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Case Report

Isolated trochlea osteochondral fracture of the distal humerus in a 6-year-old patient surgically fixed using biodegradable pins: A case study with over 3 years of follow-up

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ABSTRACT

Isolated humeral trochlea fracture, particularly in skeletally immature children, is extremely rare. The exact mechanism of this injury remains unknown because the humeral trochlea is embraced within the olecranon fossa without any muscular or ligamentous attachment. We report the treatment of a 6-year-old boy who sustained an isolated trochlea osteochondral fracture when he fell with his elbow in a flexed position while skateboarding. The patient had a history of lateral condyle fracture of the ipsilateral humerus one year previously. At the diagnosis, computed tomography (CT) revealed a small bony fragment displaced anteromedially from the superior border of the trochlea with lifting of its lateral border. Ultrasonography confirmed instability of the fractured segment. At the time of surgery, the anterior trochlea surface fracture formed a hinged fracture line on its proximal and medial border. The fracture was anatomically reduced and fixed using biodegradable pins.

Postoperatively, the involved elbow showed a sufficient functional recovery to a normal level without complications during 3 years of observation, although the biodegradable pins remained radiographically in place with partial degradation. The laterally opened avulsed fragment on primary CT clearly depicted the mechanism of injury: the impact entered from the lateral side of the elbow and progressed from the longitudinal ridge of the coronoid process onto the sulcus of the trochlea to shear off the anteromedial portion of the trochlea in a medial direction. The use of biodegradable pins for fixing a trochlea fracture in a skeletally immature patient provided favorable fracture healing; however, close observation is necessary until the completion of skeletal growth because of the lack of sufficient information on the long-term prognosis of trochlea fracture, especially when treated using biodegradable implants.

Introduction

The humeral trochlea is embraced within the articular notch of the olecranon and coronoid process without any muscular or ligamentous attachment, which naturally makes it inaccessible to direct trauma [1]. Because of its anatomical characteristics, the

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Fig. 1. Primary plain radiographs (A and B) and computed tomography (CT) images (C-H) of the involved elbow. A, Anteroposterior view. B, Lateral view, a bony fragment was observed anterior to the distal humerus (arrowhead). C, Representative axial image. D-F, Representative sagittal image at the medial section involving the bony fragment (D), at the middle section including the olecranon and coronoid fossa (E), and the lateral section

including ossification center of the capitellum and radial head (F). Note the normal congruity of the humeroulnar joint and normal position of the ossification center of the capitellum. G and H, 3D reconstructed images, a laterally opened avulsed fragment was observed (blank arrowheads in C, D, G and H). Arrows in G and H show the estimated direction of the impact that entered from the lateral side of the elbow and progressed from the coronoid process onto the sulcus of the trochlea.

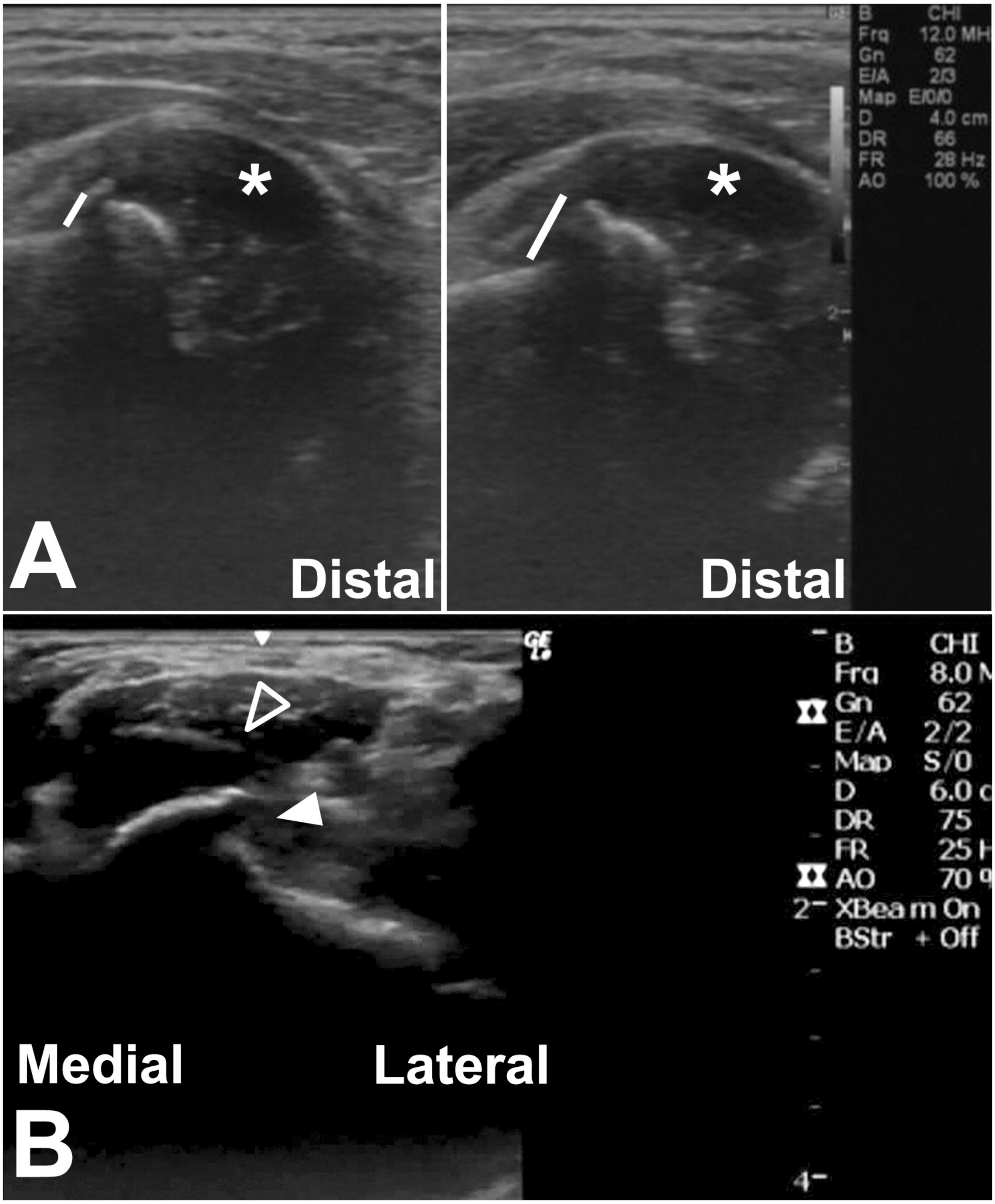

Fig. 2. Preoperative ultrasonographic images of the involved trochlea in the sagittal (A) and coronal (B) planes. A, The difference in the length of the bars shows instability of the trochlea with motion of the elbow. Asterisks shows the cartilaginous region of the trochlea. B, The bone fragment and surrounding cartilaginous surface had a separating border at the middle portion of the trochlea. The separation was observed on both the articular surface (blank arrowhead) and bone (arrowhead) layers.

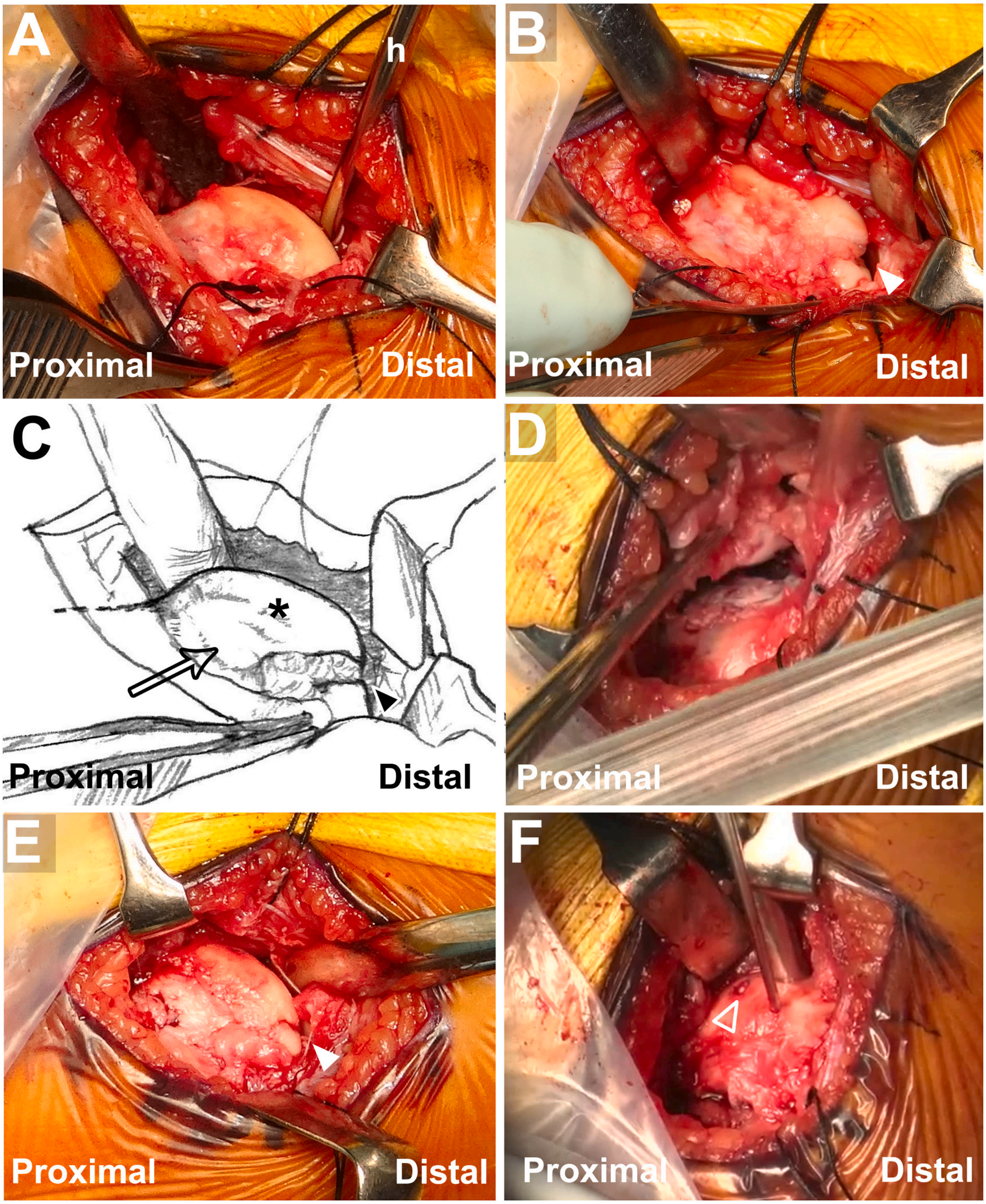

Fig. 3. Intraoperative photographs and a drawing. A, At the medial exposure of the proximal surface of the trochlea. Probing the lateral border of the fracture with a hook (h). B, At the medial exposure of the anterior surface of the trochlea. The arrowhead shows a stepped-off fracture site. C, The drawing depicting the characteristics of medial surface of the trochlea. The asterisk shows the medial surface of the trochlea. The black arrowhead shows the stepped-off fracture site. The arrow shows the medial hinged fracture site without a visible fracture line. D, After cutting the hinged medial fracture line. E, Achievement of articular reduction. The stepped-off fracture was anatomically reduced (arrowhead). F, Insertion of biodegradable pins (blank arrowhead).

incidence of isolated trochlea fracture is extremely rare and there is limited information on this injury, especially in relation to the mechanism of injury and treatment—particularly so in skeletally immature children [2–5].

We present the case of a pediatric patient with an isolated trochlea fracture that was treated with internal fixation using biodegradable pins. Informed consent was obtained from the patient and his parent for the publication of this case report.

Case presentation

A 6-year-old boy presented to our emergency department with strong pain on the medial side of left elbow after falling on the lateral side of the left elbow in flexion while skateboarding. He had a history of lateral condyle fracture of the ipsilateral humerus, which was surgically treated with tension band wiring at 5 years of age, for which the hardware was removed 12 weeks later.

On physical examination, the left elbow showed slight swelling with restriction of range of motion (ROM) and a normal peripheral neurovascular status. Plain radiographs revealed only a bony fragment anterior to the distal humerus. Computed tomography (CT) showed that the fragment was approximately 7.5 $\times$ 9.5 mm in size and anteromedially displaced from the superior border of the trochlea; no other bone injury was identified, with the congruity of the humeroulnar joint and the position of the ossification center of the capitellum being found to be normal (Fig. 1). For a further evaluation, ultrasonography confirmed that the fragment had continuity with the cartilaginous trochlea, which exhibited instability on elbow motion (Fig. 2A), and it had a border at the middle portion of the trochlea in the coronal plane (Fig. 2B). The diagnosis was isolated trochlea osteochondral fracture with intraarticular instability, based on the fact that the fracture consisted of an avulsed bone fracture and surrounding cartilaginous tissue of the trochlea, with the fracture

Fig. 4. Representative CT images obtained 29 months after surgery (A and B) and plain radiographs obtained 43 months after surgery (C, D, E and F); A, Coronal image. A sclerotic rim around the most proximal pin and hollow area around the 2nd proximal pin were observed. B, Sagittal image. An ossification center appeared in the trochlea (arrowheads in A and B). C and D, Lateral and anteroposterior (A-P) views of the contralateral elbow. E and F, A-P and lateral views of the involved elbow. A slight difference in the radiographic carrying angle was observed.

bordered laterally within the trochlea region without any concomitant injury around the elbow. Surgical fixation was indicated.

Four days after the injury, the patient underwent surgery. Under general anesthesia, the elbow joint was exposed via a medial approach. The fracture fragment was identified on the antero-medial surface of the trochlea with anterior displacement with a stepped-off longitudinal fracture line at its lateral and distal borders and the formation of hinges without a visible fracture line at the proximal and medial border (Fig. 3A–C). Since it was difficult to directly observe the lateral fracture border, a hook was used to probe the border, confirming the instability of the fragment (Fig. 3A). To obtain accurate reduction, the medial hinged line of the fragment was initially cut to facilitate mobility (Fig. 3D). After reduction, the fragment was fixed by inserting threaded biodegradable pins (diameter 2.0 mm, $n = 3$; diameter 1.5 mm, $n = 1$) made of forged composites of unsintered hydroxyapatite/ poly-L-lactide (F-u-HA/PLLA) (Osteotrans Plus, Takiron Co. Ltd., Hyogo, Japan) into the proximal side of the fragment to obtain adequate stability (Fig. 3E, F). Each pin was buried so that it would not protrude from the articular surface. Postoperatively, the arm was immobilized for 20 days. Reduction of the bony fragment was maintained on postoperative radiographic assessments. CT at 29 months after surgery demonstrated that the shape of biodegradable pins became obscure and collapsed, meanwhile a sclerotic rim surrounding the most proximal pin, and a hollow feature around the 2nd proximal pin was observed. A new ossification center appeared in the trochlea (Fig. 4A, B).

At the most recent visit, at 43 months after surgery, he had no complaints regarding the involved elbow and could participate in sports activities. The physiological valgus of the involved elbow decreased to 0°; the physiological valgus of the contralateral elbow was 10°. The elbow ROM reached 10–150° in extension and flexion, and 90° and 75° in supination and pronation, respectively. Radiographically, biodegradable pins were vaguely visible, and the ossification center in the trochlea was developing. The radiographic carrying angle of the involved and contralateral elbow was 171° and 167°, respectively (Fig. 4C–F), however the angle of the involved elbow did not change from that (170°) of 3 months before the trochlea fracture during follow-up for prior lateral condyle fracture. No complications requiring additional treatment occurred postoperatively.

Discussion

The bony fragment identified in the plain radiographs of the elbow included differential diagnoses other than isolated trochlea osteochondral fracture, such as epiphyseal separation of distal humerus with metaphyseal fracture and coronal shear fracture of the capitellum with extension to the lateral crista of the trochlea [6]. However, CT revealed a normal condition of the humeroulnar joint and ossification center of the capitellum. In a case of epiphyseal separation of the distal humerus, the humeroulnar joint and ossification center of the capitellum would have appeared to be dislocated radiographically. If coronal shear fracture of the capitellum had been involved, the shape of the capitellum would have been disrupted. The lateral border of the fractured segment at the middle portion of the trochlea observed on ultrasonography supported the findings that the fracture was limited to the trochlea region.

To our knowledge, four case reports of pediatric isolated trochlea fracture have been published in English (Table 1). These fractures were fixed with headless screws or Kirschner wires (K-wires), and all patients achieved a favorable recovery of the elbow ROM after 1–2.5 years of follow-up. Our present patient recovered full elbow ROM without complications following fixation with biodegradable

Table 1
Previous case reports of isolated trochlea fracture of the humerus in pediatric and adult patients.

Author (references)	Age/sex	Mechanism of injury	Elbow position at injury	Fixation implants
Pediatric patients				
Singh et al. [2]	15/F	Falling when hit by a bicycle	Flexed	HLS
Zimmerman et al. [3]	13/F	Falling while cheerleading	Flexed	HLS
Tomaru et al. [4]	7/M	Falling while playing soccer	Extended	K-wires
Yano et al. [5]	7/M	Falling on the ground	Extended	K-wires
Representative reports of adult patients				
Nakatani et al. [7]	58/M	Falling when hit by a car	Extended	HLS
Sen et al. [8]	25–46/M ($n = 4$), F(n = 1)	5 patients, falling in prone position	Flexed	Screws or K-wires

Author (references)	Follow-up period (years)	Achieved elbow arc of motion in extension-flexion (°)	Remarks
Pediatric patients			
Singh et al. [2]	2	5–130	A delayed diagnosis at 10 weeks after injury.
Zimmerman et al. [3]	2	0–135	
Tomaru et al. [4]	2.5	0–130	A history of epiphyseal separation of the ipsilateral DH.
Yano et al. [5]	1	0–130	A history of lateral condylar fracture of the ipsilateral DH.
Representative reports of adult patients			
Nakatani et al. [7]	0.75	15–135	
Sen et al. [8]	Mean, 2.7 (1.2–4.0)	Mean arc of motion, 101	

M, male; F, female; HLS, headless screws; K-wire, Kirschner wire; DH, distal humerus.

pins, and the outcome was comparable to that of previous reports. Isolated trochlea fractures can occur with the elbow in both extension and flexion positions, in which the act of load from the coronoid process and varus stress onto the trochlea at impaction are considered to be the leading injury mechanism of isolated trochlea fracture; however, the exact mechanism remains unclear [4,5,7,8].

The direction of fracture displacement on primary CT (Fig. 1) in our present patient supported the mechanism of the injury proposed in previous reports [4,5,7,8]. The laterally opened avulsed fragment depicted the trace of the impact, which entered from the lateral side of the elbow and progressed from the longitudinal ridge of the coronoid process onto the sulcus of the trochlea (Fig. 1G and H). Then, the resultant load split the surface of the anteromedial portion of the trochlea, shearing off the osteochondral segment medially and proximally. An association between isolated trochlea fracture and prior elbow fracture was suggested in a previous report [4,5]. Yano et al. reported the case of a 7-year-old boy with isolated trochlea fracture caused by falling with an extended elbow, and proposed the influence of varus deformity resulting from prior lateral condyle fracture to transfer the varus and axial force from the radiocapitellar joint to the ulnohumeral joint at injury [5]. In our patient, in accordance with the abovementioned injury mechanism, residual varus alignment may have enhanced the topical stress at the origin of fracture, where the remaining uneven articular surface due to prior lateral condyle fracture could add vulnerability to stress.

Regarding fixation implants for the trochlea, the use of headless screws would be appropriate in older children and adult patients with mature bone and closed physis, with the screws able to be firmly engaged without protrusion from the articular surface [1–3,7]. Conversely, the use of K-wires would be feasible for small and immature fractures, as in our present patient [4,5]. However, the use of K-wires carries a risk of wire insertion site infection in cases with the wires exposed to the skin or the need for removal surgery in cases with the wires buried under the skin. Therefore, the use of biodegradable pins was introduced in the treatment of our patient as a novel approach.

Biodegradable implants have been applied for various pediatric orthopaedic fixation without the need for routine implant removal as is performed for metallic hardware [9–11]. Implants made of F-u-HA/PLLA have advantages over PLLA-only implants, including: expectation of greater initial mechanical strength [9], implant radio-opacity enables radiographic observation during healing, good biocompatibility throughout the resorption process, and direct binding to surrounding bone without intervention involving fibrous tissue [10]. F-u-HA/PLLA implants may cause foreign body reactions associated with PLLA releasement. However, according to an experimental study, the possibility of this adverse reaction was small because composite F-u-HA/PLLA showed steady hydrolysis and the degradation of PLLA which otherwise provoked adverse tissue responses when uneven PLLA fragments were released at irregular time intervals [12]. In our patient, the hollow feature observed around the biodegradable pin could represent a foreign body reaction and the sclerotic rim could represent consequent ossification filling the hollow; however, these were subclinical. Several clinical experiences involving placement of F-u-HA/PLLA pins in osteochondral fragments in adolescent osteochondritis dissecans patients [9] and in physeal fragments in humeral lateral condyle fractures [10], without serious complications or growth disturbance, have been reported. These uncomplicated results would advocate the use of biodegradable pins, including young osteochondral tissue. A previous experimental study demonstrated that F-u-HA/PLLA pins were totally replaced by natural bone tissue at 5.5 years after implantation [12]. In our patient complete absorption of the biodegradable pins will take several more years.

In conclusion, we presented a case of pediatric isolated trochlea fracture that was surgically treated with biodegradable pins. In the diagnostic process, CT clearly depicted the direction of the shearing force of injury. Since information on the long-term prognosis of this fracture is insufficient—especially in cases treated using biodegradable implants—our patient should be followed until the completion of skeletal growth.

Declaration of competing interest

The authors declare no conflicts of interest in association with the present study.

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References

[1] J.B. Jupiter, K.A. Barnes, L.J. Goodman, A.E. Saldaña, Multiplane fracture of the distal humerus, J. Orthop. Trauma 7 (3) (1993) 216–220.
[2] A.P. Singh, I.K. Dhammi, A.K. Jain, S. Jain, Neglected isolated fracture of the trochlea humeri, Chin. J. Traumatol. 13 (4) (2010) 247–249, https://doi.org/10.3760/cma.j.jssn.1008-1275.2010.04.011.
[3] L.J. Zimmerman, J.J. Jaurengui, C.E. Aarons, Isolated shear fracture of the humeral trochlea in an adolescent: a case report and literature review, J. Pediatr. Orthop. B 24 (2015) 412–417, https://doi.org/10.1097/BPB.0000000000000175.
[4] M. Tomaru, D. Osada, K. Tamai, H. Taneichi, Isolated coronal shear fracture of the nonossified humeral trochlea in a 7-year-old patient, J. Hand Surg. Am. 43 (2) (2018) 191.e1–191.e5, https://doi.org/10.1016/j.jhsa.2017.10.007.
[5] K. Yano, Y. Kaneshiro, H. Sakanaka, Isolated osteochondral fracture of the trochlea in the coronal plane in a child before ossification of the trochlea: a case report and literature review, J. Hand Surg. Am. 43 (2) (2018) 190.e1–190.e5, https://doi.org/10.1016/j.jhsa.2017.07.004.
[6] M. Silva, P. Moazzaz, Coronal shear fracture of the distal humerus in an 11-year-old patient, J. Pediatr. Orthop. B 20 (2011) 50–55, https://doi.org/10.1097/BPB.0b013e32833cb784.

[7] T. Nakatani, S. Sawamura, Y. Imaizumi, A. Sakurai, H. Fujioka, M. Tomioka, et al., Isolated fracture of the trochlea: a case report, J. Shoulder Elb. Surg. 14 (2005) 340–342, https://doi.org/10.1016/j.jse.2004.07.012.
[8] R.K. Sen, S.K. Tripathy, T. Goyal, S. Aggarwal, Coronal shear fracture of the humeral trochlea, J. Orthop. Surg. 21 (1) (2013) 82–86.
[9] S. Uchida, H. Utsunomiya, T. Taketa, S. Sakoda, A. Hatakeyama, T. Nakamura, et al., Arthroscopic fragment fixation using hydroxyapatite/poly-L-lactate acid thread pins for treating elbow osteochondritis dissecans, Am. J. Sport Med. 43 (5) (2015) 1057–1065, https://doi.org/10.1177/0363546515570871.
[10] N. Takada, T. Otsuka, H. Suzuki, K. Yamada, Pediatric displaced fractures of the lateral condyle of the humerus treated using high strength, bioactive, bioresorbable F-u-HA/PLLA pins: a case report of 8 patients with at least 3 years of follow-up, J. Orthop. Trauma 27 (5) (2013) 281–284.
[11] A.F. Marvogenis, A.D. Kanellopoulos, G.N. Nomikos, P.J. Papagelopoulos, P.N. Soucacos, Early experience with biodegradable implants in pediatric patients, Clin. Orthop. Relat. Res. 467 (2009) 1591–1598, https://doi.org/10.1007/s11999-008-0537-4.
[12] Y. Shikinami, Y. Matsusue, T. Nakamura, The complete process of bioresorption and bone replacement using devices made of forged composites of raw hydroxyapatite particles/poly L-lactide (F-u-HA/PLLA), Biomaterials 26 (2005) 5542–5551, https://doi.org/10.1016/j.biomaterials.2005.02.016.