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Double ulnar osteomy for the treatment of congenital radial head dislocation

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ABSTRACT

Objective: The aim of this study was to retrospectively evaluate the effects of our double osteotomy technique in the treatment of congenital radial head dislocation (CRHD).

Methods: A total 14 children (14 elbows; 71.42% male; mean age: 9.31 ± 3.06 years) with CRHD who underwent double osteotomy of the proximal ulna between April 2010 and June 2015 were included in the study. The patients with CRHD were identified according to medical history, plain radiographs or magnetic resonance imagings. The outcomes were evaluated through comparison of the preoperative and postoperative motion range of elbow and Mayo Elbow Performance Score (MEPS).

Results: After a follow-up of 13–35 months (22.29 ± 5.80), compared with pre-operation, the flexion (132.14 ± 3.23° vs 123.21 ± 7.75°, P = 0.003), extension (8.21 ± 4.21° vs 1.07 ± 3.50°, P = 0.003), and pronation of elbow (83.21 ± 4.21° vs 80.36 ± 4.14°, P = 0.011) improved significantly in all patients. Furthermore, the carrying angle was recovered to the normal level (5–15°) in all of these patients (18.57 ± 5.69° vs 8.21 ± 2.49°, P = 0.001). MEPS score was significantly increased postoperatively (96.79 ± 2.49 vs. 90.71 ± 1.82, P = 0.000), with the good outcome in CRHD patients.

Conclusion: The results of our study suggested that this double osteotomy on the proximal ulna might be an effective method for the treatment of CRHD.

Level of Evidence: Level IV, Therapeutic Study.

Introduction

The congenital radial head dislocation (CRHD) is usually found in elbows with a bilateral deformity of children with an incidence rate of 0.06%–0.16%.[1,2] Due to hypoplasia of the capitellum, anterior or posterior dislocations of the radial head (RH), the RH appears to be domed shape and the ulna is relatively shorter than the radius.[3] As the persistent "shortening of ulna, the dislocations of RH will be further exacerbated.[3] Therefore, it's better to treat as soon as possible for children with CRHD.

Several beneficial operative treatments have been recommended to children with CRHD. For example, Yamazaki et al used the open reduction and ulnar osteotomy for a five-year boy with CRHD in 2007, which demonstrated that the boy obtained significant improvement in elbow motion and had no pain, no osteoarthritic changes at 10 years follow-up.[4] Subsequently, the single bone forearm procedure, single osteotomy, derotation osteotomy are applied to CRHD, which corrects the elbow flexion and motion.[6–8] However, these surgery methods involve complications (infection, hematoma, and thrombosis, etc.) and functional loss.[5] More recently, our teams establish an effective operative treatment (ulnar rotation osteotomy) for children in CRHD to enhance the motion of elbows.[9] The distal cut surface is rotated in the posterolateral side to make humeroradial joint recovered during the ulnar rotation osteotomy. To further improve the outcome, we proposed the double osteotomy on the proximal ulna for CRHD. In the present study, the outcomes after double osteotomy on the proximal ulna for 14 children with CRHD from April 2010 to June 2015 were assessed according to comparison of the preoperative and postoperative clinical indexes, as well as plain radiographs. The double osteotomy was that proximal radioulnar joint was rotated in the posterolateral side after the double planes of ulna were cut. It was useful to improve the motion of elbow in the children undergoing surgery.

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Material and methods

Subjects

The inclusion criteria were as followed: 1) CRHD patients with anterior dislocations of RH; 2) patients without history of injury; 3) CRHD patients were identified through, disease history, magnetic resonance imaging (MRI) and CT that there were not any scars around humeroradial joint. From April 2010 to June 2015, a total of 14 children (14 elbows) with CRHD were treated by a double osteotomy on the proximal ulna in Xi'an Honghui Hospital. There were ten boys and four girls, whose ages ranged from four years old to fourteen years old (9.31 ± 3.06 years). CRHD was confirmed according to the medical history, plain radiographs of elbow and MRI.

Surgical technique

The skin incision began with the 2.5 cm of proximal elbow, laterally came to the triceps tendon and distally over the lateral side of the tip of the olecranon, along the subcutaneous border of the ulna. Subsequently, the RH was exposed using Boyd approach, which was useful to reach the radius and ulna in their proximal position.[9] We found that the RH was the anterior dislocation, and after exposure of the RH, there was normal synovial fluid in the intact articular cavity of elbow joint and without scar tissue (Fig. 1A). Double osteotomy was performed at once. Firstly, the first surgical plane was determined, which was the coronal plane of the ulna and the horizontal plane of the RH. Secondly, another surgical plane was determined under the first one with 1.0–1.5 cm, which can maintain the completeness of proximal radioulnar joint. Subsequently, the ulna was cut with an electric saw based on the two planes (Fig. 1B and C). Lastly, the radioulnar joint was rotated along the posterolateral orientation until the RH reduction, which was determined by plain radiographs. During the rotating process, the relative position between radius and ulna was changeless, and the rotation of the fragment didn't affect the congruency of the ulnohumeral joint. A diagram of double osteotomy using a planning software is presented in Fig. 2. After RH reduction, the osteotomy site was fixed using the ulnar intramedullary Kirschner wire or a plate and screws. Subsequently, the stability of RH after surgery was assessed according to the motion range of the elbow. In the end, the elbow was immobilized using a plaster cast at 80–90° with the forearm for 3–4 weeks and the plaster cast was removed after wound closure.

Outcome measures

The range of motion (ROM) of the elbow joint was measured with universal standard goniometers based on the previous study preoperatively and postoperatively,[10–12] including elbow flexion and extension, as well as forearm pronation and supination. The patient's elbow was fixed closely to the side of the body and kept at 90°. Thus the angle between the vertical axis of the humerus and the wrist end was ROM of forearm pronation or supination. Moreover, the carrying angle of each patient was measured (normal range: about 5–15°).[13]

Postoperative examination was consistent with the preoperative clinical examination. In addition, Mayo Elbow Performance Score (MEPS) was used to assess the function of elbow, including pain (45 scores), motion (20 scores), stability of joint (10 scores) and daily functions (25 scores).[14] The outcome was classified into 3 categories: (1) good: the score was more than 90; (2) mediocre: the score was from 60 to 89; (3) poor: the score was less than 60.

Statistical analysis

Statistical analysis was performed using SPSS 19.0 (SPSS Inc., Chicago, IL, USA). All results were presented with means ± standard deviation (X_ ± SD). The Wilcoxon Signed Rank Test was used to compare the preoperative and postoperative measurements. $P < 0.05$ was defined as a statistical significance.

Results

The characteristics of CRHD

The results of MRI of elbow showed that annular ligament was found among normal children (Fig. 3A) and children with CRHD who had an anterior dislocation of RH (Fig. 3B). However, annular ligament was not found among children with the old Monteggia fracture (Fig. 3C). Additionally, the radial notch of the ulna was found on the anterior-lateral side of the ulna in children with CRHD other than the lateral side of normal and the old Monteggia fracture patients (Fig. 3). What's more, the children with CRHD had a prominence on RH (Fig. 4B), which was different from the normal children (Fig. 4A) and children with the old Monteggia fracture (Fig. 4C).

Postoperative outcomes and follow-up

The children after surgery was followed up ranging from 23 to 45 months (mean = 32.28 ± 5.80). Taken together, the postoperative outcomes showed that there were no major complications such as infection, nerve injuries, or nonunion after surgery. Moreover, there were no hypertrophic scars on the forearm, nonunion and recurrence of dislocation for all. Additionally, there was no limitation in the ROM of elbow joint and wrist, or daily function at follow-up. Briefly, we found that full elbow mobility was

Fig. 1. The intraoperative images of the double osteotomy from two patients. A. The radial head (RH) was exposed using Boyd approach. There was normal synovial fluid in the intact articular cavity of elbow joint, and scar tissue hadn't been found in the representative case with the anterior dislocation of RH. B. The first surgical plane was the coronal plane of the ulna and the horizontal plane of the RH in the other case (it is different case from that in A). C. The second surgical plane was determined under the first one (it is the same case with that in A).

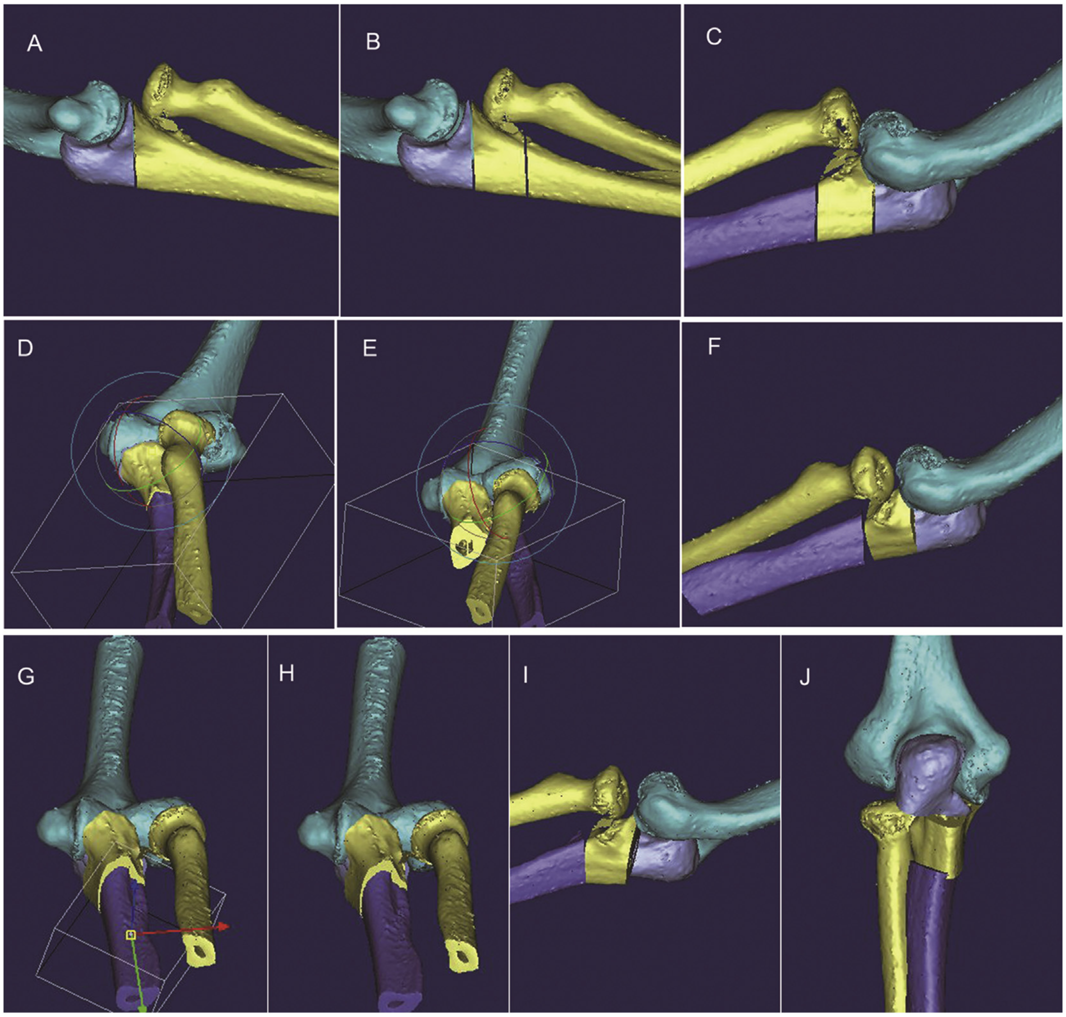

Fig. 2. Diagram of double osteotomy on the proximal ulna. A. The first surgical plane in the lateralis aspect of elbow. B. The two surgical planes in the lateralis aspect of elbow joint. C. The two surgical planes in the medialis aspect of elbow joint. D-H. The relative position between radius and ulna was changeless during rotating process. I. The medialis aspect of elbow joint after rotation. J. The anterior aspect of elbow joint after rotation.

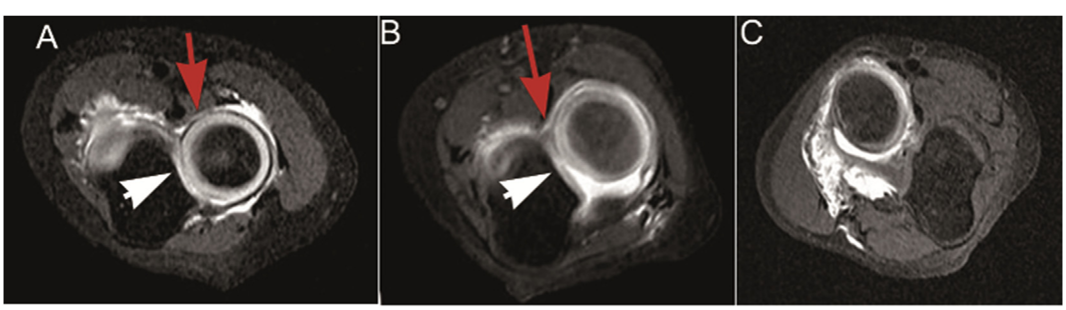

Fig. 3. The magnetic resonance imaging (MRI) of elbow on transverse. A. The normal children. B. The patients with congenital radial head dislocation. C. Children with an old Monteggia fracture. The red arrows presented annular ligament, and the white arrows presented the radial notch of the ulna.

regained on the 6–12 months after operation, and the ROM of the elbow joint is displayed in Table 1. The range of elbow joint flexion significantly improved from preoperative 123.21 ± 7.75° to postoperative 132.14 ± 3.23° ($P = 0.003$). The extension of elbow joint had a significant difference between preoperative and postoperative measurements (1.07 ± 3.50° *vs* 8.21 ± 4.21°, $P = 0.003$). After surgery, the range of forearm pronation significantly increased (80.36 ± 4.14° *vs* 83.21 ± 4.21°, $P = 0.011$). However, there was no significant difference in forearm supination (90° ± 0° *vs* 88.93 ± 2.89°, $P = 0.18$). Furthermore, the carrying angle markedly recovered to the normal level (5–15°) in all of patients (18.57 ± 5.69° *vs* 8.21 ± 2.49°, $P = 0.001$). MEPS score was

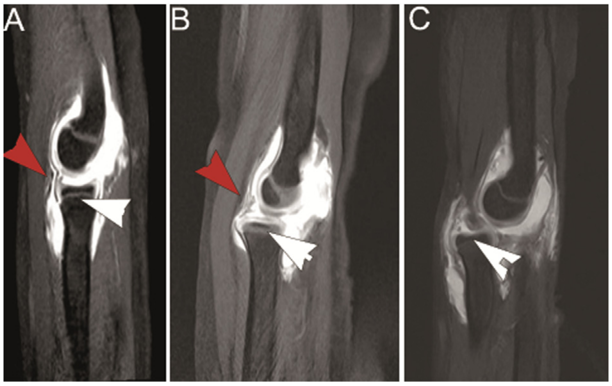

Fig. 4. The magnetic resonance imaging (MRI) of elbow on sagittal view. A. The normal children. B. The patients with congenital radial head dislocation. C. Children with an old Monteggia fracture. The red arrows represented articular capsule, and the white arrows presented the radial head.

significantly increased after surgery in comparison to pre-operation (96.79 ± 2.49 *vs* 90.71 ± 1.82, $P = 0.000$). MEPS scores were more than 95 in all of patients, which illustrated a good outcome in CRHD patients undergoing the double osteotomy.

At the last follow-up, the prominence on RH was completely disappeared on the lateral Plain radiographs (Fig. 5). Particularly, all of patients obtained a significant improvement in elbow motion, included flexion, extension, pronation, and supination. Furthermore, the photographs and X radiographs of the elbows of a typical case are shown in Fig. 5, respectively of children.

Discussion

CRHD is an infrequent congenital disease characterized by asymmetry of bilateral elbow and sometimes restricted movement on elbow.[15] This disease is very likely neglected before adolescence in most of the patients with CRHD because of mild symptoms.[16] Someone may present with elbow pain and limited ROM in adulthood.[1] Therefore, it may be that the earlier they start treatment, the better for the patients with CRHD. In this present study, total of 14 children (14 elbows) with CRHD were treated by a double osteotomy on the proximal ulna in Xi'an, China. Our results indicated that the double osteotomy provided a good effect without serious complications, non-union, and recurrence of dislocation within an average 32-month follow-up.

The radial notch of the ulna was found on the anterior-lateral side of the ulna in children with CRHD other than the lateral side of normal children through MRI, which has been reported by Gupta et al.[17] Moreover, annular ligament was found in children with CRHD, which was different with COMF as reported in the previous study.[18] What's more, the children with CRHD had a prominence on RH, which was similar to the study of Glener, et al and different to the normals and children with COMF.[19] These differences illustrated that the disorder of radioulnar joint might be the key factor for CRHD. The annular ligament and radial notch of the ulna constitute a bone ring with fiber and encircle the RH, which can adapt to the rotation of radius.[20] Therefore, we projected an ulnar rotation osteotomy to adjust the radial notch of ulna and resolve the dislocation of RH. Although this rotation method could improve the ROM of the elbow flexion and extension, the elbow function of pronation or supination was limited in some patients at follow-up.[9] For this reason, a new method named as double osteotomy was used to resolve this deficiency.

Similarly, the relative position between radius and ulna had no change when rotating during the double osteotomy. Pronator is a muscle in the arm that produces pronation, and supinator is a muscle in the arm that turns the arm in order to the palm faces upwards.[21] According to a meta-analysis, pronator and supinator are useful for reduction of RH in children.[22] Therefore, the pronator and supinator might maintain a stabilized function for RH during the rotating process.

Rotational osteotomies have been used to correct the CRHD, such as osteotomy at the synostosis,[23] osteotomy at two sites in the radius and the ulna,[24,25] osteotomy at one site in the distal radius,[26] and osteotomy of the proximal ulna and the distal radius.[11] The fewer complications were found in the double-level rotational osteotomy at two sites exempt for internal fixation.[5] As shown in our study, there were no complications such as infection, nerve injuries, or nonunion through double osteotomy on the proximal ulna for CRHD. Additionally, the normal "carrying angle" of the elbow is about 5–15°, which allows your forearms to clear your hips when you swing your arms.[13] Besides, MEPS presented a good outcome after surgery when the score was 83 as reported in the previous study.[28] Therefore, the ROM of elbow obtained promotion through the double osteotomy modulating the carrying angle of elbow.

It should be noted that this study has its limitations, such as the small sample size, the single center and shorter follow-up period in some patients. The small sample size is due to the low incidence of CRHD in Shaanxi province. However, these patients will be followed in the future if they are willing to. In addition, this osteotomy was only appropriate for CRHD with anterior dislocations. The further study on CRHD with posterior dislocations will be performed in the next. Meanwhile, ulna should be lengthened before osteotomy for some severe dislocation. Therefore, more information about the effects of this surgery would be collected.

In conclusion, the revisited technique was successful for all of children in this study. After surgery, the function of elbow was improved and reduced to normal carrying angle. In addition, there were no major complications, nerve injury and recurrence of dislocation in all of patients at follow-up. Therefore, this double osteotomy on the proximal ulna had a good outcome for the children with CRHD.

Table 1
The range of motion of the elbow in patients with congenital radial head dislocation and Mayo Elbow Performance Score (MEPS) before and after double osteotomy on the proximal ulna.

	Range of motion of the elbow					MEPS
	Flexion (°)	Extension (°)	Pronation (°)	Supination (°)	Carrying angle (°)	
Before double osteotomy	123.21 ± 7.75	1.07 ± 3.50	80.36 ± 4.14	88.93 ± 2.89	8.21 ± 2.49	90.71 ± 1.82
After double osteotomy	132.14 ± 3.23**	8.21 ± 4.21**	83.21 ± 4.21*	90 ± 0	18.57 ± 5.69**	96.79 ± 2.49**

$^{*}P < 0.05$, $^{**}P < 0.01$; $P < 0.05$ was defined as a statistical significance.

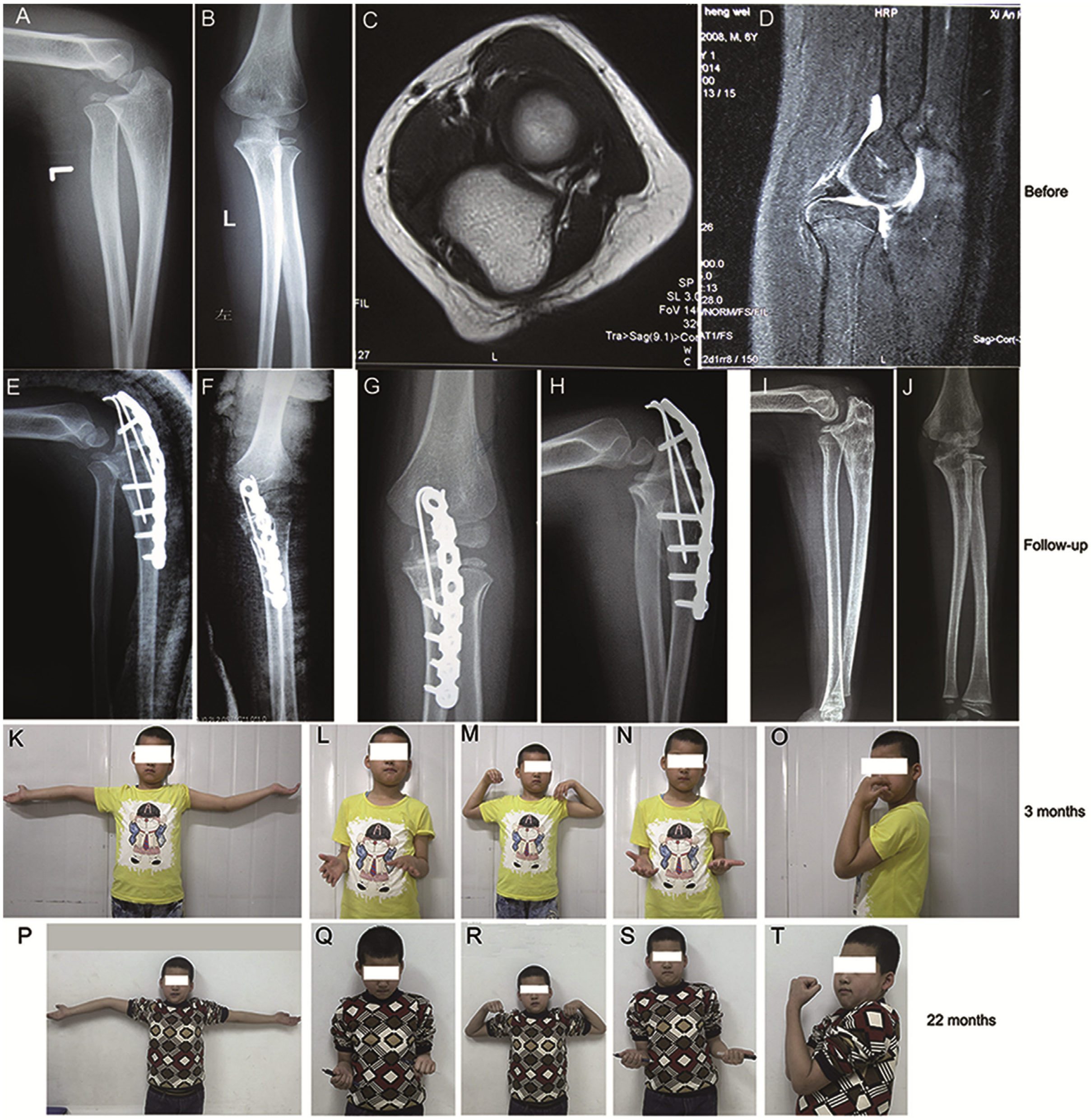

Fig. 5. A six-year-old boy. A-B. A lateralis aspect and anteroposterior X radiograph of elbow before surgery, respectively. C-D. MRI on sagittal view of elbow before surgery, respectively. E-F. A lateralis aspect (E) and anteroposterior (F) X radiograph of elbow after surgery, respectively. G-H. A lateralis aspect (G) and anteroposterior (H) X radiograph of elbow at 3 months after surgery, respectively. I-J. A lateralis aspect (I) and anteroposterior (J) X radiograph of elbow at 22 months after surgery, respectively. The group images in 3 months (K–O) and 22 months (P–T) showed the motion of elbow.

Conflict of interest

There is no conflict of interest.

Acknowledgments

None.

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