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Repair of Fractures of the Lateral Aspect of the Humeral Condyle in Skeletally Mature Dogs with Locking and Non-Locking Plates

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Abstract

Objective The aim of this study was to report the functional outcome and complications following transcondylar screw and epicondylar plate fixation of skeletally mature dogs with fractures of the lateral aspect of the humeral condyle using a string of pearls, limited contact dynamic compression plate (LC-DCP) or locking compression plate (LCP).

Study Design This study was a retrospective review of clinical records, radiographic images and canine brief pain inventory evaluation with a supplementary non-validated questionnaire.

Results Thirty-one fractures in 29 dogs were included. The majority of dogs were Spaniels (23/29). Thirty fractures had evidence of humeral intracondylar fissure. Sixteen fractures had string of pearls, eight LCP and seven LC-DCP. There were two minor complications and three major complications. Perioperative (median: 6 weeks, range: 6–12) outcome was considered fully functional for 24 fractures and acceptable for 6 fractures. One dog had an unacceptable outcome due to the failure of an LCP that healed following revision surgery. Fractures with radiographic follow-up had a persistent visible intracondylar fracture line in 20/26. Twenty-six of twenty-seven owners perceived an excellent outcome (median: 135 weeks, range: 25–246).

Conclusion Repair of fractures of the lateral aspect of the humeral condyle with a transcondylar screw and epicondylar plate has a good perioperative, mid- and long-term outcome with 10% major complication rate, despite incomplete or non-union of the intracondylar fracture in 20/26 elbows.

Keywords
- humeral
- condylar
- fracture
- dog
- plate

Introduction

Humeral condylar fractures are common and may occur as simple intracondylar articular fractures involving the lateral or medial side of the humeral condyle, or as comminuted 'T - Y' fractures. Fractures of the lateral aspect of the humeral condyle (FLHC) are the most common.[1] Most FLHC occur in skeletally immature dogs, with a peak incidence at 4 months, prior to closure of the distal humeral physis.[1,2] Skeletally mature dogs suffering from fracture of the humeral condyle with a minimally traumatic fracture aetiology may have humeral intracondylar fissure (HIF), previously referred to as incomplete ossification of the humeral condyle, as a predisposing factor.[3,4] In the United Kingdom, the English Springer Spaniel is an over-represented breed.[1,5] These dogs may be expected to have increased rates of postoperative

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complications as it is common for the intracondylar component of the fracture not to heal after repair, resulting in increased risk for fatigue failure of implants.[5] As these fractures are articular, they require anatomic reduction and rigid fixation to maximize joint function.[6] It has been reported that the use of a transcondylar screw and epicondylar plate reduces the risk of postoperative complications.[7] Reported risk factors for complications include transcondylar screw angle, surgical time, persistence of an intracondylar fracture line, presence of HIF, age greater than 8 months and epicondylar Kirschner wire with transcondylar screw fixation.[7–10] The use of string of pearls (SOP) or locking compression plates (LCP) for stabilizing FLHC has previously been described in 'Y'/'T' fractures.[11–13] Choice of plate is based on surgeon preference in the absence of evidence to support the use of one plate type over another. The aim of this study was to report perioperative, mid, and long-term outcomes following transcondylar screw and epicondylar plate fixation of skeletally mature dogs with FLHC. The major and minor complications for each plate type (SOP, LCP and limited contact dynamic compression plate [LC-DCP]) were reported.

Materials and Methods

The hospital (Anderson Moores Veterinary Specialists) database was searched for the medical records of dogs greater than 8 months of age that had a FLHC surgically stabilized with a transcondylar screw and epicondylar plate between January 1, 2015 and December 31, 2019. The following information was gathered for each patient: signalment, body weight, pre- and postoperative radiographs, implants used, complications, use of perioperative and postoperative antibiotic medications, postoperative lameness and evidence for presence of HIF as previously described.[7] Dogs were excluded from the study if the medical record was incomplete, radiographic examination had not been performed at least 6 weeks following the surgery or the animal was lost to follow-up. The study was approved by the Royal College of Veterinary Surgeons' Ethics Review Panel.

Surgical Technique

A standard lateral approach to the humeral condyle and epicondyle was used in all cases including partial elevation of the extensor carpi radialis to expose the cranial aspect of the capitulum.[14] An 'inside out' technique was used for transcondylar screw placement, aiming for a screw with an outer diameter 30 to 50% of the diameter of the humeral condyle at its narrowest point.[9] The drill hole was sequentially enlarged using increasing sizes of drill bits until the final glide hole was drilled. The fracture was then anatomically reduced (confirmed by ensuring perfect alignment at the epicondylar ridge and absence of a step at the cranial articular surface [unless comminution at the epicondylar ridge precluded the ability to assess this, in which case only the articular surface was assessed for reduction]). Reduction was maintained with pointed bone reduction forceps, a temporary transcondylar Kirschner wire or digital pressure according to surgeon preference. A drill sleeve was placed in the glide hole and used to guide the drilling of the pilot hole in the medial portion of the humeral condyle. All screws were placed as lag screws and none were placed through a plate hole. After placement of the transcondylar screw, the epicondylar plate was contoured and secured with screws. The choice of SOP (Orthomed, Huddersfield, United Kingdom), LCP (Veterinary Instrumentation, Sheffield, United Kingdom) or LC-DCP (DePuy Synthes, Oberdorf, Switzerland) plate and lateral or caudal plate placement was based on surgeon preference. The aim was to place at least two screws in the distal segment and three in the proximal segment. Following the surgery, owners were instructed to limit their dog's activity, and return for re-examination and radiography after 6 to 8 weeks, or sooner/longer depending on the progression of fracture healing or development of complications.

Radiographic Assessment

Preoperative radiographs, computed tomography scans, or both and postoperative radiographs were reviewed for the following information: supracondylar comminution, lateral or caudal plate application, plate type, size and length, screw type (locking or non-locking, bicortical or monocortical) and number in the distal fragment, the use of any additional implants and persistence of an intracondylar fracture line. The accuracy of articular surface reduction, demonstrated by the width of the visible intracondylar fracture line at the level of the articular surface, and the height of any step between the lateral and medial part of the humeral condyle at the articular surface (articular step height), was assessed. These measurements were determined from craniocaudal radiographs and graded as 0 ($<$1mm), 1 (1–2 mm) or 2 ($>$2 mm) respectively. Follow-up radiographs obtained 6 to 8 weeks after surgery were also assessed for visible intracondylar fracture line and articular step height as well as signs of fracture healing and implant stability. Radiographs were assessed by two authors (ME and VG) and a consensus reported.

Outcome Assessment

Clinical records were evaluated for recorded information about the perioperative (0–3 months) follow-up including subjective lameness score, elbow range of motion, instability, swelling, crepitus or signs of discomfort.[15] All clinical assessments had been made by one of five board-certified small animal surgeons or a surgical resident under their supervision. Overall subjective clinical outcome was defined according to standardized definitions.[16] Full function was defined as a return to pre-injury limb function without a need for medication. Acceptable function was defined as restoration to pre-injury exercise levels that was limited in duration or intensity or required medication to achieve full function. All other outcomes were considered unacceptable function. Complications were defined as previously recommended.[16] Postoperative infection was considered to be associated with surgery if occurring within 12 months. Mid-term (6–12 months) and long-term (> 12 months) follow-up was based on owner-reported canine brief pain inventory and an additional owner questionnaire (Supplementary Material [available online only]).[17]

Results

The medical records of 30 dogs in which a FLHC was repaired with transcondylar screw and epicondylar plate were identified (representing 33 fractures). From these, one dog (2 fractures) was excluded from our study due to loss to follow-up. Thirty-one fractures in 29 dogs met the inclusion criteria. Mean age was 4.8 years (standard deviation: 2.31). There were 13 male dogs, 2 female, 7 male neutered and 7 female neutered. Fractures were evenly distributed between left and right limbs. Body weight ranged from 10 to 40 kg (median: 17.6 kg). The majority of dogs were Spaniels (23/29), with English Springer (14/29), Cocker (8/29) and Clumber (1/29) Spaniels represented. The remaining dogs were Labrador Retrievers (2/29), Bernese Mountain Dog (1/29), Terrier (1/29), a German Shorthaired Pointer (1/29) and a Pug cross (1/29). Thirty of 31 fractures had category 4 level evidence of HIF.[7] Thirty of 31 surgery reports documented a sclerotic appearance at the intracondylar fracture surfaces combined with a minimally traumatic fracture aetiology. One of 31 fractures occurred after a fall from a first-floor window (Bernese Mountain Dog). Two of 29 dogs had a FLHC after loosening of a previously placed transcondylar screw used to stabilize HIF. Six dogs had previous or subsequent contralateral humeral condylar fractures and one had a concurrent contralateral 'Y'/'T' fracture. Two dogs suffered from bilateral FLHC; the fractures in both of these dogs occurred on separate occasions. Seven of 29 dogs had computed tomographic confirmation of HIF in the contralateral limb. One of 7 dogs had a HIF screw placed prophylactically in the contralateral limb at the time of FLHC repair. The other six of these seven dogs had a prophylactic HIF screw placed at a later date. One of twenty-nine dogs (German Shorthaired Pointer) had previously had amputation of the contralateral thoracic limb due to a humeral condylar fracture. Four of thirty-one fractures had supracondylar comminution. All 29 dogs received intra-operative cefuroxime (Zinacef, GlaxoSmithKline, Brentford, United Kingdom [20 mg/kg intravenously every 2 hours]) and postoperative cephalexin (Rilexine, Virbac, Bury St Edmunds, United Kingdom [15–20mg/kg per os twice daily]) for 7 days.

Implants

Of the 31 fractures, 16 had SOP plates, 8 had LCP and 7 had LC-DCP (►**Figs. 1–3**). Twenty-three of thirty-one had a transcondylar 4.5 mm shaft screw (Veterinary Instrumentation, Sheffield, United Kingdom) and nine had a cortical lag screw (five: 4.5mm, three: 3.5mm, one: 2.7mm [Veterinary Instrumentation, Sheffield, United Kingdom]). Plate size relative to body weight is shown in ►**Table 1**. The epicondylar plate was applied laterally in 15 fractures and caudally in 16. Twelve of 16 SOP were applied laterally. Only 3/9 LCP (including the single

Fig. 1 Case 2 (English Springer Spaniel) preoperative (**A** and **B**) radiographs documenting a simple lateral humeral condylar fracture. The fracture was repaired with a 4.5 mm transcondylar shaft screw and caudally applied 2.7 mm limited contact dynamic compression plate with a persistent intracondylar fracture line in the immediate postoperative (**C** and **D**) and 6 to 8-week postoperative radiographs (**E** and **F**).

case undergoing revision surgery) and 0/7 LC-DCP were applied laterally. Six-hole plates were most commonly used regardless of plate type or size (range: 5–7). All fractures had a median of two screws in the distal fragment (range: 2–3). Monocortical screws were used in the distal fragment only (median number of monocortical screws: SOP: 1.5 [range: 0–3), LCP: 2 [range: 0–3), LC-DCP: 1 [range: 0–2]).

Additional Implants

One of thirty-two fractures, and the single case undergoing revision surgery, had a medial nylon nut engaging the threads of the transcondylar screw, with a Kirschner wire driven through the nut to decrease the risk of loosening. The fracture having a nut placed at the primary surgery had previously

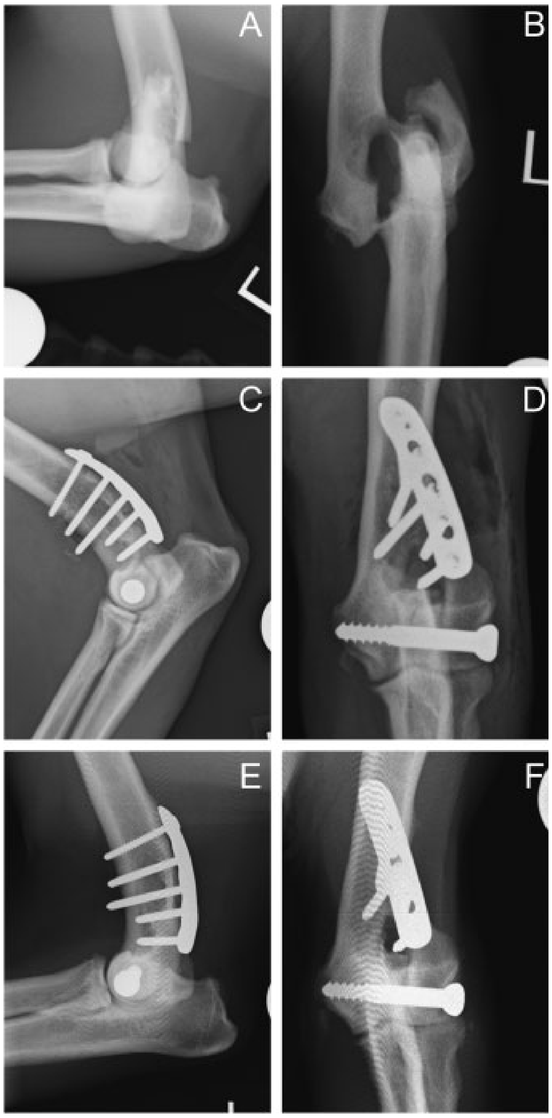

Fig. 2 Case 23 (German Shorthaired Pointer) preoperative (**A** and **B**) radiographs documenting a lateral humeral condylar fracture with minor supracondylar comminution. The fracture was repaired with a 4.5 mm transcondylar shaft screw and caudally applied 2.7 mm locking compression plate with a persistent intracondylar fracture line in the immediate postoperative (**C** and **D**) but not the 6 to 8-week postoperative radiographs (**E** and **F**).

Fig. 3 Case 6 (Terrier) preoperative (**A** and **B**) radiographs documenting a simple lateral humeral condylar fracture. The fracture was repaired with a 3.5 mm transcondylar lag screw and laterally applied 2.0 mm string of pearls plate with a persistent intracondylar fracture line in the immediate postoperative (**C** and **D**) but not the 6 to 8-week postoperative radiographs (**E** and **F**).

been treated for HIF with a transcondylar screw. In two cases, transcondylar screws were placed with washers.

Accuracy of Fracture Reduction and Fracture Healing

Immediate postoperative radiographs demonstrated an articular step height grade of 0 in all 31 fractures. The visible intracondylar fracture line grade was 0 in all fractures (the intracondylar fracture line was not detectable on postoperative radiographs in 5/31 elbows, and was apparent, but less than 1 mm in 26/31). Six- to eight-week follow-up radiographs were available for 26 fractures. Nineteen had evidence of union at the supracondylar fracture line (SOP: 10/13, LCP: 5/7, LC-DCP: 4/6). Six had evidence of progressive bone healing with stable implants (SOP: 3/13, LCP: 1/7, LC-DCP: 2/6). One LCP case had distal screw failure and loss of reduction 6 weeks after surgery and was revised. There was persistence of a visible intracondylar fracture line in 20/26 cases and not in 6/26 cases in the 6 to 8 week postoperative radiographs. In the absence of complications, no further imaging was performed.

Perioperative Outcome

All fractures had perioperative follow-up data available for review. Perioperative outcome was considered fully functional for 24 fractures and acceptable for six. One dog had unacceptable function (non-weightbearing lameness) requiring revision surgery. This dog was fully functional 8 weeks after revision surgery.

Table 1 Plate sizes and body weight

Plate size (mm)	0–10 kg	10.1–20 kg	20.1–30 kg	30. 1–40 kg
2.0	–	3	–	–
2.4	–	1	–	1
2.7	1	16	9	1

Complications

Minor complications (both SOP) were diagnosed in 2/31 elbows (►**Table 2**). One developed a seroma which resolved with no intervention. The other had loosening of a transcondylar 4.5 mm cortical lag screw with a stable plate/screw implant construct and union of the supracondylar fracture but persistence of a visible intracondylar fracture line. This case had had transcondylar screw loosening and FLHC following treatment of HIF. At the time of FLHC repair, a nylon nut with a Kirschner wire had been placed to reduce the risk of repeat screw loosening. None of the loosened implants were subsequently removed.

There were 3 (10%) major complications (►**Table 2**). One LC-DCP case developed clinical signs of infection that resolved with 6 weeks of antibiotic treatment. This dog had pre-existing chronic skin disease. One case (2.0 mm LCP, weight: 14.9 kg) had failure of the distal locking screws by breakage at the plate–screw interface and transcondylar screw loosening (►**Fig. 4**). This was revised with a replacement transcondylar screw and nylon nut and a 2.7 mm LCP. Following revision surgery, recovery was uneventful. One SOP case had a 2.7 mm cortical transcondylar screw loosened with a stable plate/screw construct and union of the supracondylar fracture but persistence of a visible intracondylar fracture line. The loosened transcondylar screw was removed and not replaced at the time of the follow-up radiographs.

Mid- to Long-Term Outcome

Owners returned both questionnaires for 28 fractures (27 dogs) and the revision surgery. Mid-term follow-up was available for 2 of 28 fractures (2 of 27 dogs) with a median follow-up time of 35.5 weeks (range: 25–46). Both dogs were reported to have 'excellent' quality of life and the success of surgery was considered 'excellent'. Long-term follow-up was available for 26 fractures (25 dogs) with a median follow-up time of 156 weeks (range: 52–246). Twenty-four dogs (96%) were reported to have 'excellent' quality of life and the success of surgery was considered 'excellent'. One dog (2 fractures and a revision surgery) was reported to have 'very good' quality of life and the success of surgery considered 'satisfactory'. Plate size, complications and outcomes are summarized in ►**Table 2**.

Non-steroidal anti-inflammatory drugs were required in 6/25 dogs after the onset of posttraumatic osteoarthritis. Twenty-six of 27 owners were 'very satisfied' with the outcome, one was 'satisfied'. The median CPBI pain interference score was 0 (range: 0–1) and pain severity score was 0 (range: 0–3.25).

Discussion

Perioperative outcome was considered acceptable or fully functional in 30/31 fractures. One fracture had unacceptable function due to implant failure but became fully functional after revision surgery. The overall outcome in this study is particularly relevant as our population of dogs were skeletally mature and the majority had evidence of HIF which are both predisposing factors for complications.[7]

A high proportion of English Springer Spaniels was present in this study as documented in previous studies in the United Kingdom.[1,9,18] Recently, French bulldogs have been identified as being over-represented for humeral condylar fractures.[19] This is not replicated in this study. This may be because the mean age of the cohort in this study was above that reported for French bulldogs suffering FLHC, different predisposing factors for FLHC in French Bulldogs compared with Spaniel breeds or because this study excluded fractures of the medial aspect of the humeral condyle.[19–21]

The lateral aspect of the distal humerus is a challenging area in which to apply a plate due to the required contouring.

Table 2 Plate type, size and associated complications/outcomes

Plate	Size (mm)	Number	Minor complications	Major complications	Perioperative functional outcome	Mid-term outcome	Long-term outcome
SOP	2.0	2	0/2	0/2	Acceptable (2/2)	–	Excellent (1/1)
	2.7	14	2/14	1/14	Full (13/14) Acceptable (1/14)	Excellent (1/1)	Very good (1/13) Excellent (12/13)
LCP	2.0	1	0/1	1/1	Unacceptable (1/1)	–	–
	2.4	2	0/2	0/2	Full (2/2)	–	Excellent (2/2)
	2.7	6	0/6	0/6	Full (5/6) Acceptable (1/6)[r]	Excellent (1/1)	Very good (1/5)[r] Excellent (4/5)
LC-DCP	2.7	7	0/7	1/7	Full (5/7) Acceptable (2/7)	–	Excellent (5/6)

Abbreviations: LCP, locking compression plate; LC-DCP, contact dynamic compression plate; SOP, string of pearls.
Note: The entry labelled[r] refers to the revision surgery.

Fig. 4 Case 19 (English Springer Spaniel) preoperative (**A** and **B**) radiographs documenting a lateral humeral condylar fracture with minor supracondylar comminution. The fracture was repaired with a 4.5 mm transcondylar shaft screw and laterally applied 2.0 mm locking compression plate (**C** and **D**). This repair failed 8 weeks after surgery (**E** and **F**) and was revised with a lateral 2.7 mm locking compression plate (**G** and **H**). Note the Kirschner wire driven into the radiolucent nylon nut at the medial humeral condyle. No further complications were noted following revision, though follow-up radiographs were declined at the 6 to 8-week re-examination.

Additionally, plate screws directed lateral-medial toward the anconeal fossa must be short or monocortical to avoid impinging on the anconeal process. Locking plates used with locking screws may confer an advantage, as the plates do not require the same degree of contouring as non-locking plates. Locking plates and screws do not pull the fragment to the plate. Non-locking plates and screws will pull the bone to the plate if the plate is not accurately contoured and this can result in loss of reduction during screw tightening.[22] However, a disadvantage of the locking plates used in this study is the inability to vary the screw angle, which prevents aiming the screws away from the fracture or joint. This can be overcome by the use of monocortical screws for a lateral plate or caudal plate application and bicortical screw placement, or by using an angled cortical screw in an LCP or LC-DCP. Caudal plate application also allows for longer screws to be used distally. Plate position (lateral or caudal) did not affect the outcome in this study.

Monocortical screws were frequently placed in the distal fragment regardless of plate type (although less commonly in LC-DCP) with no clear negative outcome. Similar findings were reported in a study assessing outcome after repair of humeral 'Y'/'T' fractures.[12] It has been suggested that at least two monocortical angle-stable locking screws should be used per major fragment in non-osteoporotic bone.[23] String of pearls plates use standard cortical screws rather than specific locking screws, which generally have a larger core diameter than their equivalent cortical screw. Using cortical screws as locking screws increases the risk of breakage of screws at the screw–plate interface.[24] No SOP failures of this nature occurred. Although the SOP locking mechanism has been proven to be less strong than the LCP mechanism *in vitro*, this did not seem to have a clinical effect in this study.[25] The only major implant failure occurred with a 2.0 mm LCP. This plate was considered to be under-sized for the patient based on radiographic assessment. The width of the epicondylar crest on the mediolateral radiograph was 10.5 mm. It has been recommended that drill holes for orthopaedic implants do not exceed 33% of the diameter of the bone, although this limit was established for the diaphysis of long bones, and therefore what constitutes an appropriate implant size in the lateral epicondylar crest is currently unknown.[26] A screw hole for 2.7mm cortical or locking screws was within this limit, and a 2.7mm plate would have been more appropriate. The type of failure of this 2.0 mm LCP was screw breakage at the plate–screw interface. This is one of the most common failure modes of LCP plates.[27] The transcondylar screw had also loosened. It is not possible to determine whether this resulted in failure of the LCP or happened subsequent to plate/screw failure.

Two cases had transcondylar screw loosening. In both cases, the loosened screw was not tightened or replaced. One of these cases had previous loosening of a prophylactic HIF screw and subsequent fracture. Despite application of a medial nylon nut, the screw became loose again after fracture repair. The height of the humeral condyle was 12mm. This would have permitted revision with a 5.5mm screw which may have prevented subsequent screw loosening. This case had long-term follow-up of 203 weeks during which time there were no further documented complications, despite persistence of a visible intracondylar fracture line, and owner-assessed outcome based on the canine brief pain inventory was excellent. The use of an epicondylar plate may have contributed to the excellent long-term outcome by providing sufficient support to the lateral epicondylar crest to prevent re-fracture, compared with a Kirschner wire, despite failure of the transcondylar screw. A high proportion of cases (20/26) did not have documentable intracondylar fracture healing, although longer radiographic follow-up may have shown evidence of healing in time. Healing of the epicondylar part of the fracture is expected, but nonetheless, there may be increased reliance on the implant construct to achieve long-term stability. The presence of epicondylar healing but absent or partial intracondylar healing is analogous to a dog with a complete/partial HIF (depending on what proportion of the condyle has healed) and such dogs can be fully functional, but preservation of the implants would be preferable to mitigate the risk of re-fracture. When considering repair of FLHC, especially when there is evidence of HIF, implants which are likely to be resilient to fatigue failure should be used as intracondylar union may not be achieved.[5,28] Alternatively, consideration could be given to techniques which aim to improve the likelihood of intracondylar union, although presently there is no evidence to suggest improved outcomes when techniques of this sort are utilized.[29,30]

A high proportion of transcondylar screws in this study were 4.5 mm shaft screws (23/32). The effect of this is unclear in the current study, but this may have contributed to the low complication rate as 4.5 mm shaft screws may be more resistant to fatigue failure in cases where intracondylar union is not achieved due to HIF.[5] They can also achieve higher interfragmentary compression than fully-threaded screws.[31]

Our complication rates (overall: 16%, major: 10%, minor: 6%) compare favourably to the literature despite our patients being skeletally mature, which has been shown to be a risk factor for complications.[7] One previous report of FLHC treated with a supracondylar screw or plate and transcondylar screw indicated a 16% major complication rate, with major complications defined as those requiring revision surgery.[7] If we apply this definition to our results, then 2/31 (6.45%) cases in our study had major complications.

When considering a case series of this type, it is important to acknowledge that subjective clinical assessment is susceptible to a care-giver placebo effect which can make direct comparison difficult.[32] However, this study was designed to current recommendations for outcome determination in orthopaedic studies.[16] In addition, in the authors' experience owners find accurate assessment of thoracic limb lameness difficult (e.g. mis-identification of the clinically affected limb is common). Previously, it has been documented that a significant proportion of dogs with HIF has additional elbow pathology.[33] It is possible that progressive osteoarthritis and lameness may be attributable to undiagnosed elbow pathology rather than posttraumatic osteoarthritis. Computed tomography may offer better assessment of intracondylar bone healing compared with orthogonal radiographs as well as documenting elbow co-morbidities.[30,34] Minor variation in surgeon technique, the retrospective nature and small sample size are further limitations of the current study. It is likely that the effect size of plate type on postoperative complications is small requiring recruitment of a larger cohort of subjects than the current study. Statistical analysis was not performed to avoid introducing type II error. This precludes the ability to recommend one type of plate over another.

Conclusion

Repair of FLHC in skeletally mature dogs with a transcondylar screw and epicondylar plate has a good perioperative, mid- and long-term outcome with a 10% major complication rate when accurate reduction in the articular surface is achieved, despite persistence of a visible intracondylar fracture line at final radiographic follow-up in the majority of cases.

Note

Preliminary data from this study was presented as an abstract at the 2020 autumn meeting of the British Veterinary Orthopaedic Association.

Authors' Contributions

M.K.E. contributed to conception of study, study design acquisition of data, data analysis and interpretation. V.G. contributed to conception of study, study design and data analysis and interpretation. A.P.M. and J.M. contributed to data analysis and interpretation. All authors drafted, revised and approved the submitted manuscript.

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Conflict of Interest

None declared.

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In tribute to my brother, Tim Eayrs.

References

1 Denny HR. Condylar fractures of the humerus in the dog; a review of 133 cases. J Small Anim Pract 1983;24(04):185–197

2 Sumner-Smith G. Observations on epiphyseal fusion of the canine appendicular skeleton. J Small Anim Pract 1966;7(04):303–311

3 Farrell M, Trevail T, Marshall W, Yeadon R, Carmichael S. Computed tomographic documentation of the natural progression of humeral intracondylar fissure in a cocker spaniel. Vet Surg 2011;40(08):966–971

4 Marcellin-Little DJ, DeYoung DJ, Ferris KK, Berry CM. Incomplete ossification of the humeral condyle in spaniels. Vet Surg 1994;23 (06):475–487

5 Moores AP, Tivers MS, Grierson J. Clinical assessment of a shaft screw for stabilization of the humeral condyle in dogs. Vet Comp Orthop Traumatol 2014;27(03):179–185

6 Cole G, Beale B. Minimally invasive osteosynthesis techniques for articular fractures. Vet Clin North Am Small Anim Pract 2020;50 (01):213–230

7 Perry KL, Bruce M, Woods S, Davies C, Heaps LA, Arthurs GI. Effect of fixation method on postoperative complication rates after surgical stabilization of lateral humeral condylar fractures in dogs. Vet Surg 2015;44(02):246–255

8 Morgan ODE, Reetz JA, Brown DC, Tucker SM, Mayhew PD. Complication rate, outcome, and risk factors associated with surgical repair of fractures of the lateral aspect of the humeral condyle in dogs. Vet Comp Orthop Traumatol 2008;21(05):400–405

9 Moores A. Humeral condylar fractures and incomplete ossification of the humeral condyle in dogs. In Pract 2006;28(07):391–397

10 Cook JL, Tomlinson JL, Reed AL. Fluoroscopically guided closed reduction and internal fixation of fractures of the lateral portion of the humeral condyle: prospective clinical study of the technique and results in ten dogs. Vet Surg 1999;28(05):315–321
11 Ness MG. Repair of Y-T humeral fractures in the dog using paired 'String of Pearls' locking plates. Vet Comp Orthop Traumatol 2009; 22(06):492–497
12 Moffatt F, Kulendra E, Meeson RL. Repair of Y-T humeral condyle fractures with locking compression plate fixation. Vet Comp Orthop Traumatol 2019;32(05):401–407
13 García J, Yeadon R, Solano MA. Bilateral locking compression plate and transcondylar screw fixation for stabilization of canine bicondylar humeral fractures. Vet Surg 2020;49(06):1183–1194
14 Johnson KA. Approach to the lateral aspect of the humeral condyle and epicondyle in the dog. In: Piermattei's Atlas of Surgical Approaches to the Bones and Joints of the Dog and Cat. 5th edition. St. Louis: Elsevier; 2014:202–207
15 Quinn MM, Keuler NS, Lu Y, Faria MLE, Muir P, Markel MD. Evaluation of agreement between numerical rating scales, visual analogue scoring scales, and force plate gait analysis in dogs. Vet Surg 2007;36(04):360–367
16 Cook JL, Evans R, Conzemius MG, et al. Proposed definitions and criteria for reporting time frame, outcome, and complications for clinical orthopedic studies in veterinary medicine. Vet Surg 2010; 39(08):905–908
17 Brown DC, Boston RC, Coyne JC, Farrar JT. Development and psychometric testing of an instrument designed to measure chronic pain in dogs with osteoarthritis. Am J Vet Res 2007;68 (06):631–637
18 Cockett PA, Jones DGC. The repair of humeral condylar fractures in the dog: a review of seventy-nine cases. J Small Anim Pract 1985; 26(09):493–520
19 Sanchez Villamil C, Phillips ASJ, Pegram CL, O'Neill DG, Meeson RL. Impact of breed on canine humeral condylar fracture configuration, surgical management, and outcome. Vet Surg 2020;49(04): 639–647
20 Cariou M, Sgro G. French Bulldogs Predisposition to Unicondylar Humeral Fractures [Internet]. Presented at: WSAVA/FECAVA/ BSAVA World Congress 2012. [cited 2020 May 2]. Accessed Aug 17, 2021 at: https://www.vin.com/apputil/content/defaultadv1.aspx?id=5328455&pid=11349&print=1
21 Smith MAJ, Jenkins G, Dean BL, O'Neill TM, Macdonald NJ. Effect of breed as a risk factor for humeral condylar fracture in skeletally immature dogs. J Small Anim Pract 1983;2020:1–7
22 Egol KA, Kubiak EN, Fulkerson E, Kummer FJ, Koval KJ. Biomechanics of locked plates and screws. J Orthop Trauma 2004;18 (08):488–493
23 Gautier E, Sommer C. Guidelines for the clinical application of the LCP. Injury 2003;34(Suppl 2):B63–B76
24 Field MR, Butler R, Wills RW, Maxwell WM. Retrospective evaluation of perioperative and short term clinical outcomes in appendicular long bone skeleton fractures repaired via the string of pearls (SOP) locking plate system. BMC Vet Res 2018;14 (01):386
25 Boero Baroncelli A, Reif U, Bignardi C, Peirone B. Effect of screw insertion torque on push-out and cantilever bending properties of five different angle-stable systems. Vet Surg 2013;42(03): 308–315
26 Edgerton BC, An K-N, Morrey BF. Torsional strength reduction due to cortical defects in bone. J Orthop Res 1990;8(06): 851–855
27 Filipowicz D, Lanz O, McLaughlin R, Elder S, Werre S. A biomechanical comparison of 3.5 locking compression plate fixation to 3.5 limited contact dynamic compression plate fixation in a canine cadaveric distal humeral metaphyseal gap model. Vet Comp Orthop Traumatol 2009;22(04):270–277
28 Moores AP. Humeral intracondylar fissure in dogs. Vet Clin North Am Small Anim Pract 2021;51(02):421–437
29 Fitzpatrick N, Smith TJ, O'Riordan J, Yeadon R. Treatment of incomplete ossification of the humeral condyle with autogenous bone grafting techniques. Vet Surg 2009;38(02):173–184
30 Walton MB, Crystal E, Morrison S, et al. A humeral intracondylar repair system for the management of humeral intracondylar fissure and humeral condylar fracture. J Small Anim Pract 2020;61(12):757–765
31 Klaue K. The dynamic compression unit (DCU) for stable internal fixation of bone fractures. [dissertation] Perren S, editor. University of Basel; 1981
32 Conzemius MG, Evans RB. Caregiver placebo effect for dogs with lameness from osteoarthritis. J Am Vet Med Assoc 2012;241(10): 1314–1319
33 Moores AP, Agthe P, Schaafsma IA. Prevalence of incomplete ossification of the humeral condyle and other abnormalities of the elbow in English Springer Spaniels. Vet Comp Orthop Traumatol 2012;25(03):211–216
34 Carrera I, Hammond GJC, Sullivan M. Computed tomographic features of incomplete ossification of the canine humeral condyle. Vet Surg 2008;37(03):226–231

