Diagnosis, management and complications of distal humerus lateral condyle fractures in children

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Abstract

We review the diagnosis, evaluation and management of paediatric lateral condylar fractures. The complications of these fractures are also discussed, including the management of fracture non-union.

Keywords

fracture, humerus, lateral condyle, non-union, paediatric

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Level of evidence

Level V (Expert opinion)

Introduction

Lateral condyle fractures of the elbow are the second most common paediatric elbow fractures after supracondylar fractures.^{1,2} These fractures of the distal humerus can be problematic in terms of diagnosis, treatment and complications. This review discusses the evaluation and management of paediatric lateral condylar fractures.

Anatomy

The ossification centre of the lateral condyle of the distal humerus usually appears before 1 year of age; however, this can be delayed until 24 months.³ The ossification centre is initially spherical and becomes progressively hemispherical as the distal humerus matures.⁴ The capitellum fuses with the medial condyle and the lateral epicondyle at approximately 10 years of age in girls and 12 years in boys.⁴ This common epiphyseal unit then fuses with the humeral metaphysis at 12 years to 14 years in boys and 13 years to 16 years in girls⁵ (Fig. 1). The capitellar physis is wider posteriorly than anteriorly, and may be mistaken for a fracture. The blood supply to the lateral condyle is derived from the radial artery through the radial recurrent, radial

collateral and interosseous recurrent branches that enter the lateral condyle posteriorly, just lateral to the capsular origin and proximal to the articular cartilage near the origin of anconeus muscle^{4,6,7} (Fig. 2).

Epidemiology

Lateral condyle fractures account for 12% to 17% of all distal humerus fractures in children, with a peak incidence at 6 years of age.^{1,2,4} The majority of fractures occur in isolation; however, associated fractures of the radial neck and proximal ulna and dislocation of the elbow have been reported.^{8–10} Unlike supracondylar fractures, lateral condylar fractures rarely result in neurovascular injury.¹¹

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Figure 1. Ossification and fusion of the growth centres of the distal end of the humerus. (a) Appearance of the distal humeral ossification centres in the early years. (b) Closure of the distal humeral ossification centres. Adapted from Haraldsson⁶.

Mechanism of injury

The mechanism of injury is either: (i) an avulsion by the pull of the common extensor origin and/or lateral collateral ligament owing to a varus stress exerted on the extended elbow ('pull off' theory) or (ii) a fall onto an extended upper extremity resulting in an axial load transmitted through the forearm, causing the radial head to impinge on the lateral condyle ('push off' theory).⁴

Classifications

Although, numerous classification systems have been described to classify lateral condylar fractures, the two most commonly used clinically are those proposed by Milch and Jakob^{12,14} (Figs 3 and 4).

The Milch classification system classifies the fracture according to the location of the fracture line in relation to the trochlear groove.¹² In type I injuries, the fracture line courses lateral to the trochlear groove representing a Salter-Harris type IV fracture: the elbow is usually stable because the trochlea is intact. In type II injuries, the fracture line propagates into the trochlear groove, representing a Salter-Harris type II fracture; the elbow can be unstable because the trochlea is disrupted.¹² A poor correlation between pre-operative radiographic diagnosis and intra-operative findings has been demonstrated with the use of this classification system.¹³

The Jakob classification is based on degree of displacement and rotation of the lateral condylar fragment and has three stages.^{14,15} In stage 1, there is less than

Figure 2. Intraosseous blood supply of the distal humerus. The main supply to the lateral condyle is via the radial collateral artery which enters posteriorly. IR, interosseous recurrent artery; MC, middle collateral artery; RC, radial collateral artery; RR, radial recurrent artery. Adapted from Yamaguchi et al.⁷

2 mm of displacement indicating an intact cartilage hinge. In stage 2, the displacement is between 2 mm and 4 mm but without rotation of the fragment. Stage 3 fractures involve displacement greater than 4 mm and rotation of the fracture fragment. There is good reliability between pre-operative anteroposterior

Figure 3. Milch and Jakob classifications. (a) Physeal injury (Milch type I) through the ossific nucleus of the lateral condyle (b) Physeal injury (Milch type II) through the nonossified trochlea. Jakob stages of displacement. Stage I displacement: articular surface intact. Stage II displacement: articular surface disrupted. Stage III displacement: fragment rotated. Adapted from Song.¹⁴

Figure 4. Anteroposterior radiographs of lateral condyle fractures demonstrating the classification in practice. (a) Jakob stage I, Milch type II. (b) Jakob stage 2, Milch type I. (c) Jakob stage 3, Milch type II.

radiograph and intra-operative findings with this classification system.¹⁶

Assessment: clinical/radiological

The child with a lateral condyle fracture will usually present with lateral elbow pain and a limited range of elbow motion.⁴ Unlike supracondylar fractures, lateral condyle fractures may not be associated with an obvious swelling or deformity. A high index of clinical suspicion and appropriate radiographic investigations are required to recognize the more subtle fracture patterns.¹⁷

Undisplaced fractures may not be easily detectable on standard anteroposterior and lateral radiographs therefore the addition of oblique views has been advocated.¹⁸ Comparative radiographs of the contralateral uninjured elbow may be helpful in children with subtle fractures. It has been suggested that children with a clinical suspicion of a fracture without radiographic evidence may be treated in a cast which is removed at 4 days to 7 days post-injury and repeat elbow radiographs performed to assess for secondary displacement.¹⁹ However, the diagnostic accuracy of such a protocol remains questionable and may delay the initiation of definitive treatment.²⁰

High-resolution ultrasonography has been shown to be a useful adjunct to plain radiography in the diagnosis of lateral condylar fractures. The advantages of ultrasonography are that it is easily available, may be performed on the day of injury and does not require the child to be sedated or anaesthetized. The use of the normal contralateral elbow for comparison may increase the diagnostic yield. The major disadvantage of this investigative modality is that it is highly operator-dependent and requires a radiologist skilled in the assessment of paediatric fractures.²⁰

The use of multidetector computed tomography (CT) has been shown to be very accurate in both diagnosing a fracture and assessing the degree of displacement. CT scans in children usually do not require sedation and/or anaesthesia and are readily available in most centres. However, the major drawback with the use of CT is that it involves radiation exposure.²¹

Magnetic resonance imaging has also been shown to be an accurate imaging modality for both diagnosing lateral condylar fractures and in the case of minimally displaced fractures to differentiate between fractures with an intact cartilage hinge, which are inherently stable, and fractures which extend into the joint which may be potentially unstable.²²

With the increasing diagnostic accuracy of the imaging modalities described above, the use of arthrography in the diagnosis of lateral condylar fractures has considerably declined.

Management

Conservative treatment

Undisplaced or minimally displaced fractures (≤ 2 mm) can be treated with long-arm casting with the forearm in supination and the wrist extended to reduce the muscle pull of the supinator-extensor muscle complex attached to the lateral condyle.²³ Radiographs need to be repeated at day 4 post-injury and weekly thereafter to assess for early displacement.¹⁹ If close observation is not possible, then surgical stabilization is indicated. Up to 10% of fractures that originally appear undisplaced on radiographs may subsequently displace with conservative treatment.¹⁹ Risk factors for late displacement include degree of soft tissue swelling, fracture crepitus or significant loss of soft tissue attachments.

Surgical treatment

Operative fixation is recommended when fracture displacement is ≥ 2 mm and/or there is loss of articular cartilage hinge. Intra-operative stability of the fracture can be determined by varus and valgus stress radiography. If displacement occurs on stressing, then the cartilaginous hinge is not intact and the fracture is deemed unstable and will require operative stabilization. Although all displaced fractures should be treated with internal fixation, operative stabilization should be performed judiciously as open surgery increases the risk of non-union and avascular necrosis (AVN). The blood supply to the lateral condyle enters the posterolateral portion of the condyle in close proximity to the lateral collateral ligament and extensor muscles. It is imperative this muscular attachment is not detached to prevent AVN.

The methods of fixation involve closed reduction and percutaneous pinning (CRPP), arthroscopically assisted percutaneous pinning and open reduction and internal fixation (ORIF).

Closed reduction may be performed with direct manipulation of the fracture fragment or use of a Kirschner wire ('K' wire) inserted into the fracture fragment as a joystick to aid reduction. An arthrogram may be helpful in determining extension into the joint and the need for open reduction as opposed to percutaneous fixation. The fracture can be stabilized with two to three divergent 'K' wires that penetrate the far cortex without crossing at the fracture site²² or a single cannulated metaphyseal compression screw.²⁵ Fracture reduction can be confirmed with arthrography or arthroscopy.²⁶ Exposed 'K' wires can be removed in the clinic without the need for further general anaesthesia.²⁷ Screw fixation may possibly reduce the incidence of lateral prominence; however, screw removal is recommended between 8 weeks and 12 weeks

postoperatively.²⁸ Bioabsorbable wires and/or screws have been shown to be a safe alternative to metallic hardware.²⁹

Fractures not amenable to CRPP are treated with ORIF using either the posterolateral (Kocher) or the direct lateral (Kaplan) approach. It is imperative to visualize the anterior joint line/articular surface prior to fixation.

Complications

Possible complications following paediatric lateral condyle fracture is lateral condylar overgrowth, cubitus varus or valgus, fishtail deformity, osteonecrosis, neurological injuries, physeal arrest and malunion.

The most common complication following lateral condyle fracture is lateral condylar overgrowth or spur formation occurring in up to 73% of cases. It is considered to be related to coronal malrotation of the distal fragment leading to displacement of the periosteum and new bone formation. Lateral condylar spur formation occurs more commonly following displaced fractures and has a marginally higher incidence following ORIF than following CRPP. Lateral condyle spurs are rarely symptomatic but can occasionally cause pain and/or decreased range of motion.^{24,30}

The second most common complication following lateral condyle fractures is a cubitus varus deformity, occurring in up to 40% of cases. It can occur following both operative and non-operatively treated fractures.³¹ The exact mechanism resulting in this deformity is not completely understood but is postulated to be related to either inadequate fracture reduction and/or growth stimulation of the lateral condylar physis. A cubitus varus deformity is rarely symptomatic.³²

Although a cubitus valgus deformity can also occur following a lateral condyle fracture, it is less common than a cubitus varus deformity. Cubitus valgus is considered to be a consequence of premature epiphysiodesis of the lateral condylar physis and is associated with non-union of lateral condylar fractures. Rarely, a tardy ulnar nerve palsy may occur as a sequelae of the cubitus valgus deformity.^{32,33}

A fishtail deformity usually occurs as a result of osteonecrosis of the central portion of the distal humerus physis with continued growth of the lateral condyle. This deformity can take two forms: first, as a sharp angled wedge because of persistence of a gap at the lateral physis leading to failure of proper formation of the lateral crista or, second, as a smooth curve because of osteonecrosis of the lateral part of the medial trochlea crista.³³ This deformity rarely compromises function.

Physeal arrest is very rarely seen following a lateral condyle fracture and usually does not result in a

significant limb length discrepancy because only 20% of humeral growth occurs at the distal physis.⁴

The loss of terminal degrees of extension and flexion are common following lateral condyle fractures but rarely cause functional impairment.³⁴

Non-union can present either as a result of delayed presentation, displacement of a conservatively managed fracture, early removal of fixation or traditional non-union of an undisplaced fracture. Lateral condyle fractures tend to heal more slowly than other physeal fractures, especially when they are treated non-operatively.² Failure of fracture union by 8 weeks is regarded as delayed union, whereas non-union is defined as failure of the fracture to heal by 12 weeks.³⁵ Non-unions tends to occur more commonly following undisplaced fractures or undiagnosed fractures initially treated non-operatively.⁴ The cause of the non-union is most likely the result of a lack of bony apposition of the thin lateral condyle fragment, as well as the pull of the forearm extensor muscles. The lack of support of the non-united lateral condyle column and continued growth of the medial condyle results in a cubitus valgus deformity. Traditional indications for open reduction and internal fixation are limited because of a fear of causing AVN; however, they include pain, loss of function, progressive deformity and tardy ulnar nerve palsy.³⁴ More recent studies have shown that non-unions in general respond well to fixation with good union rates, especially if surgery is performed within 16 weeks. Fracture reduction and stabilization can be performed either using a percutaneous technique³⁶ or a more traditional open technique utilizing the interval between brachioradialis/extensor carpi radialis longus and triceps. It is imperative with any open technique to beware and preserve the posterior soft tissue attachments and therefore the blood supply, as well as avoid the epiphyseal plate.³⁷ If an open technique is used, then autologous bone grafting has been advocated to encourage correction of the local biology.

Secondary displacement of a conservatively managed fracture should be treated as above, usually necessitating open reduction and fixation with 'K' wires or metaphyseal screws. In this group of patients, anatomical reduction should be attempted; however, this should not be performed at the expense of the posterior soft tissue envelope because of the high risk of AVN. A useful technique to aid reduction of a displaced fracture is to lengthen the common extensor origin by making multiple incisions along the common extensor aponeurosis.³⁸

Delayed presentation often presents a unique dilemma because patients may be relatively asymptomatic. However, the risks of coronal plane deformity and neurological sequelae of displaced fractures is an indication for surgical correction after careful discussion

with the parents. The proportion of patients with a satisfactory or good outcome as measured by functional scores decreases with interval from injury. A good result can be expected in the first 5 weeks, with this declining towards 12 weeks.³⁹ Beyond this time and with increasing displacement, good results can be achieved but the risks increase.^{40,41} In these most difficult cases in the presence of a symptomatic elbow, fixation without anatomic reduction gave a functional result with little or no pain.⁴²

Delayed presentation and/or non-union are no longer considered contra-indications to surgical correction

Conclusions

Lateral condyle fractures can be problematic in terms of diagnosis, treatment and complications. A high index of clinical suspicion and appropriate radiographic investigations are required to avoid missing a fracture. Operative fixation is recommended when fracture displacement is ≥ 2 mm and/or there is loss of articular cartilage hinge. Most complications following lateral condyle fractures do not cause functional problems. Delayed presentation and/or non-union are no longer considered contra-indications to surgical correction.

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References

- Bhandari M, Tornetta P and Swiontkowski MF The Evidence-Based Orthopaedic Trauma Working Group. Displaced lateral condyle fractures of the distal humerus. *J Orthop Trauma* 2003; 17: 306–308.
- Hardacre JA, Nahigian SH, Froimson AI and Brown JE. Fractures of the lateral condyle of the humerus in children. *J Bone Joint Surg Am* 1971; 53: 1083–1095.
- Buhr AJ and Cooke AM. Fracture patterns. *Lancet* 1959; 1: 531–536.
- Beaty JH and Kasser JR. The elbow region: general concepts in the paediatric patient. In: Beaty JH and Kasser JR (eds) *Rockwood and Wilkins' fractures in children*. Philadelphia, PA: Lippincott Williams & Wilkins, 2010, pp.475–486.
- Silberstein MJ, Brodeur AE and Graviss ER. Some vagaries of the capitellum. *J Bone Joint Surg Am* 1979; 61: 244–247.
- Haraldsson S. The intra-osseous vasculature of the distal end of the humerus with special reference to capitulum; preliminary communication. *Acta Orthop Scand* 1957; 27: 81–93.
- Yamaguchi K, Sweet F, Bindra R et al. The extraosseous and intraosseous arterial anatomy of the adult elbow. *J Bone Joint Surg Am* 1997; 79: 1653–1662.
- Pace A, Gibson A, Al-Mousawi A and Matthews SJ. Distal humerus lateral condyle mass fracture and olecranon fracture in a 4-year old female – review of the literature. *Injury Extra* 2005; 36: 368–372.
- Sharma H, Sibinski M and Sherlock DA. Outcome of lateral humeral condylar mass fractures in children associated with elbow dislocation or olecranon fracture. *Int Orthop* 2009; 33: 509–514.
- Dattani R, Patnaik S, Kantak A and Lal M. Distal humerus lateral condyle fracture and Monteggia lesion in a 3-year old child: a case report. *Acta Orthop Belgica* 2008; 74: 542–545.
- Shrader MW. Pediatric supracondylar fractures and pediatric physeal elbow fractures. *Orthop Clin N Am* 2008; 39: 163–171.
- Milch H. Fractures and fracture dislocations of the humeral condyles. *J Trauma* 1964; 4: 592–607.
- Mirsky EC, Karas EH and Weiner LS. Lateral condyle fractures in children: evaluation of classification and treatment. *J Orthop Trauma* 1997; 11: 117–120.
- Jakob R, Fowles JV, Rang M and Kassab MT. Observations concerning fractures of the lateral humeral condyle in children. *J Bone Joint Surg Br* 1975; 57: 430–436.
- Song KS. Lateral Condylar Fracture of the Humerus in Children: Is the Closed Pinning Satisfactory? *J Korean Fract Soc* 2012; 25: 163–168.
- Song KS, Shin YW, Oh CW, Bae KC and Cho CH. Closed reduction and internal fixation of completely displaced and rotated lateral condyle fractures of the humerus in children. *J Orthop Trauma* 2010; 24: 434–438.
- Gaston MS, Irwin GJ and Huntley JS. Lateral condyle fracture of a child's humerus: the radiographic features may be subtle. *Scot Med J* 2012; 57: 182.
- Song KS, Kang CH, Min BW, Bae KC and Cho CH. Internal oblique radiographs for diagnosis of nondisplaced or minimally displaced lateral condylar fractures of the humerus in children. *J Bone Joint Surg Am* 2007; 89: 58–63.
- Pirker ME, Weinberg AM, Hollwarth ME and Haberlik A. Subsequent displacement of initially nondisplaced and minimally displaced fractures of the lateral humeral condyle in children. *J Trauma* 2005; 58: 1202–1207.
- Vocke-Hell AK and Schmid A. Sonographic differentiation of stable and unstable lateral condyle fractures of the humerus in children. *J Paed Orthop Part B* 2001; 10: 138–141.
- Chapman VM, Kalra M, Halpern E, Grottkau B, Albright M and Jaramillo D. 16-MDCT of the posttraumatic pediatric elbow: optimum parameters and associated radiation dose. *Am J Roentgenol* 2005; 185: 516–521.

22. Kamegaya M, Shinohara Y, Kurokawa M and Ogata S. Assessment of stability in children's minimally displaced lateral humeral condyle fracture by magnetic resonance imaging. *J Paed Orthop* 1999; 19: 570–572.
23. Song KS and Waters PM. Lateral condylar humerus fractures: which ones should we fix? *J Paed Orthop* 2012; 32(Suppl 1): S5–S9.
24. Launay F, Leet AI, Jacopin S, Jouve JL, Bollini G and Sponseller PD. Lateral humeral condyle fractures in children: a comparison of two approaches to treatment. *J Paed Orthop* 2004; 24: 385–391.
25. Mintzer CM, Waters PM, Brown DJ and Kasser JR. Percutaneous pinning in the treatment of displaced lateral condyle fractures. *J Paed Orthop* 1994; 14: 462–465.
26. Perez Carro L, Golano P and Vega J. Arthroscopic-assisted reduction and percutaneous external fixation of lateral condyle fractures of the humerus. *Arthroscopy* 2007; 23: 1131 e1–e4.
27. Chan LW and Siow HM. Exposed versus buried wires for fixation of lateral humeral condyle fractures in children: a comparison of safety and efficacy. *J Child Orthop* 2011; 5: 329–333.
28. Li WC and Xu RJ. Comparison of Kirschner wires and AO cannulated screw internal fixation for displaced lateral humeral condyle fracture in children. *Int Orthop* 2012; 36: 1261–1266.
29. Andrey V, Tercier S, Vauclair F, Bregou-Bourgeois A, Lutz N and Zambelli PY. Lateral condyle fracture of the humerus in children treated with bioabsorbable materials. *Sci World J* 2013; 2013: 869418.
30. Pribaz JR, Bernthal NM, Wong TC and Silva M. Lateral spurring (overgrowth) after pediatric lateral condyle fractures. *J Paed Orthop* 2012; 32: 456–460.
31. So YC, Fang D, Leong JC and Bong SC. Varus deformity following lateral humeral condylar fractures in children. *J Paed Orthop* 1985; 5: 569–572.
32. Skak SV, Olsen SD and Smaabrekke A. Deformity after fracture of the lateral humeral condyle in children. *J Paed Orthop* 2001; 10: 142–152.
33. Rutherford A. Fractures of the lateral humeral condyle in children. *J Bone Joint Surg Am* 1985; 67: 851–856.
34. Peterson HA. *Epiphyseal growth plate fractures*. Berlin: Springer, 2007.
35. Flynn JC. Nonunion of slightly displaced fractures of the lateral humeral condyle in children: an update. *J Paed Orthop* 1989; 9: 691–696.
36. Knight DM, Alves C, Alman B and Howard A. Percutaneous screw fixation promotes healing of lateral condyle nonunion in children. *J Paed Orthop J* 2014; 34: 155–160.
37. De Boeck H. Surgery for nonunion of the lateral humeral condyle in children: 6 cases followed for 1–9 years. *Acta Orthop Scand* 1995; 66: 401–402.
38. Gaur SC, Varma AN and Swarup A. A new surgical technique for old ununited lateral condyle fractures of the humerus in children. *J Trauma* 1993; 34: 68–69.
39. Saraf SK and Khare GN. Late presentation of fractures of the lateral condyle of the humerus in children. *Indian J Orthop* 2011; 45: 39–44.
40. Agarwal A, Qureshi NA, Gupta N, Verma I and Pandey DK. Management of neglected lateral condyle fractures of humerus in children: a retrospective study. *Indian J Orthop* 2012; 46: 698–704.
41. Tejwani N, Phillips D and Goldstein RY. Management of lateral humeral condylar fracture in children. *J Am Acad Orthop Surg* 2011; 19: 350–358.
42. Wattenbarger JM, Gerardi J and Johnston CE. Late open reduction internal fixation of lateral condyle fractures. *J Paed Orthop* 2002; 22: 394–398.