

# Closed reduction with crossed Kirschner wire fixation for displaced supracondylar femoral fractures in young children

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## Abstract

Supracondylar femoral fractures are uncommon in children, but may result in various deformities. Though many approaches have been used to manage them, there is no literally approved standard yet.

From 2015 to 2017, 12 young children at the average age of 2.5 years old (range 3.6–1.6) with displaced supracondylar fractures were admitted to our department and received closed reduction with crossed Kirschner wire (K-wire) fixation as treatment. After the surgeries, we performed follow-up to every patient at the average length of 26 months (range 24–30) and used the Knee Society Score scale to evaluate the outcome.

Fracture healing was observed within 10 weeks for all patients and walking was resumed between 10 to 13 weeks. No patient reported a valgus deformity more than 10°, neurovascular injury or knee infection. The average limb length discrepancy was 0.4 cm at the end of our follow-up. Every patient had perfect score on the Knee Society Score scale.

Our study suggests that closed reduction with percutaneous crossed Kirschner wire is a favorable method for displaced supracondylar femoral fractures in young children.

**Abbreviations:** K-wire = Kirschner wire, KSS = Knee Society Score.

**Keywords:** displaced, Kirschner wire, supracondylar femoral fractures, young children

## 1. Introduction

Supracondylar femoral fractures are considered to be uncommon in children, reported to account for only 7% of all-age-group distal femur fractures and 12% of children's femoral fractures.<sup>[1–3]</sup> However, displaced supracondylar femoral fractures, accounting for approximately 57% of supracondylar femoral fractures and even more rare in children under 4 years old, are more complex, and surgical interventions are more likely required due

to the instability in fracture ends.<sup>[1]</sup> But this type of fracture may result in various complications, such as malunion, length differences between bilateral limbs and genu valgum.<sup>[4–6]</sup> Undisplaced supracondylar femoral fractures can easily reach satisfying outcomes with plaster cast or brace.<sup>[3,7]</sup> Many approaches have been used to treat displaced supracondylar fractures, such as external fixation, plate fixation, percutaneous crossing wiring and epiphyseal pinning.<sup>[1,7–10]</sup> There is no widely accepted conclusion on the optimal treatment yet.<sup>[1,3,4,11]</sup>

Conventional traction has a high probability of failing in anatomically reduction and stabilization due to the unbalanced pull of muscles and distal nature of the fracture. There are many scholars who prefer closed reduction along with percutaneous crossed Kirschner wire (K-wire) and have revealed its ideal outcome literally.<sup>[3,10,12,13]</sup> Known for less invasive, this method is now standard treatment when dealing with displaced paediatric supracondylar fractures of the humerus and distal femoral physal fractures.<sup>[3,14]</sup> Although Smith et al<sup>[1]</sup> reported closed reduction with percutaneous crossed K-wire could achieve securing reduction in a less invasive way, it still needs to cross physis and cannot rule out the risk of damaging the femoral vessels medially.

Closed reduction along with percutaneous crossed K-wire was used to treat supracondylar femoral fractures in young children in the author's institute. This study retrospectively treated 12 cases with this method, and attempt to provide supportive evidence for considering it as the preferred operation for young children.

## 2. Patients and methods

From April 2015 to August 2017, 12 children under 4 years old with displaced supracondylar fractures were admitted to the author's institute. All of their guardians were fully informed of

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JL and JM contributed equally to this work and are the co-first authors.

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the study protocols and signed consents, then the patients received closed reduction with percutaneous crossed K-wire fixation as treatment. To make the definition of a supracondylar fracture clear, the distance from the fracture's center to the knee joint have to be no longer than the widest part of the growth plate (AO/American Orthopaedic Paediatric Long Bone Fracture Classification).<sup>[15]</sup> This retrospective research was approved by the author's IRB institution. Under general anaesthesia with muscle relaxation, reduction by manual traction and flexion was performed in anteriorly displaced fractures and extension in posteriorly displaced fractures. Then fixation was achieved by using percutaneous cross-pinning with 2.0 mm in diameter smooth Kirschner wires under image intensifier control. The pins were left protruding percutaneously after surgeries. All patients received a plaster cast after the surgery and it retained for 3 to 4 weeks. The pins were removed after X-ray evaluation 4 weeks postoperative, then functional rehabilitation began.

Every patient got a follow-up at the average length of 26 weeks (range 24–30) and the Knee Society Score (KSS) scale<sup>[16]</sup> was used to evaluate the recovery of knee joint function. At the meanwhile, information about range of movement, alignment and length difference between bilateral legs was collected.

### 3. Results

The average age of patients was 2.5 years (range 1.6–3.6). All fractures were closed, displaced and non-physcal. According to the AO classification, 7 of them were 33A1, the rest of them were 33A2. Except 3 from traffic accidents, the other 9 were caused by falling from a height. None of the patients were with associated injuries, such as injury of nerves or vessels. General characteristics about patients are shown in Table 1. All patients had operations after 33-hours delay from injuries on average (range 18–52). The average duration of operation was 27 minutes (range 22–32). The intraoperative blood loss was 4.6 mL and the inpatient time was 4.3 days in average. All patients presented evidences of clinical and radiological union within 10 weeks (Fig. 1), and the walking ability was regained between 10 to 13 weeks. Only 1 patient reported superficial infection near the needle-tract, which was easily controlled with oral antibiotics. The function of knees was resumed within 3 months. At the last follow-up, all patients gave a full score on the KSS scale, which indicated satisfying recovery and no pain or movement limitation in knee joint. No patient had a more than 10° valgus deformity,

**Table 1**

**Characteristics about patients.**

No.	Gender	Age, y	Limb	AO Classification
1	F	1.8	R	33A1
2	F	2.4	L	33A2
3	M	2.2	R	33A2
4	M	1.6	L	33A1
5	M	2.8	L	33A2
6	F	3.2	L	33A2
7	M	3.6	L	33A1
8	F	2.5	R	33A2
9	F	2.9	R	33A1
10	M	2.1	R	33A1
11	M	2.4	L	33A1
12	F	3	L	33A1

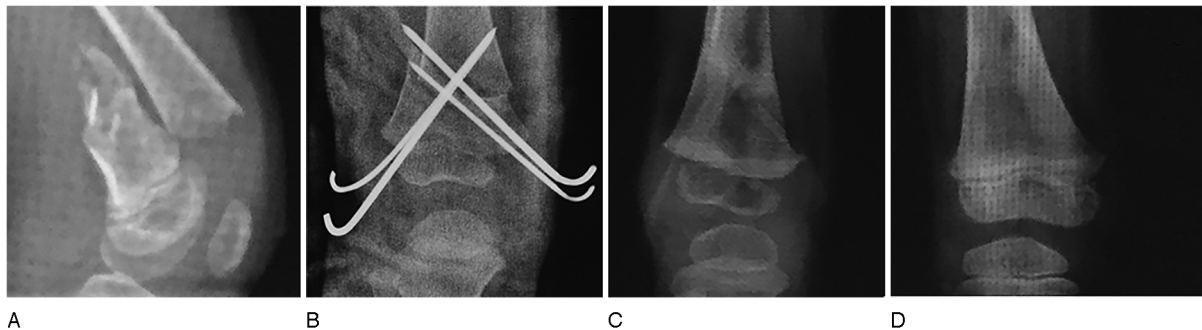
AO classification = American Orthopaedic Paediatric Long Bone Fracture Classification.

and 9 of them were less than 2°. Compared with contralateral limb, the average affected limb length discrepancy was 0.4 cm (range 0.2–0.6). Surgery-related and follow-up information are seen in Table 2.

### 4. Discussion

Displaced supracondylar femoral fractures are rarely seen in young children under 4 years old, who are less likely to be exposed to traumatic injuries.<sup>[17]</sup> The most common cause for these fractures is fall from a height (usually less than 1 m) and pathologic bone is more likely to get injured, perhaps owing to the relatively fragile supracondylar region.

There are various treatments used to deal with displaced supracondylar femoral fractures, and yet there is no widely recommended method in the literature. When choosing a proper treatment, the age and physique of the patient, the injured site, the pattern of the fracture, and whether there are any associated injuries, should be taken into consideration. The advised approach for children has to control alignment, length and rotation, minimizes joint stiffness, and ensure good functional recovery under minimum complications. In the meantime, it should be comfortable and convenient for the patient and family, and cause the least negative psychological impact possible.<sup>[10,18,19]</sup> The unbalanced pull of the gastrocnemius or adductor muscle makes it difficult to control the alignment,



**Figure 1.** A Lateral radiograph of the right supracondylar femoral fracture in a 2-year-old girl. 1B Post-operative anteroposterior view of the same patient. 1C Anteroposterior radiograph two months after the surgery. The Kirschner Wires have been removed and fracture healing is seen. 1D Anteroposterior radiograph at twelve months after the surgery.

**Table 2****Surgery-related and Postoperative information.**

No.	Operation Time, min	Hospital Stay, d	Radiographic Union Duration, w	Walking Resume Duration, m	Limb Length Discrepancy, cm	Valgus Deformity Degree	KSS
1	22	5	8	11	0.4	< 2°	100
2	24	6	9	10	0.5	< 2°	100
3	26	3	8	11	0.2	< 2°	100
4	32	6	8	12	0.6	< 2°	100
5	30	4	8	11	0.5	< 2°	100
6	29	5	8	12	0.6	2–10°	100
7	25	3	8	11	0.3	< 2°	100
8	28	4	9	11	0.5	< 2°	100
9	27	5	8	12	0.3	< 2°	100
10	29	4	8	13	0.6	< 2°	100
11	27	3	10	11	0.2	2–10°	100
12	25	3	8	11	0.2	2–10°	100

KSS = Knee Society Score.

thus the traditional method of traction is likely to fail when used to manage displaced supracondylar femoral fractures.<sup>[1,20]</sup> The prolonged bed rest and hospital stay required also have negative effects on growing children both socially and psychologically. The appliance of hip spica casting is difficult in elder children and there is no guarantee on the control of alignment.<sup>[8]</sup> Some authors advocated that tibial Less Invasive Stabilization System plate had satisfying fixation of distal fracture fragment and presented good outcomes when applied to children, while the disadvantages were the need of another operation for implant removal and more expensive implants compared with traditional ones.<sup>[19,21]</sup> External fixation has been widely used in femoral fractures with a relatively easy procedure and minimal invasion, and it also fits elder children with higher weight. But the risks of pin-tract infection, refracture, bending and delayed union were reported literally.<sup>[22–24]</sup> Parikh et al<sup>[25]</sup> used elastic nailing for paediatric supracondylar femoral fractures and reported a high complication rate (38%).

Though closed reduction with percutaneous crossed K-wire has been reported used for paediatric displaced supracondylar femoral fractures, there was no research focused on young children. Its prominent feature lies on being less invasive, which indicates benefits of appearance and following function rehabilitation. Short inpatient time also helps the children return to family and school. However, Smith et al<sup>[11]</sup> thought that closed reduction and percutaneous fixation with crossed wires had to either cross the growth plate or articular cavity to achieve fixation, where there were risks of damaging the femoral vessels medially and growth disturbance for the former option and purulent arthritis for the latter one. But in fact, epiphyseal injury is not likely to occur due to K-wires penetration. A destruction of 7% of the cross-sectional area of the growth plate was required to cause permanent growth disturbance and shortened limb in an experimental study of rabbits.<sup>[26]</sup> The smooth K-wires used in our study were only 1.5 to 2.0 mm in diameter, which means the penetration area was approximately 1% of the growth plate. According to the results of this research, neither growth disturbance nor significant limb length discrepancy was reported, which coincides with existing results of former researches dealing paediatric supracondylar femoral fractures with percutaneous pinning.<sup>[3,4]</sup> Purulent arthritis is barely seen in existing literature with avoidance of entering the articular cavity during penetration, strict septic manipulation in surgery and mature antimicrobial prophylaxis when needed. According to our follow-up

findings, the long-term function rehabilitation was quite satisfying. All patients regained full range of motion of the knee without hyperextension or pain while walking. Three patients in our study had valgus deformity between 2° to 10°. Since we limited the age of patients to under four, a minor valgus deformity within 10° among children in this age can be regarded as physiological, and may persist or gradually get diminished over time.<sup>[27,28]</sup> While Butcher et al<sup>[3]</sup> reported 2 cases of 10° flexion deformity and one 11° to 20° sagittal deformity with 6° to 10° valgus deformity among a total of 9 patients with 10 displaced supracondylar fractures, it may be due to the complexity of injuries and older age of children (average age of 8.3 years old and range 5–13). All patients in this research were younger children under 4 years old with closed fractures without associated injuries. They maybe more suitable for less invasive methods and are more likely to reach fracture union without stiffness and deformity.<sup>[29]</sup> For older children who weigh more, K-wires may not be able to provide sufficient mechanical support and anti-rotational stability, which indicates risks of delayed union or malunion. Thus, we prefer percutaneous K-wire in younger children without severe associated injuries.

The small sample size and relatively not long enough follow-up period is real limitations of this study. Further studies with more cases and long-term follow-up are necessary. But this study still provides evidence that closed reduction with percutaneous crossed K-wire is a favourable method for displaced supracondylar femoral fractures in young children.

### Author contributions

XT, JW, KLC, XKG, and CJY were involved in data collection and follow-up assessments. XT and JL were responsible for literature search, study design, JWM and JL drafting the manuscript. JWM and XT finalized the manuscript. Xin Tang orcid: 0000-0002-6860-6530.

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