Proximally displaced medial humeral epicondyle fracture in pediatric patients: A clinical case series

Lujie Xu (xulujie@zju.edu.cn)
Zhejiang University School of Medicine Children's Hospital https://orcid.org/0000-0003-2822-6549
Wensong Ye
Zhejiang University School of Medicine Children's Hospital
Haibing Li
Zhejiang University School of Medicine Children's Hospital
Jingfang Xu
Zhejiang University School of Medicine Children's Hospital
Weiwei Zhu
Zhejiang University School of Medicine Children's Hospital
Yi Yang
Zhejiang University School of Medicine Children's Hospital

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First author &Corresponding author: Lujie Xu, MD, Senior Fellow, Department of Orthopaedics, Children's Hospital, Zhejiang University School of Medicine, Tel: +86-15088639373, E-mail: xulujie@zju.edu.cn;

Second author: Wensong Ye, MD, Chief of Department of Orthopaedics, Children's Hospital, Zhejiang University School of Medicine, Tel:+86-13758208078, E-mail: 6192005@zju.edu.cn

Third author: Haibing Li, MD, Department of Orthopaedics, Children's Hospital, Zhejiang University School of Medicine, Tel:+86-18258288624, E-mail: lihaibing@zju.edu.cn

Forth author: Jingfang Xu, MD, Department of Orthopaedics, Children's Hospital, Zhejiang University School of Medicine, Tel:+86-13675848865, E-mail: 6514234@zju.edu.cn

Fifth author: Weiwei Zhu, MD, Department of Orthopaedics, Children's Hospital, Zhejiang University School of Medicine, Tel:+86-13758213659, E-mail: 907349209@qq.com

Sixth author: Yi Yang, MD, Department of Orthopaedics, Children's Hospital, Zhejiang University School of Medicine, Tel:+86-15868424050, E-mail: yynick_2mm@zju.edu.cn

The authors' address: 14th Floor, Inpatient Building, No. 3333 Binsheng Road, Hangzhou, Zhejiang, P.R.China

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Abstract:

Background: Medial epicondyle fracture comprises a considerable proportion of pediatric elbow injury. The fracture fragment is typically pulled distally by the muscle and the ligament. This study aims to suggest proper recognition of a subset of the fracture that differs from its usual presentation.

Methods: A retrospective case study was conducted during 2011-2016. Of those cases, a subset was identified as proximally displaced (atypical) ones. Distinctive radiologic images, as well as the injury causes, demographic data, clinical signs, treatment ways, and final follow-ups regarding these atypical ones, were presented and discussed. The fracture mechanism was carefully inferred from former theories and the operative findings, and a tentative management strategy was suggested.

Results: Seven out of 112 cases were distinguished as the atypical, which represents 6.25% of the whole sample. Injury causes were all direct or combined direct/indirect force injuries instead of indirect force mostly seen in the typical. Five were operated while two nonoperatively treated. Operated cases revealed stripping of medial epicondyle from its surrounding periosteum/muscle origin or even cartilage. The fracture fragment was either pulled by proximal periosteum or even proximally dissociated. The outcomes of those atypical were mostly acceptable despite some minor defects.

Conclusion: The proximally displaced cases do constitute a portion of medial humeral epicondyle fracture in children. As well as its skeletal manifestation, awareness of its injury mechanism and soft tissue damage is required. Precise restoration of its anatomical structure might be vital for its treatment. Further scientific work is needed regarding its mechanism and management.

Level of evidence: Level 4.

Keywords: Medial humeral epicondyle fracture, Pediatric, Children, Proximally displaced, Atypical

Background: Medial humeral epicondyle fracture in children is not unusual. Numerous articles have been written over the past half-century. The earlier researches had mostly focused on the mechanisms [1] and manifestations [2], and later more preferences were given to the treatment options [3] and the surgical indications [4]. Recently, though still no consensus on rigorous treatment algorism, more attention has been drawn to specific details like better ways to measure the fracture displacement [5,6], which raised a challenge to the traditional classification system that mostly based on fracture displacement and the displacement amount measured on plain anterior-posterior(AP) X-ray view.

In our case series, a further query was made about the existing categorization through a subset of medial humeral epicondyle fracture in children, the particular type that few predecessor authors had systematically discussed. Current opinion usually described the fracture fragment to be pulled by the flexor-pronator mass or the ulnar collateral ligament(UCL) and displaced distally anteriorly and medially [7]. However, in our work, proximally displaced medial epicondyle fracture was presented, raising new puzzles concerning its mechanism, categorization, management, and prognosis.

In this retrospective study, seven out of 112 consecutive cases were identified and defined as the proximally displaced (the atypical) and the rest the typical. The histories, demographic data, clinical signs, image manifestations, treatment ways, final follow-ups of the atypical were presented and the probable mechanism, the treatment decision-making, and the prognosis were discussed.

Methods:

After approval of the ethical board of our medical center, 112 consecutive cases were reviewed of pediatric medial humeral epicondyle fracture between 2011 and 2016, and seven cases were identified as the atypical (proximally displaced) according to the image findings. Cases information were listed out as table-1 below. Four distinctive images of proximally displaced medial epicondyle fracture were given [Fig.1]. Comparative pictures were presented between the atypical and the typical medial humeral epicondyle fracture regarding preoperative images, intraoperative findings, and illustrative images [Fig.2]. Initial, post-operative, and final images of Case #1 and #2 were demonstrated in Fig.1a,b, and Fig.3. Case #1 was presented as an illustrative case.

Results:

The atypical cases represent 6.25% (7 out of 112) of the whole sample. Of these seven cases, five were male and two were female. The ages range from six to twelve, with a uniform distribution.

Four were single fracture, among them one with hemophilia; the other three were respectively combined with ulnar fracture, radial head subluxation, and multiple elbow lesion. All of the seven presented certain degree nerve irritation while no elbow dislocation or fragment incarceration was discovered. Valgus stress tests were performed and positive on all the operated five cases. Cases information was given in Table 1.

Though featured uneventfully in demographic data, the atypical ones did show some differences. Direct-forces or high-energy were revealed as the injury cause, rather than indirect-forces like valgus avulsion or muscle-pull on the medial humeral epicondyle which were fairly common in the typical cases. And uncommon combined injuries were noticed like lateral humeral condyle fracture (in Case #4) and Montegia equivalent lesion (in Case #3). The proximally displaced part could be the medial epicondyle itself (Case #2-#6), or a part of it (Case #1, #7). Anterior (Case #3, #5, #6) or posterior (Case #1) displacement could coexist with the proximal displacement. Any direction and extent of fragment rotation could also occur in all these cases.

For the treatment, open reduction and pins fixation were conducted except for Case #5 and #6. Case #3 went with an additional closed reduction on the humeroradial joint and Case #4 an additional open reduction of lateral condyle and fixation with pins. Case #5 was non-operatively treated mostly for the hematologic complication, and Case #6 mostly for the minimal fracture displacement. Depicted two cases (Case #1, #2) showed excellent reduction and proper fixation. Intraoperative suture of periosteum and cartilage was done for both. Final bony union was achieved in Case #1, though with heterotopic ossification developed in the lower and anterior position of the epicondyle, while fibrous union occurred in Case #2 [Fig.1a, b] [Fig.3].

For the operative findings, both the typical and atypical revealed a tear of periosteum in the medial part of the distal humeral. In the typical, the epicondyle fragment together with the attached periosteum was pulled distally. While for the seven atypical, the fragment retracted proximally with the attached proximal periosteum, yet some detached periosteum was pulled distally by the flexor-pronator mass [Fig.2a-f]. On some extreme occasion, the epicondyle ossification nucleus was stripped bare from the surrounding cartilage and dissociated proximally, and the remaining structure was pulled distally (Case #1).

The follow-up duration ranged from two to three years. The last follow-up results were excellent in four, good in one and fair in two cases (according to the Mayo Elbow Performance Score [8]).

Elbow was stable and pain-free for all seven. Two presented a fibrous union with no symptom. No cubitus valgus or ulnar nerve palsy resided.

Illustrative case:

A seven-year-old girl fell from parallel bars with her dominant elbow hit the ground directly. Arm plywood was put on immediately in a local clinic. The next day, she presented to our department, with pain and swelling in the medial elbow, restriction of the elbow joint and slightly numb in the little finger. Three-dimensional computed tomography (3D-CT) showed medial humeral epicondyle fracture, with fragment proximally displaced and rotated and a piece of epicondyle attached to fracture bed [Fig.1a]. Open reduction, fixation with two K-wires was carried out two days after injury. Intraoperative findings showed swelling of the ulnar nerve, detached flexor-pronator origin which was reattached to the proximal humeral periosteum but the UCL was intact [Fig.2b,d,f]. Longarm splint was applied, pins and splint were removed four weeks after surgery while active functional recovery started. Bony union achieved seven weeks postoperatively. At the final follow-up two years postoperatively, though X-ray revealed slightly heterotopic ossification near epicondyle, the patient regained a stable and pain-free elbow, with merely seven-degree extension loss [Fig.3a,b]. The final results were rated excellent.

Discussion:

Medial humeral epicondyle fracture accounts for 11-20% of pediatric elbow fractures [9], A relatively small amount to draw enough attention from pediatric orthopedists. However, over the past few decades, as diagnostic technology advanced and attitudes toward pediatric injury improved, more and more concern has been given on it. Its classification has since evolved. Multiple classification systems existed in English literature. In 1950, Smith [10] described five types of medial epicondyle injuries based on the amount of fracture displacement and entrapment of the fragment in the elbow joint. In 1982, Papavasiliou [11] modified the classification into four types, making it the most succinct and widely used criterion among the orthopedic practitioners since then. The Wilkins's [7] classification system, in which medial epicondyle injuries were divided into acute injury patterns and chronic tension stress patterns, was a more comprehensive one. The Papavasiliou four types and those with fracture lines through the epicondyle were included in the acute injuries in this classification. However, all of the above categorizations postulated that the separated fracture fragment was displaced towards distal and medial direction for the strong pull from the flexor-pronator mass. The proximally displaced ones were not even included. To date, only one study on a single case of this type in the English literature was identified, in which the authors presented a case that our Case #1 resembled [12]. Regretfully, the authors did not infer the mechanism in their case study and a single case revealed little of the commonality of this subset. Thus, the mechanism and the treatment algorism for this type need to be further clarified.

Currently, three existing theories regarding the mechanism for medial epicondyle fracture have been described: direct trauma [8], an avulsion mechanism involving an indirect muscular pull [9,13], and a combined association with elbow dislocation [3,14]. We managed to apply these theories to the cases in our series and described them as follows. As to the typical ones, direct force or indirect muscular traction cause avulsion of the epicondyle and periosteum surround it. Subsequently, the periosteum, cartilage, and the UCL sticking to the epicondyle as a whole, and altogether they are pulled distally by the musculus flexor [Fig.2e]. While for the atypical ones, from intraoperative findings of the subset, we speculated that though the avulsion part is similar, the epicondyle is dissociated from the distal periosteum or even the epicondyle ossification is stripped off from the cartilage surrounding it, and due to proximally-directed force, displaced proximally with or without rest attached periosteum [Fig.2f].

Management strategy somehow remains controversial even for typical medial humeral epicondyle fracture. It is already consensual to perform cast immobilization on those with low-energy mechanisms, stable elbows, and minimal displacement and to operate on those with traumatic/high-energy injury, significant displacement, elbow instability/dislocation, incarcerated fracture fragment, open fractures and ulnar neuropathy [15]. However, for those with moderate displacement, debates are still going on, mostly around the exact displacement amount to justify the surgical intervention.

Traditional treatment algorism for moderate displaced ones suggests cast immobilization when the displacement is less than 5mm, and operation when the displacement is more than 5mm [1,5]. A research by Edmonds [16] et al did show the relationship between displacement amount and outcomes like wrist flexion strength (approximate 2% decrease for every 1mm of anterior displacement due to muscle shortening). Yet the deemed displacement was usually measured on AP or lateral plain X-rays, which was with great deviation and did not represent the true displacement of the fracture, making it hard to justify the treatment strategy [17]. Not until recently have the researchers introduced more sophisticated ways like 45-degree oblique [5] and distal humerus axial view [6] to improve plain X-ray measurement. Yet, these established measurement ways were typically for the distal displacement cases, while for more complexed occasions in the proximal displaced, simple and reliable ways to measure were still in need, which is why this study resorted to more sophisticated ways like 3D-CT scans to get a precise measurement. In a recent review, Beck [18] and her colleagues acknowledged that besides the displacement measurement, the decision for surgery should be made on specific factors such as arm dominance and sport type the patients were to take.

Taking into account these specific factors, though, non-operative treatment still represents the mainstream and has been historically adopted [19]. Josefsson [20] et al. carried out a long-term follow-up retrospective study of 56 non-operatively treated fractures, which showed good results with minimal presence of ulnar nerve symptoms. To date, there are growing numbers of comparative studies supporting similar outcomes between operative and non-operative treatment [21,22]. Also, fracture displacement may improve over the conservative treatment period, a study result presented by Lim [23] and his colleagues, in which an average improvement of 1.55mm from 5.34mm at initial radiographs obtained. Yet high nonunion rates with up to 90% (17/19) in Farsetti [4] et al.'s and 50% (28/56) in Josefsson [18] et al.'s cohorts respectively occur in nonoperatively treated patients, though always asymptomatic. Yet, symptoms relating to nonunion like pain, elbow instability, and wrist flexion weakness do exist in some conservatively treated patients, especially in those adolescent athletes and the deciding factors and true incidence are still unknown, which explains the favor of some orthopedists for operative intervention. They believed that anatomical reduction and proper fixation allows earlier return to sports and recovery to a preinjury level of function [24]. However, general anesthesia, surgery-induced trauma, and extra medical expenses raised further concern about the indication for surgery.

Although precise displacement amount was able to acquire with 3D morphological images in proximally displaced cases, rigorous treatment algorithm is still lacking, as in the typical ones. Considering the complex mechanism, the diversified injury extent, and the multiple combined elbow injuries, the algorithm should therefore be even more complex. Deemed indications for surgery roughly include fragment displacement, combined injuries, patient needs, orthopedist experience. The history of direct injury or high energy injury and the indication of elbow instability like valgus test positive should be seriously taken into account for treatment decisions. The authors suggest open reduction when the displacement is apparent, soft tissue damage is assumed severe, combined elbow injuries are present and complex, or the patient is an adolescent athlete, requiring sooner return to activity and better performance on sports. It might be suggested to be very cautious with non-operative treatment for the atypical, as our study revealed the disruption of the anatomical structure tended to be more severe, which justified proper fixation. For the operation technique, the preliminary experience gained was to try best to restore normal anatomical (skeletal and ligamental) structure around the epicondyle in children. Whenever the surgery is decided, keeping the separated epicondyle and periosteum/cartilage fit together closely, firmly and durably is highly recommended, no matter what kind of hardware is used.

This case series provided a new subset of medial humeral epicondyle fracture which few predecessors had mentioned in the English literature. Though a small proportion of all pediatric medial humeral epicondyle fracture in this study, the proximally displaced one may update the current view on this topic. Dissociation between the epicondyle and distal periosteum/cartilage might be the vital pathological change. More complex and higher energy injury lead to more severe soft tissue damage and more often combined elbow injures, compared with those typical ones. Not only the fracture fragment but also the detached soft tissue is recommended to be anatomically reduced and fixated. The separation between epicondyle and periosteum/cartilage might stimulate subperiosteal ossification or entochondrostosis, which probably compromises the outcome. Although this work provided preliminary discussion and tentative treatment strategy, it did offer proper recognition of this unique subset of pediatric medial humeral epicondyle fracture for pediatric orthopedists. Considering its distinct appearance, mechanism, and intriguing treatment strategy, we cautiously recommend to add it into an even more extensive classification system to facilitate future clinical practice.

Abbreviations:

anterior-posterior(AP), ulnar collateral ligament(UCL), figure(Fig.), Three-dimensional computed tomography(3D-CT)

Declarations:

Ethics approval and consent to participate:

This retrospective case series study was approved by the institutional ethics committee of Children’s Hospital, Zhejiang University, School of Medicine.

Consent for publication:

Consent was received from the patients and their guardians to use the clinical data for study and publication. A copy of the written consent is available for review by the Editor of this journal.

Availability of data and material:

Whole data and material needed to support our findings were included in the paper and available for publication. Confidential patient data was not shared.

Competing interests:

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Authors’ contributions:

All of the authors have read and approved the manuscript. Specific authors’ contributions are as follows:

Guarantor of integrity of entire study: LX; WY; YY; WZ; JX; HL

Study concepts: LX; WY;

Study design: LX; WY

Literature research: LX; HL

Clinical studies: LX; HL; JX

Data acquisition: LX; WZ; HL

Data analysis/interpretation: LX; WZ; YY

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Manuscript revision/review: LX; WY; YY; WZ; JX; HL

Manuscript final version approval: LX; WY; YY; WZ; JX; HL

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Figure legends:

Fig.1

Multiple 3D-CT appearances of proximally displaced medial humeral epicondyle fracture.

a. Fragment displaced proximally and rotated posteriorly with part of the epicondyle attached to the humeral metaphysis (Case #1).

b. Fragment displaced and rotated proximally (Case #2).

c. Fragment displaced anteriorly proximally (Case #3).

d. Fragment slightly displaced anteriorly and proximally (Case #5).

Fig.2

The comparison of typical (a, c, e) and atypical (b, d, f) medial epicondyle fracture in radiologic images (a, b), intraoperative findings (c,d), and illustrative sketches (e,f).

a. 3D image of the typical medial humeral epicondyle fracture showing distally displaced epicondyle.

b. Atypical one showing proximally displaced epicondyle.

c. Typical one showing the epicondyle beneath the musculus flexor, tear between epiphyseal periosteum and the periosteum around epicondyle.

d. Atypical one showing bare epicondyle, tear between epiphyseal periosteum and the periosteum around epicondyle, also tear between epicondyle and its surrounding periosteum.

e. Sketch of typical one showing rupture of epiphyseal periosteum, intact UCL, and attachment of surrounding epicondyle periosteum.

f. Sketch of atypical one showing avulsion between epicondyle and its surrounding cartilage and periosteum. UCL is ruptured, epicondyle is pulled proximally by the attached epiphyseal periosteum.

1. Epiphyseal periosteum

2. The epicondyle and its migrate direction

3. The periosteum and cartilage surrounding epicondyle

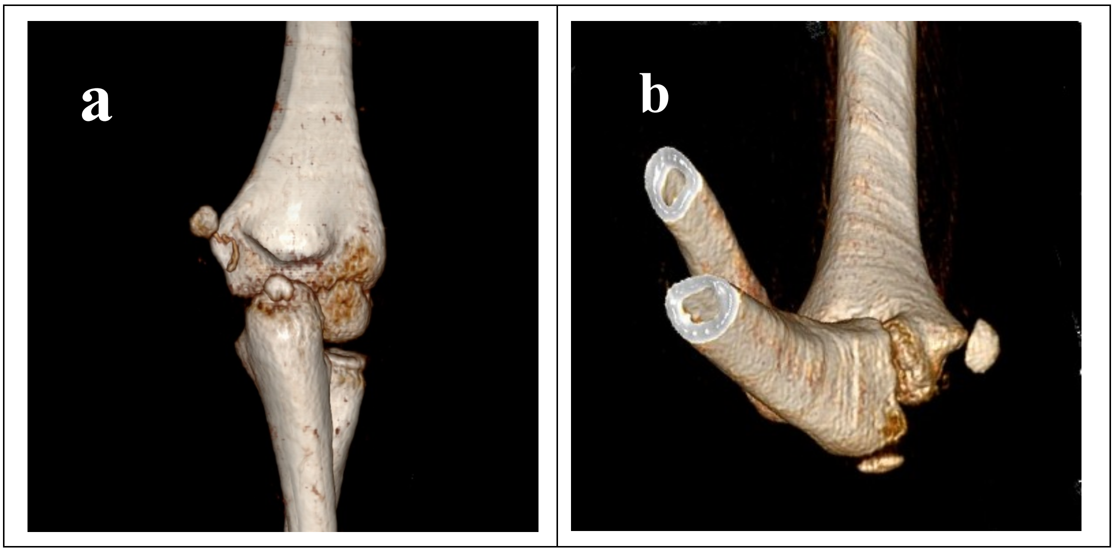
4. The ulnar collateral ligament (UCL)

5. The flexor-pronator mass.

Fig.3

Operative treatment for illustrative case #1 (a, b) and case #2 (c, d). A and c show immediate postoperative X-rays and b and d show two months follow-up X-rays. White arrows show heterotopic ossification near epicondyle. Preoperative images see Fig. 1a and Fig. 1b respectively.

Fig.1



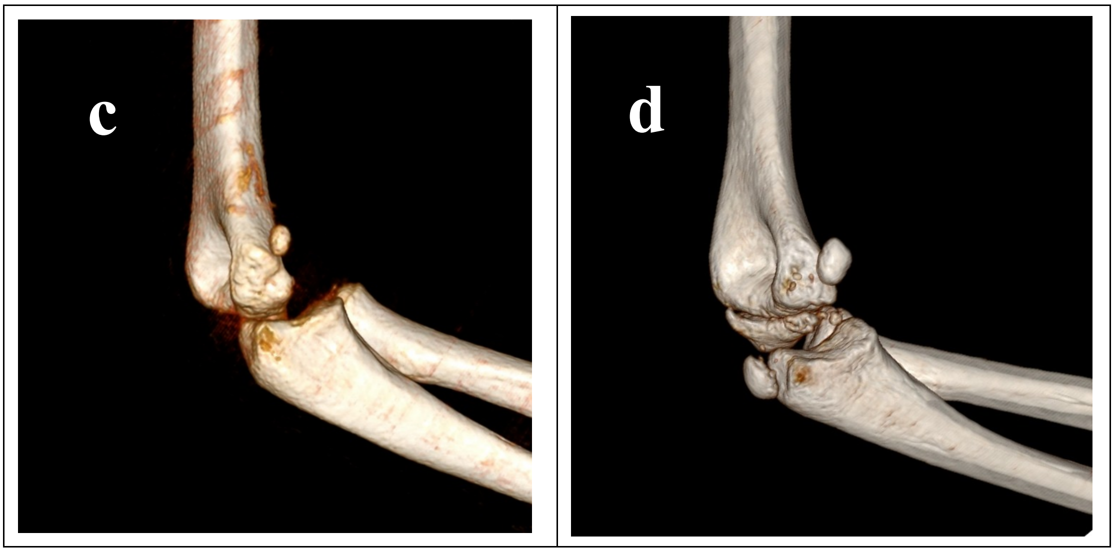
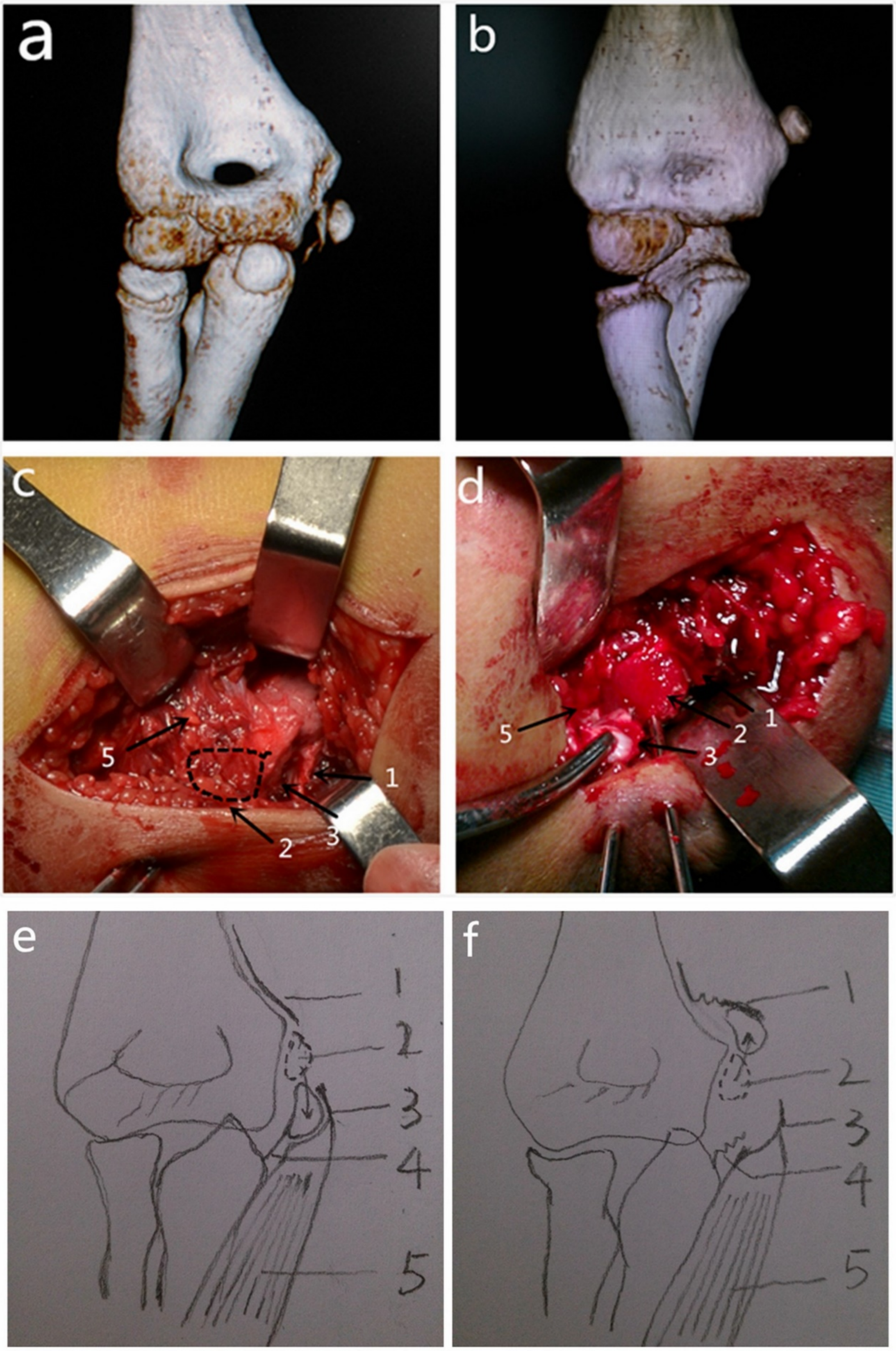


Fig.2



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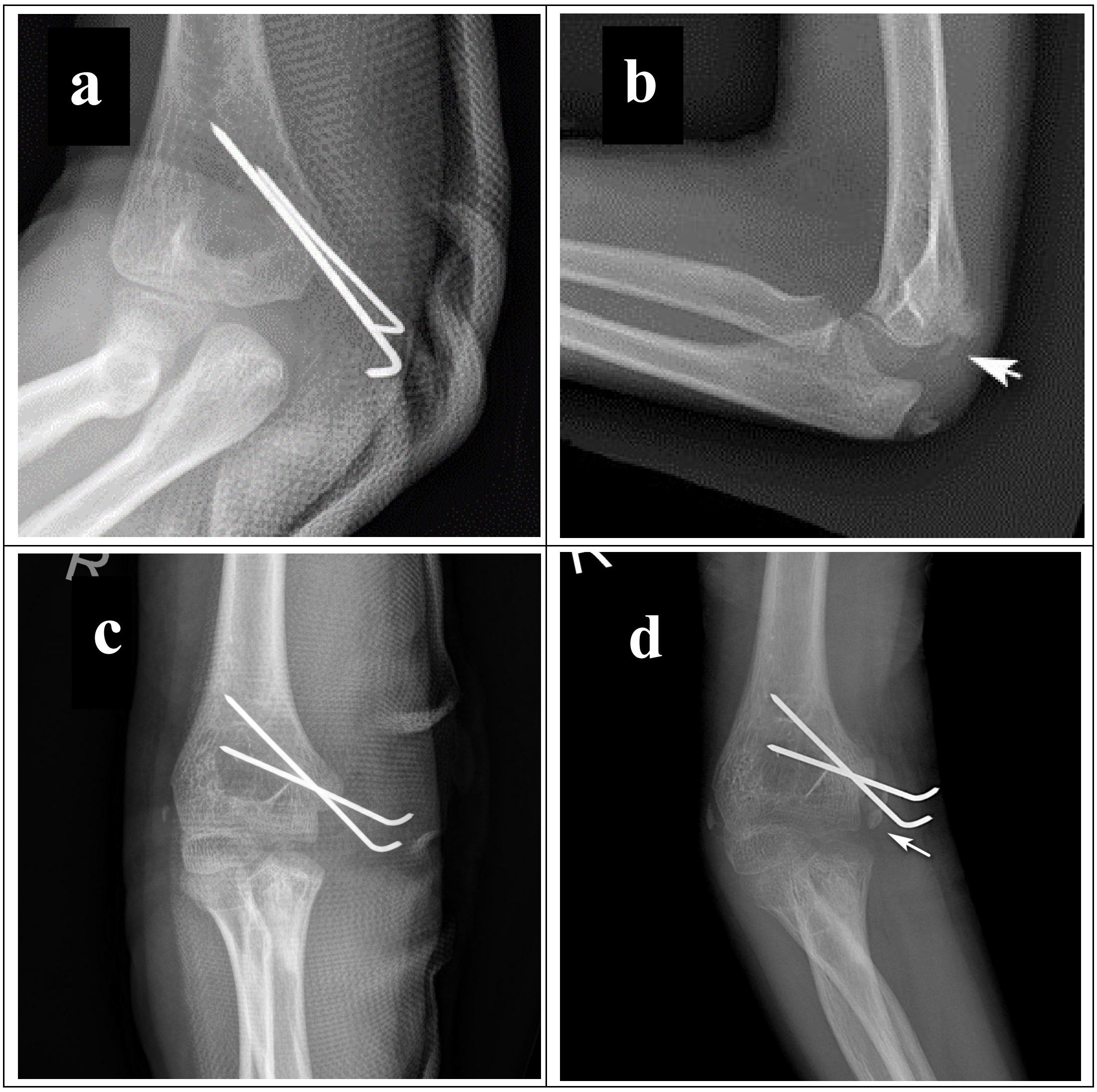

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Figures

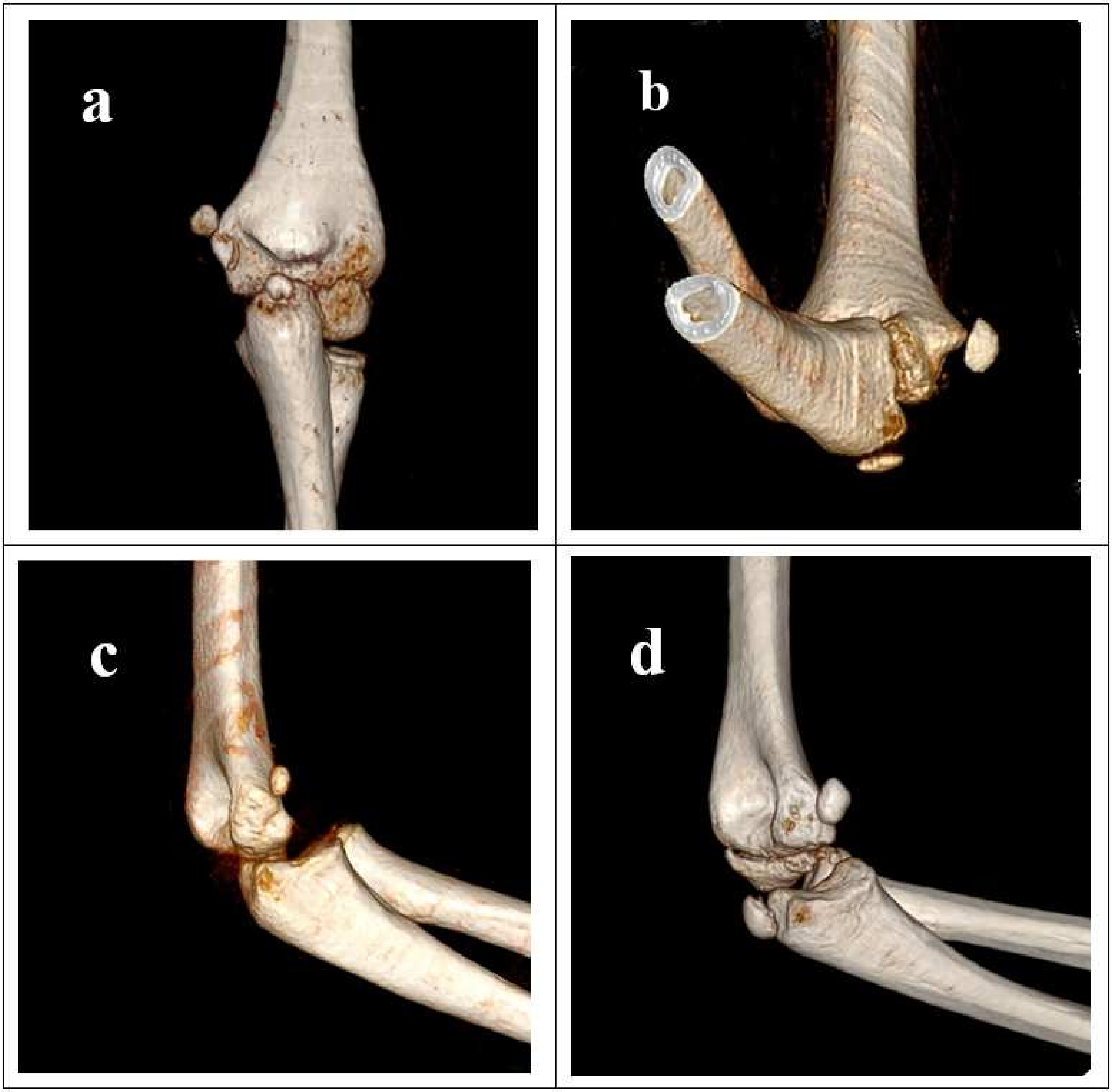

Figure 1

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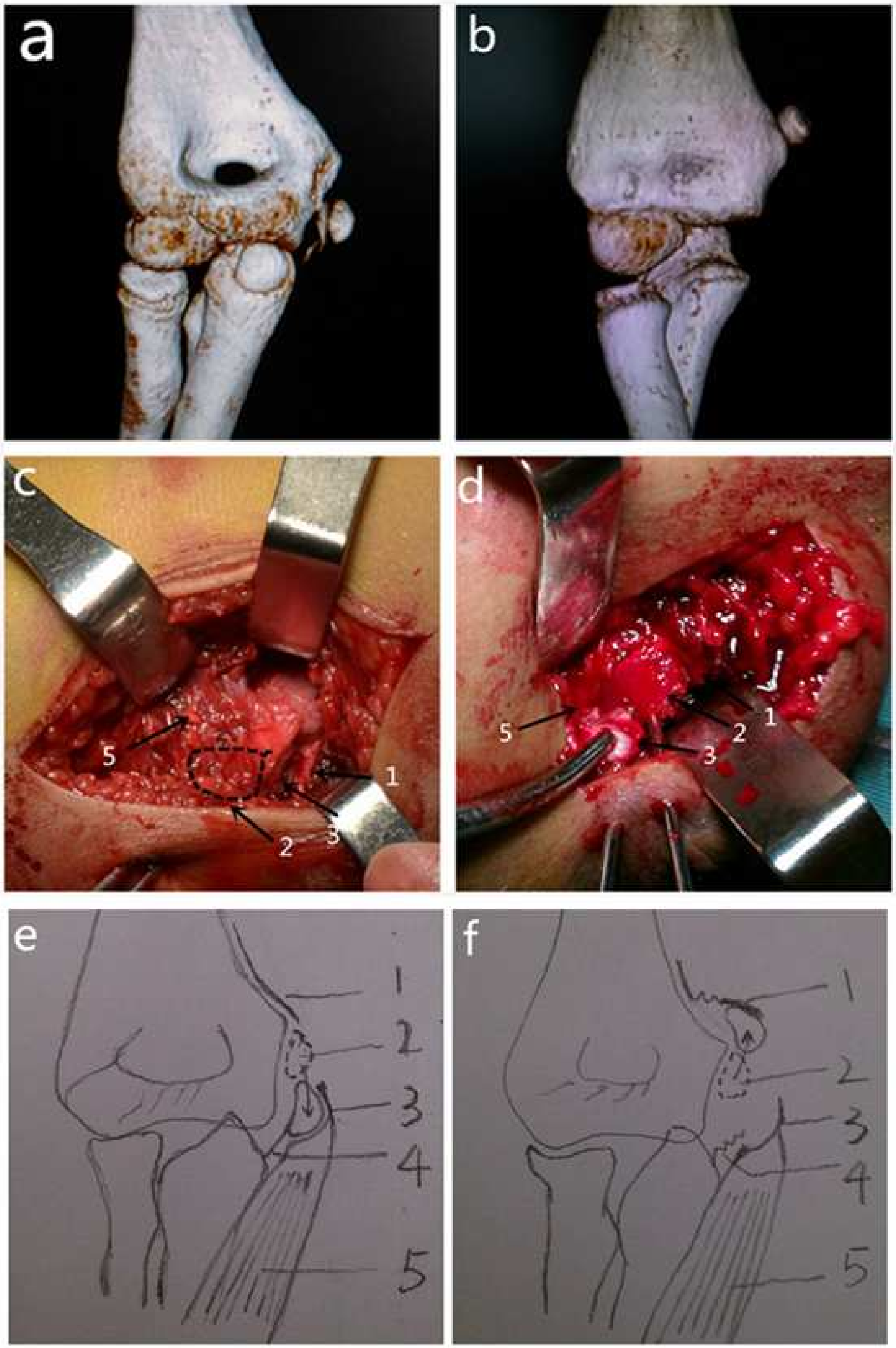

Figure 2

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Figure 3

Operative treatment for illustrative case #1 (a, b) and case #2 (c, d). A and c show immediate postoperative X-rays and b and d show two months follow-up X-rays. White arrows show heterotopic ossification near epicondyle. Preoperative images see Fig. 1a and Fig. 1b respectively.

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