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# Intraoperative Distraction Device for Open Reduction of Nascent Lateral Humeral Condylar Fractures in Five Dogs

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## Abstract

Lateral humeral condylar (LHC) nascent malunion fractures are challenging to treat because of extensive callus formation, scar tissue and contracture of surrounding tissues. The objective of this retrospective case series is to describe the novel procedural use of an intraoperative distraction device to aid in the reduction and anatomical alignment of nascent malunion LHC fractures along with long-term functional outcomes in these cases. Medical records of five consecutive cases of dogs with seven nascent malunion LHC fractures that were treated between 2015 and 2018 with the aid of an intraoperative distraction device were reviewed. Relevant clinical and radiographic data, forelimb circumference, elbow goniometry and clinical outcome were evaluated. Anatomic reduction and fixation with complete healing were achieved in all seven cases. Implants were removed in four cases to resolve persisting lameness. Three dogs (4 cases) were available for long-term follow-up: mean circumference and range of motion were decreased in the operated limbs as compared with the contralateral normal limbs. One dog (with bilateral fractures) was euthanized due to poor outcome. In the other five elbows, outcome was acceptable. Based on the results of this case series, use of an intraoperative distraction device to aid in anatomical reduction and fixation of nascent malunion LHC fractures should be considered.

**Keywords**

- humeral condylar fractures
- malunion
- intraoperative distraction
- dog

## Introduction

Fractures of the distal humeral condyle, including lateral, medial or Y/T fractures, account for approximately 50% of all humeral fractures in dogs.[1] Fractures of the lateral humeral condyle account for approximately 66% of these cases as the lateral humeral condyle is both directly in line with the thoracic limb's axis of weight bearing and has a smaller and weaker epicondylar crest than the medial humeral condyle.[1,2] The most common presentations of lateral humeral condylar fractures are Salter Harris type IV fractures in puppies less than 4 months old and intercondylar fractures in juvenile and adult dogs.[3] Being intra-articular, acute open reduction and internal fixation of lateral humeral condyle fractures are always recommended to achieve anatomic reduction, rigid stability and acceptable limb function.[4,5]

Nascent malunion fractures, defined as incompletely healed fractures with poor radiographic alignment of the lateral humeral condyle are more difficult to treat with surgical reduction than acute fractures because of the extensive callus formation, scar tissue and contracture of surrounding tissues.[6,7] The surgical approach to these cases has traditionally involved the use of osteotomes and debridement of callus to facilitate fracture site visualization

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to aid reduction. Historically, when these methods were not effective, the fracture was deemed non-reducible and dogs were managed medically or treated with salvage procedures such as amputation or arthrodesis.[8]

The objective of this retrospective case series is to describe the use of an intraoperative distraction device to aid in the reduction and anatomical alignment of nascent malunion lateral humeral condylar fractures along with long-term functional outcomes.

## Case Histories

Medical records for five dogs with seven total lateral Salter-Harris IV fractures of the distal humerus with proximal displacement and mineralized callus formation (nascent malunion) treated with intraoperative distraction and internal fixation between 2015 and 2018 were reviewed. All records were obtained from a single referral surgical practice. Two of the dogs[2,4] were presented by rescue organizations. Median estimated age at surgery was 142 days (range: 95–156) and median weight was 13.0 kg (range: 6.7–21.8). Lameness grading and radiographic osteoarthritis grading were documented in the medical records.[9,10] The specifics regarding each dog's history are as follows:

Dog 1 (elbows 1–2) was a 5-month-old, 10 kg intact male bulldog adopted with a known history of a one-story fall prior to adoption. Intake examination notes ambulation with a stilted, short-strided forelimb gait. Radiographs revealed nearly symmetric nascent malunion bilateral distal humeral condylar Salter-Harris type IV fractures with severe proximolateral displacement and evidence of early remodelling and an osteoarthritis score of 0.

Dog 2 (elbow 3) was a 4-month-old, 11 kg neutered male Pitbull terrier presented for evaluation of a 'fractured elbow' of unknown aetiology. The dog had a pronounced left forelimb lameness and severe left elbow thickening. Radiographs revealed a nascent malunion Salter-Harris IV fracture of the distal left humerus with moderate proximolateral displacement and mineralized callus formation and an osteoarthritis score of 0.

Dog 3 (elbow 4) was a 3-month-old, 6.5 kg intact female mixed breed dog was presented with trauma of unknown origin. Physical examination revealed a 3/4 right forelimb lameness, marked soft tissue swelling around the elbow and limited right elbow flexion. Radiographs revealed a nascent malunion Salter-Harris IV fracture of the distal right humerus with significant craniolateral displacement and moderate soft tissue swelling and an osteoarthritis score of 0.

Dog 4 (elbows 5–6) was a 4-month-old, 22 kg neutered male mixed breed dog presented for bilateral forelimb lameness. Radiographs revealed nearly symmetric nascent malunion bilateral distal humeral condylar Salter-Harris type IV fractures with extension through the lateral aspects of the condyles, severe proximolateral displacement, moderate mineralized callus formation, regional soft tissue swelling, subchondral sclerosis of the semilunar notches of the ulnas and an osteoarthritis score of 1.

Dog 5 (elbow 7) was a 4-month-old, 10 kg intact female mixed breed dog presented for evaluation of a left forelimb fracture of unknown aetiology. Physical examination found a 4/4 left forelimb lameness with firm elbow thickening and crepitus. Radiographs revealed a nascent malunion Salter-Harris IV fracture of the distal left humerus with craniolateral displacement, mild mineralized callus formation, mild soft tissue swelling of the elbow and an osteoarthritis score of 0.

Preanesthetic biochemistry and haematology results were unremarkable for all dogs.

### Surgery

In all cases, a lateral approach to the humeral condyle was performed. Mineralized callus was debrided with rongeurs and Cottle osteotomes until the fractured condylar fragment could be identified and mobilized. An Orthofix straight minirail system (Orthofix LTD, Maidenhead, UK) was then positioned across the fracture site using one 2.4 mm SCAT pin (IMEX Veterinary Inc., Longview, Texas, United States) placed in the distal humerus proximal to the fracture and a second 2.4 mm SCAT pin placed in the proximal radius (►**Fig. 1**). The fracture and associated soft tissues were then distracted to reduce the effects of soft tissue contraction until anatomic reduction of the humeral condylar articular surface could be achieved. Distraction was maintained for at least 5 minutes.

Fractures were stabilized with a cortical transcondylar lag screw with washer in all cases, as well as a lateral Kirschner wire proximally across the lateral epicondyle (elbows 1–4 and 7) or a lateral locking bone plate in elbows 5 to 6 (Synthes, West Chester, Pennsylvania, United States). Transcondylar lag screws were placed using a retrograde drilling technique. Surgical sites were irrigated with saline and closed routinely in three layers. Orthogonal postoperative radiographs were obtained in all cases (►**Fig. 2**).

### Postoperative Care and Outcomes

All dogs received fentanyl constant rate infusions (3.3 µg/kg/h) and isotonic fluids overnight and were discharged the following day with oral medications. Analgesics administered during the initial postoperative period included tramadol (1–4 mg/kg, per os [PO], q 8 hour) and carprofen (2.2 mg/kg, PO, q 12 hour). All dogs were prescribed cefpodoxime (7 mg/kg, PO, q 24 hour $\times$ 7 days), provided an e-collar, splinted and bandaged for 10 to 14 days following surgery with instructions for 4 to 6 weeks of strict rest.

In all dogs, both short-term ($<$ 6 months) and long-term ($>$ 1 year) follow-up evaluations were recommended, but long-term evaluations were not completed for three elbows. Evaluations included a physical examination, orthogonal radiographs of the operated elbow(s) and evaluation of the surgical site for signs of infection as defined by the Centers for Disease Control and Prevention.[11] Additionally, all long-term follow-up examinations included elbow goniometry as described by Formenton and colleagues and forelimb circumference measurements.[12] Outcomes were considered successful when dogs returned to adequate function (lameness grade of 0–1/4) and had no complications requiring a

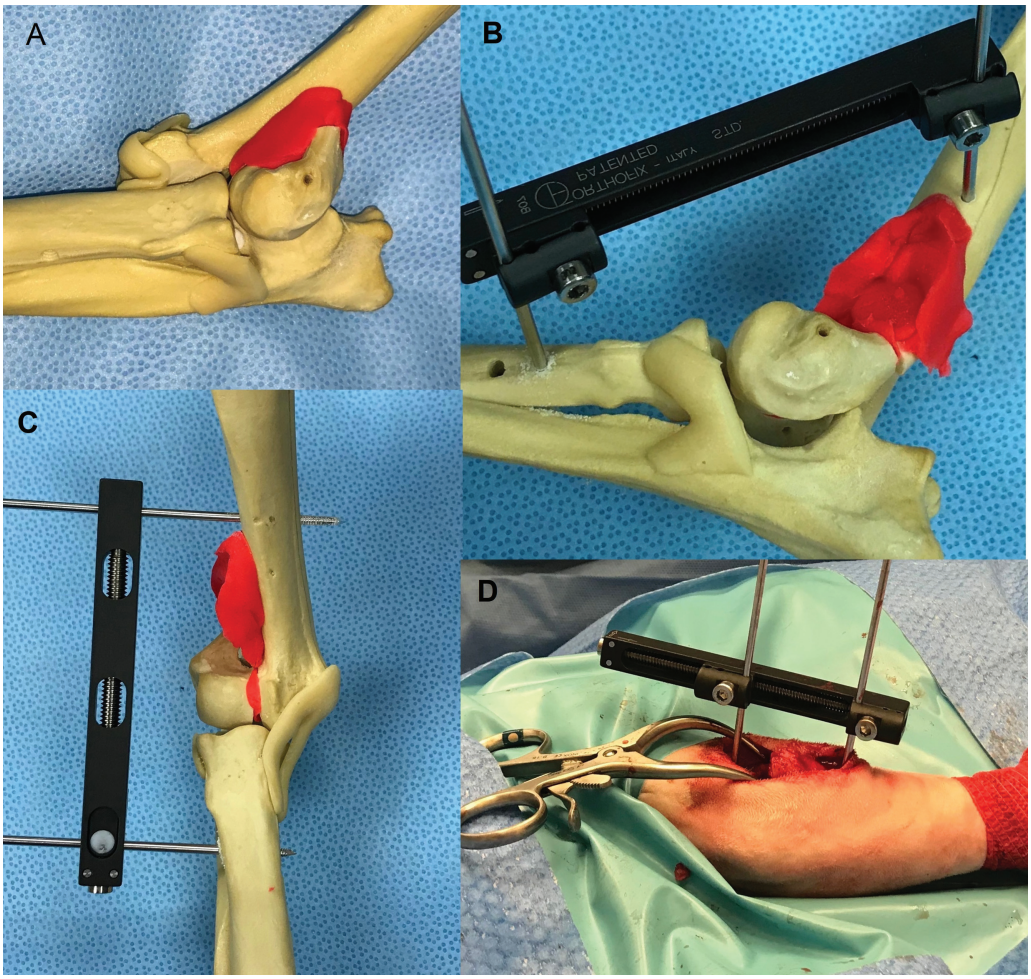


**Fig. 1** (**A**) A model depicting the lateral surgical approach to the humeral condyle. Red modelling clay has been used to illustrate callus associated with nascent malunion fractures. (**B**) An Orthofix straight minirail system positioned across the fracture site using one SCAT pin placed in the distal humerus proximal to the fracture and another pin in the proximal radius. (**C**) A craniocaudal view of the positioned distraction device. (**D**) An intraoperative image of the positioned distraction device.

salvage procedure for resolution.[13] Subjective client communication medical record notes about owner-perceived outcomes were also reviewed.

Dog 1 (elbows 1–2) was non-ambulatory (lameness score 4/4, bilaterally) at the short-term evaluation (56 postoperative days) due to a surgical site infection. Purulent material was aspirated from the joint space and submitted for aerobic culture, and the dog was treated with appropriate antibiotic medications for 2 weeks. Following treatment, his lameness grade was unchanged and his elbow joints had persistent swelling and crepitus. Radiographs revealed loss of reduction, craniolateral displacement of the left elbow and changes consistent with osteomyelitis of both elbows including lucency along the margins of the transcondylar screws. Salvage procedures were discussed, but the owner pursued bilateral implant removal surgery the following week. This dog was lost to follow-up and euthanatized at another hospital 12 weeks following the procedure. As a result of the catastrophic complications in this dog, treatment was considered unsuccessful.

Dog 2's (elbow 3) incision site was healing appropriately at the short-term re-check appointment (27 postoperative days) and radiographs confirmed anatomical alignment and development of grade 1 osteoarthritis. At the long-term re-check (961 postoperative days), a 1/4 right forelimb lameness score was noted. No soft tissue swelling or pain was elicited on palpation or manipulation of the elbows bilaterally. The owner reported he was very active and comfortable at home but would occasionally hold his right forelimb up after activity.

Dog 3 did not complete the short-term re-check. A lameness score of 1/4 was observed at the long-term re-check (749 postoperative days) and the owner communicated that the dog was active and painless at home. Radiographs obtained at both re-check examinations demonstrated mild peri-articular proliferation and development of grade 2 osteoarthritis but appropriate anatomic alignment and fracture healing.

Dog 4's (elbows 5–6) incision sites were healing appropriately at the short-term re-check (27 postoperative days). The dog had normal range of motion in both elbows with no observable forelimb lameness. Radiographs confirmed appropriate anatomic alignment and fracture healing with grade 2 osteoarthritis documented in both elbows. At the

 

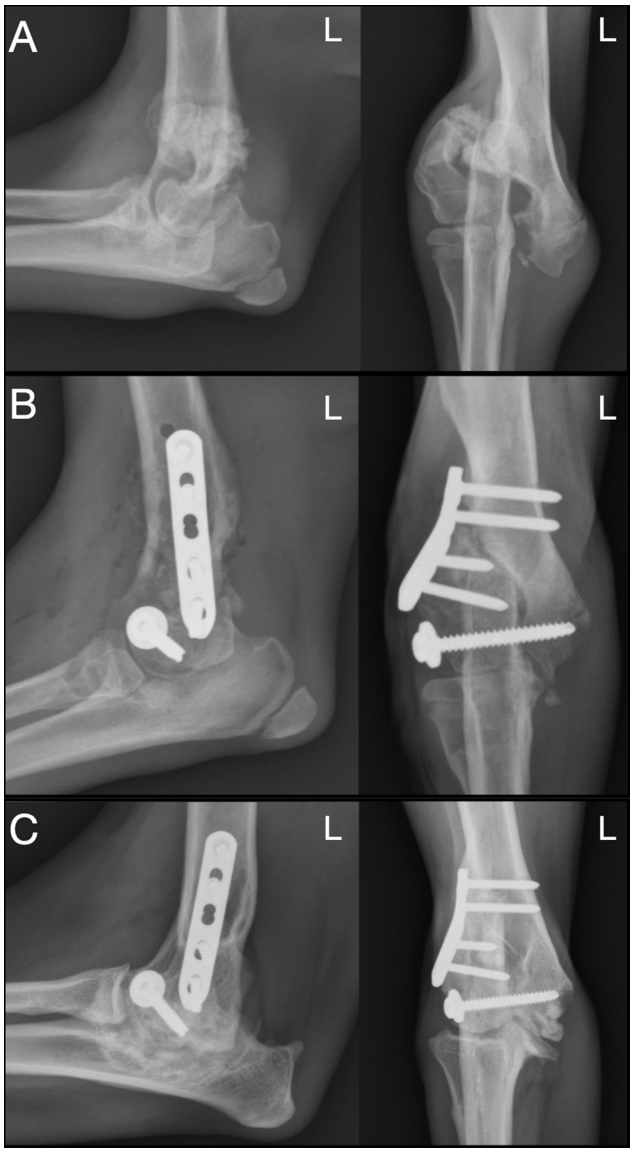


**Fig. 2** (**A**) Preoperative lateral and craniocaudal radiographic images of a nascent malunion lateral humeral condylar fracture with proximal displacement and mineralized callus. (**B**) Immediate postoperative lateral and craniocaudal radiographic images of a nascent malunion lateral humeral condylar fracture with surgical reduction and fixation. (**C**) Long-term (14-month) postoperative lateral and craniocaudal radiographic images of a nascent malunion lateral humeral condylar fracture with surgical reduction and fixation.

long-term evaluation (411 postoperative days), the dog was walking well but radiographs revealed a hypertrophic callus formation on the lateral aspect of the right elbow at the distal end of the plate. Implant irritation was suspected, and implant removal was performed. At the time of suture removal, the dog's lameness grade was 1/4.

Dog 5's (elbow 7) incision site was swollen at the short-term evaluation (83 postoperative days), and the dog had persistent 1/4 lameness at trot. Radiographs revealed mild soft tissue swelling attributed to implant irritation and development of grade 1 osteoarthritis. The implants were removed. This dog was lost for long-term follow-up.

In the four elbows with long-term follow-up, elbow goniometry, limb circumference measurements and orthopaedic examination were performed. The measurements were clinically but not statistically compared between the operated and non-operated limbs in unilaterally affected dogs. Median angle of elbow extension in the operated and non-operated limbs was 150 degrees (range: 145–160) and 140 degrees (no range) respectively. Median elbow flexion angle in the operated and non-operated limbs was 77.5 degrees (range: 50–110) and 40 degrees (range: 35–45) respectively. Median long-term circumference of the operated and non-operated limbs was 21.5 cm (range: 21–23) and 26.0 cm (range: 24–28) respectively.

## Discussion

This case series represents the first published group of dogs with nascent malunion lateral humeral condylar fractures to be treated with traditional open reduction and internal fixation with the aid of an intraoperative distraction device. Fracture reduction and anatomic alignment were achieved in all seven elbows. While this independently demonstrates that the intraoperative distraction device was useful in enabling fracture reduction in cases of nascent malunion condylar fractures with associated contracture, we also assessed limb function and monitored postoperative outcomes.

All but one elbow demonstrated proper anatomic alignment and fracture healing at the short-term evaluations. Additionally, the three dogs (4 elbows) that were presented for long-term examinations had appropriately healed incision sites, lameness scores of 1/4 and good owner-perceived mobility and comfort. Of these cases, dog 3 is the only dog with a recorded pre-surgical lameness score to compare with the long-term evaluation. Her score improved dramatically from 3/4 to 1/4. Although lost to long-term follow-up after plate removal surgery, dog 5 also demonstrated dramatic improvement of limb function, improving from 4/4 to 1/4 at the short-term evaluation. The remaining dog (2 elbows) was euthanatized for unknown reasons during convalescence, though it is expected that the owner's decision was influenced by multiple postoperative complications in that dog's surgical sites, including surgical site infection in both elbows and loss of reduction in one elbow, which were not seen in the other operated elbows.

Range of motion and circumference measurements of surgical limbs were worse when compared with the unaffected limb in unilateral cases. Reference measurements for goniometry and limb circumference data are not available for acutely repaired humeral condylar fractures, but we suspect they do not consistently return to pre-injury values. When compared with the reference ranges established by Formenton and colleagues, all measurements in our cases fell within two standard deviations of the normal dog elbow reference values.[12]

Progression of osteoarthritis was appreciated radiographically in all dogs except for dog 1 due to osteomyelitic changes present in the follow-up radiographs. This progression of osteoarthritis despite proper fracture alignment is consistent with previously reported results which demonstrated that

humeral condylar fracture reduction score was not correlated to the long-term outcome measured by radiographic osteoarthritis score.[14] While computed tomography would have been helpful for assessing articulation and osteoarthritis, Shubert and colleagues reported that assessment of elbow joint osteoarthritis was consistent between radiographic and computed tomographic examination.[15]

Our report was limited by incomplete and inconsistent follow-up. Intervals from surgery to recheck evaluations were variable, possibly skewing the results of our limb circumference and lameness measurements in particular. Additionally, several objective measurements of functional outcomes including preoperative orthopaedic examinations and specifics regarding postoperative limb function were not fully documented in the medical records. In our study, only an Orthofix straight minirail system was utilized for intraoperative distraction, but we expect that any distraction device would be effective. Lastly, reduction using solely traditional methods prior to using the distraction device was not attempted in any cases, making it difficult to form strong conclusions regarding the use of this device in cases specifically refractory to traditional methods of reduction alone.

While prospective research into this method is warranted, our case outcomes suggest that the use of an intraoperative distraction device to aid in anatomical reduction and fixation of nascent malunion lateral humeral condylar fractures with associated soft tissue contracture should be considered.

### Conflict of Interest

None declared.

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