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ORIGINAL RESEARCH

Humeral unicondylar fractures in immature dogs treated using a bone screw and Kirschner wire

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Abstract

Background: To investigate the incidence of implant-related complications when humeral unicondylar fractures in immature dogs are stabilised with a transcondylar bone screw and epicondylar Kirschner wire (K-wire)/pin.

Methods: Records of cases treated by the author in this clinic over a 10-year period were screened for those involving humeral condylar fractures. These were then reduced to include those patients who were less than 7 months of age with unicondylar fractures and follow-up radiographs.

Results: Thirty fractures in 29 dogs met the inclusion criteria. All of these had been stabilised with a transcondylar bone screw and epicondylar K-wire. Fracture healing was documented in all dogs. Surgical site infection was not recorded. Implant-related major complications were reported in four (13%) dogs and successfully treated by either implant removal or replacement. Short-term outcome was judged as excellent in 23 out of 30 and good in seven out of 30 of these fractures.

Conclusion: The use of a transcondylar bone screw in combination with an epicondylar K-wire is an appropriate fixation method for humeral unicondylar fractures seen in puppies less than 7 months of age.

INTRODUCTION

Historically, the recommended treatment for medial or lateral humeral condylar (unicondylar humeral) fractures has been internal fixation using a transcondylar bone screw and an antirotational device, generally a Kirschner wire (K-wire) or Steinmann pin, placed across the epicondylar ridge component of the fracture.[1–4] More recently, the stability of this construct has been brought into question by the frequency of implant-related complications when K-wires are used to stabilise the epicondylar ridge fracture compared to when bone plates are used.[5,6] This concern was supported by cadaveric studies showing that stiffness, yield load and load to failure are all greater when bone plates rather than K-wires are used in conjunction with a transcondylar bone screw.[7] As a result of these observations, recommendations have gravitated towards the use of epicondylar bone plates rather than K-wires or pins, in combination with transcondylar bone screws, to manage these patients,[8] including when such fractures are treated in puppies.[9] However, little attention has been directed at whether these recommendations are appropriate across the entire spectrum of patients treated for these fractures and, in particular, whether there might be a different approach to the management of puppies compared with adult dogs. One study[5] showed a difference in complication rate when epicondylar plates were used, compared with epicondylar K-wires, to manage lateral condylar fractures in a population of dogs of all ages. They also suggested that this difference would be found in puppies, as a sub-group of their population, once co-confounding factors had been taken into account. However, their conclusions still included a statement that further studies to clarify the effects of age, among other factors, would be useful. In another study,[6] there was found to be no significant difference in complication rate between patients less than or greater than 1 year of age, but the nature of the complications in these two sub-groups was not outlined.

The purpose of this study was to investigate the use of transcondylar bone screws in conjunction with K-wires to treat puppies aged less than 7 months with unicondylar humeral fractures and, in particular, to record the incidence of implant-related complications during fracture healing.

MATERIALS AND METHODS

Case records were used to identify all patients presented at this clinic with humeral condylar fractures, and the records from patients aged less than 7 months were reviewed. Details taken were breed, age, sex,

presence of prodromal lameness, fracture configuration and presence of an intracondylar fissure in the non-injured limb (based on radiographic examination), method of fixation and follow-up information relating to clinical and radiographic examination about 6 weeks post-surgery.

The surgical approach to manage a lateral condylar fracture was based on that described elsewhere.[10] If exposure of the lateral epicondyle allowed accurate reduction of the fragment (assessed by stability and visualisation of the fracture line in the epicondylar ridge), then direct placement of the transcondylar bone screw was undertaken. If the latter could not be achieved, then the anconeus muscle was transected close to the caudal border of the epicondyle to allow rotation of the lateral fragment and permit retrograde drilling of that fragment. The surgical approach to manage a medial condylar fracture replicated this, with reflection of the medial head of the triceps muscle from the medial epicondylar ridge, if required, to rotate the medial fragment outwards and allow retrograde drilling of the fragment. The diameter of bone screw chosen for any given patient was determined by the following factors: the diameter of the condyle at its isthmus (measured from radiographs and choosing a bone screw with an outside diameter of about 50% of the condylar diameter at the isthmus), evaluating the margin of bone that would be left around the pilot or gliding hole in the condylar fragment when placing the screw in a retrograde fashion (generally trying to allow at least 2 mm around the screw).

All patients received perioperative broad-spectrum antibiotic therapy followed by a 5-day course of postoperative treatment. No bandage was applied postoperatively, skin sutures were removed after about 10 days and owners were advised to restrict the puppies to pen rest and regular walks on a short lead several times a day. Physiotherapy was not used in any of the cases.

Healing of the fracture was determined radiographically (including vertical and horizontal beam craniocaudal views) and, particularly where any remaining lucency within the condyle might be artefact or the result of a persistent fissure, the appearance of the epicondylar fracture line was used to determine healing. In terms of complications, these were classified as major (requiring surgical or medical intervention) or minor (not requiring further surgical or medical intervention) as defined previously.[11] Outcome was graded as excellent, good, fair or poor using the descriptors from an earlier study,[9] where outcomes from a similar population of dogs were being reported (Table 1).

TABLE 1 Grading system for evaluating outcome[9]

Grade of outcome	Descriptor
Excellent	No lameness and normal/near normal range of motion in elbow joint
Good	Mild lameness and normal/near normal range of motion in elbow joint
Fair	Moderate to severe lameness
Poor	Non-weight-bearing lameness

TABLE 2 Breed incidence for 50 puppies (aged 3–7 months) with humeral unicondylar fractures

Breed	Number in original population	Number in population with follow-up
French Bulldog	25	13
English Springer Spaniel	4	3
Cocker Spaniel	2	0
British Bulldog	2	1
Pug	2	2
Crossbreed	8	6
Total	50	29

Note: In addition, one puppy from each of the following breeds was recorded in the initial total: Bichon Frise, Border Terrier, Cavalier King Charles Spaniel, Labrador Retriever, Jack Russell Terrier, Miniature Pinscher and Shih Tzu (total of seven). In the case of the puppies with follow-up, one from each of the following additional breeds was recorded: Border Terrier, Cavalier King Charles Spaniel, Labrador Retriever and Jack Russell Terrier.

RESULTS

During a period of just over 10 years (March 2011–August 2021), 52 consecutive lateral (43) or medial (nine) humeral condylar fractures in 51 puppies aged 3–6 months (inclusive) were treated. Fifty-one fractures were treated using a transcondylar bone screw and epicondylar K-wire. A single puppy with a unilateral medial condylar fracture was treated with a transcondylar screw and epicondylar screw and was excluded from this analysis. No such fractures, in patients within this age range, were treated using epicondylar bone plates during this period.

The breeds of the 50 dogs involved are shown in Table 2, which shows the predominance of the French Bulldogs (25). Ages ranged from 11 to 30 weeks (median 16 weeks). Bodyweight ranged from 1.5 to 16.9 kg (median 5.5 kg) and, of the 50 dogs, 24 were males and 26 were females. Table 2 also shows the breeds of dogs for which follow-up information was available.

Prodromal lameness was recorded in only two cases, one French Bulldog and one mixed breed, with lameness having been noted for 1–2 days prior to fracture. Determining the presence of an intracondylar fissure in the non-injured limb was difficult because intracondylar ossification appeared incomplete in many and evaluating whether an apparent fissure extended proximally into the metaphysis was somewhat unreliable due to positioning, patient size and Mach lines caused by the superimposed ulna. A convincing fissure was noted in the contralateral elbow of four of the 49 dogs (two French Bulldogs, one Labrador and one mixed breed) with unilateral fractures and was suspected in a further five (four French Bulldogs and one English Springer Spaniel). Of the two dogs showing a prodromal lameness one, the French Bulldog, did not have a contralateral fissure evident radiographically and the other, mixed breed, did.

TABLE 3 Implant size in relation to bodyweight used to treat the 51 fractures

Transcondylar bone screw					Kirschner wire/Steinmann pin		
Size (mm)	Total		Number	Mean bodyweight (kg)	Size (mm)	Number	Mean bodyweight (kg)
2.7	17	Retrograde	7	3.1	0.9	1	2.2
		Direct	10	4.0	1.1	10	3.6
3.5	28	Retrograde	20	6.2	1.6	30	5.5
		Direct	8	6.2	2.0	7	7.3
4.5	6	Retrograde	4	10.8	2.4	3	12.6
		Direct	2	9.7			

TABLE 4 Major complication rates in cohorts of dogs with humeral condylar fractures in relation to epicondylar fixation method as an adjunct to stabilisation with a transcondylar bone screw

Study	Age of dogs	Fracture configuration	Method of fixation	Major complications		
				Implant related	Infection	Combined total
Current	<7 months	Lateral or medial	K-wire/pin	4/30 (13%)	0/30 (0%)	13%
Perry et al. (2015)	All ages	Lateral	K-wire	17/61 (28%)	4/58 (7%)	35%
			Screw or plate	8/74 (11%)	15/72 (21%)	32%
Sanchez Villamil et al. (2020)	All ages	All	K-wire	9/28 (32%)	0/28 (0%)	32%
			Plate	4/64 (6%)	9/64 (14%)	20%
Kvale et al. (2022)	<6 months	Lateral or medial[a]	Plate	4/38 (11%)	1/38 (<1%)	11%

[a]Although this case series included all configurations of condylar fracture, the information relating to just lateral or medial condylar fractures has been tabulated here.

Of the 51 fractures, 20 affected the left limb and 31 affected the right limb, while 43 involved the lateral part of the humeral condyle and eight affected the medial part. Of the 26 unicondylar fractures seen in French Bulldogs, 25 were lateral and only one affected the medial part of the condyle. All transcondylar screws were non-self tapping cortical bone screws of 316L stainless steel (Orthomed, UK). Twenty-three were placed in lagged fashion while 28 were placed as positional screws. The diameters of the bone screws used along with whether they were placed in direct or retrograde fashion and the mean bodyweight for each sub-group are detailed in Table 3. Washers were used under the screw head in seven cases and in all of these the bone screw had been placed in lagged fashion. The size of K-wire/Steinmann pin used to stabilise the epicondylar ridge component (along with the mean bodyweight for that group) is also detailed in Table 3. None of the patients with unilateral fractures had any treatment of the contralateral limb, even where an intracondylar fissure was suspected.

Fracture healing was documented radiographically in 30 fractures (29 dogs) after a follow-up period of 30–61 days (median 42 days). The remaining dogs were lost to follow-up and so their outcomes are entirely unknown. No minor complications occurred in any of the patients with follow-up information. Four dogs (13%) in total experienced a major complication, all of which were implant related. During the healing period, one dog displayed evidence of implant migration (Figure 1a) requiring revision surgery to re-tighten the transcondylar screw and replace the K-wire with a larger diameter pin. The complications in the other three dogs were noted at the time of follow-up radiography and had not created a problem during healing of the fracture. In one case, the bone screw had backed out causing 'tenting' of the skin (Figure 1b) and this was removed through a small incision at the time of follow-up radiography. In another, a French Bulldog where an intracondylar fissure was suspected, the 3.5 mm transcondylar (lagged) cortical screw had backed out by about 30% of its length (Figure 1c) and, at the time of radiography, was replaced with a 4.5 mm cortical screw placed in a positional fashion. The final dog with an implant-related complication (Figure 1d) was showing a moderate lameness at follow-up examination, which resolved after implant removal. From clinical examination and discussion with their owners, the short-term outcome was considered excellent for 23 out of 30 (77%) and good for seven out of 30 (23%) of the fractures, albeit that four of these patients had required implants to be removed or replaced. None of these cases has returned to this clinic for complications relating to the treatment of their fracture(s) or for treatment of fracture of the contralateral limb. In addition, no other clinic has requested information relating to treatment of these patients.

DISCUSSION

This study identified a series of 30 unicondylar humeral fractures treated in 29 puppies aged between 3 and 7 months over a period of 10 years with

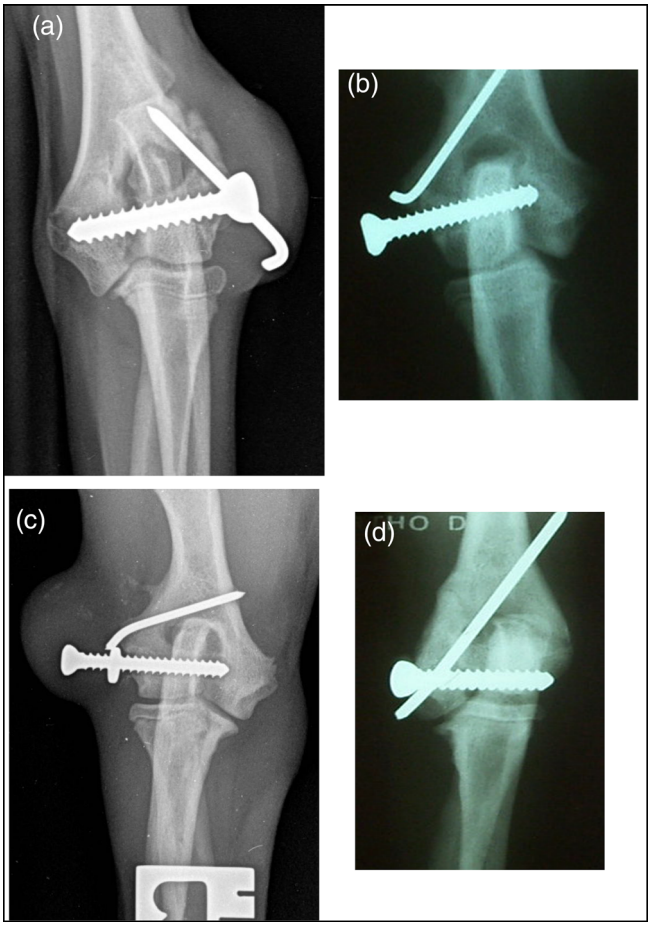

FIGURE 1 (a) Craniocaudal radiograph of the left elbow of a 17-week-old Golden Doodle taken 3 weeks after treatment. The 2.0 mm K-wire has migrated and the bone screw (positional) backed out. Fracture reduction has been retained and revision involved re-tightening of the bone screw and placement of a 2.4 mm pin. (b) Craniocaudal radiograph of the right elbow of an 18-week-old Jack Russell Terrier taken 6 weeks after treatment. The bone screw has backed out and was removed through a stab incision at the time of radiography. (c) Craniocaudal radiograph of the right elbow of a 22-week-old French Bulldog taken 8 weeks after treatment. The 3.5 mm bone screw has backed out and was replaced with a 4.5 mm bone screw because a faint fracture line is still evident in the condyle distal to the bone screw raising concern over a condylar fissure, especially given the breed involved. (d) Craniocaudal radiograph of the left elbow of a 19-week-old Pug taken 6 weeks after treatment. A moderate lameness was present, which resolved within 4 weeks of implant removal

follow-up information detailing the short-term outcome. All fractures were stabilised using a transcondylar bone screw and epicondylar K-wire or pin. Bone union was achieved in all of these 30 fractures with no minor complications but four major complications that were all implant related. Following appropriate revision of these complications, an excellent or good short-term outcome was seen in all 29 puppies.

The breed incidence within the treated population shows a clear bias towards the French Bulldog (25/50, 50%). The numbers for each breed for which follow-up information was available appear to correlate with the incidence of breeds for those presented for treatment (Table 1). Making comparisons of breed incidence recorded in this series of cases with other studies is compromised by the fact that other studies include dogs of all ages and all configurations of condylar fracture. Some studies have shown a predisposition to these fractures in the French Bulldog breed,[6,12] although other early studies recorded few of this breed in their populations, 0 of 133,[13] 0 of 20[14] and 1 of 83.[15] It is also of interest to note that of the 46 adult dogs treated for humeral condylar fractures at this clinic over the same period, only two (4%) were French Bulldogs. This might suggest that French Bulldog puppies are predisposed to humeral condylar fractures, while adults might not be, although it could also reflect the demographics of particular breeds in the catchment area of this clinic. The median age of this fracture population was 16 weeks, and this agrees with other studies where a peak incidence was noted at around 3–4 months of age.[13,15] Similarly, the proportion of unicondylar fractures that involved the lateral or medial component of the condyle (43:8) is in accordance with previous studies; 74:14,[13] 52:10,[15] 50:9,[16] 127:13[12] and 75:10.[6] Interestingly, the predisposition towards a higher proportion of medial condylar fractures in the French Bulldog (13 lateral:6 medial) reported in one study[6] was not found in the series of cases reported here (25 lateral:1 medial).

The incidence of prodromal lameness was low, two out of 51 fractures (4%), but evaluation of this might well have been hampered by the patients being of an age where exercise levels are still fairly restricted. Likewise, the age of the patients may have led to an underestimate of the incidence of a predisposing fissure because of the need to differentiate a fissure from the normal incomplete ossification of the epiphysis when the normal time for epiphyseal ossification to become complete has not been recorded definitively for any breed. The use of computerised tomography might have clarified this aspect.

With respect to the implant size chosen, it was not surprising to find that the mean weight of patient in each category increased with the size of implant, with both the bone screw and the K-wire/pin size chosen showing this trend. The criteria used in choosing implant size are described above, but in all cases the diameter of bone screw chosen was the largest the author felt could be accommodated by the condyle. The reasons for this were, firstly, that a larger diameter bone screw has a greater thread pitch, and so greater purchase within the bone, and secondly, in the event of a persistent condylar fissure, the implant could be expected to have better resistance to fatigue failure.

Fracture healing was documented in all patients (30 fractures in 29 dogs) presented for follow-up radiography and none showed malunion. Of these, the short-term outcome (median 6 weeks) was considered excellent in 23 out of 30 (77%) and good in seven out of 30 (23%) of the fractures. This compares favourably with the reported short-term outcome in a series of 45 fractures in French Bulldog puppies treated for humeral condylar fractures (all configurations) using a transcondylar bone screw and epicondylar plate(s).[9] In that study, the short-term outcome (mean 5.6 weeks) was reported as excellent in 35 out of 45 (78%), good in nine out of 45 (20%) and poor in one out of

45 (2%). It also compares favourably with the outcome (median 7 weeks) reported in an earlier study[5] for 135 lateral condylar fractures treated in any age or breed of dog where outcome was reported as excellent in 67 out of 135 (50%), good in 28 out of 135 (21%), fair in 31 out of 135 (23%) and poor in seven out of 135 (5%). However, the descriptors used in the latter study[5] to define the four grades of outcome were more critical than those used here and in the study involving only French Bulldog puppies,[9] and were in line with descriptors outlined in a much earlier paper.[17]

Major complications (requiring further surgical or medical management) during the healing period were seen in only one fracture (3%), where implant migration recognised at 3 weeks post-surgery led to re-tightening of the (positional) bone screw and replacement of the epicondylar K-wire with a, larger diameter, Steinmann pin. Whether or not, without revision, this would have led to failure of reduction before healing had been achieved is uncertain. Beyond fracture healing, a further three patients (10%) required additional surgery; one to remove a transcondylar bone screw that had backed out and was 'tenting' the skin, one to replace a transcondylar screw (that had 'backed out') with a larger diameter bone screw because an intracondylar fissure was suspected in the contralateral elbow, and one to have implants removed because of residual lameness that then resolved. Reviewing the case details of the three showing implant migration, there was no consistency in terms of breed, sex, bone screw size or method of placement. The only observation that suggested any consistency at all was that all three sustained fractures were at 12–14 weeks of age, below the median age of 16 weeks. This is not definitive proof of a risk factor, but it is conceivable that loss of purchase of a transcondylar screw might be more likely in a younger patient with less dense/mineralised cancellous bone.

The overall major complication rate of 13% (4/30) in this cohort of dogs is comparable to the 12.9% (8/62) major complication rate seen in patients less than 8 months of age reported previously,[5] where varying methods of fixation had been used, and the 11% (4/38) of major complication rate was seen in French Bulldogs less than 6 months of age treated for unicondylar fractures using epicondylar plates.[9] It is also favourable when the incidence of implant-related complications (13%, 4/30) is compared with other cohorts of dogs treated for humeral condylar fractures using a transcondylar bone screw and epicondylar K-wire or pin; 28% (17/61) for a group of dogs of all ages with lateral condylar fractures,[5] 17.1% (7/41) for the dogs less than 7 months of age treated this way[5] and 32% (9/28) in a group of dogs of all ages with any fracture configuration.[6] In addition, while no minor complications were reported in this case series, other studies have recorded an incidence of 22% (9/41) for lateral condylar fractures in patients less than 7 months of age treated with a transcondylar bone screw and epicondylar K-wire[5] and 5.3% (2/38) for unicondylar fractures in patients less than 6 months of age treated with a transcondylar bone screw and epicondylar plate.[9] There are clearly limitations to making these comparisons because of the range of ages of patient and varying methods of management, as illustrated in Table 4. From this comparison, it would appear that the use of transcondylar bone screws with adjunct K-wires to stabilise humeral unicondylar fractures in puppies produces less implant-related complications than in fracture populations that include all ages of dog. The reason for this might well relate to fracture healing time in that stability needs to be maintained for less time in puppies than it does in adults and so the stability afforded by a K-wire might be more likely to suffice in a puppy than it is in an adult dog.

There are a number of limitations to this study in that it is retrospective, only includes short-term outcome, lacks a control group comparing other fixation techniques and that all surgeries were performed by one, experienced surgeon in a referral clinic. Hence, further multicentre studies with longer term follow-up would be required to show this technique can be applied with consistent results in both the short and longer term, when compared to other methods of fixation. Furthermore, only one of the patients in this study showed comminution of the epicondylar ridge and although healing was uneventful it is perfectly reasonable to consider that such patients might be more reliably managed with an epicondylar plate rather than a K-wire.

CONCLUSION

In this report, the use of a transcondylar bone screw in combination with an epicondylar K-wire/pin to manage humeral unicondylar fractures in puppies of less than 7 months of age led to an excellent or good short-term outcome in all 30 fractures with follow-up information. Complication rates were comparable to those reported with other fixation systems in dogs of a similar age and lower than those reported when transcondylar bone screw and epicondylar K-wire fixation are used in adult dogs. Hence, the use of such an implant system for these fractures in puppies can be expected to give good results with complication rates that are comparable to, or better than, other published case series so long as implant size and positioning are appropriate. The use of epicondylar plates, which has become accepted practice for adult patients with such fractures, may not be necessary in dogs 3–7 months of age. Although implant-related complications were seen in four (13%) of the fractures with follow-up, only one of these required further treatment during the healing period, all complications were readily resolved by implant removal or replacement and no catastrophic failures were seen.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHOR CONTRIBUTIONS

All of the work involved, both in patient management and the writing of the manuscript was undertaken by the author.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

FUNDING INFORMATION

The study involved the collection of data from clinical cases where the cost of treatment was covered by their owners. No other funding was received to undertake the study.

ETHICS STATEMENT

As all animals involved in this study were owned by clients who consented to their pets' treatment, no ethical approval was required.

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