Long-Term Outcome and Complications after Transcondylar Screw Placement for Canine Humeral Intracondylar Fissure

Daniel Low[1] Victoria Hutchings[1] Scott Rutherford[1]

[1] frank. Pet Surgeons., Leeds, United Kingdom

Vet Comp Orthop Traumatol 2024;37:206–212.

Address for correspondence Daniel Low, BVetMed, MRCVS, frank. Pet Surgeons., Leeds, United Kingdom (e-mail: daniel.kuan.chong.low@gmail.com).

Abstract

Objective The aim of this study was to report postoperative complications and long-term outcomes following transcondylar screw placement for humeral intracondylar fissure (HIF).

Study Design It was a retrospective single-centre case series. Medical records (2018–2022) were reviewed for dogs with HIF treated with transcondylar screw placement. Data collected included signalment, concurrent orthopaedic disease, partial or complete HIF, surgeon, surgical approach, surgical technique and implant type, transcondylar screw angulation, postoperative complications and outcomes. Long-term outcome was assessed with owner questionnaire, orthopaedic examination and follow-up radiography. Statistical analysis was performed to identify risk factors predisposing to a complication or a poor outcome.

Results Forty-seven dogs (57 elbows) met the inclusion criteria; long-term follow-up was available in 41 dogs (50 elbows). Minor and major medical complications were noted in seven and three elbows respectively. The total complication rate was 17.5%. Increasing age was significantly associated with a reduced risk of postoperative complications ($p = 0.0051$). No other risk factors were identified. A postoperative complication was not associated with a less than full outcome ($p = 0.5698$).

Conclusion Transcondylar screw placement for HIF is associated with a low complication rate and good outcome.

Keywords
- humeral intracondylar fissure
- transcondylar screw
- complication
- outcome

Introduction

Humeral intracondylar fissure (HIF) is a cause of thoracic limb lameness in dogs[1] but can also be an incidental finding.[2,3] Affected dogs are predisposed to humeral condylar fracture during normal activity.[4] The incidence is higher in English Springer Spaniels[5] and American Cocker Spaniels, but other breeds are also affected.[6–9] Humeral intracondylar fissure may be unilateral or bilateral.[6]

The aetiology of HIF is uncertain and has been attributed to a failure of the separate centres of ossification of the humeral condyle to unite.[10] Recently, case reports showing de nouveau formation of a HIF[11] and progression of a partial HIF[12] have questioned incomplete ossification of the humeral condyle as the underlying mechanism. This theory also does not explain complete HIF which extends to the supratrochlear foramen, given that the intracondylar growth plate only extends to the distal humeral physis.[2] Clinical, radiographic and histopathological findings are more consistent with HIF as a stress fracture.[11]

Humeral intracondylar fissure may be associated with clinically significant lameness.[5] Transcondylar screw placement may be considered,[1–4] to reduce interfragmentary motion within the humeral condyle, decrease the risk of

received
June 28, 2023
accepted after revision
November 17, 2023
article published online
January 8, 2024

Georg Thieme Verlag KG,
Rüdigerstraße 14,
70469 Stuttgart, Germany

DOI https://doi.org/10.1055/s-0043-1777808.
ISSN 0932-0814.

condylar fracture and resolve lameness. Surgical techniques vary. A medial or lateral approach to the humeral condyle is made, and a variably sized screw[13] is placed in position or lag fashion.[14,15] Complementary use of fluoroscopy, arthroscopy, three-dimensional (3D)-printed drill guides or cannulated drill systems has been described[16–19] and an autograft or allograft may be placed at the fissure site.[20,21] Various HIF-specific implant systems have been reported.[20–22] Despite the use of multiple techniques, healing of the HIF remains inconsistent.[15] Non-union subjects the transcondylar screw to cyclic loading and at risk of fatigue failure months to years later.[23]

The risks of treatment weighed against the risks of no treatment informs therapeutic decision-making. Epidemiological metrics such as the number needed to treat,[24–26] number needed to harm[27] and the absolute risk reduction[28] can be used to quantify this.

Transcondylar screw placement has been associated with a high postoperative complication rate between 35.7 and 69.2%,[6,14,16,18,19] which includes transcondylar screw failure or loosening, seromas and surgical site infection. The presence of complications has been associated with poorer outcomes.[6,18] As such, based on the currently available literature, the risks associated with transcondylar screw placement appear to be high.

In occult HIF, the risks of no treatment include developing lameness or condylar fracture; however, a study reported that this only occurred in 18 and 6% of dogs respectively.[4]

In summary, the findings of previous studies[6,14,16,18,19] suggests higher risks with transcondylar screw placement than with non-surgical treatment of HIF. However, in the authors' experience, transcondylar screw placement is associated with a lower complication rate than previously reported. Given the impact that this will have on surgical decision-making, establishing an accurate complication rate is critical. The purpose of this study is to report the intraoperative, short-term and, long-term complications and long-term outcome following transcondylar screw placement for HIF. Analysis of clinical data was performed to identify risk factors for development of complications.

Materials and Methods

Data Collection

Medical records (EasyVET, VetZ GmbH, Germany) between February 2018 and December 2022, from a surgical referral practice in the United Kingdom, were searched for 'HIF' and 'transcondylar screw' on 29 December 2022 by a single operator (DL). Records of dogs with HIF diagnosed by computed tomography imaging of the elbow[29] and transcondylar screw placement were included. Cases were included if a minimum of 12-month follow-up was available and were included regardless of approach, screw type, or surgical technique. Cases were excluded if humeral surgery had previously been performed.

Breed, age, weight, sex, presence and type of concurrent orthopaedic disease, complete or partial HIF, surgeon, screw type, medial or lateral approach, method of transcondylar screw placement, intraoperative complications, transcondylar screw angulation and outcome data were collected. Complete and partial HIF were defined as a hypoattenuating line extending from the articular surface of the humeral condyle to the supratrochlear foramen, or extending only part-way across the humeral condyle, respectively.[29] Transcondylar screw angle was calculated as previously described.[30] Postoperative radiographs were evaluated by a board-certified specialist surgeon for medial epicondylar fissure fracture, a novel intraoperative complication.[14] Outcomes and complications were defined as previously described.[31] Short-term and long-term outcomes were recorded. Complications were defined as any complication occurring after recovery from general anaesthesia. Surgical site infections were diagnosed according to standard criteria.[32]

Imaging and Anaesthesia

All cases had computed tomographic imaging (Revolution ACT 16-slice (General Electric, Boston, USA) of both elbows performed under general anaesthesia. Cefuroxime (Zinacef (GlaxoSmithKline, London, United Kingdom; 20 mg/kg) was administered intravenously 30 minutes prior to first incision and repeated every 90 minutes intraoperatively. The administration of antibiotic medication was not continued in the postoperative period.

Surgical Procedures

All surgical procedures were performed at the same practice, either by a board-certified specialist or an experienced certificate holder. A 3.5 or 4.5 mm 316LVM stainless steel cortical screw (Veterinary Instrumentation, Sheffield, United Kingdom) was placed via a mini open medial or lateral approach, according to surgeon preference. Transcondylar drilling was performed with patient-specific 3D-printed guides (Vet3D, Cumbria, United Kingdom), a universal aiming device (IMEX Veterinary, Texas, USA) or performed freehand, according to surgeon preference. The humeral condyle was drilled with a 2.0mm drill bit to assess transcondylar screw trajectory before overdrilling with the appropriately sized drill bit for positional screw placement. Postoperative radiography confirmed accurate placement of the transcondylar screw. Patients were hospitalized for 24 to 48 hours with administration of opioid medication and discharged with non-steroidal anti-inflammatory medication and instructions for lead walks for 4 to 6 weeks.

Short-Term Follow-Up

Short-term follow-up was requested at 4 to 6 weeks postoperatively and was via orthopaedic examination or telephone, according to surgeon preference. Complications were recorded on the medical records. Normal exercise resumed at 8 to 10 weeks postoperatively.

Long-Term Follow-Up

Long-term follow-up was defined as a minimum of 12 months and was routinely obtained via telephone. Two validated client-reported outcome measures,[33] the Liverpool Osteoarthritis in Dogs (LOAD) and Canine Orthopaedic Index (COI), were completed. Where bilateral transcondylar screws

were placed, questionnaires were completed for each forelimb. Where a less than full outcome was reported, long-term follow-up was supplemented by orthopaedic examination and radiography at the same practice.

Statistical Analysis

Statistical analysis was performed with commercial software (SPSS, IBM; New York, United States). Categorical data were reported as numbers and percentages. Continuous data were assessed for normality using the Shapiro–Wilk test. Normally distributed data were reported as means, standard deviations and ranges. Non-normally distributed data were reported as medians and ranges. To assess for risk factors predisposing to complications or a poor outcome, categorical variables were compared using Fisher's exact test, while normally distributed and non-normally distributed continuous variables were compared using a *t*-test or Mann–Whitney U test respectively. Where more than two groups of independent variables were analysed, a Kruskal–Wallis test was used. Where significance was noted after analysis of continuous variables, univariate logistic regression was used to determine odds ratios with 95% confidence intervals. Significance was defined as *p*-value less than 0.05.

Results

Records of 64 dogs (72 elbows) were identified from the database search. Forty-seven consecutive cases (57 elbows) met the inclusion criteria, forming the sample population. There were 34 males (11 neutered) and 13 females (5 neutered). Median age was 38 months (range: 3–130 months). Mean bodyweight was 17.15 ± 5.883 kg (range: 6–31 kg). English Springer Spaniels were overrepresented ($n = 19$). Other breeds included the Cocker Spaniel ($n = 12$), crossbreed dogs ($n = 8$), French Bulldog ($n = 4$), German Shorthaired Pointer, ($n = 1$), Labrador Retriever ($n = 1$), Cane Corso ($n = 1$) and Boston Terrier ($n = 1$).

Concurrent orthopaedic disease was present in 26/47 dogs, which included contralateral humeral condylar fracture ($n = 23$) and ipsilateral medial coronoid disease ($n = 3$).

Twenty-six right elbows and 31 left elbows underwent transcondylar screw placement. Complete HIF was present in 50/57 elbows.

A medial approach was used in 50/57 elbows and a lateral approach in 7/57. Transcondylar screw placement was performed freehand in 42 elbows; in the remainder placement was facilitated via 3D-printed guides ($n = 7$) or a universal aiming device ($n = 8$). A 4.5mm cortical screw was used in 50/57 elbows and a 3.5mm cortical screw in 7/57 elbows. Thirty-seven dogs underwent unilateral transcondylar screw placement, while ten dogs had bilateral transcondylar screw placement in a single-stage procedure. One intraoperative complication was noted whereby the transcondylar screw placed freehand was placed intraarticularly, necessitating repeat placement.

Medial epicondylar fissure fracture was not noted on the postoperative radiographs in any of the 57 operated elbows. Screw angulation with each transcondylar screw placement method is shown in ►**Table 1**.

There were minor complications in six dogs (seven elbows), consisting of lateral seromas ($n = 5$) and medial seromas ($n = 2$). There were major medical complications in three dogs (three elbows), where surgical site infection was suspected after postoperative lameness prompted non-routine re-examination. Physical examination and arthrocentesis findings (►**Table 2**) were consistent with bacterial septic arthritis. All three were managed medically with amoxicillin clavulanate, based on culture and sensitivity where available, resulting in resolution of lameness and subsequent full function. There were no cases with concurrent minor and major medical complications. There were no major surgical or catastrophic complications. The total complication rate was 10/57 elbows

Short-term follow-up via orthopaedic examination with the attending surgeon was available in 21 dogs (28 elbows) at a median of 43 days (range: 13–195 days). Short-term follow-up was conducted remotely via telephone in 11 dogs (12 elbows) at a median of 42 days (range: 22–50 days). Fifteen dogs (17 elbows) were lost to short-term follow-up.

Long-term follow-up was available in 41 dogs (50 elbows). All dogs were alive at the time of long-term follow-up except for two dogs (two elbows) who were euthanized for unrelated disease. One dog (two elbows) developed immune-mediated polyarthritis within 1 year of transcondylar screw placement and was excluded due to potential confounding. Long-term follow-up was obtained remotely in 36 dogs (44 elbows). Gait assessment and orthopaedic examination were performed in the remaining five dogs (six elbows). Of these five dogs, four were examined due to the presence of a mild or intermittent lameness or the requirement for analgesics. The remaining dog was examined for a contralateral humeral condylar fracture follow-up. In one dog, examination of the operated elbow was unremarkable and client consent for radiography was withheld. In the remaining four dogs (five elbows), radiography was performed which showed no transcondylar-screw-associated complications.

Full function was reported in 37 dogs (45 elbows). Acceptable function was reported in four dogs (five elbows). No unacceptable outcomes were reported. The LOAD and COI questionnaires were completed for all 50 elbows. Mean time to follow-up was 907 ± 377.4 days (range 361–1820 days).

Table 1 Median screw angulation with each TCS placement method and ranges in brackets

	3D-printed guides	Universal aiming device	Freehand
Screw angulation	2.7 degrees (1.8–14.5 degrees)	4.8 degrees (0.5–8.7 degrees)	9.4 degrees (0.5–21.5 degrees)

Abbreviation: 3D, three-dimensional; TCS, transcondylar screw.

Table 2 Major complications after TCS placement

Case	Signalment	Contralateral elbow	Complication	Arthrocentesis results	Treatment	Outcome
1	10m M French Bulldog	Bicondylar fracture, medial and lateral plate and TCS	Bacterial septic arthritis 17 days post-surgery	Staphylococcus pseudintermedius, neutrophilic inflammation	Amoxicillin-clavulanate 20mg/kg PO BID for 10 weeks	Full outcome
2	2y, 8 m MN Crossbreed	No pathology	Bacterial septic arthritis 10 days post-surgery	Negative bacterial growth, neutrophilic inflammation	Amoxicillin-clavulanate 12.5mg/kg PO BID for 6 weeks	Full outcome
3	4m M English Springer Spaniel	HIF and TCS at same surgery	Bacterial septic arthritis 63 days post-surgery	Staphylococcus pseudintermedius, neutrophilic inflammation	Amoxicillin-clavulanate 25 mg/kg PO BID for 6 weeks	Full outcome

Abbreviations: BID, twice a day; HIF, humeral intracondylar fissure; PO, per os; TCS, transcondylar screw.

Median LOAD and COI scores were 0.5 (range: 0–16) and 1 (range: 0–20) respectively. Thirty-seven dogs (45 elbows) returned a LOAD score of 10 or less. Four dogs (five elbows) returned a LOAD score between 11 and 20 (►**Fig. 1**). Thirty-nine dogs (47 elbows) returned a COI score of 10 or less. Two dogs (three elbows) returned a COI score between 11 and 20 (►**Fig. 2**).

Due to the low number of complications, statistical analysis was performed with major and minor complications as a whole. A significant risk reduction was found with increasing age ($p = 0.0051$, odds ratio = 0.6052 for year increase, [95% confidence interval = 0.3819–0.9590]). All other risk factors assessed were not significantly associated with development of a complication (►**Appendix Table 1**, available in the online version). Transcondylar screw placement method was significantly associated with a difference in screw angulation ($p = 0.02356$).

A complication was not associated with a less than full outcome ($p = 0.5698$), a LOAD score of more than 10 ($p = 1.0$) or a COI score of more than 10 ($p = 0.4561$).

Discussion

In comparison to previous studies evaluating complications associated with transcondylar screw placement for HIF, this study reports a lower complication rate of 17.5% associated with good long-term clinical outcomes in a population of client-owned dogs. Increasing age at time of surgery was associated with a reduced risk of postoperative complications. Method of transcondylar screw placement was associated with screw angulation but neither were associated with the risk of postoperative complications. The presence of a postoperative complication did not impact long-term outcome.

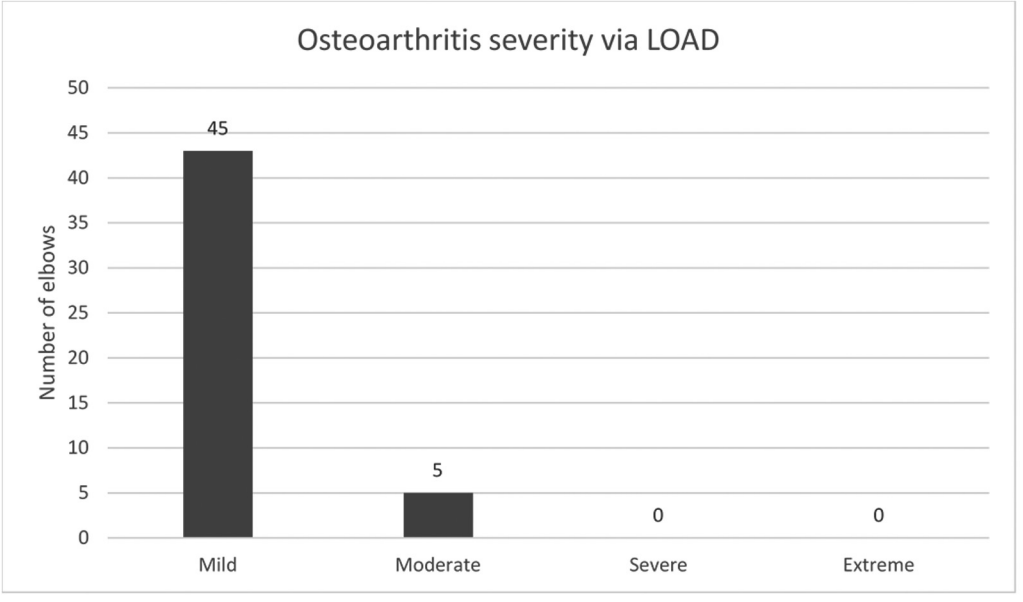

Fig. 1 Long-term outcome data determined via Liverpool Osteoarthritis in Dogs (LOAD) questionnaire.

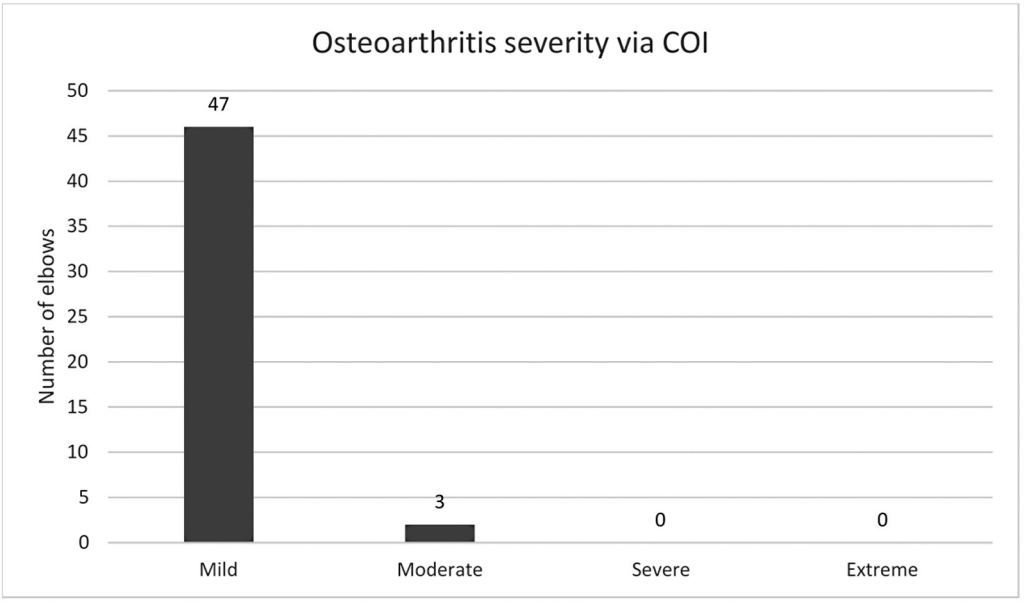

Fig. 2 Long-term outcome data determined via Canine Orthopaedic Index (COI) questionnaire.

Complication rates between 35.7 and 69.2% were previously reported.[6,14,16,18,19] Although variation in case selection, surgical technique and perioperative management do not allow direct comparison between studies, this study's findings pertain directly to therapeutic decision-making. Previously, it was thought that the benefit of transcondylar screw placement, namely the reduced risk of humeral condylar fracture, did not outweigh the risk of complications.[4] The low complication rate and good outcomes reported herein suggest that the risks of treatment may be lower than previously reported. That being said, the consequences of untreated HIF remain unquantified. The use of number needed to treat, number needed to harm and absolute risk reduction metrics would be needed; however, this would require a control group and several years of follow-up. This was beyond the scope of this study but should be a focus for future research.

The difference in complication rates between studies may be partly explained by a learning curve. A surgical learning curve with transcondylar screw placement has not been specifically investigated but has been demonstrated in other veterinary orthopaedic procedures.[34] The prevalence of HIF in dogs in the United Kingdom is unknown[15] but likely relatively low, as reflected in the sample sizes of this study and that of previous studies.[6,14,16,18,19] A downward trend in complication rate is expected as surgeons become more proficient with the procedure. Indeed, other authors[14] recently reported a complication rate of 24.9%, although this was not their primary objective. A medial approach was overrepresented in our study, which may also be associated with a lower risk of complications.[6,14,35]

This study did not find a significant association between laterality of approach and risk of complications, although findings were approaching significance. Considering the sample size and low complication rate, a type II error cannot be ruled out. Other factors are considered when choosing the surgical approach. Medial-to-lateral drilling has been shown to increase the risk of joint penetration.[36] Prospective, randomised studies investigating the optimal surgical approach are warranted.

This study found that increased age at the time of surgery was associated with a reduced risk of complications. This may be explained by reduced activity in older dogs or because greater bone density in older dogs offers greater transcondylar screw stability and pull-out resistance. Alternatively, the aetiology of HIF may be different in young versus older dogs. Previous studies have not found such an association and instead reported an increased risk of complications with increasing bodyweight,[16,18,37] which was not borne out by this study.

No postoperative antibiotic medications were administered in this study, yet a relatively low rate of surgical site infection was observed (5.3%). This is similar to other elective orthopaedic procedures such as tibial plateau levelling osteotomy, with reported surgical site infection rates between 6.8 and 7.7%.[38,39] Postoperative antimicrobials in veterinary surgery are an area of controversy and have not consistently been shown to be protective against surgical site infection.[38,40,41] The mini open surgical approach, technique and choice of implants herein are likely to have had an effect.[15] Given the comparably low surgical site infection rate reported, this study supports the use of perioperative antibiotic prophylaxis alone.

The English Springer Spaniel was overrepresented in this study. This is also reflected in other studies[1,3] and may allow limited extrapolation of these findings to other dogs. The sample population also included French Bulldogs and a limited number of other breeds. French Bulldogs present with humeral condylar fracture at a younger age[42,43] and therefore the aetiology of HIF in this population of skeletally immature dogs cannot be assumed to be similar to that in Spaniels. By extension, the aetiology of HIF in other breeds is also unknown

and the HIF lesions among the sample population were likely heterogeneous and a source of uncontrolled bias.

Transcondylar screw angulation was associated with placement method, with 3D-printed guides resulting in an angle closest to 0 degrees. A universal aiming device was less accurate than a 3D-printed guide but more accurate than freehand placement. An ex vivo study reported that screw angulation was as accurate when placed with an aiming device compared with fluoroscopy.[44] However, the clinical significance of an angled transcondylar screw is unknown, and in this study, was not shown to be associated with an increased risk of postoperative complications. Transcondylar screw angulation has been investigated in humeral condylar fracture repair[30,37] and a greater angle has been shown to result in a larger intracondylar fracture gap. The clinical significance of a greater transcondylar screw angle when used for treatment of HIF is unknown and represents an area for further study.

The complication rate reported herein should be interpreted in light of the methodology. Short-term follow-up via orthopaedic examination was only available in 28/57 of elbows. This may have led to underestimation of the true complication rate because of a lack of systematic orthopaedic and radiographic follow-up and limited client recognition of signs. While the long-term follow-up rate of this study was high (50/57 elbows), the development of undetected late complications is possible and may have been underestimated by remote follow-up, which is limited by client recall and is subject to participation bias.

Although no transcondylar screw failure was found through long-term follow-up, late transcondylar screw failure is a lifelong risk. This may occur beyond twelve months and up to four years after surgery.[18,23] Plain radiography and computed tomography are also limited in detecting transcondylar screw failure.[18,45] Therefore, false-negative radiographic results could not be completely excluded.

This study is limited by its retrospective nature, and the lack of a control group managed non-surgically, long-term radiographic follow-up in the majority or lifelong follow-up. Many cases also had contralateral humeral condylar fracture, which would have confounded lameness assessment. The small sample size, and number of complications in particular, may have led to non-identification of statistical associations. Finally, the single-centre nature of the study introduces a regional genetic and lifestyle bias which may not necessarily be applicable to the general canine population.

Overall, this study suggests that transcondylar screw placement for HIF is associated with a low complication rate and good outcome. Increasing age was associated with a lower risk of complications. Outcome was not affected by the presence of a complication. Screw angulation is dependent on method of transcondylar screw placement.

Authors' Contribution

D.L. contributed to study design, data collection, data analysis, interpretation of results and manuscript writing. V.H. contributed to data collection, data analysis, interpretation of results and manuscript writing. S.R. contributed to study conception, study design, interpretation of results and manuscript writing. All authors approved the final manuscript.

Conflict of Interest

None declared.

References

1 Butterworth SJ, Innes JF. Incomplete humeral condylar fractures in the dog. J Small Anim Pract 2001;42(08):394–398
2 Marcellin-Little DJ, DeYoung DJ, Ferris KK, Berry CM. Incomplete ossification of the humeral condyle in spaniels. Vet Surg 1994;23 (06):475–487
3 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
4 Moores AP, Moores AL. The natural history of humeral intracondylar fissure: an observational study of 30 dogs. J Small Anim Pract 2017;58(06):337–341
5 Moores AP. Humeral intracondylar fissure in dogs. Vet Clin North Am Small Anim Pract 2021;51(02):421–437
6 Chase D, Sul R, Solano M, Calvo I, Joslyn S, Farrell M. Short- and long-term outcome after transcondylar screw placement to treat humeral intracondylar fissure in dogs. Vet Surg 2019;48(03): 299–308
7 Robin D, Marcellin-Little DJ. Incomplete ossification of the humeral condyle in two Labrador retrievers. J Small Anim Pract 2001;42(05):231–234
8 Gnudi G, Martini FM, Zanichelli S, et al. Incomplete humeral condylar fracture in two English Pointer dogs. Vet Comp Orthop Traumatol 2005;18(04):243–245
9 Almeida M, Yeadon R. Humeral intracondylar fissure in a boxer breed dog. Vet Rec Case Rep 2022;10(02):
10 Martin RB, Crews L, Saveraid T, Conzemius MG. Prevalence of incomplete ossification of the humeral condyle in the limb opposite humeral condylar fracture: 14 dogs. Vet Comp Orthop Traumatol 2010;23(03):168–172
11 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
12 Witte PG, Bush MA, Scott HW. Propagation of a partial incomplete ossification of the humeral condyle in an American cocker spaniel. J Small Anim Pract 2010;51(11):591–593
13 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
14 Jenkins G, Moores AP. Medial epicondylar fissure fracture as a complication of transcondylar screw placement for the treatment of humeral intracondylar fissure. Vet Surg 2022;51(04): 600–610
15 Hattersley R, McKee M, O'Neill T, et al. Postoperative complications after surgical management of incomplete ossification of the humeral condyle in dogs. Vet Surg 2011;40(06):728–733
16 Meyer-Lindenberg A, Heinen V, Fehr M, Nolte I. Incomplete ossification of the humeral condyle as the cause of lameness in dogs. Vet Comp Orthop Traumatol 2002;15(03):187–194
17 Easter TG, Bilmont A, Pink J, Oxley B. Accuracy of three-dimensional printed patient-specific drill guides for treatment of canine humeral intracondylar fissure. Vet Surg 2020;49(02):363–372
18 Carwardine D, Burton NJ, Knowles TG, Barthelemy N, Parsons KJ. Outcomes, complications and risk factors following fluoroscopically guided transcondylar screw placement for humeral intracondylar fissure. J Small Anim Pract 2021;62(10):895–902
19 McCarthy J, Woods S, Mosley JR. Long-term outcome following management of canine humeral intracondylar fissure using a

medial approach and a cannulated drill system. Vet Rec 2020;186 (15):490–497
20 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
21 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
22 Coggeshall JD, Lewis DD, Fitzpatrick N, et al. Biomechanical comparison of two implants for the stabilization of incomplete ossification of the humeral condyle lesions in dogs. Vet Surg 2014; 43(01):58–65
23 Charles EA, Ness MG, Yeadon R. Failure mode of transcondylar screws used for treatment of incomplete ossification of the humeral condyle in 5 dogs. Vet Surg 2009;38(02):185–191
24 Laupacis A, Sackett DL, Roberts RS. An assessment of clinically useful measures of the consequences of treatment. N Engl J Med 1988;318(26):1728–1733
25 Cook RJ, Sackett DL. The number needed to treat: a clinically useful measure of treatment effect. BMJ 1995;310(6977): 452–454
26 Sackett DL, Deeks JJ, Altman DG. Down with odds ratios. Evid Based Med 1996;1:164–166
27 Altman DG. Confidence intervals for the number needed to treat. BMJ 1998;317(7168):1309–1312
28 Hutton JL. Number needed to treat: properties and problems. J R Stat Soc Ser A Stat Soc 2000;163:403–419
29 Carrera I, Hammond GJ, Sullivan M. Computed tomographic features of incomplete ossification of the canine humeral condyle. Vet Surg 2008;37(03):226–231
30 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
31 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
32 Weese JS. A review of post-operative infections in veterinary orthopaedic surgery. Vet Comp Orthop Traumatol 2008;21(02): 99–105
33 Radke H, Joeris A, Chen M. Evidence-based evaluation of owner-reported outcome measures for canine orthopedic care - a COSMIN evaluation of 6 instruments. Vet Surg 2022;51(02): 244–253
34 Hayes GM, Ramirez J, Langley Hobbs SJ. Use of the cumulative summation technique to quantitatively assess a surgical learning curve: canine total hip replacement. Vet Surg 2011;40(01):1–5
35 Carwardine D, Mather A, Schofield I, et al. Medial versus lateral transcondylar screw placement for canine humeral intracondylar fissures: a randomised clinical trial. BVOA Proceedings 2022
36 Barnes DM, Morris AP, Anderson AA. Defining a safe corridor for transcondylar screw insertion across the canine humeral condyle: a comparison of medial and lateral surgical approaches. Vet Surg 2014;43(08):1020–1031
37 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
38 Välkki KJ, Thomson KH, Grönthal TSC, et al. Antimicrobial prophylaxis is considered sufficient to preserve an acceptable surgical site infection rate in clean orthopaedic and neurosurgeries in dogs. Acta Vet Scand 2020;62(01):53
39 Husi B, Overesch G, Forterre F, Rytz U. Surgical site infection after 769 tibial plateau leveling osteotomies. Front Vet Sci 2023; 10:1133813
40 Budsberg SC, Torres BT, Sandberg GS. Efficacy of postoperative antibiotic use after tibial plateau leveling osteotomy in dogs: a systematic review. Vet Surg 2021;50(04):729–739
41 de Jonge SW, Boldingh QJJ, Solomkin JS, et al. Effect of postoperative continuation of antibiotic prophylaxis on the incidence of surgical site infection: a systematic review and meta-analysis. Lancet Infect Dis 2020;20(10):1182–1192
42 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 2020;61(06):374–380
43 Strohmeier UW, Harris KP. Humeral intracondylar fissures in French bulldogs. Vet Rec 2021;189(11):e504
44 Neal KM, Gallaher HM, Thompson A, Kerby MD. The effect of an aiming device on the accuracy of humeral transcondylar screw placement. Vet Surg 2023;52(04):538–544
45 Labrador J, Witte PG, Holdsworth A. Use of an extended CT scale reconstruction to diagnose metal implant failure in a canine elbow. Vet Radiol Ultrasound 2021;62(06):e63–e66