ORIGINAL ARTICLE

Percutaneous Kirschner Wire fixation in distal radius metaphyseal fractures in children: does it change the overall outcome?

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Abstract

Background and Objectives: The aim of this study was to determine the effect of Kirschner wire fixation after closed reduction of radial metaphyseal fractures with high risk of redisplacement.

Patients and Methods: In this retrospective study 40 cases were studied in two groups. In group 1 (n=20, average age 11.2 years), K-wire fixation was performed after closed reduction. In group 2 (n=20 average age 10.1 years), only plaster immobilization was applied following closed reduction. The compared clinical and radiological parameters were, pain, limb deformitiy, range of motion of the wrist, angulation of the fracture site, radial distal epipihyseal angle and severity of translation.

Results:Redisplacement rate was 10% in group 1 and 50% in group 2. This shows, Kirschner wire fixation has a positive effect in the maintanence of the initial reduction ($p<0.05$). Age, gender, reduction quality had no effect on redisplacement ($p>0.05$). Concerning the severity of translation, the risk of redisplacement increases in stage 3 (50%-100%) and stage 4 (>100%) fractures ($p<0,05$). Concomitant complete ulnar fracture has also redisplacement risk ($p<0.05$). Redisplacement risk increases when the distance of fracture line to epiphyseal line was between 11-20 mm ($p<0.05$). There was no significiant difference between two groups after last evaluation based on radiological parameters and clinical results ($p>0.05$).

Conclusions:This study shows that Kirschner wire fixation prevents redisplacement in early follow-up of first three weeks but there is no superiority after 20 months follow-up in distal metaphyseal fractures of children. Hippokratia 2010; 14 (4): 265-270

Key words: radius, metaphyseal, fracture, kirschner wire

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Distal metaphyseal fractures of the radius are the most common childhood fractures (20.2%)[1]. The most commonly use treatment modality is closed reduction and immobilization in plaster. Conservative treatment is gold standart in long term follow up of children with distal radius metaphyseal fracture[2]. The most important problem in this treatment is to maintain the reduction in a plaster brace; loss of reduction and malunions are frequently seen[3,4]. In order to choose the best treatment modality, it is very important to identify the patients with high risk of reduction loss. Although this subject is not clear in the English literature, translation to either radial or ulnar side more than half of the bone diameter was reported as the most important risk factor [5]. Beside this, volar angulation, non-anatomic reduction (in the first manupulation), associated ulnar fracture at the same level of radius fracture, experience of the surgeon, quality of the plaster and type of anesthesia are common risk factors for the loss of reduction of conservative treatment[5-13].

Metaphyseal fractures of the distal radius in children have high capability of remodelling when compared with adults, therefore functional loss is infrequent in children. However loss of rotational capacity of the forearm was reported in 15-29% of the cases after closed treatment[5,14,15]. Functional loss could be persistent even after prompt remodelling of the angular deformity[15-.18]. Fixation with percutaneous Kirschner wire (K-wire) is recommended in patients who carry high risk of reduction loss after clesed treatment in order to prevent forearm rotationa loss[7-9, 19-23].

In this study pediatric patients who had distal metaphyseal radius fracture with high risk of reduction loss were reviewed retrospectively. The patients were divided into two groups. K-wire fixation was used in one group, and the remaining patients were treated with plaster immobilization only. We aimed to determine the effect of percutaneous K-wire fixation after the first reduction manoeuvre in the patients who had risk of reduction loss in the plaster brace.

Material and Methods

In this study 40 patients (5-15 years old) who had distal metaphyseal radius feacture and who had high risk of reduction loss were reviewed retrospectively. All the patients were treated at the same center. Translation more

than half of the bone diameter, associated ulnar fracture at the same level of the radius fracture, angulation of 30˚ under the age of 10, and 20˚ after the age of 10, boyanet position and volar angulation were accepted as unstable fractures[2,3,5].

The patients who met the inclusion criteria above were divided into two groups according to treatment of choice. The patients were assigned to one of the two groups retrospectively. Group 1 (20 children) included the patients who were treated with closed reduction, percutaneous K-wire fixation and plaster bracing and group 2 (20 children) included the patients who were treated with closed reduction and plaster bracing.

For the fixation of the fractures in group 1 one K-wire was used in 12 (60%) patients and two K-wires were used in 8 patients (40%). K-wires were removed at third week in 11 (55%) patients and at fourth week in 9 (45%) patients.

The patients in group 1 were all treated in operating room under fluoroscopy and general enesthesia. K-wires were removed three to four weeks after the formation of radiologically visable callus. The reduction of the fractures in group 2 were performed in emergency room under sedative anesthesia. Long arm plaster brace (elbow in 90˚ flexion) was applied to all patients after the reduction was confirmed radiologically. Elbow motion was allowed at third week and the plaster was removed at sixth week.

Initial, after reduction, early follow up (6 week), late follow up (average 20 months) and normal side x-rays of the patients were evaluated. Translation, angulation, epiphyseal angle and the distance between the fracture line and physis were measured by the same othopaedic surgeon.

Translation was defined as displacement at radial-ulnar plane and it was classified into four grades: grade 1 no translation, grade 2 translation less than half of the diameter of the bone, grade 3 translation more than half of the diameter of the bone and grade 4 complete translation [5]. Angulation was defined as displacement at volar-dorsal plate.

Quality of reduction was classified radiologically. Reduction without any translation and angulation was accepted as anatomic reduction. Less than 10˚ angulation or less than 2 mm translation was accepted as good reduction, and 10˚-20˚ angulation or 2-5 mm translation or less than 5˚ of radial deviation or 5˚-10˚ angulation with less than 2 mm translation were all accepted as fair reduction[12].

In the follow up x-rays of the patients, more than 10˚ of volar or dorsal angulation, more than 5˚ of radial deviation, more than 3 mm translation or 2-3 mm translation with 5˚-10˚ angulation were evaluated as loss of reduction[12].

The latest follow up records of the patients were used for functional evaluation. More than 15˚ loss of motion in any direction when compared with normal side was accepted to be due to the fracture. Resistant pain or visable deformity were also evaluated as clinical failure[5].

In statistical analysis the suitability of data to normal distribution was confirmed with Kolmogorov Smirnov test. The data which did not fit to normal distribution was compared according to the groups with t test and the data which fit to normal distrubition was compared according to the groups with Mann Whitney-U test. The qualitative data was analyzed with the help of ki-square and exact ki-square tests. Spearmen Correlation Analysis was used to observe relations between the variables. General Linear Model Benferroni test was used for the multiplet comparison of angular changes in initial, post-reductive, early follow up and late follow up radiographies in each group. For all tests, p values less than 0.05 was accepted as the statistically significant value.

Results

The average age of the patients was 11.2 (5-15 years) in group 1 and 10.1 (6-14 years) in group 2; statistically both groups were identical according to average age ($p>0.05$). Average follow up was 19 months (6-84 months) for group 1 and 22 (6-84) months for group 2; there was not any statistically significant difference between the groups ($p>0.05$).

Ipsilateral distal metaphyseal ulna fracture (8 green stick, 9 complete fractures) was observed in 17 (85%) patients in group 1. There were 16 (80%) ipsilateral distal metaphyseal ulna fractures (7 green stick, 9 complete fracture) in group 2.

When range of motion of the fractured side was compared with normal side during the last follow up no

Table 1: Average wrist motion according to the groups.

Wrist Motion	Group 1 Ave. (min-max)°	Group 2 Ave. (min-max)°	p value p<0.05
Dorsal flexion	74(60-90)	73(60-85)	0.044*
Palmar flexion	75(60-90)	74(50-90)	0.943*
Ulnar deviation	32(20-45)	32(20-45)	0.989*
Radial deviation	22(10-40)	21(15-30)	0.478*
Pronation	85(60-90)	80(60-90)	0.018**
Supination	81(60-90)	81(70-90)	0.843*

(*): t test (**): Mann Whitney U test, Ave: Average

statistically significant difference was observed for each group ($p>0.05$), however when average range of motion was compared between the groups, degree of pronation in group 2 was smaller than group 1 ($p<0.05$) (Table 1).

The difference between the measurements of the fractured side and the normal side was presented in Table 2. These measurements were evluated statistically. In group 1 there was not any statistically significant difference between the values obtained from postreductive and early follow up radiographs ($p>0.05$), however, for group 2 this difference was statistically significant ($p<0.05$).

The patients were also evaluated statistically for the quality of reduction. In group 1 we obtained four (20%) anatomic, fifteen (75%) good and one (5%) fair reduction, for group 2 patients there were 2 (10%) anatomic, 16 (80%) good and 2 (10%) fair reducutions. The statistical evaluation showed no significant difference between the two groups in terms of reduction quality ($p>0.05$).

Redisplacement was seen in two (10%) patients in group 1 and 10 (50%) patients in group 2. The difference of redisplacement ratio between the two groups was statistically significant ($p<0.05$).

Besides angular measurements, the distance of fracture line to the physis was also measured (Table 3). The mean distance was 14,9 mm (6-26 mm) in group 1 and 16 mm (5-30) in group 2. This difference between the groups was not statistically significant ($p>0.05$).

We investigated the possible factors causing redisplacement. While the effect of age, sex and quality of reduction on redisplacement was not statistically significant ($p>0.05$), 11-20 mm of distance of fracture line to physis, grade 2 or more translation, and complete fracture of the ulna had statistically significant effect on redisplacement ($p<0.05$).

In our patients average number x-rays was 9 for group 1 and 13 for group 2. This difference was not statistically significant.

Kirschner wire migration was seen in four patients (20%) without any clinical sign in group 1. Infection, neurovascular or physeal injury was not seen in our patients. One patient in group 2 was complicated with pressure sore due to plaster brace which was treated with wound care and it was healed with scar tissue; and one patient in this group had median and ulnar nerve dysfunction which was completely recovered in 12 months. Compartment syndrome or physeal growth arrest was not seen in any of the patients.

Figure 1: 10 year old boy had a radius distal metaphyseal fracture (a-b) and he was treated with closed reduction and splinting (Group-1) (c-d). The reduction was lost (e-f) during follow-up, however the family did not allow correction. The fracture was healed (g-h) with 10° loss of supination. The latest follow-up showed remodalization of the fracture (i-j).

Discussion

Distal radius metaphyseal fractures can easily be treated with non-operative treatment in children. How-

Table 2: The differences between the measurements of fractured side and the normal side.

X-rays	Group 1 Ave. (min-max)				Group 2 Ave. (min-max)			
	Angulation (°)		Epiphyseal Angle (°)		Angulation (°)		Epiphyseal Angle (°)	
	AP	L	AP	L	AP	L	AP	L
Initial	21(1-44)	24.5(0-54)	18.2(0-40)	19(1-50)	20.4(0-53)	26(2-40)	18,2(4-54)	22(5-35)
After Reduction	6.3(0-15)	7.5(0-14)	6.2(0-11)	5(0-10)	6.3(1-20)	9,9(2-20)	5,4(0-10)	8(0-20)
Early Follow-up	6.6(0-19)	9.5(0-18)	5.5(0-16)	6.7(1-10)	13(0-32)	14,6(2-34)	11,4(1-26)	12,7(1-29)
Late Follow-up	3(0-9)	4.9(0-14)	3(0-9)	3.8(0-12)	4.2(0-17)	6,3(0-19)	4,3(0-21)	4(0-8)

AP: Anterior-posterior, L: Lateral, Ave: Average

Table 3: The distance of fracture line to the epiphysis.

Epiphyseal Distance	Group 1	Group 2
0-10 mm	4	6
11-20 mm	14	9
>20 mm	2	5
Toplam	20	20

ever they have a high tendency to redisplace in plaster brace. There are still many questions waiting for answer. Should we obtain anatomic reduction in all cases or wait for remodelling of the residual deformity, is plaster brace sufficient for the maintanence of the reduction or should we use additional fixation methods. Challenge on these subjects still continues in English literature[2,5,6,8.10,11,21,24].

Howe and Brudvik[2] evaluated 88 cases (7-15 years old) who had healed distal radius fracture with angular deformity (8 of the cases had more than 15° of angulation), and observed complete remodelling with normal functions after 7 years of follow up; they concluded conservative treatment as golden standart. Fuller and McCullough[24] reported satisfactory remodelling under the age of 14. On the other hand according to Zimmermann et al[25] residual deformity during recovery do not effect long term results under the age of 10, however, bad result is likely when the angular deformity is more than 20° and translation is more than half of the bone diameter after the age of 10.

Larsen et al[26] followed 70 patients with distal radius fracture for 3.5 years and found a significant association between epiphyseal angle and change in fracture angulation. In our study we found that angulation of the fracture and changes in epiphyseal angle were correlated

Figure 2: 12 year old boy suffered from distal radius fracture (a-b) and he was treated with closed reduction and percutaneous Kirschner wire fixation (Group-2) (c-d). The fracture was healed without any sequela (e-f).

significantly ($p<0.05$) in both groups, we did not observe and overcorrection. Therefore we think that epiphyseal angle is a useful instrument for radiological follow up of distal radius fractures.

The most important problem in the treatment of childhood radius distal metaphyseal fractures is redisplacement. Voto et al[11] evaluated 90 patients who were remanipulated due to redisplacement, and reported that redisplacement was seen in the first two weeks of the reduction and can be remanipulated safely in the first 24 days. In our study all redisplacements were seen in the first 10 days. We did not remanipulate any of our patients in group 2. One of the patients in group 1 was remanipulated after the removal of K-wire, and the fracture was fixed with two K-wires after closed reduction.

Many studies investigated unstable fracture patterns which had high risk of redisplacement and risk factors were determined. In their retrospective study including 94 children Mani et al[5] reported 60% failure in the treatment of distal radius fractures which had translation more than half of the bone diameter. In these patients periosteal continuity is lost and therefore they are prone to rotational deformities. Translation exceeding more than half of the bone diameter increases redisplacement risk, and should be fixed with K-wires[21].

Zamzam and Khoshhal[8] reported 25% of redisplacement ratio in their retrospective study including 183 children and comfirmed that translation was the most important risk factor. They also stressed the need of K-wire fixation in these patients; anatomic reduction in the presence of translation would not decrease the risk of redisplacement. In our study redisplacement ratios were found as 50% for group 2 and 10% for group 1. This difference between the groups was statistically significant ($p<0.05$). K-wire fixation improved the results and decreased the rates of redisplacement. Translation more than half of the bone diameter (grade 3 and 4) significantly increased redisplacement ($p<0.05$). It was also founded founded that 11-20 mm of distance of fracture line to physis also carried a risk of redisplacement. On the other hand quality of reduction (anatomic reduction) did not affect the rates of redisplacement ($p>0.05$). We suggest K-wire fixation of completely translated fractures to decrease the risk of redisplacement.

Zamzam and Khoshhal[8] and Bohm et al[27] mentioned that associated ulnar fracture increased the risk of redisplacement in distal radius fractures. In our series associated ulnar fracture significantly increased the risk of redisplacement ($p<0.05$), therefore in the presence of ulna fracture K-wire fixation can be used for the fixation of distal radius fracture to prevent redisplacement.

Haddad and Williams[6] discussed about the experience of the surgeon who performed the reduction and plaster. Under experienced hands the risk of redisplacement was decreased. In our study all reductions were

performed by senior residents therefore we did not make any comparisons about this subject.

In our study we compared the range of motion of wrist in all directions between the two groups, and between the normal side and the fractured side for all grous. Loss of pronation was significantly higher in group 2 ($p<0.05$), however in group two the pronation difference between the normal side and the fractured side was not statistically significant ($p>0.05$). In our study there were two patients who had loos of rotational motion more than 15˚ (one in group 1 and one in group 2). The patient in group one was a multitraumatized patient. Loss of motion was thougt to be due to prolonged immobilization and lack of rehabilitation. The patient in group 2 had 7˚ of residual radial deviation, therefore the loss of motion was due to narrowing of the interosseous space. Improvement of motion is expected in this patient with further remodelling. Since distal fragment of the fracture with volar angulation is at pronation, Zimmermann et al[28] found loss of supination in these fractures. We had two fractures with volar angulation, however supination loss was not seen in our patients.

McLaughlin et al[10] prospectively investigated 68 unstable distal radius fractures. They divided the patients into two groups. Closed reduction and plaster immobilization was applied to 33 patients and closed reduction, K-wire fixation and plaster immobilization was applied to the remainder. After 3 months of follow up functional results were not statistically different. Redisplacement was seen in 7 patients in closed reduction and plaster immobilization group; no redisplacement was seen in the other group. It was concluded that in completely displaced fractures, even after anatomical reduction, there is a high risk of redisplacement, therefore K-wire fixation was recommended in these fractures to maintain alignment. Besides this follow up intervals increased and radiography frequency decreased in K-wire fixation group, and overall radiation uptake of these patients decreased. In our patients average number x-rays was 9 for group 1 and 13 for group 2. This difference was not statistically significant. On the other hand the reduction of group 1 patients was performed under fluoroscopy, however group 1 patients were not affected from fluoroscopic irradiation.

Choi et al[21] reported 5.7% superficial pin tract infection and 1.4% neuropraxia, Muratlú et al[22] reported 4.5% superficial pin tract infection and McLaughlan et al[10] reported one K-wire migration which required surgical intervention as complications. In our series we had four (20%) pin migration which was diagnosed on x-rays. However they did not present any clinical symptoms, and we did not remanipulate these patients. Pin tract infection, neurovascular and physeal damage, compartment syndrome and osteomyelitis were not observed in our cases.

Conclusion

In this study it was found that, the risk of redisplacement significantly decreased after K-wire fixation of distal radius fractures in children. Besides this after K-wire fixation the plaster was not thightened to achieve three point fixation. Follow-up of compartment syndrome and swelling was easier and safer with loose splinting. The reliability of the patients and parents to the treatment increased, because follow-up intervals increased and the need of x-ray decreased for these patients. On the other hand, although we did not see any complications in K-wire fixation group, serious complications like physeal growth arrest, osteomyelitis and neurovascular damage can be seen. There was no difference between the groups functionally and radiologically in our study. After 20 months of follow up results of both treatment modalites did not show superiority to each other. We think that advantages and disadvantages of both treatment modalities should be explained to parents and the child, and the choice should be done according to the expectations of the family.

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