

Surgical Treatment of Supracondylar Humerus Fractures in Children

Chirurgická léčba suprakondylických zlomenin humeru u dětí

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ABSTRACT

PURPOSE OF THE STUDY

Surgical techniques for the treatment of supracondylar fractures in children are repeatedly the subject of discussion. The aim of the present study was to compare experience with the technique of crossed Kirschner wires at our own hospital with current literature.

PATIENTS AND METHODS

In the period from 2000–2006 a total of 86 children aged 1.7 to 12.7 years were treated by means of crossed K-wire osteosynthesis. Follow up was conducted at an average of 32 months. Outcomes were evaluated based on von Laer's criteria.

RESULTS

Reported complications were migration of the K-wires in 7% of cases and secondary dislocation and re-operation in 4% of cases. Lesion of the radial nerve was diagnosed postoperatively in two cases. Hospital stay was 1.5 days on average. Postoperative immobilization in an upper arm splint and implant removal after 6 weeks on average. 57% of the children received physiotherapy during the course of treatment. Slight varization was found in 11% of children and an unsatisfactory range of motion in 13%. Satisfactory outcomes were recorded for 83% of patients.

CONCLUSION

K-wire osteosynthesis is associated with a low complication rate and continues to be a safe standard procedure for the stabilization of supracondylar humerus fractures.

Key words: supracondylar humerus fracture, Kirschner wires, paediatric fractures.

INTRODUCTION

The most frequent fracture pattern at the elbow in children is the supracondylar humerus fracture with an incidence of around 3–16.6% (4, 9, 12, 13, 17, 25). The large number of articles, extensive body of literature and numerous treatment proposals reflect the importance of this fracture (14). Although fractures that are undisplaced or only slightly displaced clearly remain the domain of conservative therapy and are treated with an upper arm splint or Blount sling (8, 14), a colorful variety of treatment recommendations is on offer for the more severe, displaced fractures, whereby surgery is always recommended. The techniques advocated by the various authors range from K-wire osteosynthesis to external fixator to ESIN (6, 9, 14, 15, 21), although the different methods are constantly under controversial discussion. These discussions focus mainly on expected outcomes, stability and aftercare as well as possible complications. The latter include not only vascular and neurological lesions but also axial deviations

such as Cubitus varus or valgus, which may lead to asymmetries and permanent restriction of movement (4, 23).

Despite the frequency of this injury and the myriad of articles written about it, there is no consensus as to the preferred technique.

The aim of the present study was to compare our own results after crossed K-wire fixation of supracondylar humerus fractures with the clinical outcomes reported in the literature, including a study of economic considerations such as operation time, length of hospital stay and the frequency of physiotherapeutical aftercare.

MATERIAL AND METHODS

In the period from January 2000 to January 2006 a total of 86 children aged 1.7 to 12.7 years with a supracondylar humerus fracture were treated surgically by means of crossed K-wire osteosynthesis. Patient data was collected retrospectively from the patient files and radiographs at our hospital.

All the patients were invited by letter to come to a follow up assessment with their parents. After documenting the relevant data on a standardized questionnaire clinical examination was conducted according to the case report form and included assessment of function and axial alignment. Between the different known classifications we decided to use the classification of Lutz von Laer for our study based on the available radiographs (5, 6, 24). Any relevant previous or concomitant disorders were also recorded as well as operation time, screening time, and the number and duration of physiotherapy sessions after surgery.

The findings at follow-up were analyzed by the assessment method of von Laer (22). According to this method evaluation of treatment success is based on joint orientation and restriction of movement compared with the contralateral side as shown in table 1.

Tab. 1. Table showing evaluation according to von Laer (22)

Outcome	Axial deviation	Restricted movement
satisfactory	0° - 5°	0° - 10°
unsatisfactory	> 5°	> 10°

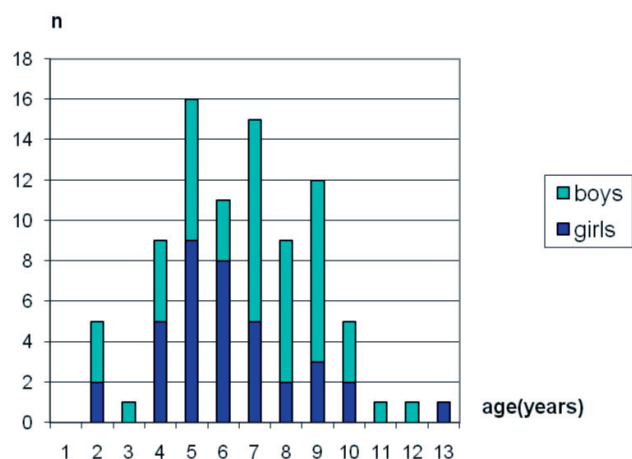
An outcome is considered unsatisfactory if there is an axial deviation >5° and/or a functional deficit of >10°. In the evaluation of treatment outcome for any patient, the poorer result determines the overall outcome (19).

The retrospective data and the data from follow up were entered into Microsoft Office Excel 2003, which was also used for analysis and to create the tables.

RESULTS

A total of 63 (73%) children that had received crossed K-wire osteosynthesis were available to follow up. Twenty-one (33.9%) of these children were operated in open technique and 42 (66.1%) in closed technique. Seven children required revision surgery and six of them came to follow up. At the time of the accident average patient age was 6.6 years (range 1.7 – 12.7 years). Figure 1 shows age distribution at the time of the accident.

Graph 1. Age distribution at the time of the accident



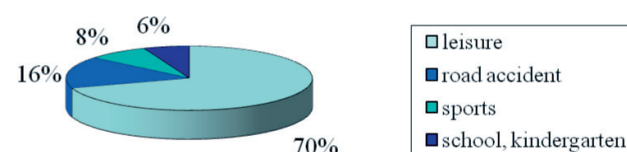
The children most affected were the about 5-year-olds.

25 girls (40%) and 38 boys (60%) were affected. In 27 patients (43%) the right arm was injured and in 36 patients (57%) it was the left arm.

Follow up took place on average 32 months (range 8 – 73) after the accident. The children were between 2.6 and 15.9 years (average 9.8 years) at the time of follow up.

The majority of patients sustained their injuries during play and leisure activities (69.9%). Other causes were accidents on the road, during sports, and on the way to school (see Fig. 2).

Graph 2. Cause of accident



The most frequent cause of fracture was falling off a bicycle (13%), followed by falling off a climbing frame (12%) and falling off a horse (7%).

Eight children (9.3%) sustained concomitant injuries during the accident all of which involved the ipsilateral arm.

In three cases (3.5%) the child presented at our hospital with an open fracture. One child had ruptured the brachial artery. Another child had partial lesion of the radial nerve. Five patients (5.8%) had also fractured the distal radius. Three of these cases were treated by means of K-wire osteosynthesis. Another child suffered a fracture of the distal forearm.

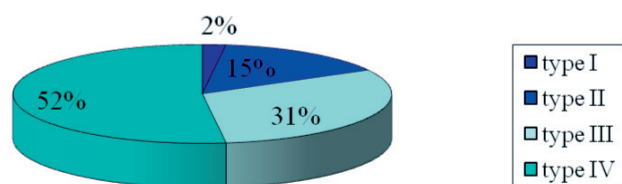
Of the total sample 14 children (16.3%) experienced peri- or postoperative complications. In 6 children (7%) there was migration of the K-wires that required re-osteosynthesis in two cases but only premature implant removal in the four other cases. In 4 cases (4.7%) fracture dislocation was diagnosed in the postoperative period leading to subsequent open revision.

Damage to the radial nerve was only observed post-operatively in 2 children (2.3%). In one child the lesion had already been treated before the follow up appointment and full function had been restored, although a slight feeling of numbness in the forearm remained. The nerve lesion in the other child was only diagnosed during the follow up examination.

One boy was re-operated to treat consolidation in malalignment. The surgical procedure involved open reduction and stabilization by plate fixation. At follow up there was still obvious axial deviation and flexion contracture. The boy also complained of recurrent pain in the shoulder and arm and a feeling of numbness in the forearm.

Fracture classification was based on the preoperative radiographs (see Fig. 3). 95.5% of patients had extension fractures and 4.5% flexion fractures.

Graph 3. Fracture distribution according to the von Laer classification (24)



One third of the fractures treated were identified as von Laer Type III fractures (example in Fig. 4) and more than half as von Laer Type IV fractures (example in Fig 5). Surgical treatment was generally performed on the day of the accident (83.7%). 11.6% of patients were treated on the following day. Four children were only operated later due to secondary dislocation or late presentation.

Open surgery was performed in 30 patients (34.9%) because closed reduction proved impossible. Revision surgery was required in 7 cases due to various complications.

Average operation time in the patient sample under investigation was 40 minutes (range 12–146) with a clear difference between closed (average 27; range 12–75) and open (average 72 min; range 28–146) procedures.

Time of fluoroscopy on average was 66 seconds (range 2–312). There were no significant differences between groups for open and closed reduction.

In all children the arm was immobilized postoperatively in an upper arm plaster cast. Implant removal took place in average after 43 days (range 27–60).

Hospital stay for our patient sample lasted an average of 1.5 days (range 0–10).



Fig. 4. 7-year-old boy with a Type 3 fracture after football.



Fig. 5. 8-year-old boy with a type 4 supracondylar fracture after bicycle accident.

In the patient sample under investigation 35 children (56%) attended physiotherapy during the period of aftercare, whereby the number of physiotherapy sessions varied considerably (2–40 sessions, average 10). 27 children (43.5%) were not prescribed physiotherapy.

In 8 patients (13%) the range of motion was unsatisfactory. The average range of motion was 10–0–140, i.e. (min: 0–40–130; max 20–0–150). Ultimately, pronation and supination was fully restored in all patients.

In 7 children (11%) unsatisfactory restoration of the anatomical axis of the arm was identified. A slight varus axis of the injured arm was apparent in all these cases, whereby 2 children were clear cases of cubitus varus.

Evaluation according to von Laer yielded a satisfactory treatment outcome in 83% of children (Tab. 2).

Tab. 2. Evaluation according to von Laer (22)

Outcome	Axial deviation	Restricted movement	Total outcome	Percent
satisfactory	56	55	52	82.5%
unsatisfactory	7	8	11	17.5%

DISCUSSION

Supracondylar humerus fractures are a frequent injury in childhood with an age peak between 4 and 9 years (12, 16, 19, 24). So far standard technique to stabilize displaced fractures has been crossed K-wire osteosynthesis. However, the need for postoperative immobilization for a period of 4 weeks and the high risk of damage to the ulnar nerve often described in the literature at a rate of up to 20% (11, 24, 25) prompted the search for and testing of alternative techniques.

An alternative to standard technique has been the more recent use of ESIN (elastic stable intramedullary nailing) for fracture stabilization (17). The stabilization of the supracondylar humerus fracture in children with the ESIN is still discussed controversially(6). The declared advantages are to be found in the areas of early functional rehabilitation and in the preservation of the ulnar nerve. The complication rates found in studies of this technique are surprisingly low. Early functional care has the special advantage that full range of motion is soon restored. Having said that, the existing data on temporary immobilization after crossed K-wire fixation also show free range of motion at the end of the treatment period.

The high risk of ulnar nerve damage was not a problem in the study presented here. A disorder of this kind was not diagnosed in any of our patients. Only one case of temporary radial nerve lesion was seen. In this case, it is likely that the lesion had already existed pre-operatively since the patient was not easy to assess, or that it occurred during reduction, which would not be a problem specific to the procedure. One clear advantage of K-wire fixation over ESIN stabilization is the much

shorter screening time. Schaffer et al. report a screening time of 306 seconds (17). In comparison, a time of only 66 seconds was recorded for our patient sample. In contrast to our study, however, the fractures treated with ESIN were 85% Type II fractures (17), which means that direct comparison will only be possible when a larger patient sample with more severe fractures becomes available.

The data we recorded revealed a relatively high proportion of open reductions that accounted for 34% of the total. One way of reducing the proportion of open reductions might be the application of a lateral external fixator as proposed by Slongo et al. (20). The implementation of this technique led to a reduction in the rate of open reductions to less than 10% in their patient sample. Furthermore, this procedure permits early mobilization. Despite these good results and generally good acceptance by the patients and their parents this approach cannot be viewed as a standard procedure but rather as a "salvage procedure" for fractures that are difficult to treat in closed technique or where there are concomitant injuries (20).

Given the high risk of ulnar damage described in the past, several authors investigated lateral K-wire fixation only (1, 3, 7, 19). Kallio et al. found reduction loss in 14% of cases. Skaggs et al. recorded displacement in 7% of cases for fixation with two lateral pins compared to only 1% for crossed technique. In all cases, primary malposition of the wires was established. Therefore, the insertion of a third wire was recommended for more severe, unstable fractures. A similar rate of reduction loss (8%) was also found in the present study, which corresponds more or less to the findings of the multicenter study by Weinberg et al. (24) with a revision rate of 6%. In comparison with other published reports this initially appears to be a high percentage. Kocher et al., Schaffer et al. and Skaggs et al. (10, 18, 19) report no revisions and Mangwani et al. (12) only 1% revision surgeries. However, if the investigation is scrutinized, Mangwani et al. (12) found a rate of 11% in the groups with Type III and Type IV fractures alone.

Weinberg et al. showed in their biomechanical study that crossed K-wires showed the highest stiffness and lowest loss of reduction under cyclic loading. The external fixators proved to be good alternatives (19). In another biomechanical study Zionts et al. (26) compared crossed K-wire technique with lateral K-wire fixation alone. Greater stability was achieved with the crossed technique. Given these biomechanical findings and the results of our own study, we cannot state any clear advantage for lateral technique alone.

Comparison of range of motion in terms of extension and flexion showed that our result of 87.4% satisfactory outcomes at follow up was similar to the values reported in the literature. These values lie between 82.6% to 100% for bilaterally equal range of motion (17, 18, 20, 23, 24). The most frequently described axial deviation is valgus deformity (14, 22, 23). The number of deformities reported varies widely, for example,

Skaggs et al. (19) report no varus deformities. Mangwani et al. (12) found varus deformity in 3% of their cases and varus deformity in 1%. Much higher values were given for the multicenter study by Weinberg et al. who reported 11.7% varus and 7.2% valgus deformities. The children we examined at follow up presented with a similar number of varus deformities. The explanation for the higher number of growth disorders in our study and in the study by Weinberg et al. is certainly to be found in the much higher number of more severe injuries. However, on the whole, Weinberg et al. did not find any evidence of clinically relevant consequences of growth disorders.

With regard to the constant demand for cost reduction in the health sector, the patient sample was investigated in terms of possible savings. Hospital stay after closed reduction was 1.3 days on average and after open reduction it was 2.0 days. In this respect it seems that the so-called "savings potential" as addressed in the von Laer et al. multicenter study has been implemented (22) since hospital stay for their patients was 5.2 days (closed reduction) and 7.4 days (open reduction).

In the context of aftercare, physiotherapy was prescribed for 56.5% of children in our patient sample. It was prescribed for 22% according to the multicenter study conducted by von Laer et al. in 2002. These percentages are high considering that it is repeatedly stated that physiotherapy is not meaningful or is even unnecessary unless there is some special indication. A difficult problem in our study was that the parents demanded physiotherapy even after adequate explanation. In particular, the paediatricians in charge of aftercare tended to give in to this demand. From an economic point of view, the indications for physiotherapy should be critically examined and prescription should be tailored to meet individual needs. It can be assumed that in our patient sample the area of physiotherapeutic aftercare offers great savings potential.

CONCLUSION

Crossed K-wire fixation is a well proven standard procedure in the treatment of supracondylar humerus fractures in children (2). Good clinical results and a low complication rate confirm the continued validity of the procedure. In our opinion, further studies of the ESIN method need to be completed before sound recommendations can be given. Current assessment of this method concludes that it is better suited to the treatment of simple fractures and that there is a clear disadvantage in terms of radiation exposure due to the longer screening times. If fractures are difficult to reduce, a valuable alternative to open reduction may be stabilization by means of external fixator, whereby this solution is currently under clinical investigation. From an economic standpoint, the high number of physiotherapy session needs to be evaluated as to their necessity and, if possible, reduced. In contrast, a further reduction in the length of hospital stay seems impossible.

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