

The Treatment of Pediatric Supracondylar Humerus Fractures

Andrew Howard, MD
 Kishore Mulpuri, MD
 Mark F. Abel, MD
 Stuart Braun, MD
 Matthew Bueche, MD
 Howard Epps, MD
 Harish Hosalkar, MD
 Charles T. Mehlman, DO, MPH
 Susan Scherl, MD
 Michael Goldberg, MD
 Charles M. Turkelson, PhD
 Janet L. Wies, MPH
 Kevin Boyer

This clinical practice guideline was approved by the American Academy of Orthopaedic Surgeons on September 23, 2011.

The complete guideline, which includes all tables, figures, and appendices, is available at <http://www.aaos.org/research/guidelines/SupracondylarFracture/SupConFullGuideline.pdf>

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Abstract

Based on the best current evidence and a systematic review of published studies, 14 recommendations have been created to guide clinical practice and management of supracondylar fractures of the humerus in children. Two each of these recommendations are graded Weak and Consensus; eight are graded Inconclusive. The two Moderate recommendations include nonsurgical immobilization for acute or nondisplaced fractures of the humerus or posterior fat pad sign, and closed reduction with pin fixation for displaced type II and III and displaced flexion fractures.

Overview and Rationale

This clinical practice guideline was approved by the American Academy of Orthopaedic Surgeons (AAOS) on September 23, 2011. It 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 also highlights gaps in the literature and areas that require future research.

The purpose of this clinical practice guideline is to help improve treatment of pediatric supracondylar humerus fractures based on the current best evidence. Current evidence-based practice standards demand that physicians use the best available evidence in their clinical decision making. To assist in this, this clinical practice guideline consists of a series of systematic reviews of the available literature regarding the treatment of supracondylar fractures of the humerus in children. These systematic reviews were conducted between October 2009 and July 2010 and show where there is good evidence, where evidence is lacking, and what topics future research must target to improve the treatment of pediatric patients with su-

pracondylar fractures of the humerus. 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.

Potential Harms and Contraindications

Most treatments are associated with some known risks, especially invasive and surgical treatments. In addition, contraindications vary widely based on

the treatment administered. A particular concern in 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, comorbidities, skeletal maturity, and/or specific patient characteristics, including obesity. Clinical input based on physician experience increases the probability of identifying patients who will benefit from specific treatment options. The 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 and physician.

Methods

The methods used to develop this clinical practice guideline were designed to combat bias, enhance transparency, and promote reproducibility. Their purpose is to allow in-

terested readers the ability to inspect all of the information that the AAOS Treatment of Pediatric Supracondylar Fracture of the Humerus guideline work group used to reach all of its decisions, as well as to verify that these decisions are in accord with the best available evidence. The draft of this guideline was subject to peer review and public commentary, and it was approved by the AAOS Evidence-Based Practice Committee; Guidelines Oversight Committee; Council on Research and Quality; and the Board of Directors. All tables, figures, and appendices, as well as the details of the methods used to prepare this guideline, are detailed in the full clinical practice guideline, which is available at <http://www.aaos.org/research/guidelines/SupracondylarFracture/SupConFullGuideline.pdf>

Recommendations

Recommendation 1

The AAOS guideline suggests non-surgical immobilization of the in-

jured limb for patients with acute (eg, Gartland type I) or nondisplaced pediatric supracondylar fractures of the humerus or posterior fat pad sign.

Strength of recommendation: Moderate. Evidence is addressed in two level II studies.^{1,2}

This recommendation is based on two moderate quality studies that analyzed collar and cuff immobilization versus back-slab (posterior splint) immobilization for nondisplaced pediatric supracondylar humeral fractures. Ballal et al² was a prospective double-cohort study with a total of 40 patients—20 in each group (collar and cuff versus back slab). Oakley et al¹ presented a randomized controlled trial (RCT) with similar comparison groups, with a total of 50 patients (27 randomized to a posterior slab group, 23 to a collar and cuff). The RCT was classified as moderate quality. Both of these prospective studies found better pain relief within the first 2 weeks of injury with the posterior splint/back-slab method of immobilization. The critical outcomes

From the Division of Orthopaedic Surgery, Hospital for Sick Children, Toronto, ON, Canada (Dr. Howard), the Division of Orthopedic Surgery, BC Children's Hospital, Vancouver, BC, Canada (Dr. Mulpuri), Kluge Children's Rehabilitation Center, Charlottesville, VA (Dr. Abel), Tufts Medical Center, Boston, MA (Dr. Braun), M&M Orthopaedics, Naperville, IL (Dr. Bueche), Fondren Orthopedic Group, Houston, TX (Dr. Epps), Rady Children's Hospital, San Diego, CA (Dr. Hosalkar), Children's Hospital Medical Center, Cincinnati, OH (Dr. Mehlman), Department of Orthopaedic Surgery, Children's Hospital and Medical Center, Omaha, NE (Dr. Scherl), Children's Hospital and Regional Center, Seattle, WA (Dr. Goldberg), and the Department of Research and Scientific Affairs, American Academy of Orthopaedic Surgeons, Rosemont, IL (Dr. Turkelson, Ms. Wies, and Mr. Boyer).

Dr. Mulpuri or an immediate family member serves as a board member, owner, officer, or committee member of the Pediatric Orthopaedic Society of North America. Dr. Abel or an immediate family member serves as a board member, owner, officer, or committee member of the Scoliosis Research Society. Dr. Bueche or an immediate family member serves as a board member, owner, officer, or committee member of the Pediatric Orthopaedic Society of North America and Scoliosis Research Society. Dr. Epps or an immediate family member serves as a board member, owner, officer, or committee member of the American Orthopaedic Association, Pediatric Orthopaedic Society of North America, and Texas Orthopaedic Association. Dr. Hosalkar or an immediate family member is a member of a speakers' bureau or has made paid presentations on behalf of Synthes; serves as a paid consultant to Syntaxin and Synthes; has stock or stock options held in GlaxoSmithKline, Johnson & Johnson, and Pfizer; and has received research or institutional support from Zimmer. Dr. Mehlman or an immediate family member serves as an unpaid consultant to Stryker and serves as a board member, owner, officer, or committee member of the American Academy of Orthopaedic Surgeons, Pediatric Orthopaedic Society of North America, and Scoliosis Research Society. Dr. Scherl or an immediate family member serves as a board member, owner, officer, or committee member of the American Academy of Orthopaedic Surgeons, Orthopaedic Trauma Association, and Pediatric Orthopaedic Society of North America. Dr. Goldberg or an immediate family member serves as an unpaid consultant to Stryker and serves as a board member, owner, officer, or committee member of the American Academy of Orthopaedic Surgeons. Ms. Wies has stock or stock options held in Merck/Schering-Plough. None of the following authors or any immediate family member has received anything of value from or owns stock in a commercial company or institution related directly or indirectly to the subject of this article: Dr. Howard, Dr. Braun, Dr. Turkelson, and Mr. Boyer.

not reported include cubitus varus, hyperextension, and loss of reduction.

Recommendation 2

The AAOS guideline suggests closed reduction with pin fixation for patients with displaced (eg, Gartland types II and III and displaced flexion) pediatric supracondylar fractures of the humerus.

Strength of Recommendation: Moderate. Evidence is addressed in nine level III studies³⁻¹¹ and two level II studies.^{12,13}

Forty-eight outcomes from 14 studies formed the basis of this recommendation. Gartland type II and III fractures were analyzed in aggregate because 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. The quality, applicability, and strength of the evidence generated a preliminary strength of recommendation of Weak. The work group upgraded the recommendation to Moderate based on the potential for harm from nonsurgical treatment of displaced pediatric supracondylar fractures. For example, casting the arm in hyperflexion may cause limb-threatening ischemia.

Among the noncritical outcomes, pin fixation was statistically superior to nonsurgical treatment in a meta-analysis of Flynn's criteria (Figure 2, available in the full guideline on the AAOS website). This outcome incorporates both range of motion and carrying angle. Two noncritical outcomes, infection and pin tract infection, favored nonsurgical treatment because they can occur only in patients who receive surgical treatment.

Although surgical treatment introduces the risk of infection, the improved critical outcomes, combined with the decreased risk of limb-

threatening ischemic injury, outweigh these risks.

Closed reduction and percutaneous Kirschner wire pinning is the preferred treatment of most displaced supracondylar fractures of the humerus. A meta-analysis demonstrates more favorable outcomes for closed reduction and pinning with regard to cubitus varus (Figure 1, available on the AAOS website) and Flynn's elbow criteria (Figure 2). The number needed to treat (NNT) for cubitus varus is 20, and the NNT for Flynn's elbow criteria is 7. However, as may be expected, closed reduction and casting is favored when considering iatrogenic ulnar nerve injury as the outcome. The number needed to harm (NNH) is 108 (Figure 3).

Recommendation 3

The AAOS guideline suggests 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: Weak. Evidence is addressed in 13 level III studies^{5,14-25} and four level II studies.²⁶⁻²⁹

Pin configuration and 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 re-

duction were statistically significant in favor of medial pins. The remaining four studies reported no statistically significant difference between lateral and medial pins.

When iatrogenic ulnar nerve injury is the outcome, meta-analysis data favor lateral pinning. The NNT for retrospective studies is 21 and the NNT for RCTs is 36 when the data are categorized by study type. When the data are stratified by study quality, the NNT for low-quality studies is 20, and an NNT cannot be calculated for the study of moderate quality (Figures 4 and 5). Using Flynn's elbow criteria as the outcome, medial pinning is favored with an NNT of 65 (Figure 6). When change in the Baumann angle is used as the outcome, there is almost no difference, with lateral pinning being slightly favored (Figure 7).

Recommendation 4

The AAOS guideline 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. No studies that met the selection criteria addressed this recommendation.

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 versus open medial pin placement. There were no existing adequate data to address the technique of medial pin placement.

Recommendation 5

The AAOS guideline is unable to recommend for or against a time thresh-

old for reduction of displaced pediatric supracondylar fractures of the humerus without neurovascular injury.

Strength of Recommendation: Inconclusive

Data on 30 outcomes from six studies³⁰⁻³⁵ were found for this recommendation. All outcomes were of low quality. All six studies were retrospective comparative studies that resulted in flawed prospective, group assignment, and blinding domains. Five outcomes had unflawed measurement domains (infections, hospital stay, and operation time). These outcomes are directly observable without the need for testing and/or are 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.

Without consistent, objective criteria for the requirement for open treatment, it is difficult to assess the results of the studies. Furthermore, these nonrandomized retrospective studies are prone to selection bias. More severe injuries may have been selected for earlier treatment, potentially confounding the comparative data.

There is mixed evidence regarding whether delaying surgery for >8 hours increases the need for open reduction in Gartland type III supracondylar fractures. When a 12-hour cutoff is used, there is a statistically significant difference favoring early surgery to avoid the need for an open reduction. In other outcomes, there is no statistically significant evidence to suggest that a reasonable delay in surgical treatment increases the incidence of complications (Table 2).

Recommendation 6

The AAOS guideline suggests that 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: Weak. Evidence is addressed in eight level III studies.³⁶⁻⁴³

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 weakly 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 were found for only two of these outcomes. Aktekin et al³⁶ reported that stiffness was greater in patients treated with open reduction compared with patients treated with a closed reduction and pinning. Li et al⁴² reported that the fractures treated open had a lower incidence of loss of reduction compared with displaced fractures that could be managed successfully with closed reduction and pinning. Sibly et al⁴⁰ found no statistically significant difference between groups for cubitus varus or elbow stiffness.

Recommendation 7

In the absence of reliable evidence, the AAOS guideline suggests that emergent closed reduction of displaced pediatric supracondylar humerus fractures be performed in pa-

tients with decreased perfusion of the hand.

Strength of Recommendation: Consensus. No studies that met the selection criteria addressed this recommendation.

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 seven 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 affect 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 is 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.

Recommendation 8

In the absence of reliable evidence, the AAOS guideline suggests 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. No studies that met the selection criteria addressed this recommendation.

In most 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.

Recommendation 9

The AAOS guideline 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. No studies that met the selection criteria addressed this recommendation.

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 with absent wrist pulse, or the likelihood of avoiding adverse outcomes from this circumstance by open exploration of the antecubital fossa.

Recommendation 10

The AAOS guideline is 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. No studies that met the selection criteria addressed this recommendation.

Prolonged pinning and immobilization might cause pin tract infection or elbow stiffness.

Early removal of pins may increase the risk of redisplacement or refracture. There were no studies in which the duration of pinning or of immobilization was explicitly linked to any outcome of interest.

Recommendation 11

The AAOS guideline is 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. No studies that met the selection criteria addressed this recommendation.

We addressed this topic because of concerns regarding range of motion after healing of the fracture. Critical outcomes sought included range of

motion after 1 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 1-year end point.

However, statistically significant results were seen at earlier end points. Patients in the physical therapy group had better range of motion at both 12 to 13 weeks and 18 to 19 weeks.

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

Recommendation 12

The AAOS guideline is 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. No studies that met the selection criteria addressed this recommendation.

We addressed this topic because unnecessary restriction of activity contributes to the morbidity of a fracture from the perspective of both patient and parent; however, 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.

Recommendation 13

The AAOS guideline is unable to recommend optimal timing of or indica-

tions for electrodiagnostic studies or nerve exploration in patients with nerve injuries associated with pediatric supracondylar fractures of the humerus.

Strength of Recommendation: Inconclusive. No studies that met the selection criteria addressed this recommendation.

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.

Recommendation 14

The AAOS guidelines 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. No studies that met the selection criteria addressed this recommendation.

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.

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 are lacking. Of the 44 included studies in this clinical practice guideline, only 7 were RCTs. None of these RCTs had strong scientific ev-

idence because of methodologic 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 methodologic flaws of retrospective study design are the primary reason so few recommendations in this guideline can achieve a strength of evidence better than Weak.

Clearly, controversy exists regarding the best treatments of pediatric supracondylar humerus fractures. Properly designed RCTs 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 (ie, improvements that matter to the patients). Consideration may also be given to validated family-based outcomes because their inclusion may improve recommendations for younger patients. Future studies would also benefit from attempts to increase the applicability of study results (ie, generalizability), as described by the PRECIS instrument.⁴⁴

Specific trials that would be helpful to improve recommendations include the following:

- 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 (eg, iatrogenic ulnar nerve injuries), along with maintenance and quality of reduction

- 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 (eg, up to 1 year) patient-centered outcomes of simplified treatments of 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 of adolescent supracondylar fractures
- Prospective investigation for treating versus transferring, with a focus on how to optimize outcomes in a geographically dispersed area

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