Is biodegradable pin a good choice for lateral condylar fracture of humerus in children
A comparative study of biodegradable pin and Kirschner wire

Jin Li, MD, PhD, Saroj Rai, MD, PhD, Yudong Liu, MD, PhD, Renhao Ze, MD, PhD, Xin Tang, MD, PhD, Ruikang Liu, MD, Pan Hong, MD, PhD

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 for 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, fistula 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
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 available for both groups. The KW group consisted of 85 patients, whereas the BP group consisted of 76 patients, including 47 males and 29 females, were included in the KW group, whereas 76 patients, including 50 males and 35 females, were included in the KW group. The two groups were not significantly different in 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. The average age of patients in the KW group was 5.2 years, and that of BP was 5.9 years. There was no significant difference between the groups.

The operated arm was immobilized in the long-arm posterior slab cast. The operated side was supported by a 1–0 number bioabsorbable suture in a figure of 8 fashion. 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 cast 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 χ² 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 deformity 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 fístail 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, fístail 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.
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.\(^\text{[13,14]}\) 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 $\geq 2$ 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 recommended by certain authors.\(^{[16,17]}\) However, in significantly displaced and rotated fractures, ORIF comes, 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.\(^{[28,29]}\) As the KW was bent to bury 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.

Table 1

| 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 |

Table 2

| 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  |
| MEPS 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 |

Table 3

| Clinical outcomes | KW (n=85) | BP (n=76) | P    |
|-------------------|-----------|-----------|------|
| Flynn criteria    |           |           |      |
| Excellent         | 78        | 70        | .69  |
| Good              | 7         | 6         |      |
| 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  |

BP = biodegradable pinning, KW = Kirschner wire, MEPS = Mayo elbow performance score.
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.
Data curation: Xin Tang.
Formal analysis: Ruikang Liu.
Investigation: Pan Hong.
Resources: Renhao Ze.
Software: Ruikang Liu.
Writing – original draft: Pan Hong.
Writing – review & editing: Jin Li, Saroj Rai, Yudong Liu, Pan Hong.

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