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Elastic stable intramedullary nailing versus Kirschner wire pinning: outcome of severely displaced proximal humeral fractures in juvenile patients

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Background: Significantly displaced juvenile proximal humeral fractures (Neer-Horowitz type 3 and 4) usually require reduction and fixation. The most commonly used fixation methods are Kirschner wire (K-wire) pinning or retrograde elastic stable intramedullary nailing (ESIN). However, results comparing the long-term outcome of both methods are absent in the literature. The aim of this study was to provide an outcome comparison of both techniques.
Methods: Included were 40 patients treated between 1998 and 2008 and who had complete records concerning operation time, duration of hospital stay, and time until implant removal. The assessment of clinical (Disabilities of Arm, Shoulder and Hand [DASH] and Constant-Murley scores) and radiologic long-term outcome was possible in 31 patients (78%). Preoperative, postoperative and follow-up radiographs of these patients were evaluated for angular deformity, reduction, and remodeling.
Results: The mean follow-up of the 31 patients (16 ESIN; 15 K-wire) was 5.8 ± 3.6 (standard deviation) years. The operative time of the primary fixation procedure was shorter in the ESIN group ($P < .001$), but the hospital stay and the time until implant removal were significantly longer. No significant difference was seen between the groups at follow-up for the mean DASH (ESIN, 1.44; K-wire, 1.66) or Constant-Murley (ESIN, 89.5; K-wire, 92) scores. The neck-shaft angle was significantly improved by reduction in both groups ($P < .001$) and remained unchanged at follow-up.
Conclusions: ESIN and K-wire pinning have a favorable and comparable functional outcome and therefore seem to be adequate methods for treating Neer-Horowitz type 3 and 4 proximal humeral fractures in juvenile patients. The initially achieved improvement of the neck-shaft angle can be maintained at long-term follow-up.
Level of evidence: Level III, Retrospective Cohort Study, Treatment Study.

Keywords: growing skeleton; proximal humeral fractures; displaced

Fractures of the proximal humerus are rare in children, accounting for only 3% of all physeal injuries[19]; however, these fractures still represent the most common physeal injuries of the shoulder and upper arm.[5] In 1965, Neer and Horowitz introduced a classification system grading these

The Medical University of Graz Ethics Committee approved this study (EK 23-229 ex 10/11).

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injuries according to their displacement (type 1: <5 mm; type 2: <1/3 shaft width; type 3: >1/3 and <2/3 shaft width; and type 4: > 2/3 shaft width).

The physis of the proximal humerus is responsible for approximately 80% of the humeral growth.[3,23] This unique structure is responsible for the high remodeling potential of proximal humeral fractures and the widespread acceptance that most proximal humeral fractures can be treated conservatively, depending on the degree of displacement, angulation, rotation, or translation.[3,4,10,19]

However, remodeling has been clearly identified as being age-dependent and recognized as an important factor in determining the treatment regimen of juvenile proximal humeral fractures.[6,11,12,17] Adolescents have a limited correction potential of proximal humeral fractures because remodeling capacity in this age group is already limited compared with younger children with a greater opportunity for remodeling. Several authors therefore favor a surgical approach in adolescents with Neer-Horowitz type 3 and 4 fractures with axial deformities of more than 30° varus and more than 10° valgus.[6,12]

Operative management includes closed or open reduction, followed by fixation with variable options.[21] The use of percutaneously placed pins has been well described.[6,11] Nevertheless, retrograde elastic stable intramedullary nailing (ESIN) using flexible titanium or stainless steel implants[7,12] has been strongly supported in recent years, although studies comparing the outcome of both techniques are rare. Hutchinson et al[14] compared the early postoperative outcome of skeletally immature patients treated for displaced proximal humeral fractures by ESIN or Kirschner wire (K-wire) pinning and reported no differences between the methods.[14] However, longer-term results of ESIN vs K-wire pinning for proximal humeral fractures have not been reported so far. Thus, the hypothesis of the present study was that the functional and radiologic long-term results of proximal humeral fractures treated with ESIN or K-wire pinning do not differ significantly.

Methods

The Department of Pediatric and Adolescent Surgery, Medical University of Graz, Austria, is the only level 1 pediatric trauma center within a catchment area covering the entire State of Styria that takes care of children and adolescents up to the age of 18 years. A retrospective analysis of the hospital's trauma database was performed to identify children and adolescents (up to the age of 18 years) treated for displaced proximal humeral fractures, Neer and Horowitz type 3 and 4, between 1998 and 2008 and treated by K-wire pinning or ESIN.

Inclusion criteria were the diagnosis of proximal humeral fractures, Neer-Horowitz type 3 and 4, confirmed by x-ray imaging, complete clinical data sets with information about age, sex, trauma mechanism, type of treatment, operation time for primary operation, duration of hospital stay, operation time for implant removal, and time to implant removal.

Exclusion criteria were proximal humeral fractures due to bone tumors (eg, juvenile or aneurysmatic bone cysts), patients with other underlying diseases affecting bone density, and patients with neurologic disorders unable to complete Disabilities of Arm, Shoulder and Hand (DASH) and Constant-Murley scores.

All patients were invited to a follow-up examination to assess the long-term functional and radiographic outcomes.

Angulation was assessed in radiographs at three time points (time of the injury, first follow-up visit, and final follow-up). The neck-shaft angle in anteroposterior radiographs, as described by Agudelo et al[1] was measured preoperatively, postoperatively, and at follow-up.

The Constant-Murley and the DASH scores, as approved tools to evaluate the treatment results of upper extremity injuries, were assessed at follow-up.[9,20] Both scores were completed in all patients.

For statistical analysis, IBM SPSS Statistics 20 software (IBM Corp, Armonk, NY, USA) was used. The independent sample *t* test was applied to compare the functional outcomes between the 2 groups. The Kruskal-Wallis test was used to compare the neck-shaft angles, according to Agudelo et al,[1] because the data did not show normal distribution according to the Kolmogorov-Smirnov test. Values are expressed as means ± standard deviations and ranges. A P value of $<.05$ was considered to be statistically significant.

Surgical techniques

Choice of surgical technique was the surgeon's choice.

A 2-nail technique was used for ESIN. A skin incision of at least 2 cm in length was performed just above the lateral epicondyle of the humerus. The bone was opened with an awl in an oblique manner, without perforating the opposite cortex. Nail diameter was chosen according to the diameter of the bone marrow space: each of the 2 nails had a diameter of one-third of the bone marrow space.[16] The nail was inserted and brought up to the fracture site. By traction, abduction, and 90° external rotation, the fracture was reduced under fluorographic control; then, the nail was passed into the proximal fragment. A second nail was inserted into the humerus using the same insertion site. The nails were cut about 10 mm from the cortex.

Postoperative treatment included early functional treatment without immobilization. ESIN removal was performed at least 4 weeks postoperatively when callus formation was visible on control x-ray images. Because immobilization is not required and the nail ends usually do not irritate the soft tissue, planning for implant removal can be more flexible, taking into account each patient's personal circumstances.

For pinning, K-wires with a diameter between 2.0 and 2.5 mm were used. By traction, abduction, and 90° external rotation, the fracture was reduced. The correct reduction was checked by using fluoroscopy. The first pin was inserted into the distal fracture fragment close to the deltoid tuberosity. The K-wire was passed across the fracture site in a superomedial direction using a wire driver. To avoid intra-articular placement and to check stability, the shoulder joint was moved under fluoroscopy. A second K wire was positioned more anteriorly or posteriorly as needed. Because bending has to be avoided during fixation and for accurate stability of the fracture fragments, we use 2.0-mm or 2.5-mm K-wires according to the protocol in our department. Pins were cut under the skin.