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Is biodegradable pin a good choice for lateral condylar fracture of humerus in children

A comparative study of biodegradable pin and Kirschner wire

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Abstract

Introduction: Lateral condylar fracture (LCF) of the humerus in children is one of the commonest elbow injuries in children. Early recognition of the problem and appropriate management usually yields satisfactory outcomes. Closed or open reduction with Kirschner-wire (KW) is a cost-effective choice of fixation method for displaced fracture. However, various other methods, including partially threaded cannulated cancellous screw and biodegradable pin (BP), have also been used. This study aimed to investigate the efficacy of BP and compare its clinical outcomes with KW.

Material and methods: Patients with LCF admitted from January 2008 to January 2016 at our institute were reviewed retrospectively. Baseline information and clinical data were collected from Hospital Database. Patients were divided into the KW group and BP group.

Results: In all, 85 patients (male 50, female 35) in the KW group and 76 patients (male 47, female 29) in the BP group were included in this study. The average age of patients in the KW group was 5.2 years, and that of BP was 5.9 years. No nonunion or malunion was observed in either group. At the last follow-up visit, there was no statistically significant difference between the 2 groups with regard to elbow function and appearance. The incidence of long-term complications, including avascular necrosis, fishtail deformity, and lateral prominence, showed no significant difference between both the groups. The incidence of hardware prominence was higher in the KW (13/85, 15.6%) than BP (2/76, 2.6%) group ($P < .001$).

Conclusions: Both KW and BP are safe and effective choices for LCF of the humerus in children. Both the implant designs produce satisfactory and comparable clinical outcomes. However, BP has the advantage of less hardware prominence, no need for hardware removal, and fewer long-term complications.

Abbreviations: AVN = avascular necrosis, BP = biodegradable pinning, CRPP = closed reduction and percutaneous pinning, KW = Kirschner wire, LCF = lateral condylar fracture, ORIF = open reduction and internal fixation, TMC = trimethylene carbonate.

Keywords: biodegradable pin, internal fixation, Kirschner wire, lateral condylar fracture

1. Introduction

Lateral condylar fracture (LCF) of the humerus is one of the commonest elbow injuries in children.[1,2] Early recognition of the problem and appropriate management usually yields satisfactory outcomes. Surgery is highly recommended for displaced and unstable LCF in order to avoid complications.[3] KW is a cost-effective choice for fixation, but whether it should be buried under the skin remains controversial.[4,5] Biodegradable pin (BP) has been used to treat pediatric fractures,[6–8] but certain complications, including osteolysis, loosening, and resultant secondary displacement, have been reported.[9,10] To our knowledge, this study is the first study to compare clinical

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The authors report no conflicts of interest.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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outcomes between KW and BP in head-to-head fashion for the treatment of LCF of the humerus and evaluate the possible long-term complications of BP in vivo.

2. Patients and methods

Patients with LCF of the humerus operated at our institute, from January 2008 to January 2016, were reviewed retrospectively. Inclusion criteria were: patients managed with open reduction and internal fixation (ORIF) with either the use of KW or BP, presentation within the period of 2 weeks after the trauma, availability of both the clinical and radiological data, and the follow-up period of 48 months or more. The exclusion criteria were: open or pathological fracture, concomitant injuries (fractures or dislocation), and previous elbow fracture or instrumentation.

The patient's legal guardians were thoroughly explained about each of the procedures, including CRPP, ORIF with KW or BP, and risks and benefits of the procedures as well as implant designs, and let them choose.

The patients were divided into 2 groups, the KW group and the BP group. The KW group consisted of 85 patients, whereas the BP group consisted of 76 patients. Demographic data, including sex, age at the time of surgery, operated side, and implant material, were collected from the hospital database. Preoperative radiographs were reviewed and classified according to Jakob classification.[10] Baumann angle, carrying angle, avascular necrosis, lateral prominence, and fishtail necrosis were recorded during the out-patient visits. The function of the elbow joint was evaluated according to Flynn Criteria[11] and the Mayo elbow performance index (MEPI) score.[12] Complications, including infection, malunion, nonunion, cubitus varus deformity, stiffness of the elbow joint, failure of fixation, and exposure of implants, were also recorded.

This study was approved by the Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology on 01/06/2016, and the file number is IORG0003571. Written consent was obtained from the patient's legal guardians.

2.1. Biodegradable pin

BP is made up of a blend of L-lactide, D, L-lactide and trimethylene carbonate (TMC). It has a diameter of 1.5 mm or 2.0 mm and a length of 5.0 cm.

2.2. Surgical technique

Under general anesthesia or brachial plexus block with a pneumatic tourniquet applied on the proximal part of the arm, closed reduction (CR) was attempted for every patient. If the CR was failed to achieve satisfactory reduction, then the patient was managed with either ORIF with KW or ORIF with BP as per the patient's guardian's choice.

2.3. ORIF in the KW group

A lateral incision was made to expose the lateral condyle of the humerus, and the fragment was reduced and fixated by 2 to 3 KW (diameter, 1.6 mm or 2.0 mm). The incision was closed in layers, and the KW was buried under the skin routinely (Fig. 1).

2.4. ORIF in the BP group

Same as in the KW group, a lateral incision was made to expose the lateral condyle of the humerus. After the satisfactory reduction was achieved, the fragment was stabilized temporarily with KW under direct visualization. The length of the KW inside the bone was measured, and then 2 KWs were replaced by BP of the same length. Routinely, the fixation was further strengthened by a 1–0 number bioabsorbable suture in a figure of 8 fashion. Finally, the incision was closed in layers (Fig. 2).

2.5. Postoperative care and follow-up

The operated arm was immobilized in the long-arm posterior slab for 3 to 5 weeks. After removal of the slab, an active range of motion (ROM) exercise was encouraged. Patients were followed-up every month for the first 3 months, then every 3 months until 1 year, and then annually. The KWs were removed in 3 to 6 months after the surgery.

2.6. Statistical analysis

SPSS statistical package program (SPSS 19.0 version; SPSS Inc., Chicago, IL) was used for statistical analysis. The categorical data were analyzed using the χ^2 test, and the continuous data were analyzed using Student t test. Fisher exact test was used under those circumstances with fewer subjects in groups of interest. Data were presented as mean ± SD (range), median (range), or n (%). $P < .05$ was considered significantly different.

3. Result

As shown in Table 1, there was no significant difference between the 2 groups concerning sex and age. Eighty-five patients, including 50 males and 35 females, were included in the KW group, whereas 76 patients, including 47 males and 29 females, were included in the BP group ($P = .70$). The average age of patients in the KW group was 5.2 years, and that of BP was 5.9 years ($P = .20$). Patients in both groups were followed-up for at least 4 years, with an average of 5.4 years (4–6 years).

There was no nonunion and malunion in both groups. The fracture classification and duration form injury to surgery showed no significant difference between both groups.

As shown in Table 2, at 6-month follow-up, all patients in both groups displayed good to excellent elbow function, with no significant difference statistically ($P = .81$). There were no significant differences in the MEPI score and Baumann angle in both groups. However, the difference in the incidence of hardware prominence was statistically significant ($P < .001$).

As shown in Table 3, there was no incidence of AVN and elbow stiffness in either group. The incidence of cubitus varus was also low in both the groups, which included 2.4% in the KW group and 2.6% in the BP group. There was no significant difference between the KW and BP groups regarding the incidence of fishtail deformity and lateral prominence.

4. Discussion

Both KW and BP are safe and effective choices for LCF of the humerus. BP is able to produce a satisfactory clinical outcome, and is comparable to the KW, with a lower incidence of hardware prominence. Furthermore, the BP has the advantage of not needing second surgery for implant removal. Besides that, the long-term complications, including AVN, fishtail deformity, and lateral prominence, showed no significant difference between 2 groups.

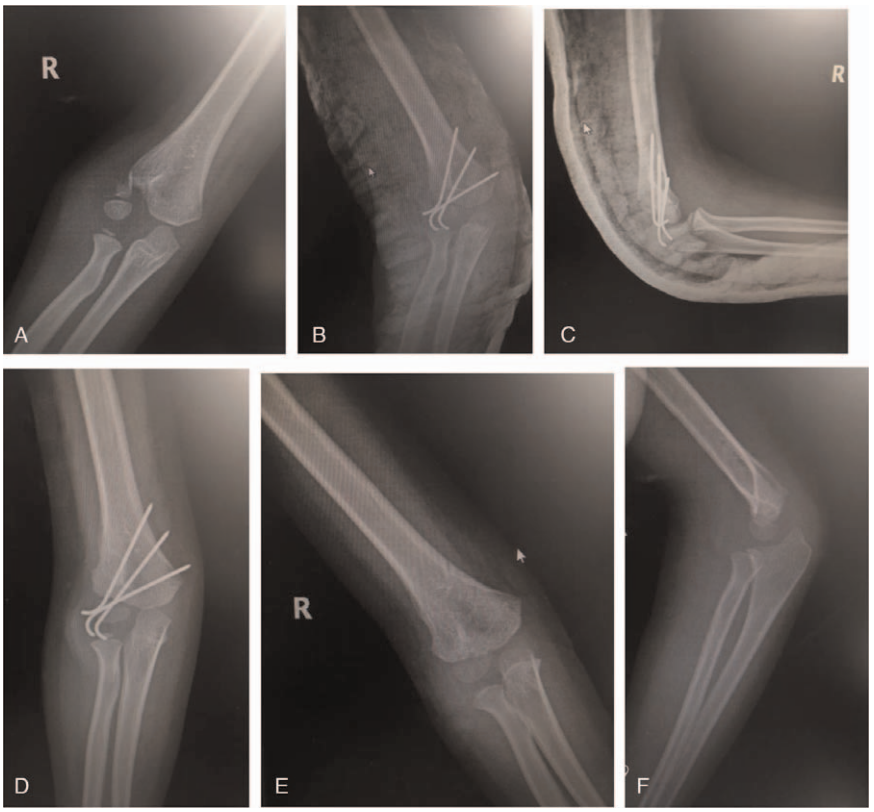

Figure 1. Six-year-old boy with right lateral condylar fracture treated with K-wires. (A) AP view of the elbow before surgery. (B) AP view of the elbow after the surgery. (C) Lateral view of the elbow after the surgery. (D) AP view of the elbow at 3th month follow-up. (E) AP view of the elbow after K-wire removal. (F) Lateral view of the elbow after the K-wire removal.

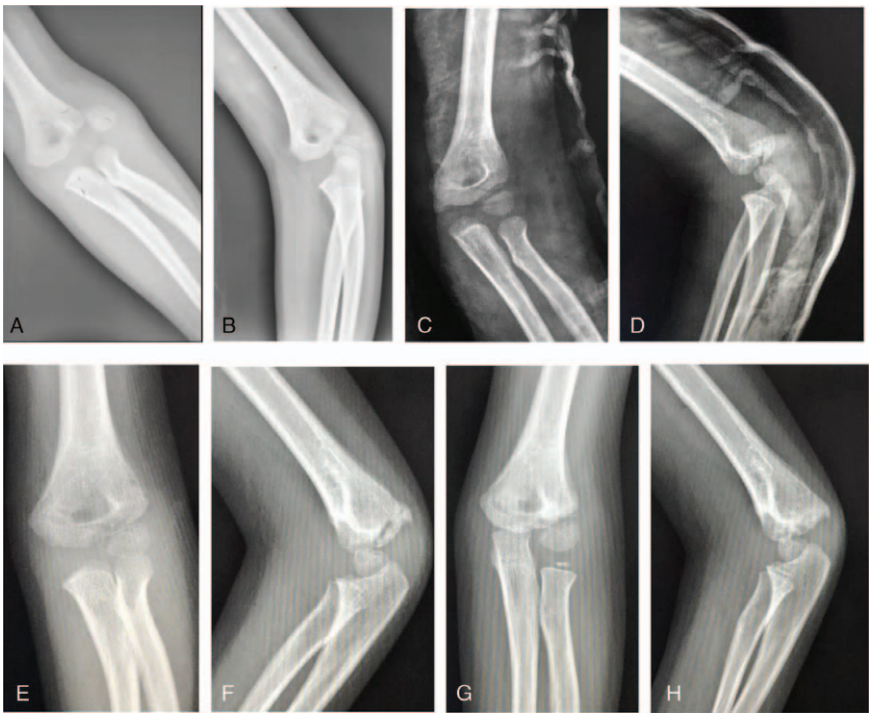

Figure 2. Six-year-old boy with left lateral condylar fracture treated with biodegradable pins. (A) AP view of the elbow before the surgery. (B) Lateral view of the elbow before the surgery. (C) AP view of the elbow after the surgery. (D) Lateral view of the elbow after the surgery. (E) AP view of the elbow at 1st month follow-up. (F) Lateral view of the elbow at 1st month follow-up. (G) AP view of the elbow at 4th month follow-up. (H) Lateral view of the elbow at 4th month follow-up.

Table 1

Demographics of the patients.

Parameters	K-wire (n = 85)	Biodegradable Pin (n = 76)	*P*
Age, y	5.2 ± 1.4	4.9 ± 1.5	.20
Sex			
Male	50	47	.70
Female	35	29	
Side			
Left	51	46	.70
Right	34	30	
Jakob classification			
Type II	30	26	.89
Type III	55	50	
From injury to surgery, days	1.9 ± 0.8	1.9 ± 0.8	.99

Treatment choice for LCF of the humerus depends on the fracture displacement and stability. A modified classification system has been proposed by Song et al[13,14] to clarify the ambiguity of Jakob type I fracture. Indication for surgery includes fractures with equally displaced medial and lateral gaps (Song type III)[15] and fractures with >2 mm displacement (Song type IV and V).

Closed reduction and percutaneous pinning (CRPP) is an intriguing solution with fewer complications, and it has been recommended by certain authors.[16,17] However, in significantly displaced and rotated fractures, CRPP is a challenging task, which might result in prolonged operative time and excessive exposure of x-ray. Cannulated lag screw (CLS) has been reported to be associated with a lower rate of ORIF,[18] but CLS usually requires secondary surgery for implant removal. Both KW and CLS found to produce satisfactory clinical outcomes for a fresh LCF of the humerus.[19] However, KW is the preferred choice at our institute. ORIF with a single absorbable screw has been reported to treat LCF,[20] but it is not a feasible choice for the younger child or smaller fragment.

In this study, there was no case of malunion and nonunion in both groups. Nonunion in the pediatric population is a problematic situation that might be influenced by both systemic and local factors[21,22,23,24,25] and is usually associated with conservative treatment.[26]

Table 2

Clinical outcome of the patients at 6th month follow-up.

Clinical outcomes	KW (n = 85)	BP (n = 76)	*P*
Flynn Criteria on 6th mo			
Excellent	68	62	.81
Good	17	14	
Fair	0	0	
Poor	0	0	
Baumann angle	17.7 ± 5.7	17.4 ± 5.4	.70
Carrying angle	4.8 ± 3.4	4.3 ± 3.1	.29
MEPI score	90.2 ± 3.2	89.9 ± 3.2	.49
Nonunion	0	0	>.99
Malunion	0	0	>.99
NV compromise	0	0	>.99
Exposure of implant	7 (8.2%)	2 (2.6%)	.12
Failure of implant	0	0	>.99
Revision surgery	0	0	>.99
Implant prominence	13 (15.3%)	2 (2.6%)	<.001
Superficial infection	2 (2.4%)	2 (2.6%)	.92
Pain	0	0	>.99

BP = biodegradable pinning, KW = Kirschner wire, MEPI = Mayo elbow performance index, NV compromise = neurovascular compromise.

Table 3

Clinical outcome of patients at final follow-up.

Clinical outcomes	KW (n = 85)	BP (n = 76)	*P*
Flynn criteria			
Excellent	78	70	.69
Good	7	6	
Fair	0	0	
Poor	0	0	
Baumann angle	16.7 ± 3.7	16.4 ± 3.4	.62
Carrying angle	5.8 ± 3.2	5.3 ± 3.3	.22
MEPS	94.2 ± 3.6	93.9 ± 3.7	.29
AVN	0	0	>.99
Unresolved stiffness	0	0	>.99
Cubitus varus	2 (2.4%)	2 (2.6%)	.92
Fishtail deformity	7 (8.2%)	6 (7.9%)	.95
Lateral prominence	7 (8.2%)	6 (7.9%)	.95

AVN = avascular necrosis, BP = biodegradable pinning, KW = Kirschner wire, MEPS = Mayo elbow performance score.

Patients in both groups displayed satisfactory clinical outcomes, and the results were consistent with the previous literature on LCF managed in acute setting.[11,16,17] Since implants in both groups were buried under the skin, the superficial infection rate was as low as 2.4% and 2.6%, respectively. Raghavan et al recommended not to bury the KWs as it required a second surgery for hardware removal, and that was relatively costly in developing countries.[27] However, we routinely buried the KWs under the skin. That led to a higher incidence rate (15.3%) of hardware prominence as the KW was bent to bury under the skin, whereas the BP was cut along the bony surface. Two patients in the BP group displayed implant prominence at the follow-up visit, that's possibly because of degradation and resultant pin loosening. And both patients healed uneventfully. In younger patients, the hardware prominence might hinder functional training. However, the clinical outcomes showed no significant difference between the 2 groups at 6 months and the final follow-up visit.

At the last follow-up visit, all the patients in both groups reported good to excellent results according to Flynn criteria. Among all the patients, 92% of the patients in the BP group and 91.7% in the KW group reported excellent results.

Avascular necrosis and physeal arrest is a challenging situation usually following ORIF for neglected LCF, and there was no case of AVN in our study, possibly due to careful dissection and limited soft tissue stripping during the surgery. Fishtail deformity is a late manifestation of LCF healing,[28,29] and as shown in the result, the BP degradation in vivo did not increase its incidence. Lateral condylar prominence is postulated to result from fracture stimulation to lateral condyle and remodeling. It is usually asymptomatic and more common in the neglected LCF treated by ORIF.[30]

Placement of implant across the physis is inevitable in the treatment of LCF of the humerus using KW or BP. Smooth and small diameter KW across physis was not reported to be associated with growth arrest[31]; however, its safety has not been fully investigated.[32] In our study, the radiographic manifestation at the last follow-up did not show abnormality of physis in the BP group. It was consistent with a report in an animal model.[33]

We undertook a retrospective investigation; therefore, our findings should be interpreted with caution. The allocation process of patients to either the KW group or BP group partly depended on the preference of the surgeon in charge, and this strategy may cause allocation bias. The follow-up was not long enough, and the long-term impact upon growth remains unclear. Besides, the biodegradable pins were more expensive (500–600 US dollars for each pin) than KW (5–10 US dollars), and it was not covered by the basic medical insurance in our province.

5. Conclusion

Both KW and BP are safe and effective choices for LCF of the humerus in children. Both the implant designs produce satisfactory and comparable clinical outcomes. However, BP has the advantage of less hardware prominence, no need for hardware removal, and fewer long-term complications. However, the biodegradable pins are more expensive as compared with Kirschner wires.

Author contributions

Conceptualization: Pan Hong.
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Investigation: Pan Hong.
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Writing – original draft: Pan Hong.
Writing – review & editing: Jin Li, Saroj Rai, Yudong Liu, Pan Hong.

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