

# A retrospective comparative study of open reduction and cannulated screw fixation and Kirschner wire fixation in the treatment of fracture of lateral condyle of humerus in children

XIANYONG LUO

Zhengzhou University First Affiliated Hospital

XINRANG CHEN

Zhengzhou University First Affiliated Hospital

JIAXIANG WANG (✉ [wjiaxiang08@126.com](mailto:wjiaxiang08@126.com))

Zhengzhou University First Affiliated Hospital

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## Research Article

**Keywords:** Lateral condylar fractures of the humerus, Cannulated screw, Kirschner wire, Prognosis

**Posted Date:** February 24th, 2021

**DOI:** <https://doi.org/10.21203/rs.3.rs-165597/v1>

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# Abstract

**Objective** To evaluate the clinical efficacy of two surgical methods in the treatment of fracture of lateral condyle of humerus in children and the application value of two kinds of internal fixation materials.

**Methods** A total of 32 children with fracture of lateral condyle of humerus were treated in our hospital from June 2015 to June 2018, with an average age of 5.6 years, including 18 males and 14 females. The patients were divided into two groups: group A (n = 12) and group B (n = 20). By comparing the operation time, removal of internal fixation time, Dhillon elbow function evaluation, HHS elbow function score, X-ray measurement of postoperative carrying angle, Baumann angle and distal humerus anteversion angle, the operation-related complications were recorded in detail.

**Results** The operation time was  $0.9 \pm 0.2$  hours in group A,  $0.8 \pm 0.2$  hours in group B,  $P > 0.05$ . The removal internal fixation time was  $91 \pm 8$  days in group A,  $59 \pm 10$  days in group B ( $P < 0.05$ ). The Dhillon elbow function score was  $8.2 \pm 0.6$  in group A,  $8.0 \pm 0.8$  in group B, and  $93 \pm 5$  in group A and  $89 \pm 4$  in group B ( $P > 0.05$ ). The carrying angle was  $10^\circ \pm 1^\circ$  in group A and  $10^\circ \pm 2^\circ$  in group B ( $P > 0.05$ ). The Baumann angle was  $15^\circ \pm 4^\circ$  in group A and  $16^\circ \pm 3^\circ$  in group B ( $P > 0.05$ ). The anteversion of distal humerus was  $33^\circ \pm 3^\circ$  in group A and  $33^\circ \pm 4^\circ$  in group B ( $P > 0.05$ ). In the last follow-up, the excellent and good rate of elbow joint function in group A was excellent in 8 cases and good in 4 cases, and the excellent and good rate in group B was 100%. In group B, 13 cases were excellent, 6 cases were good, and 1 case was moderate, with an excellent and good rate of 95%. The postoperative complications were observed in group A, including avascular necrosis of lateral condyle in 1 case, premature closure of epiphysis in 1 case, skin irritation in 5 cases, needle exudation and incision infection in 2 cases, hyperplasia of lateral condyle in 3 cases, and loss of extension and flexion in 1 case.

**Conclusions** There was no significant difference in operation time, elbow function recovery and imaging measurement between the two surgical methods in the treatment of lateral condylar fracture of humerus. Kirschner wire group had a certain advantage over cannulated cancellus screw group in fracture healing and removal of internal fixation. however, the clinical observation screw group has advantages in postoperative nursing and early exercise.

## Introduction

Fracture of lateral condyle of humerus in children is a common fracture of elbow joint in children, and it is also the second most common fracture of elbow. Due to the difference of medical level in different regions, doctors have different diagnosis and treatment methods for this kind of fracture, and children may have different prognosis. This fractures have a common complications including nonunion, malunion, ulnar nerve paresis, hypertrophic scar, avascular necrosis of ossific nucleus and angular deformity. At present, the opinions on the treatment of fractures of lateral condyle of humerus are basically the same. It is considered that fractures with displacement  $\leq 2\text{mm}$  can be treated

conservatively, while fractures with displacement > 2mm should be treated by operation.<sup>1</sup> In terms of surgical treatment, the choice of internal fixation materials is different. The commonly used methods of internal fixation include Kirschner wire and screw fixation, however, the prognosis seems to vary regardless of the treatment. This study group compared the clinical effects of cannulated cancellus screw and Kirschner wire in the treatment of fracture of lateral condyle of humerus in children, and summarized the differences in postoperative recovery and complications of the two internal fixation methods.

## Materials And Methods

The study design was retrospective, nonrandomized, comparative study. Institutional ethical clearance and informed patient consent were obtained before enrolment of patients for the study.

### I. General information

A total of 32 children with fracture of lateral condyle of humerus were treated in our hospital from June 2015 to June 2018, with an average age of 5.6 years (range from 3 to 8 years). There were 18 males and 14 females. All the patients underwent X-ray films of the anterior and lateral position of the elbow joint when they were admitted to the hospital, and the fractures with displacement of 2mm or left or right were diagnosed by CT scan of the elbow joint. According to Jacob classification,<sup>2</sup> there were 18 cases of type II and 14 cases of type III. All children in this group were treated with open operation after routine examination after admission and exclusion of surgical contraindications. The time from injury to operation was 2–8 days, with an average of 3.5 days. Exclusion criteria: (1) cases treated for more than one week after injury, and (2) cases fixed with Kirschner wire after closed reduction. According to the choice of internal fixation materials, the patients with open reduction were divided into group A (n = 12) and group B (n = 20).

### II. Treatment methods

All the children were treated with general intravenous anesthesia, including 5 cases with brachial plexus combined anesthesia, upper axillary tourniquet before operation, Kocher elbow lateral incision through the space between brachioradialis and triceps brachii to periosteum, avoiding radial nerve, opening periosteum to expose fracture end, cleaning congestion, reduction of fracture with reduction forceps or cloth towel forceps under direct vision, according to the size of fracture block, whether there was lateral epicondyle bone. The broken end of the fracture was fixed with cannulated cancellus screw (partial thread) or Kirschner wire. Group A was fixed with cannulated cancellus screws with two screws, 3.0mm or 3.5mm in diameter, screws are passing in the metaphyseal portion of fracture without passing through the capitulum humeri, crossed or parallel in direction, but contralateral cortex. Group B was fixed with Kirschner wire and selected two or three Kirschner wires with a diameter of 1.5mm or 2.0mm, which could pass through the capitulum humeri if the metaphyseal portion of fracture is small, spread out in a fan shape in the direction and pass through the contralateral cortex. Typical cases are shown in Figs. 1 and 2.

During the operation, the reduction and fixation of the fracture was completed under C-arm fluoroscopy to ensure the anatomical reduction of the broken end of the fracture. In group B, the needle tail was bent and placed in the skin as far as possible. After the completion of internal fixation, mild flexion and extension of the elbow joint was performed to judge whether the fracture block was stable or not. After washing and hemostasis, the lateral supporting ligament was sutured intermittently and the skin was sutured intradermally. All the children in this group were fixed with 90–110 °upper limb plaster.

Figure 1: male, 5 years old, Jacob III type, with open reduction and cannulated cancellous screw fixation.

### III. Evaluation of curative effect

The operation time of this group of cases was recorded in detail. Through postoperative follow-up, regular X-ray examination of the anterior and lateral position of the elbow joint was performed to understand the fracture healing, the time of removal of internal fixation and the range of flexion and extension of the elbow joint. Dhillon elbow function evaluation and HHS elbow function score were used to evaluate the postoperative treatment effect of the children.<sup>3</sup> The elbow lifting angle, Baumann angle and anteversion angle of distal humerus measured by X-ray in the last follow-up were compared.

### IV. Statistical processing

The measurement data were expressed by  $\bar{x} \pm s$ , and the data were statistically analyzed by SPSS19.0 statistical software, and the difference was considered to be statistically significant by t-test.

## Results

According to the operation records, the operation time in group A was  $0.6 \pm 1.3$ h, with an average of  $0.9 \pm 0.2$ h. In group B, the operation time was  $0.5 \pm 1.1$ h, with an average of  $0.8 \pm 0.2$ h. Regular X-ray imaging examination was performed to judge the primary healing of the fracture through the blurred fracture line and the formation of new bone around the fracture. All the children in this group were fixed with plaster after operation, and some of them were protected by brace after 2 weeks. All the children in group A were treated with elbow joint function exercise after 4 weeks. The children in group B included subcutaneous indwelling at the end of needle in 16 cases, extradermal indwelling in 4 cases, wearing plaster or brace for more than 4 weeks. The protective time for those exposed to the skin with Kirschner needle reached 6 weeks. Except for 4 cases of early Kirschner needle removal in group B, two-stage incision and internal fixation was performed when the joint function reached or close to normal. The internal fixation time was  $75 \pm 106$  days in group A, with an average of  $91 \pm 8$  days in group B and  $42 \pm 80$  days in group B, with an average of  $59 \pm 10$  days.

All cases were followed up for 0.8 ~ 3.5 years (mean  $2.2 \pm 0.8$  years). All the 32 children had primary fracture healing, and no re-displacement, nonunion and nerve injury were found. The postoperative follow-up Dhillon elbow function score was  $8.2 \pm 0.6$ ,  $8.0 \pm 0.8$ ,  $93 \pm 5$  in group A and  $89 \pm 4$  in group B,  $P > 0.05$ . The elbow function scores of group A and group B were  $93 \pm 5$  and  $89 \pm 4$  respectively. The last X-

ray measurement showed that the lifting angle was  $10^{\circ} \pm 1^{\circ}$  in group A and  $10^{\circ} \pm 2^{\circ}$  in group B ( $P > 0.05$ ). The Baumann angle was  $15^{\circ} \pm 4^{\circ}$  in group A and  $16^{\circ} \pm 3^{\circ}$  in group B ( $P > 0.05$ ). The anteversion of distal humerus was  $33^{\circ} \pm 3^{\circ}$  in group A and  $33^{\circ} \pm 4^{\circ}$  in group B ( $P > 0.05$ ). According to the Dhillon score standard, 9 points were excellent, 7–8 points were good, 5–6 scores were medium, less than 5 points were poor, group A was excellent in 8 cases, good in 4 cases, excellent and good rate was 100% in group B, excellent in 13 cases, good in 6 cases, fair in 1 case, excellent and good rate of 95%. The statistical comparison among the groups is shown in Table 1:

Table 1  
Statistical comparison of data between group A and group B

	group A	group B	P
the operation time(h)	$0.9 \pm 0.2h$	$0.8 \pm 0.2h$	$P = 0.65$
removal of internal fixation time(d)	$91 \pm 8d$	$59 \pm 10d$	$P = 0.00$
Dhillon elbow function evaluation	$8.2 \pm 0.6$	$8.0 \pm 0.8$	$P = 0.31$
HHS elbow function score	$93 \pm 5$	$89 \pm 4$	$P = 0.08$
measurement of postoperative carrying angle( $^{\circ}$ )	$10 \pm 1$	$10 \pm 2$	$P = 0.93$
Baumann angle( $^{\circ}$ )	$15 \pm 4$	$16 \pm 3$	$P = 0.55$
distal humerus anteversion angle( $^{\circ}$ )	$33 \pm 3$	$33 \pm 4$	$P = 0.83$

Statistics of postoperative complications: group A included 1 case of ischemic necrosis of lateral condyle and 1 case of premature closure of epiphysis. Follow-up showed that the appearance deformity was not obvious and the functional activity was normal. In group B, there were 5 cases of skin irritation with bursitis, of which 1 case broke through the end of Kirschner needle to the skin, and the symptoms were relieved after internal fixation. There were 2 cases of needle exudation and incision infection, both of which were left out of the skin at the end of the needle, and the local scar healed by dressing change after needle extraction. There were 3 cases of lateral condyle hyperplasia with normal functional activity, 1 case lost  $10^{\circ}$  extension and  $15^{\circ}$  flexion.

## Discussion

Fractures of the lateral condyle of humerus (lateral condylar fractures of the humerus, LCF) in children are the most common elbow fractures involving the growth plate, accounting for 12–20% of all upper limb fractures in children. These fractures most commonly occur in children between 4 and 10 years old, with the highest incidence in children around 6 years old.<sup>4</sup> The common injury mechanism leading to fracture is supination of the forearm in the straight position when falling, and varus violence leads to traction of the extensor tendon and brachioradialis muscle of the forearm (traction mechanism, pull-off). Other injury mechanisms include fracture of the lateral condyle caused by elbow valgus impact (push-out mechanism, push-off) and direct injury of the elbow.<sup>5</sup> As we all know, missed diagnosis or delayed

diagnosis and treatment of LCF may lead to joint stiffness, fracture nonunion, followed by serious cubitus valgus, delayed ulnar nerve paralysis and other complications. At present, we have basically reached a consensus on the diagnosis and treatment of LCF, but there are still some disputes.

## I. selection of surgical indications and surgical methods

At present, the treatment of LCF is mainly based on the specific classification of fracture, the commonly used types are: 1Milch type, according to whether the pulley joint surface is involved into type 2, 2Jakob type, according to whether the cartilage hinge is broken and the degree of displacement is divided into 3 types. Milch type I can be considered as a variant of Salter- Harris type IV epiphyseal injury, while Milch type II is equivalent to Salter- Harris type II epiphyseal injury.<sup>6</sup>

At present, the research of evidence-based medicine thinks that the degree of X-ray fracture displacement can be used as the best basis for guiding operation and clinical decision. According to fracture displacement, type I: < 2mm, long arm plaster fixation, type II: 2mm 4mm, closed reduction percutaneous needle (closedreductionandpercutaneousspinning,CRPP), type III: > 4mm, open reduction percutaneous needle (openreductionandpercutaneousspinning,ORPP).<sup>7</sup> However, there are still controversial areas, such as Song et al.<sup>8</sup> think that closed reduction and internal fixation is an effective method for the treatment of unstable displacement of LCF in children. If the fracture displacement is more than 2mm after closed reduction, open reduction and internal fixation is recommended. For the fracture with small displacement, conservative or surgical treatment is chosen, mainly based on the stability of the fracture, the existence of articular cartilage hinges determines the stability of LCF.<sup>9</sup>

Therefore, for micro-displaced fractures whose stability can not be completely judged by X-ray films, it is suggested that the integrity of articular cartilage hinges can be judged by elbow arthrography,<sup>10</sup> or the articular surface can be detected by arthroscopy, so as to determine whether cartilage hinges are broken or not, so as to avoid missed diagnosis and mistreatment of micro-displaced LCF in children.<sup>9</sup> There are also multicenter studies in China that LCF with displacement  $\leq$  2mm is prone to re-displacement. Early percutaneous fixation is recommended to avoid complications such as open reduction, poor function and premature closure of epiphysis caused by fracture redisplacement.<sup>11</sup>

## II. Comparison of the selection of different internal fixation materials

At present, for the LCF, internal fixation materials that need surgical treatment, the main choice is Kirschner wire, hollow or lag screw, absorbable screw and so on. The selection advantage of Kirschner needle is that it is easy to operate and easy to take out, and even the Kirschner needle outside the skin can be taken out in the outpatient clinic, and there is no need for special tools. And the advantages of Kirschner wire fixation include the ability to fix smaller epiphysis or reduce the risk of epiphyseal injury.<sup>12</sup> However, the debate on Kirschner wire fixation is mainly focused on whether the Kirschner wire should be kept outside the skin. Some studies have found that there is no significant difference in the subcutaneous infection rate of whether the Kirschner wire is embedded or not, but the skin erosion rate of the buried

subcutaneous group is higher, so it is suggested that it should not be routinely buried subcutaneously in order to save more economic costs.<sup>13</sup>

As for the scholars who choose screw fixation, they think that screw fixation is more stable in biomechanics than Kirschner wire fixation.<sup>14</sup> Li et al.<sup>15</sup> comparison of Kirschner wire and cannulated screw internal fixation can effectively treat displaced LCF, there is no statistical difference between the two clinical outcomes, but Kirschner needle will occur surrounding skin infection. Das et al.<sup>16</sup> reported that the infection rate of percutaneous fixation of Kirschner needle ranged from 2–9.8%, and the subcutaneous infection rate of buried skin ranged from 0.5–2%. Due to the deep placement of screws, it rarely irritates the skin, so the infection rate is very low. However, compared with the Kirschner wire that can penetrate the head epiphysis, Gilbert et al.<sup>17</sup> suggested that screws are usually placed through the metaphysis of the lateral condyle, rather than through the ossification nucleus of the capitulum humeri, to reduce the risk of re-injury of the epiphysis.

### III. Comparison of postoperative complications and functional recovery.

The postoperative complications of LCF included bone nonunion, ischemic necrosis, premature fusion of epiphysis, overgrowth of lateral condyle, stiffness, cubitus varus or cubitus valgus and fish tail deformity.<sup>18</sup> Launay et al.<sup>19</sup> calculated that the operative complications after Kirschner wire fixation included pin site infection, lateral overgrowth and loss of fixation, while fixation failure or loss of position led to fracture displacement and reoperation or nonunion, which was a serious complication of LCF. Pace et al.<sup>20</sup> found that the overall incidence of bone nonunion after LCF was 1.4%, and the only important risk factor for bone nonunion was type III fracture. Compared with Kirschner wire fixation, screw fixation provides stronger biomechanical stability, and the incidence of lateral overgrowth, loss of fixation and infection is relatively low. However, Shirley et al.<sup>12</sup> also pointed out that the results of screw fixation and the subsequent risk of iatrogenic epiphyseal injury have not been well determined, so early epiphyseal closure and growth arrest caused by screws are still noteworthy.

Foreign studies have found that 4% of the patients with LCF screw fixation have the phenomenon of overflexion or loss of activity, and there is no growth stagnation or change of lifting angle. Long-term follow-up showed that the average extension loss was 2 °(range 0 °25 °) and the average flexion loss was 8 °(range 0 °25 °).<sup>12</sup> The growth disorder of the epiphysis of the distal humerus may affect the carrying angle and lead to cubitus valgus or varus deformity. In some cases, the hypertrophy of the posterolateral condyle of the fracture can increase the Baumann angle, leading to cubitus varus deformity, while growth stagnation reduces the Baumann angle, leading to cubitus valgus deformity.<sup>21</sup>

### IV. about the postoperative nursing and the timing of internal fixation

Whether closed or open reduction, internal fixation with Kirschner wire or screw fixation, scholars at home and abroad seem to agree that postoperative fixation should be supplemented by plaster or brace. As for how long external fixation is appropriate, there is no unified standard. Li et al.<sup>15</sup> think that Kirschner wire

fixation requires longer external fixation and local skin care. Gilbert et al.<sup>17</sup> believe that screw fixation can appropriately reduce the time of plaster external fixation, which is more conducive to postoperative exercise of elbow function and a wide range of joint motion. The external fixation time in the screw fixation group was also shorter than that in the Kirschner wire group. Early removal of external fixation and functional exercise were considered to avoid joint stiffness.

There is no uniform standard for how long to take internal fixation after LCF, and considering that intra-articular fracture healing may take longer, Cardona et al.<sup>22</sup> suggested that the time of internal fixation ranges from 3 to 8 weeks. Raghavan et al.<sup>23</sup> believe that buried Kirschner wires can allow indwelling longer, thus promoting better fracture healing, while exposure to the skin seems to need to be removed earlier, mainly to reduce the risk of pin tract infection. More studies are based on the time of fracture healing, and some studies have found that fractures heal within 6 weeks clinically and radiographically, so it is recommended that the average time of internal fixation is 6 weeks or more.<sup>22</sup> Another study found that the average healing time in the Kirschner wire group was 9.6 weeks, and the average healing time of all fractures after screw fixation was 7.8 weeks.<sup>17</sup>

#### V. Some focus and prospects on LCF

At present, about the clinical prognosis of Kirschner wire or screw fixation, most of the literature data show that there is no statistical difference. Whether the Kirschner wire is buried under the skin and whether the screw can penetrate the epiphysis of capitulum humeri, the length of fixation time is not final. Due to the bleeding and swelling after soft tissue tear, the infiltration of synovial fluid, the stimulation of internal fixation and other factors, incision infection can not be completely controlled, especially the incision scar caused by open reduction and the need for secondary internal fixation. It has been reported that the use of absorbable screws for fracture fixation will overcome the shortcomings of metal screw fixation which need to be removed by second operation. At the same time, it still retains the advantage of biomechanical stability.<sup>24</sup> It has also been reported that arthroscopy can be used to assist the displacement of humeral lateral condyle fractures larger than 2mm to achieve closed reduction and percutaneous needle puncture.<sup>25</sup> In the case of ischemic necrosis of the lateral condyle (avascular necrosis, AVN) after LCF, Conaway et al. [26] believed that the occurrence of AVN was mainly due to excessive peeling of the soft tissue of the lateral condylar fracture, rather than the approach used, and recommended that the posterior approach did not need to peel off the soft tissue, and still had a good visibility of fracture reduction.

## Declarations

Ethics approval and consent to participate

Not applicable



Consent for publication

Yes

Availability of data and materials

Yes

Competing interests

The authors declare that they have no competing interests

Funding

This study was supported by Henan Provincial Medical Outstanding Talent Foundation, Henan Provincial Medical Youth Talent Foundation.

Authors' contributions

1. Objective: WANG Jia-xiang. 2. Study selection: LUO Xian-yong and WANG Jia-xiang. 3. Data sources, Data extraction and Data synthesis: LUO Xian-yong and CHEN Xin-rang. 4. Conclusions: WANG Jia-xiang. 5. Wrote the manuscript: LUO Xian-yong. The author (s) read and approved the final manuscript.

Acknowledgements

This study was supported by Henan Provincial Medical Outstanding Talent Foundation, Henan Provincial Medical Youth Talent Foundation.

We thank the patients who volunteered to provide case data for this study.

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## Figures



**Figure 1**

male, 5 years old, Jacob III type, with open reduction and cannulated cancellous screw fixation.



**Figure 2**

male, 4 years old, Jacob III type, with open reduction and Kirschner wire fixation.