wilkins 1990	The operative management of supracondylar fractures	Narrative review, bibliography screened
Wilkins 1997	Supracondylar fractures: what's new?	Narrative review, bibliography screened
Williamson 1992	Treatment of ipsilateral supracondylar and forearm fractures in children	Not specific to supracondylar fractures, ipsilateral injury
Williamson 1993	Treatment of selected extension supracondylar fractures of the humerus by manipulation and strapping in flexion	Combines treatment results for fractures of more than one type (Pirone classification)
Wong 1996	Gunstock deformity of the elbow: Can it be prevented?	Not relevant, non-acute fracture treatment
Worlock 1987	Severely displaced supracondylar fractures of the humerus in children: a simple method of treatment	Retrospective case series
Yamamoto 1985	Cubitus varus deformity following supracondylar fracture of the humerus. A method for measuring rotational deformity	Less than 10 patients per group
Yen 2008	Lateral entry compared with medial and lateral entry pin fixation for completely displaced supracondylar humeral fractures in children. Surgical technique	Surgical Technique

Table 78 Articles Excluded from AAOS Systematic Review(s)

Author	Title	Reason for Exclusion
Yildirim 2009	Timing of surgical treatment for type III supracondylar humerus fractures in pediatric patients	Not best available evidence, very low quality
Yu 2004	The use of the 3-mm K-Wire to supplement reduction of humeral supracondylar fractures in children	Combines treatment results for fractures of more than one type (authors classification)
Yusof 1998	Displaced supracondylar fracture of humerus in children--comparative study of the result of closed and open reduction	Comparison not considered for this guideline, <10 patients in valid comparison group
Zatti 2001	The surgical treatment of supracondylar fractures of the humerus in children by percutaneous fixation using Kirschner wires: analysis of residual deformities	Retrospective case series (medical records review)
Zenios 2007	Intraoperative stability testing of lateral-entry pin fixation of pediatric supracondylar humeral fractures	Not best available evidence, very low quality
Zionts 2009	Time of return of elbow motion after percutaneous pinning of pediatric supracondylar humerus fractures	Retrospective case series

PREVIOUS REVIEWS (SYSTEMATIC OR NARRATIVE) SCREENED FOR ADDITIONAL ARTICLES

Table 79 Previous Systematic and Narrative Reviews of Pediatric Supracondylar Humerus Fractures

Author	Title	Reason for Exclusion
Babal 2010	Nerve injuries associated with pediatric supracondylar humeral fractures: a meta-analysis	Systematic review, bibliography screened
Slobogean 2010	Iatrogenic ulnar nerve injury after the surgical treatment of displaced supracondylar fractures of the humerus: number needed to harm, a systematic review	Systematic review, bibliography screened
White 2010	Perfused, pulseless, and puzzling: a systematic review of vascular injuries in pediatric supracondylar humerus fractures and results of a POSNA questionnaire	Systematic review, bibliography screened
Loizou 2009	A systematic review of early versus delayed treatment for type III supracondylar humeral fractures in children	Systematic review, bibliography screened
Brauer 2007	A systematic review of medial and lateral entry pinning versus lateral entry pinning for supracondylar fractures of the humerus	Systematic review, bibliography screened
Kurer 1990	Completely displaced supracondylar fracture of the humerus in children. A review of 1708 comparable cases	Systematic review, bibliography screened
Fatemi 2009	Delayed radial nerve laceration by the sharp blade of a medially inserted Kirschner-wire pin: a rare complication of supracondylar humerus fracture	Narrative review, bibliography screened
Hamdy 2009	Supracondylar fractures require treatment on the same day	Narrative review, bibliography screened
Pierz 2009	Fractures in children and adolescents: Distal humerus supracondylar fractures	Narrative review, bibliography screened
Robb 2009	The pink, pulseless hand after supracondylar fracture of the humerus in children	Narrative review, bibliography screened

Table 79 Previous Systematic and Narrative Reviews of Pediatric Supracondylar Humerus Fractures

Author	Title	Reason for Exclusion
Brubacher 2008	Pediatric supracondylar fractures of the distal humerus	Narrative review, bibliography screened
Omid 2008	Supracondylar humeral fractures in children	Narrative review, bibliography screened
Shin 2007	The ulnar nerve in elbow trauma	Narrative review, bibliography screened
Baratz 2006	Pediatric supracondylar humerus fractures	Narrative review, bibliography screened
Bhatnagar 2006	Diagnosis and treatment of common fractures in children: femoral shaft fractures and supracondylar humeral fractures	Narrative review, bibliography screened
Hart 2006	Broken bones: common pediatric upper extremity fractures--part II	Narrative review, bibliography screened
Loomes 2005	Removing k-wires: an audit of practice	Narrative review, bibliography screened
Weiss 2005	Lateral entry pinning of supracondylar humerus fractures	Narrative review, bibliography screened
Crombie 2004	Closed reduction and percutaneous fixation of displaced paediatric supracondylar fractures of the elbow	Narrative review, bibliography screened
Kuo 2004	Reduction and percutaneous pin fixation of displaced supracondylar elbow fractures in children	Narrative review, bibliography screened
Platt 2004	Supracondylar fracture of the humerus	Narrative review, bibliography screened
Bennet 2002	Supracondylar fractures of the humerus in children	Narrative review, bibliography screened

Table 79 Previous Systematic and Narrative Reviews of Pediatric Supracondylar Humerus Fractures

Author	Title	Reason for Exclusion
Flynn 2002	The operative management of pediatric fractures of the upper extremity	Narrative review, bibliography screened
Hasler 2001	Supracondylar fractures of the humerus in children	Narrative review, bibliography screened
Sherr 2001	Fractures of the elbow in children	Narrative review, bibliography screened
Steenbrugge 2001	Guidelines and pitfalls in the management of supracondylar humerus fractures in children	Narrative review, bibliography screened
Joist 1999	Anterior interosseous nerve compression after supracondylar fracture of the humerus: a metaanalysis	Narrative review, bibliography screened
Hammond 1998	Supracondylar humerus fractures in children	Narrative review, bibliography screened
McLennan 1997	Radiology rounds. Supracondylar fracture of the distal humerus	Narrative review, bibliography screened
Otsuka 1997	Supracondylar Fractures of the Humerus in Children	Narrative review, bibliography screened
Wilkins 1997	Supracondylar fractures: what's new?	Narrative review, bibliography screened
Austin 1995	Supracondylar fractures of the distal humerus in children	Narrative review, bibliography screened
Gillingham 1995	Advances in children's elbow fractures	Narrative review, bibliography screened
Minkowitz 1994	Supracondylar humerus fractures. Current trends and controversies	Narrative review, bibliography screened

Table 79 Previous Systematic and Narrative Reviews of Pediatric Supracondylar Humerus Fractures

Author	Title	Reason for Exclusion
Beaty 1992	Fractures and dislocations about the elbow in children	Narrative review, bibliography screened
Kasser 1992	Percutaneous pinning of supracondylar fractures of the humerus	Narrative review, bibliography screened
Van 1990	Operative treatment of supracondylar fractures of the humerus in children	Narrative review, bibliography screened
Wilkins 1990	The operative management of supracondylar fractures	Narrative review, bibliography screened
Bewes 1989	Supracondylar fractures in children	Narrative review, bibliography screened
Wilkins 1989	The management of severely displaced supracondylar fractures of the humerus	Narrative review, bibliography screened
Shifrin 1976	Open reduction and internal fixation of displaced supracondylar fractures of the humerus in children	Narrative review, bibliography screened
Griffin 1975	Supracondylar fractures of the humerus. Treatment and complications	Narrative review, bibliography screened
Prins 1974	Extension therapy with Von Ekesparre darts of supracondylar fractures of the humerus in children	Narrative review, bibliography screened
Shifrin 1972	Open reduction and internal fixation of displaced supracondylar fractures of the humerus in children	Narrative review, bibliography screened
Bates 1971	Supracondylar fractures of the humerus in children	Narrative review, bibliography screened
Newman 1969	The supracondylar process and its fracture	Narrative review, bibliography screened

Table 79 Previous Systematic and Narrative Reviews of Pediatric Supracondylar Humerus Fractures

Author	Title	Reason for Exclusion
Graham 1967	Supracondylar fractures of the elbow in children. 1	Narrative review, bibliography screened
Graham 1967	Supracondylar fractures of the elbow in children. 2	Narrative review, bibliography screened
Jacobs 1967	Supracondylar fracture of the humerus in children	Narrative review, bibliography screened
Smith 1967	Supracondylar fractures of the humerus treated by direct observation	Narrative review, bibliography screened

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