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Intra-Medullary K-wiring in Forearm Fractures in Children

Gabriel Liu* MB, Bch, BA●, M. Med(Sc), FRCS I, Hui Ho Po, James** MBBS, FRCS(Ed), FAMS, Eng Hin LEE*** MD, FRCS(C), FAMS

*Registrar Department of Orthopaedic Surgery National University of Singapore Singapore

**Assistant Professor Department of Orthopaedic Surgery National University of Singapore Singapore

***Professor & Dean Faculty of Medicine National University of Singapore Singapore

Abstract This is a prospective review of 36 patients with unstable displaced forearm fractures who were treated by intramedullary Kirschner(K) wires splint from September 1998 to September 1999. 28 boys and 8 girls were included. The mean age was 10 years old with an average follow-up period of 15 months. The indications of intramedullary fixation were failure in conservative treatment in 29 patients, open fracture in 4 patients, floating elbow in 2 patients and multiple fractures in a child. 23(64%) patients had closed fracture reduction and 13(36%) patients required open reduction.

The mean period for cast and K-wires removal was 8 weeks after operation. The results were 33(92%) patients had full range of motion and 3(8%) patients had decreased supination and pronation. There was superficial wound infection found in 3 patients who had trancutaneous K-wire placements. One patient had transient numbness on the ulna border of the palm after open reduction of ulna fracture and another suffered transient radial nerve palsy. There was also one patient who suffered osteomyelitis of the radius after treatment of her open fracture. There was no implant failure. All fractures healed.

In majority of the fractures, most healed with minimum complication and had good clinical results. We recommend K-wire intramedullary forearm fixation as a safe technique in the treatment of diaphyseal children forearm fracture.

Introduction

Children forearm fracture represents a total of 45% of all children fractures. Due to the intrinsic remodeling capacity, these fractures are treated traditionally by closed reduction and casting[1)2)8)15)25)]. However in older children, in particular for female patient from the age group of 8 years and above and for male patient from the age group of 10 years and above, such remodeling process is less efficient[4)17)27)]. This is more apparent in mid shaft fractures than distal forearm fractures[1)10)22)]. A significant of 5～32% unsatisfactory fracture corrections with redisplacement, malunion and limitation of functions have been recognized through this mode of treatment[15)18)23)]. Although these complications had been managed successful with

Key words : Children forearm fracture—Intramedullary K-wire fracture fixation

remanipulation and casting[23] yet the risk of delayed fracture angulation in cast has prompted the need for internal fracture fixation to reduce such complications[1][17][27].

In adult, internal fixation by osteosynthesis with plate and screws is the preferred treatment[15][20]. It allows early limb rehabilitation without the hindrance of external casting. The same principle has been applied for the treatment in children forearm fractures[13][27] with surgical morbidity. The need of extensive surgical exposure, tissue dissection, disturbance of fracture haematoma and the neccessity of implant removal with subsequent risk of refracture[16][21][24] have lessened the enthusiasm of such procedure in children[15][21].

In addition ; mild to moderate angulation is well-tolerated in children[1][2][6][7][10][11], this further narrow the indication for plate osteosynthesis and leads to the use of intramedullary fixation techniqus. Van der Reis described the results at 1 year post operation for both group of patients treated with plate osteosynthesis and intramedullary splinting methods as being comparable. But intramedullary fixation technique offers the advantages of short operative time, minimal soft tissue dissection, excellent cosmesis and the ease of hard wear removal[21]. This leads to a trend towards elastic/flexible intramedullary fixation of paediatric forearm fracture in the last decade[11][12][14][15].

The recent use of Kirschner (K) wires in various centers offer additional benefits[17][18][19][26][28].

It is our objective in this study to validate the above mode of treatment.

Methodology

A total of 289 forearm fractures either both bone or single bone fractures have been managed in this institution for the period from September 1998 to September 1999. Of this, a total of 36 patients were treated with closed fracture reduction with intramedullary K-wire fixation. The criteria for operative fixation were open fracture, floating elbow and inability to maintain or obtain fracture reduction to less than 15° of mal-alignment by conservative means. Once fracture reduction was achieved, the radius was pinned with a K-wire from distally to proximal at Lister tubercle, whereas the ulna was pinned in an antegrade fashion via olecranon process.

Either radius and ulna or single forearm bone were splinted intramedullary. Closed reduction with intramedullary fixation was first carried out to the radius fracture site. The rationale of this treatment was to stablize the radius as it was this bone which had the more complicated function of the two forearm bones[9]. This was followed by a closed method of ulnar fracture reduction under image intensifier guidance. Should stable, near anatomical fracture reduction be maintained, no ulnar intramedullary implant would be introduced[5][9]. An above elbow cast was applied. All K-wires were removed once the fracture consolidated.

An evaluation comprising of demographic data, type of reduction, complication and range of forearm motion after fracture union were studied.

Operative Technique

The patient was put under general anaesthesia. The injured limb was positioned on a radiolucent table. Closed fracture reduction was performed and assessed under image intensification. Should the fracture reduction pattern fit the study inclusion criteria, intramedullary

Table 1. A summary of patient demographic and operative result :

	Sex	Race	Age	Fracture Open/ Close	Fracture Radius/ Ulnar	Operative Indication	Fixation R/U	Reduction	K-wire Position	LAC (wk)	K-wire (wk)	Final Angulation (F/U)	Lack of Supination	Lack of Pronation	Complication
1	M	Ch	7	C	U	FC	U	C	T	8	8	0	0	0	SPI
2	M	Ma	11	C	R	FC	R	O	T	10	10	0	0	0	SPI
3	M	Ch	12	C	R/U	FC	R/U	C	S	8	8	0	0	0	None
4	M	Ch	7	C	R	FC	R	C	S	8	8	0	0	0	None
5	F	Ch	9	C	R/U	FC	R/U	C	T	7	7	0	0	0	None
6	M	Ch	11	C	R/U	FC	R/U	C	T	10	10	0	0	0	None
7	F	Ch	14	C	R/U	FC	R/U	O	S	10	10	0	0	0	None
8	M	Ch	13	C	R/U	FC	R/U	C	S	9	9	0	0	0	None
9	M	Ma	5	C	R/U	FC	R/U	C	S	6	6	0	0	0	None
10	M	Ch	11	C	R/U	FC	R/U	C	S	8	8	0	0	0	None
11	M	Ch	12	C	R	FC	R	C	S	8	8	0	0	0	None
12	M	Ch	11	C	U	FC	U	C	T	8	8	0	0	0	SPI
13	F	Ma	6	O	R/U	OF	R/U	O	T	6	6	0	0	0	None
14	M	I	4	C	R/U	FE	R/U	C	S	10	10	10/5	45	45	TRNP
15	M	Ch	12	C	R/U	FC	R/U	C	S	8	8	—	—	—	No follow up
16	M	Ch	12	C	R/U	FC	R/U	C	T	8	8	0	0	0	NoneI
17	M	Ma	14	C	R/U	FC	R/U	O	S	10	10	0	0	0	NoneI
18	M	Ma	8	C	R	MF	R	C	T	8	8	0	0	0	None
19	M	Ch	6	C	R	FC	R	O	S	8	8	0	0	0	SU
20	F	My	9	O	R/U	OF	R/U	O	T	10	10	0	0	0	None
21	F	Ch	9	C	R/U	FC	R	C	S	8	8	0	0	0	None
22	F	Ch	10	C	R/U	FE	R	C	T	6	6	0	0	0	None
23	M	Ch	15	C	R	FC	R	O	T	9	9	0	0	0	None
24	M	Ch	15	C	R/U	FC	R/U	O	S	10	10	0	0	0	None
25	M	Ch	12	C	R/U	FC	R/U	O	S	10	10	0	0	0	None
26	M	Ch	13	C	R/U	FC	R	C	T	7	7	0	0	0	None
27	M	Ch	11	C	R	FC	R	C	S	9	9	0	0	0	None
28	M	Ch	8	C	R/U	FC	R	C	S	6	6	0	0	0	None
29	F	Ch	9	C	R/U	FC	R/U	O	S	24	24	0	30	30	None
30	M	Ch	15	C	R/U	FC	R/U	O	S	13	13	0	0	0	TUNP
31	M	Ch	8	C	R/U	FC	R/U	C	T	6	6	0	0	0	None
32	M	Ma	9	C	R/U	FC	R/U	C	T	8	8	0	0	0	None
33	M	Ma	11	C	R/U	FC	R/U	C	T	8	8	0	0	0	None
34	F	Ch	5	O	R/U	OF	R/U	O	T	8	6	10/5	45	45	OM
35	M	Ma	11	C	R/U	FC	R/U	C	T	8	8	0	0	0	None
36	M	I	12	O	R/U	OF	R/U	O	T	10	10	0	0	0	None

Let : C=Close, Ch=Chinese, F=Female, FC=Failed conservative treatment, FE=Floating elbow, I=Indian, LAC=Long arm cast, M=Male, Ma=Malay, MF=Multiple fracture, My=Mynmese, O=Open, OF=Open Fracture, OM=Radial osteomeylitis, R=Radius

K-wires fracture splinting techniques would be employed. The fracture ends were manipulated to 50% opposition to ease the K-wire passage. The patient was clean and drapped. 1 cm longitudinal skin incision was made on the medial side of the Lister tubercule, blunt dissection was made down to bone to avoid iatrogenic tendon injury.

The patient's hand was volar flexed to 90° to expose the bony entry point and to splint the extensor pollicis longus tendon in position lateral to the Lister tubercle. The fracture reduction was maintained by a constant longitudinal traction. A straight 1.6 mm K-wire was an-

chored just medial to the Lister tubercle at the 15~20° to the radial shaft of the radius.

The K-wire was driven directly into the radius using an air drill. It passed through the reduced fracture site to proximal radial epiphyseal plate under image intensifier guidance. A similar procedure was repeated either in antegrade fashion at 1 to 1.5 cm down from the tip of the olecranon process or just proximal to the ulnar styloid process. The ulnar styloid process K-wire entry point was selected in the case where fracture site was situated at the distal end of the ulnar. If the fracture could not be reduced by close means, a limited open reduction would be used.

The percutaneous portion of the K-wires was bent backwards towards its longitudinal axis. Should one decide to leave K-wire trancutaneously, the wire would be cut at 2 cm from skin to prevent proximal implant migration.

Alternatively, one could cut the wire short and bury the wire end subcutaneous. Care must be taken to position the end of the wire pointing away from the incision site to avoid cutaneous ulcers.

Applied dressing to the wounds and kept the forearm in an above elbow back slab. The patient was discharged at the next operative day. A full cast was applied to replace the back slab a week after the operation at the clinic. The K-wires and casts were removed at the clinic or under general anaesthesia as day surgery for trancutaneous and subcutaneous K-wires placement respectively.

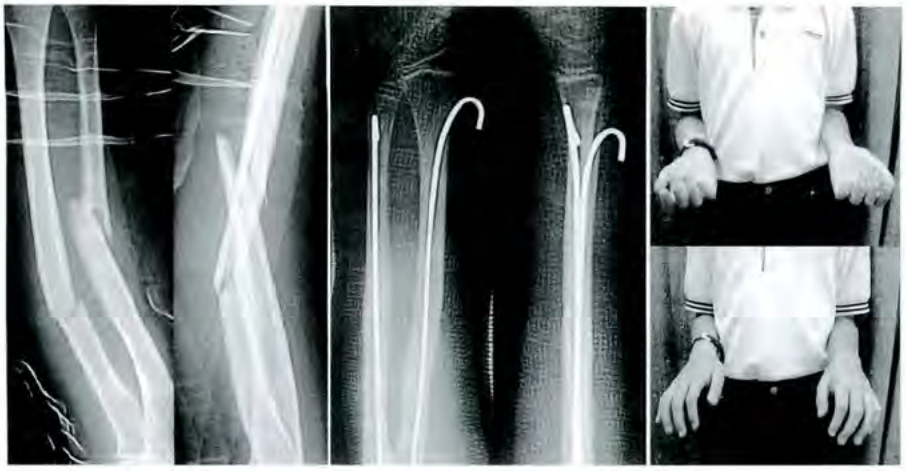
Results

A total of 36 patients were treated with intramedullary K-wiring comprising of 28 boys and 8 girls. The mean age was 10 years old with an average follow-up period of 15 months. The indications of intramedullary fixation were failure in conservative treatment in 29 patients, open fracture in 4 patients, floating elbow in 2 patients and multiple fractures in a child. 23 patients required closed fracture reduction and 13 patients had open reduction.

The mean period for cast and K-wires removal was 8 weeks after operation. One patient required 6 months of K-wiring as she had repeated fractures of the radius and ulna, and was under investigation for osteogenesis imperfecta. At the latest follow-up, 33 patients had full range of motion and 3 patients had decreased supination and pronation. There was superficial wound infection found in 3 patients who had trancutaneous K-wire placements. One patient had transient numbness on the ulna border of the palm after open reduction of ulna fracture and another suffered transient radial nerve palsy. There was also one patient who suffered osteomyelitis of the radius after treatment of her open fracture. There was no implant failure. All fractures healed.

Discussion

Delbet introduced intramedullary fixation of diaphyseal forearm fracture in early 1900[18]. With the modern expansion of various internal splinting methods and devices[7][11][12][14][15], these techniques became a standard of care in the operative treatment of unstable, displaced diaphyseal paediatric forearm fractures[3][17][18][19][21][28]. It employed the principle of a dynamic biologic fixation[17] in patients with excellent fracture remodelling capacity. This results in minimal interference of fracture haematoma, blood supply yet allows micro movement at the fracture site to stimulate



a | b | c

Fig. 1.
a : An 11-year-old boy suffered from a closed fracture of radius and ulna shaft.
b : His postoperative X-rays demonstrated fractures reduction with intramedullary K-wires insertion to achieve three-points contact fracture fixation.
c : His clinical photographs demonstrated full forearm supination and pronation after the removal of intramedullary K-wires.

early bridging callus formation[11][17].

The application of 3-point contact fixation method had been well described in using elastic intramedullary nail such as Metaizeaus, Nancy nail and rush pin[7][15][21].

Although its results was as good as the technique with plate osteosynthesis[13][21], application of these devices has the limitation of stock in different nail lengths, backing out of nail and at high cost[3][11][26].

The use of the standard 1.6 mm stainless steel Kirschner wires not only allowed the flexibility required for 3 point contacts, but was strong enough to resist deformity on its cortical entry and offered service at a low cost[15]. In addition the pre-bent wire tip at 30° aided the closed reduction of displaced fracture and further enhanced the 3-point contact fixation[17][26]. The small diameter of the wire allowed an easier entry of implant into medullary canal[7]. To our knowledge there was no report of premature physeal plate closure reported regarding this technique[24][28], although it required casting as external support.

Our clinical results, complication rates and the need for open fracture reduction were consistent with centers using the same principle of biological fixation[7][14][15][17][19][28]. All fractures united and most of the cases demonstrated an excellent range of motion with minimal complications(Fig. 1).

Cullen et al described his experience in using rush pin as intramedullary splint on 20 children[3]. In his series, 17 patients had both bone forearm fractures and only 8 patients had intramedullary fixation of both bones. Open fracture fixation approach was needed in 75% of his patients and 18 complications occurred in 10 patients were identified which included hardware migration, infection, loss of reduction, reoperation, nerve injury, significant reduction of motion, synostosis, muscle entrapment and delay union. Despite the complications, 95% of these patients had excellent or good clinical results according to Price clinical grading system of forearm fracture. Cullen went on to suggest that 55% of his complications could have been prevented by using intramedullary K-wires as splints in both forearm bone fractures.

The principle was further consolidated by the fact that since both elastic intramedullary splints were in contact with the cortical bone of the radius and ulna at 3 points ; this stretched the interosseous membrane and resulted in additional stability in fracture reduction[15].

Although abundance of information about this technique had been accumulated, there was

a | b

Fig. 2.
a : A 12-year-old boy suffered from closed forearm bones fracture.
b : Intramedullary K-wires were inserted for his fractures fixation and a lesser degree of three-points contact was noted in this case as compared to figure 1 b.

room for development. The distal radial K-wire entry point make use of the fact that the medullary canal was the widest portion of the bone and thus had a lower stress raising effect and minimized the risk of iatrogenic fracture[26]. These sites of distal radial entry points included radial styloid process and Lister tubercle[14)17)21)26)28].

In our series we used the Lister tubercle as the preferred entry point. This appeared to have the potential in reducing the risk of superficial radial nerve damage. It simplified the insertion techniques by avoiding the need of over drilling the near cortex and the use of T-handle bar in manual propellation of K-wires insertion. One potential advantage of using radial styloid as an entry point was that due to it's more curvy line of insertion it could enhance the stability of the 3 point fixation principle and lessens the general criticism of insufficient rotatory stability in intramedullary fixation[14] (Fig. 2).

Other important factors to reduce rotatory instability were fracture stability that was provided by the interdigitation of fracture fragments and the intact portion of the periosteal envelope[14]. In the event of extensive fracture comminution, or large soft tissue defects, which compromised the axial stability of reduction and the muscular tension to maintain fracture stabilization with intramedullary K-wire, plate osteosynthesis technique should be considered[14)15].

The use of an above elbow cast was not only important in maintaining the rotatory instability with the intramedullary splint technique but it gave fracture protection against potential hazardous from daily activities of a young active child.

Re-fractures and loss of reduction after removal of K-wires and cast before 4 weeks postoperatively had been reported[18]. In addition to achieve fracture union, it takes an average of 8 weeks[19)28], we recommended to keeping the K-wires with cast for a total of 8 weeks. In general, joint stiffness after cast immobilization had not been shown to be any problem[15)19)28].

To address the problem of superficial skin infection, one needs to look at whether or not the K-wire is buried subcutaneously or is left transcutaneously. This in turn is determined by the age of the patient. Pugh et al noted that the average fracture union time for children of 10 years old and below was 6.4 weeks whereas in children of 10 years and above was 8.4 weeks[14]. Hence in the anticipation of delay union, such as in older patient and open fracture, we recom-

mended burying the K-wires subcutaneous and sacrificed the convenience of transcutaneous K-wire removal in the office setting.

Finally it is interesting to note that majority of excellent and good clinical outcome of using intramedullary splint in children derives from cases of the age group between 7 to 11 years[14)17)18)26)28)]. Most of the complication found in Cullen's series occurs between 14 to 18 years of age[3)].

This lead one to expect the success of intramedullary K-wire techniques in patients who were less than 14 years old and warrant the caution needed to apply the same technique in children between 14 to 16 years of age. This was probably due to the lack of fracture remodeling ability in older children[4)17)27)] and thus left little room for error in this less anatomical fixation technique.

In summary, we proposed an expectation of success in using transcutaneous intramedullary K-wire in both forearm diaphyseal fractures in children less than 14 years of age.

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