The posttraumatic proximal cross-union of the forearm in childhood: what is recommended?

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Abstract

The posttraumatic proximal cross-union of the forearm in childhood is a rare complication after radial head, neck or proximal forearm fractures and elbow dislocations. There is no standardized treatment. Several surgical procedures with or without interposition techniques are described in the literature. The aim of this study was to analyze all children with cross-unions who underwent surgery over the last 15 years. From 1998 to 2013, 8 children with a posttraumatic proximal cross-union of the forearm (Type 3 according to Vince and Miller) received surgical treatment with resection of the cross-union or radial head. Mean age at the time of initial trauma was 9.0±2.56 years (range 6-14 years), age at the time of surgery was 11.9±3.09 years (range 7-16 years). Mean time of resection of the cross-union was 23.2 months. Follow-up time was 10.6 months (range 1-36 months). Five patients had a resection of the cross-union without any interposition techniques, in 2 cases with an additional arthrolysis of the elbow. One patient had an interposition of a local fascia flap. In 2 cases, a primary excision of the radial head, six and seven years, respectively, after trauma, was performed. All patients, except one, had non-steroidal anti-inflammatory drugs therapy after surgery. A post-operative irradiation was performed in 3 cases. The mean postoperative range of motion for pronation/supination was 36/0/53°. Controversy remains about the best procedure to adopt for posttraumatic cross-union in childhood. After analysis of our data and the literature, we recommend the resection of the cross-union within 6-24 months of occurrence without necessarily using any interposition techniques. All patients reported an improvement with regard to ordinary activities. In cases of long-term cross-union for several years with ankylosis of the elbow and bony deformities of the proximal radius, an excision of the radial head as salvage procedure is recommended.

Introduction

The posttraumatic proximal cross-union of the forearm in childhood is a rare complication after radial head and neck or proximal forearm fractures and elbow dislocations.[1-3] This uniting callus between radius and ulnar, which makes pronation and supination of the forearm impossible, was first described in adults by Gross *et al.* in 1864.[4] The first report in children was performed by Mouchet *et al.* in 1900.[5] In the existing literature, cross-unions are often described in case reports and small cases series.[6-8] In 1987, Vince and Miller reviewed 10 children with cross-union after fracture or osteotomy of the forearm.[8] Prior to this, these authors had carried out a study on cross-union in adults; they reported an incidence of 2% in a population of 2318 adults with fractures of the forearm. Furthermore, they developed a classification system with regard to the location of the cross-union. Type 1 (distal) is located in the distal intra-articular part of the forearm, Type 2 (diaphyseal) in the middle and non-articular distal third of the forearm, and Type 3 (proximal) in the proximal third, determined by the length of the ulnar.[9] Jupiter and Ring developed a subclassification of the Vince and Miller Type 3 cross-union classification. They described Type A cross-union at the location distal to the tuberosity radii and Type B up to the region of the proximal radioulnar joint. A Type C cross-union shows an additional ankylosis of the elbow and humeroulnar ossifications.[10] There is no standardized treatment and several surgical procedures with or without interposition techniques are described in the literature.[8,10-14] Furthermore, the timing of treatment is included in the discussion. Vince and Miller described an increased rate of recrudescence after an early resection of the cross-union, but on the other hand they mentioned that delayed resection might be complicated by scarring of the soft tissue and bony deformities following osteophyte development.[8] Compared to the adult population, they reported worse results in pediatric diaphyseal (Type 2) cross-unions.[9]

We retrospectively analyzed all children who underwent surgery for a cross-union in our institution over the last 15 years to determine treatment for cross-unions, complications and range of elbow motion.

Materials and Methods

Between 1998 and 2013, 8 children with a posttraumatic proximal cross-union of the forearm (Type 3 according to Vince und Miller) who received surgical treatment with a resection of the cross-union or the radial head were retrospectively analyzed. X-rays and clinical data of all patients were reviewed. Cross-union treatment, pre-, intra- and postoperative elbow range of motion (ROM) for pronation and supination, recrudescence occurrence and further surgical intervention, as well as non-operative additive therapies such as drugs and raditation, were recorded. Initial trauma causing the cross-union were fractures of the radial head and neck, or fractures of the proximal forearm. Patients were 4 (50%) girls and 4 (50%) boys. Three right (37.5%) and 5 left (62.5%) arms were affected. Average age at the time of initial trauma was 9±2.56 years (range 6-14 years), average age at the time of surgery was 11.9±3.09 years (range 7-16 years). The earliest excision of the cross-union was performed five months after fracture, the latest excision after five years. One non-union of the radial neck with an additional cross-union was observed in one patient. Mean follow up was 10.6 months (range 1-36 months).

Results

Five patients were treated with resection of the cross-union without any interposition techniques (Figures 1 and 2). Two had an additional arthrolysis of the elbow and one an addi-

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tional reinsertion of the biceps tendon. One of these patients had an arthrolysis of the elbow initially after a healed radial neck fracture and a cross-union developed which was resected one year after initial trauma. In one patient, an interposition of a local fascia flap after resection was performed. In 2 patients, a primary excision of the radial head with additional elbow arthrolysis, six and seven years after trauma was accomplished (Figures 3 and 4, Table 1.)

In our study, all patients except the one with the additional non-union, received non-steroidal anti-inflammatory drugs (NSAIDs), and 3 patients underwent postoperative irradiation.

One patient with the initial elbow arthrolysis after a radial neck fracture developed a cross-union and the resection was performed one year after primary trauma. In one case, no further treatment after recrudescence was performed and the patient who was diagnosed for a cross-union five years after trauma underwent a resection of the radial head with additional elbow arthrolysis six months after initial resection of the cross-union due to a fulminant ankylosis of the elbow. The patient who underwent a resection of the cross-union and an additional interposition of a local fascia flap required a sedated mobilization of the elbow one month later because of decreasing mobility. An improvement in the range of motion for pronation and supination intraoperatively, based on the pre-operative appearance, was observed in all patients. Also, all patients showed a loss of range of motion for pronation and supination postoperatively compared to the intraoperative appearances, even without radiological signs of a recurrent cross-union. Mean range of motion for pronation and supination was 36/0/53° (Table 2).

Discussion

The proximal radial cross-union, defined as uniting callus between radius and ulna, is rare. Cross-union is reported as the most common serious complication which can occur after radial head and neck fractures, and occurrence after open reduction of severely displaced fractures has been described.[2,15-23] Nenopoulus *et al*. reported an incidence of 9% cross-union in their study population of 45 children, which occurred in dislocated fractures;[21] Newman *et al.* described a frequency of 10%.[2] Häßle *et al*. analyzed 116 fractures of the proximal forearm in children and found 2 cross-unions. In all cases of non-reduced side dislocation, they reported 2-5 mm deformities of the radial head, radioulnar cross-union or intra-articular callus.[1] This was also reported by Newman *et al*. who, in 4 of 5 cross-unions, found a non-reduced side dislocation greater than 2 mm.[2] Vocke *et al.* reported that, after radial neck fracture, a radiolunar synostosis developed in 1 of 38 cases.[24] In our patient group, development of cross-union occurred after proximal forearm fractures, radial head fractures and elbow dislocation. Besides fracture dislocations, periostal interpositions,[25] surgical trauma,[26,27] and repeated manipulation are described as possible causes.[7] However, since the cause has not been investigated specifically, there is no consensus about treatment or the best timing of treatment. In adults, Vince and Miller suggested resection of the cross-union at least one year after trauma in order to ensure complete callus formation. But on the other hand, in the pediatric population, they reported that delayed resection might be complicated by soft tissue contractions and these might compromise recovery of a good range of motion.[9] Ogden *et al.* suggested the resection within six months.[28]

In our patient group, the time of diagnosis

Table 1. Patients and treatments.

ID	Age at therapy for cross-union	Treatment time after trauma	Treatment	Relapse	Further treatment
1	10 years	5 months	Resection + interposition fascia flap	No	Sedated mobilization
2	10 years	30 months	Resection + elbow arthrolysis	No	No
3	10 years	10 months	Resection	Yes	No
4	16 years	5 years	Resection + elbow arthrolysis	Yes	Radial head resection
5	14 years	2 months	Elbow arthrolysis	Persisted	Cross-union resection
6	7 years	22 months	Resection + biceps tendon reinsertion	No	No
7	15 years	6 years	Radial head resection + elbow arthrolysis	No	No
8	3 years	7 years	Radial head resection + elbow arthrolysis	No	No

Figure 1. Ten-year old boy after radial neck fracture with proximal radioulnar cross-union after 10 months (A, B).

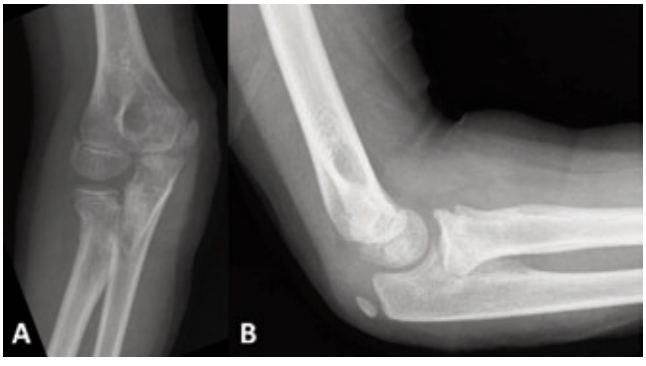

Figure 2. Ten months after trauma resection of the cross-union (A, B).

of the cross-union was between five months and seven years. All patients undergoing surgery within 60 months after trauma received a cross-union resection. But acceptable results could only be achieved in patients who underwent resection within 30 months after trauma. The patient who underwent resection after five years had to have a radial head resection due to a recrudescence. The patient who underwent cross-union resection with flap interposition required a sedated elbow mobilization one month later because of decreased mobility. Therefore, we had better results with a simple resection without interposition techniques. In 2 of 3 cases treated six and seven years after trauma, a primary resection of the radial head with elbow arthrolysis was performed with good intraoperative ROM. None of these patients experienced a recrudescence and, therefore, in cases with a delayed treatment of the cross-union a resection of the radial head may be a long-term option. However, this should only be considered a salvage procedure. Treatment with resection of the radial as salvage procedure is reported to show good results.[29,30] After reviewing the literature and our results, we suggest the resection of the cross-union within 6-24 months after occurrence. We agree with Ogden *et al*.[28] that, at this point, formation of the callus should be complete and any delay in treatment might be complicated by soft tissue contractions and difficulties in achieving a good ROM, as suggested by Vince and Miller.[8,9,28]

Treatment options are usually described in case reports or small case series.[3,8,11,13,31] Aner *et al.* reported 2 cases of cross-union: one resection without interposition techniques after 33 months with pronation/supination 45°/0/70°, and the other with resection of the cross-union after eight months with interposition of a Gore-Tex-Vascular-Graft with an pronation/supination of 80°/0/90°. They reported an increase in risk after the age of ten years and an extensive fracture dislocation.[11] Interposition of free vascularized fascia fat grafts or silicon membrane after resection of the cross-union are described.[13,31] Von Laer *et al*. mentioned that the success rate in treatment of posttraumatic cross-union is higher than in congenital cases, and that interposition of vascularized transplants may provide an opportunity for surgery.[32] The technique of these interpositions has been reported by various authors in adults.[31,33,34] Wierer *et al.* reported good results with a method developed by Kamineni *et al*.[12] with resection of 1 cm radius with no further manipulation of the cross-union.[14] Jupiter and Ring used bone wax as interposition material as well as soft tissue such as fat.[10]

The literature reports less use of additional treatment methods such as irradiation and anti-inflammatory agents after cross-union resection, and no valid conclusions can be drawn. Most reports dealing with this are of adults or address heterotopic ossifications in children with neurological issues.[35-38] Cullen *et al*. reported 4 cases of post-traumatic cross-union in adults, each of them received postoperative irradiation with 800-1000 cGy and reported no recurrence of the cross-unions.[35] Low-dose irradiation can be applied within five days after surgery and has been shown to reduce heterotopic bone in adults.[39-42] A single 800 cGy has been reported to be as effective as 1000 cGy dose given in 5 doses.[40] In adults, post irradiation sarcoma are not reported with doses less than 3000 cGy.[43] Despite these results in adults, other author do not recommend irradiation in children to avoid recurrence of heterotopic ossifications.[38] As additional therapy to avoid heterotopic ossification and recurrence of the cross-union, NSAID such as perioperative oral indomethacin have been used, but their effectiveness has not been documented.[36,37,44] A few positive results have been reported using anti-inflammatory agents in adults to avoid recurrence of heterotopic ossifications.[45,46] In our study, all patients, except the one with the additional non-union, received NSAIDs and 3 patients had postopera-

Table 2. Range of motion.

ID	Pre-operative ROM	Intraoperative ROM	ROM at last follow up
1	No pronation/supination	20-0-30° Pro/Sup	20-0-30° Pro/Sup
2	No pronation/supination	70-0-20° Pro/Sup	20-0-30° Pro/Sup
3	Pro/sup 30-0-20°	80-0-50° Pro/Sup	80-0-50° Pro/Sup
4	No pronation/supination	30-0-80° Pro/Sup	30-0-80° Pro/Sup
5	No pronation/supination	90-0-60° Pro/Sup	30-0-60° Pro/Sup
6	No pronation/supination	45-0-70° Pro/Sup	45-0-70° Pro/Sup
7	No pronation/supination	80-0-90° Pro/Sup	20-0-70° Pro/Sup
8	Pro/sup 20-0-20°	80-0-60° Pro/Sup	40-0-30° Pro/Sup

ROM, range of motion.

Figure 3. Thirteen-year old girl after radial neck fracture at the age of six years (A,B), presentation at hospital seven years after trauma with cross-union, ankylosis and bony deformity of the proximal radius.

Figure 4. Primary resection of the cross-union and arthrolysis due to fulminant ankylosis and bony deformities (A,B).

tive irradiation.

In all patients, reduced mobility was observed postoperatively with an average ROM of 36°/0/53° for pro- and supination; this was disappointing in patients with resection of the radial head who clinically showed moderately better results. But the short follow up means valid conclusions can not be drawn and a longer observation period for these patients is required. In comparison to the almost stiff preoperative pro- and supination, all patients showed an improved ROM postoperatively without experimental surgical procedures. Due to this loss of ROM, an early and aggressive physiotherapy after resection of the cross-union, with regularly and closed meshed control of the result, seems to be a major factor in preventing the loss of motion. This impression is based on the observation that all patients showed decreasing mobility postoperatively, even though they did not show radiological signs for a recurrent cross-union. This might be due to soft tissue contractions and could be addressed with aggressive physiotherapy, although this requires further investigations. A resection of the radial head in delayed diagnosed cross-union with ankylosis of the elbow might still be necessary to reach an acceptable range of motion. The patient's parents should be involved in detailed discussion with medical staff to explain and clarify all the options available and possible outcomes since their child might be handicapped in performing some types of manual work.

The limitation of this study relates to the inherent problems of retrospective evaluations and the small number of patients that makes it difficult to draw reliable conclusions. Furthermore, a longer follow up of these patients to address recurrence of cross-unions and range of motion of the forearm would be beneficial.

Conclusions

Postoperative cross-unions are rarely seen in the pediatric population and there is no consensus as to treatment. We suggest resection within 6-24 months without necessarily an interposition technique. For delayed treatment, resection of the radial head as salvage procedure can be performed. We advocate postoperative oral therapy with NSAID in all patients and irradiation in cases of delayed treatment of cross-unions; however, cases must be evaluated on an individual basis. All patients should be treated with intensive physiotherapy and continuative postoperative follow up to prevent a loss of range of motion.

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