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Multi-Centre Study of Long-Term Outcomes Following Traumatic Elbow Luxation in 37 Dogs

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Introduction

Canine traumatic elbow luxation is an uncommon injury owing to the inherent stability of the joint construct. Stability provided by strong peri-articular muscular and ligamentous structures, as well as the anconeal process engaging with the olecranon fossa results in peri-articular fracture being a more common clinical occurrence (Campbell 1969, Pass and Ferguson 1971). Luxations are usually associated with high energy trauma such as road traffic incidents, falls, fights and limb entrapments (Campbell 1971, Billings and others 1992, O'Brien and others 1992, Schaeffer and others 1999, Mitchell 2011). Elbow luxation has been hypothesised to occur as a result of direct force acting on the joint, or the indirect application of rotational forces transferred to the elbow via bridging ligaments and regional musculature (O'Brien and others 1992, Schaeffer and others 1999, Farrell and others 2007).

Excessive medial and lateral translation, abduction and adduction of the antebrachium are prevented by the collateral ligaments. In dogs, more than 90% of reported elbow luxations are in a lateral direction (Campbell 1969). This propensity is attributed to the larger humeral epicondyle and it's distally sloping articular surface providing more extensive encapsulation of the radial head and providing greater protection against medial translation and subsequent luxation (Billings and others 1992, O'Brien and others 1992). The importance of damage to the collateral ligaments during luxation is contentious, with ligament injury reported in 18-50% of patients (Griffon 2010). Historical cadaveric examination of the canine elbow demonstrated luxation with visually intact collateral ligaments (Campbell 1969), however, in a more recent bio-mechanical evaluation, luxation was not possible unless at least the lateral collateral ligament was transected. Transection of both medial and lateral collateral ligaments was required for luxation in the feline elbow (Farrell and others 2007).

Closed reduction is reported to provide a successful outcome in the majority of canine elbow luxation cases and is the recommended initial approach to treatment (Campbell 1971, Pass and Ferguson 1971, O'Brien and others 1992). If closed reduction is not possible, open reduction with surgical stabilisation is required. Numerous stabilisation methods following open reduction of elbow luxations are described and include collateral ligament repair (Campbell 1969), reattachment of ligamentous avulsions, collateral ligament replacement with synthetic suture or orthopaedic wire (Schaeffer and others 1999, McCartney and others 2010), transarticular external skeletal fixation (TESF)(Griffon 2010) and transcondylar bone tunnels with biaxial suture repair (Farrell and others 2007). The 'Campbell's Test' remains the 'Gold Standard' non-invasive assessment of collateral ligament integrity. Campbell (1969) described that in the normal dog, with the elbow and carpus both flexed to 90°, the maximum range of antebrachial rotation was 40-50° for pronation and 60-70° for supination. Compromise of the lateral collateral ligament resulted in a maximum supination of 120-140° and medial collateral injury permitted pronation of 90-100°. Following closed reduction assessment of antebrachial rotation has been reported as essential for evaluation of residual instability, with persistent instability being associated with disappointing functional outcome (Schaeffer and others 1999). Subsequent recommendations for patients demonstrating residual instability after closed reduction include surgical stabilisation as this may result in a more favourable outcome when compared with closed reduction alone (Schaeffer and others 1999, McCartney and others 2010).

To date, all large studies of canine traumatic elbow luxation have included predominantly cases managed by closed reduction with relatively few patients treated surgically. The purpose of this study was to review a large series of dogs with traumatic elbow luxation treated surgically or by closed reduction, and report the outcomes and complications encountered, plus long term follow-up using the previously validated Canine Brief Pain Inventory (CBPI) (Brown and others 2008).

MATERIALS AND METHODS

Data Collection

This study was approved by the Royal Veterinary College Ethics and Welfare Committee (URN 2015 1367). Case records for all dogs presenting with traumatic elbow luxation to the Queen Mother Hospital for Animals at the Royal Veterinary College, the Small Animal Hospital at the University of Glasgow, the Small Animal Specialist Hospital in Sydney, the Veterinary Specialist Centre Sydney and Anderson Moores Veterinary Specialists between 2006 and 2013 were reviewed. Data recorded included patient signalment, luxation aetiology and direction, time to attempted reduction (within 24 hours, between 24-48 hours or greater than 48 hours), method of reduction ('closed' vs. 'open'), surgical procedures performed, concurrent injuries, post-reduction care including method of external coaptation and complications encountered. Dogs managed with closed reduction alone were assigned to 'Group 1' and dogs managed with open reduction and/or surgical stabilisation were assigned to 'Group 2'. Complications were divided into 'minor' or 'major'; complications necessitating additional surgery or resulting in significant lameness or morbidity were described as major. Cases with both minor and major complications were categorised as having major complications.

Questionnaire follow-up was attempted for all dogs with owners contacted by telephone or e-mail and asked to complete the Canine Brief Pain Inventory. Owners were presented with 11 questions; four questions in which they were required to grade the severity of their dog's pain over the previous seven days, six questions to evaluate function over the previous seven days and one final question requesting a single global assessment of their dog's quality of life. Questions 1-10 were all graded on a discrete 0-10 numerical scale, with 0 representing no pain or interference and 10 denoting extreme pain or complete interference. Owners were asked to describe the quality of life of their dog as either 'poor', 'fair', 'good', 'very good' or 'excellent'. For each patient, the numerical scores for the pain severity and functional outcome were averaged to give a mean pain and mean function score for each dog.

Statistical Analysis

Statistical analysis was performed using a dedicated statistical software programme (SPSS 22.0, IBM). Descriptive statistics were reported for all data. The influence of reported data on complications and outcome was analysed using Chi-Squared test with a value of $P \leq 0.05$ considered statistically significant.

RESULTS

Thirty-seven dogs were identified as having sustained a traumatic elbow luxation within the study period. Twenty-two dogs were female (7 entire, 15 neutered) and 15 were male (5 entire, 10 neutered). Median age was 48 months (range 8-156 months) with a mean weight of 21.35kg (±10.42kg). Breeds included Cross Breed (n=11), Cocker Spaniel (n=3), Labrador Retriever (n=3), Rottweiler (n=3), Staffordshire Bull Terrier (n=3), Springer Spaniel (n=2) and one each of Australian Cattle Dog, Boxer, German Shorthaired Pointer, Greyhound, Whippet, Griffon, Jack Russell Terrier, Lhasa Apso, Lurcher, Papillion, Pug and Shih Tzu.

The most common cause of luxation was road traffic accident (n=22), followed by collisions, either into a human or another dog (n=3), dog attack (n=3), limb entrapment (n=3), falls (n=2), and a kick by a horse (n=1). Three causal incidents were not witnessed. Thirty-four of the 37 luxations were in a lateral direction, for the remaining 3 cases the direction of luxation was not recorded in the clinical records. Reduction was performed within 24 hours (n=24; 13 Group 1, 11 Group 2), between 24-48 hours (n=8; 5 Group 1, 3 Group 2) and greater than 48 hours (n=4; all Group 2). Time to reduction was not recorded in one dog and was excluded from analysis involving time to reduction. Closed reduction was not attempted in two cases due to concurrent anconeal process fracture. Of the cases treated at, or greater than, 48 hours post injury, 1 was treated 4 days post-trauma and two cases were treated one month after the initial luxation; these patients were referred due to persistent, repeat luxation.

Of the 37 cases included, 17 elbows were treated by closed reduction alone (Group 1) and 20 elbows required surgical intervention (Group 2). One patient had closed reduction with transarticular external skeletal fixator (ESF) placement due to residual instability and was included in the Group 2. Of the cases in Group 2, three had initially been treated with closed reduction but reluxated following recovery from anaesthesia prompting surgical stabilisation. Indications for surgical management were the inability to perform closed reduction or the presence of persistent instability/reluxation following closed reduction. No case had open reduction without concurrent stabilisation. Surgical stabilisation was grouped into 2 main categories; circumferential suture prosthesis passed through transcondylar bone tunnels (n=11) and screw/anchor placement with prosthetic ligament/orthopaedic wire placement (n=4). Combination treatments included screw/anchor placement with prosthetic ligament plus circumferential suture (n=1), screw/anchor placement with prosthetic ligament plus transarticular pin (n=1), screw/anchor placement with prosthetic ligament plus TESF (n=1), open reduction plus transarticular TESF (n=1) and closed reduction plus transarticular TESF (n=1).

Post-reduction external coaptation or fixation was employed in 30 cases; Spica splint (n= 20), support bandages including Modified Robert Jones and limb casts (n=7) and transarticular external skeletal fixation (n=3) (**Table 1**).

In total, 7 of the 37 dogs (19%) encountered major post-operative complications; reluxation (n= 6) and infection requiring implant removal (n=1). Five reluxations occurred following closed reduction; one was successfully managed with repeat closed reduction, three were surgically stabilised (recorded in Group 2) and one dog was euthanaised due to deterioration of concurrent injuries. One reluxation occurred following surgical stabilisation (lateral screw and prosthetic ligament placement) and was re-operated for placement of medial prosthetic ligament and reluxation did not occur. One dog in Group 1 operated following failed closed reduction suffered major soft tissue complication as a result of external coaptation and was euthanaised.

Five (13.5%) minor complications were encountered; superficial splint/bandage abrasions (n= 3) successfully managed conservatively and superficial surgical site infections (n=2) all of which resolved with appropriate antibiotic medication.

Gender, age, weight, breed (pedigree vs. cross breed), morphology (chondrodystrophic vs. non-chondrodystrophic) and time to reduction were not significantly associated with management (Group 1 vs. Group 2) or the incidence of post-reduction complications (Table 2).

There was no significant difference between the Group 1 and Group 2 with respect to the incidence of complications (P=1.000) or the occurrence of 'major' and minor complications (P=0.242). When analysed independently, reluxation was not significantly different between Groups 1 and 2 (p=0.660) nor was the incidence of reluxation associated with the presence or absence of external coaptation (p=1.000) or the type of coaptation applied (p=0.691).

Orthopaedic injures to additional limbs were observed in 9 cases and included unilateral coxofemoral luxation (n=2), bilateral coxofemoral luxation (n=2), coxofemoral luxation plus tibial fracture, tibial fracture plus bilateral sacroiliac luxation and unilateral tarsal instability, contralateral humeral fracture, right femoral capital physeal fracture and soft tissue laceration with patella ligament desmitis. Concurrent orthopaedic injury to another limb was significantly associated with the incidence of elbow reluxation (p= 0.02).

Twenty-one owners were contactable and agreed to complete the CPBI questionnaire (Table 3). Thirteen dogs were graded as having 'excellent' quality of life by their owners; nine from Group 2 (median pain score of 0 [range 0-2.5] and median functional score of 0 [range 0-3.33]) and four from Group 1 (median pain score of 0 [range 0-0] and median functional of score 0 [range 0-1]). Six patients were reported as having 'very good' function; two from Group 2 (median pain score of 1.63 [range 1.5-1.75] and median functional score 1.17 [range 1.17-1.17]) and four from Group 1 (median pain score of 0.25 [range 1-1.25] and median functional of score 0.25 [range 0.17-5]). One patient in Group 2 was reported as having good comfort and function (mean pain score of 3.75 and mean functional score of 3.83) and one dog in Group 1 as having fair (mean pain of score 0 and mean functional score of 4.67).

Discussion

A total of 37 canine patients with traumatic elbow luxations were treated over a seven year period between five veterinary referral institutes confirming that this is a relatively uncommon injury. Seventeen dogs were treated by closed reduction alone and twenty required surgical reduction/stabilisation. Our treatment groups (closed reduction vs. open reduction/stabilisation) were comparable with regards to patient numbers and patient signalment data and were representative of the patient cohorts previously reported (O'Brien and others 1992, Schaeffer and others 1999).

We report a considerably larger number of elbow luxations treated surgically compared with previous studies (O'Brien and others 1992, Schaeffer and others 1999). Explanation regarding this increase is likely multifactorial and potentially reflects shifts in treatment recommendations plus an increased surgical focus following the recent description of a novel technique (Farrell and others 2009). Residual instability following closed reduction of traumatic elbow luxations has been demonstrated to have a negative impact on the final outcome, with 'excellent' and 'good' follow-up results only reported when the elbow was stable immediately after reduction (Schaeffer and others 1999). It is conceivable that this finding could lead to the adoption of more aggressive management of patients in which minor instability was identified following closed reduction. The majority of surgical stabilisations employed in the present study fell into two main categories; prosthetic ligament placement with screw or suture anchors and circumferential suture prosthesis passed through transcondylar bone tunnels. The identification of lateral collateral ligament damage in all traumatic elbow luxations by McCartney (2010), plus the description of a new stabilisation technique by Farrell (2009) may have increased the focus on surgical stabilisation resulting in a higher number of surgically stabilised elbows. No significant difference in the reluxation rate or overall complication rate was identified between the Groups suggesting either method to provide adequate post-operative stability. A final explanation for the large number of surgically treated patients could be associated with the study of a referral population of dogs. It is quite possible that the patients referred reflect a sub-population of dogs in which closed reduction was more difficult or failed more frequently in primary care practice and hence referral treatment was sought. The referral of cases from primary care practices to the referral centres may also have resulted in an increased time to attempted reduction.

The most common complication following reduction of elbow luxation is reluxation (Griffon 2010). We identified no significant difference between Group 1 and Group 2 regarding the incidence of reluxation. Farrell et all (2007) showed that elbow luxation was only possible in the ex-vivo canine elbow following transection of at least the lateral collateral ligament, suggesting that in all luxations collateral ligament damage is likely; a finding echoed by a small study of surgically stabilised elbows in which all lateral collateral ligaments were found to be damaged at surgery (McCartney and others 2010). This is in contrast to early cadaveric evaluation of elbow luxation by Campbell (1969) who demonstrated visually intact collateral ligaments in a dog with radiographic evidence of luxation. One potential explanation for this could relate to the severity of collateral ligament damage sustained during luxation, with severe injuries resulting in marked instability and potential for reluxation where-as milder injuries retain sufficient constraint to maintain stability post-reduction. Unfortunately, it was not possible to ascertain the extent of the ligamentous injuries sustained in all operated patients from the clinical records and further discussion of this would be speculative.

External coaptation to allow fibrosis and healing of intrinsic support structures has been advocated for adjunctive support following closed reduction and following open reduction and repair of collateral ligaments (Griffon 2010). External coaptation focuses upon maintaining the limb in extension with engagement of the anconeal process within the olecranon fossa, preventing lateral translation and reluxation. Post-reduction coaptation was employed in 30 of the 37 cases reviewed, with Spica splint and bandages/casts being most frequently applied. No significant difference was observed in the occurrence of reluxation with respect to the presence or absence of external coaptation or between the types of coaptation used. This finding should be interpreted cautiously as we report relatively low numbers for each external coaptation variant, with variable lengths of application preventing detailed comparison in this study. The theoretical benefits of external coaptation must be weighed against the potential risk of complications, as compromise of the adjacent soft tissue is not uncommon (Meeson and others 2011); as observed with 1 major soft tissue injury and 3 cases of minor complication owing to external coaptation application. In one review of human elbow luxations, prolonged immobilisation after luxation was strongly associated with an unsatisfactory result with a significant increase in flexor contracture and more severe symptoms of pain (Josefsson and others 1987). Although, there are significant differences with regards to limb function in humans compared with canines, the deleterious effects of prolonged joint immobilisation on the health of articular cartilage are well documented (Bruce and others 2002) and must be considered when the decisions for, and the duration of, external coaptation or transarticular external skeletal fixation are made.

, the majority of elbow luxations in this study were sustained during motor vehicle incidents. This type of trauma is likely to be of high energy and additional co-morbidity is not uncommon (O'Brien and others 1992, Schaeffer and others 1999). The incidence of elbow reluxation was significantly increased in patients that had suffered concurrent orthopaedic injury; this phenomenon may be the result of forced earlier limb usage placing increased stress upon the recently reduced elbow. Recommendations regarding the most appropriate management of cases with concurrent, additional limb, orthopaedic injuries are likely to include more robust fixation/coaptation although strong evidence for a protective effect of either strategy is currently lacking.

A previous retrospective study reported that the best outcome following acute traumatic elbow luxation was achieved by closed reduction under general anaesthesia without damaging the cartilage or ligaments (Schaeffer and others 1999), with Campbell (1971) stating that when open reduction was necessary a more definite lameness or stiffness would be expected post reduction. In the present study, follow-up evaluation by owner completion of the CBPI was attempted for all cases. The CBPI has previously been validated and used for evaluation of response to treatment following a defined intervention (Brown and others 2008) and in the assessment of the severity and impact of chronic pain in dogs with bone cancer (Brown and others 2009). The CBPI consists of two dimensions; pain severity and pain interference, describing how that pain interferes with the dog's daily activity (CBPI user guide, www.CanineBPI.com). In the present study, owners reported 'very good' to 'excellent' quality of life in 11/12 (92%) cases treated surgically and 8/9 (89%) cases treated by closed reduction. This suggests that owner perception of the outcome is comparable for either surgical or non-surgical treatment. A combination of the CPBI with an objective measurement of limb function such as gait analysis and clinical examination would provide more comprehensive evaluation of long term function post reduction however is beyond the scope of the present study.

In conclusion, we report the treatment and outcome of a large population of traumatic elbow luxations in dogs, with the greatest number of dogs treated surgically to date. In agreement with previous studies, our results do not demonstrate a significant difference in the incidence of complication, or the level of function to be expected, following either closed reduction or surgical stabilisation. Additionally our study provides the first evidence that concurrent orthopaedic injury to additional limbs is a significant risk factor for reluxation following reduction of traumatic canine elbow luxation.

References:

Billings, L. A., Vasseur, P. B., Todoroff, R. J. & Johnson, W. (1992) Clinical Results After Reduction of Traumatic Elbow Luxations in Nine Dogs and One Cat. *JAAHA* **28**, 137-142

Brown, D. C., Boston, R., Coyne, J. C. & Farrar, J. T. (2009) A novel approach to the use of animals in studies of pain: validation of the canine brief pain inventory in canine bone cancer. *Pain Med* **10**, 133-142

Brown, D. C., Boston, R. C., Coyne, J. C. & Farrar, J. T. (2008) Ability of the canine brief pain inventory to detect response to treatment in dogs with osteoarthritis. *J Am Vet Med Assoc* **233**, 1278-1283

Bruce, W. J., Frame, K., Burbidge, H. M., Thompson, K. & Firth, E. C. (2002) A comparison of the effects of joint immobilisation, twice-daily passive motion and voluntary motion on articular cartilage healing in sheep. *Veterinary and Comparative Orthopaedics and Traumatology* **15**, 23-29

Campbell, J. R. (1969) Nonfracture injuries to the canine elbow. *J Am Vet Med Assoc* **155**, 735-744

Campbell, J. R. (1971) Luxation and ligamentous injuries of the elbow of the dog. *Vet Clin North Am* **1**, 429-440

Farrell, M., Draffan, D., Gemmill, T., Mellor, D. & Carmichael, S. (2007) In vitro validation of a technique for assessment of canine and feline elbow joint collateral ligament integrity and description of a new method for collateral ligament prosthetic replacement. *Vet Surg* **36**, 548-556

Farrell, M., Thomson, D. G. & Carmichael, S. (2009) Surgical management of traumatic elbow luxation in two cats using circumferential suture prostheses. *Vet Comp Orthop Traumatol* **22**, 66-69

Griffon, D. J. (2010) Surgical Diseases of the Elbow. In Veterinary Surgery: Small Animal. 1st edn. Eds K. M. Tobias and S. A. Johnston. Elsevier Saunders, St Louis, Missouri. pp 724-735

Josefsson, O., Gentz, C. F., Johnell, O. & Wendeberg, B. (1987) Surgical Versus Nonsurgical Treatment of Ligamentous Injuries Following Dislocations of the Elbow Joint. *Clinical Orthopaedics and Related Research*, 165-169

McCartney, W., Kiss, K. & MCGovern, F. (2010) Surgical Stabilisation as the Primary Treatment for Traumatic Luxation of the Elbow Joint in 10 Dogs *Intern J of Appl Res Vet Med* **8**, 97-100

Meeson, R. L., Davidson, C. & Arthurs, G. I. (2011) Soft-tissue injuries associated with cast application for distal limb orthopaedic conditions. A retrospective study of sixty dogs and cats. *Vet Comp Orthop Traumatol* **24**, 126-131

Mitchell, K. E. (2011) Traumatic elbow luxation in 14 dogs and 11 cats. *Aust Vet J* **89**, 213-216

O'Brien, M. G., Boudrieau, R. J. & Clark, G. N. (1992) Traumatic luxation of the cubital joint (elbow) in dogs: 44 cases (1978-1988). *J Am Vet Med Assoc* **201**, 1760-1765

Pass, M. A. & Ferguson, J. G. (1971) Elbow dislocation in the dog. *J Small Anim Pract* **12**, 327-332

Schaeffer, I. G. F., Wolvekamp, P., Meij, B. P., Theijse, L. F. H. & HAzewinkel, H. A. W. (1999) Traumatic Luxation of the Elbow in 31 Dogs. *Vet Comp Orthop Traumatol* **12**, 33-39

Table 1: The application of external coaptation in relation to closed reduction vs. surgically treated elbow luxations (TESF = transarticular external skeletal fixator)

	No Coaptation	External Coaptation		
		Spica	Cast/bandage	TESF
Group 1	3	10	4	1
Group 2	4	10	3	2

Table 2: The effect of variable on the incidence of closed reduction vs. open reduction/surgical stabilisation and the incidence of associated complications ('minor' and 'major' combined) *P*≤0.05 considered statistically significant.

	Group 1 vs. Group 2	Incidence of complications
Gender	p= 0.325	p= 1.000
Age	p= 0.879	p= 0.807
Weight	p= 0.511	p= 0.948
Breed (pedigree vs. cross breed)	p= 0.151	p= 1.000
Morphology (chondrodystrophic vs. non-chondrodystrophic)	p= 0.693	p= 0.389
Time to reduction	p= 0.097	p= 0.325

Table 3: Results of the Canine Brief Pain Inventory. Questions 1-4 evaluate the severity of pain over the previous 7 days. Questions 5-10 evaluate function over the previous 7 days. Question 11 requests a single global assessment of the dog's quality of life

Case Number	**Group**	**Q1**	**Q2**	**Q3**	**Q4**	**Mean Pain**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Mean Function**	**Q11**
7	1	0	0	0	0	0	0	0	o	o	o	o	0	Excellent
8	1	2	1	1	1	1.25	2	0	1	0	0	0	0.5	Very Good
12	1	0	0	0	0	0	1	0	0	0	0	0	0.17	Excellent
14	1	0	0	0	0	0	0	0	1	0	0	0	0.17	Very Good
15	1	2	0	0	0	0.5	0	0	2	0	0	0	0.33	Very Good
23	1	0	0	0	0	0	5	5	5	3	5	5	4.67	Fair
24	1	0	0	0	0	0	3	0	0	0	3	0	1	Excellent
26	1	0	0	0	0	0	0	0	0	0	0	2	0.33	Very Good
27	1	0	0	0	0	0	0	0	0	0	0	0	0	Excellent
3	2	6	1	2	1	2.5	2	1	2	4	7	4	3.33	Excellent
4	2	2	1	2	1	1.5	2	0	1	1	1	2	1.17	Very Good
10	2	2	0	0	0	0.5	0	0	0	0	0	0	0	Excellent
11	2	3	1	2	1	1.75	1	1	2	1	1	1	1.17	Very Good
13	2	0	0	0	0	0	0	0	1	1	0	1	0.5	Excellent
17	2	0	0	0	0	0	0	0	0	0	0	0	0	Excellent
20	2	0	0	0	0	0	0	0	1	0	1	0	0.33	Excellent
21	2	0	0	0	0	0	0	0	0	0	0	0	0	Excellent
22	2	0	0	0	0	0	0	0	0	0	0	0	0	Excellent
30	2	1	1	1	0	0.75	2	0	0	1	1	3	1.17	Excellent
31	2	6	2	4	3	3.75	4	5	3	4	3	4	3.83	Good
34	2	0	0	0	0	0	0	0	0	0	0	0	0	Excellent

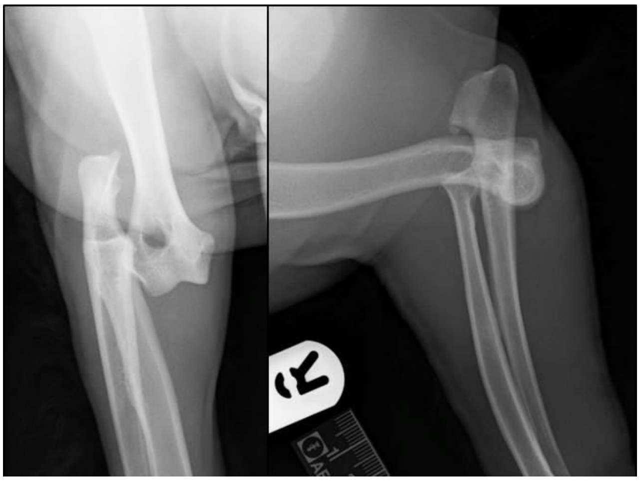

Figure 1: Craniocaudal (left) and mediolateral (right) radiographs demonstrating lateral elbow luxation in Patient 14.

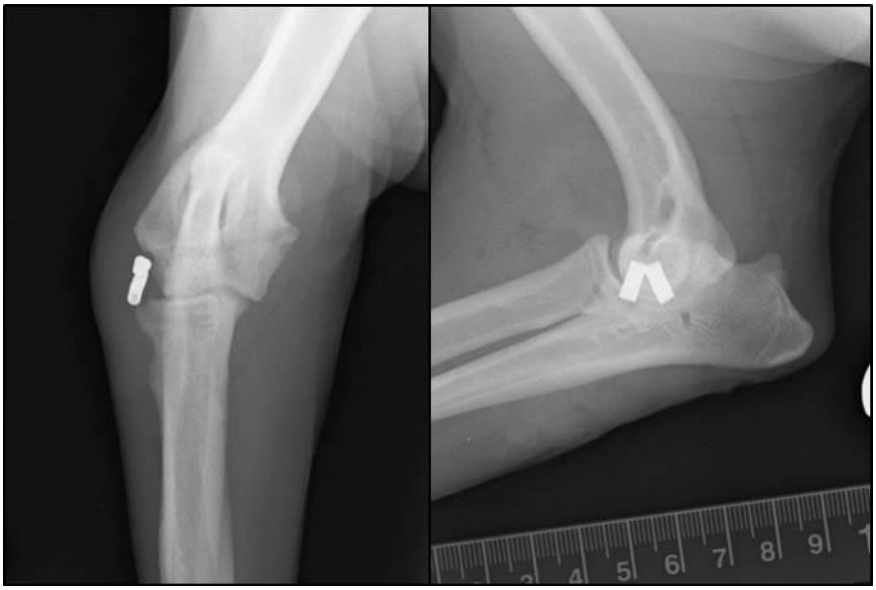

Figure 2: Craniocaudal (left) and mediolateral (right) of Patient 11. Radiographs demonstrate post-operative reduction and implant positioning following circumferential suture prosthesis passed through transcondylar bone tunnels and secured with metal crimps (Farrell and others 2007).