The anconeal process of the ulna is fundamental to the stability of the elbow joint as it prevents lateral and rotary instability in the weight-bearing stance. Typically, the anconeal process unites with the ulnar metaphysis via a separate center of ossification between 16 and 20 weeks of age. If bony union does not occur by 20 weeks, the patient is considered to have an ununited anconeal process (UAP).

The underlying etiology has yet to be definitively determined; one proposed mechanism is that growth incongruency between the radius and ulna leads to a proximal displacement of the radial head, which in turn places shear stress on the anconeal process via the trochlea of the humerus. Other potential causes include metabolic derangements, trauma and genetic predisposition.

Prompt identification of the condition and surgical correction is necessary to decrease arthrosis. Several methods for treatment of UAP have been described with the treatment of choice being dependent on evidence of fibrous bridging between the anconeal process and the ulna. Potential procedures...
include removal of the process via a lateral or caudomedial arthrotomy, lag screw fixation with an open arthrotomy, lag screw fixation via an open arthrotomy with a proximal ulnar osteotomy if bridging is not evident, or an ulnar osteotomy alone if bridging is apparent.

Computed tomography is described as a diagnostic tool to characterize elbow dysplasia, but has yet to be utilized in the literature as an interventional tool for treatment of UAP. CT provides cross-sectional imaging, which, in turn, potentially allows for more precise placement of implants. The objective of this case series was to describe a novel technique for treatment of UAP using CT-guided cannulated lag screw placement and to describe outcomes and complications in 7 canine patients.

Methods

A retrospective, descriptive case series was performed by reviewing medical records of canine patients diagnosed with UAP via radiographs or CT that subsequently underwent CT-guided cannulated lag screw placement by a single board certified surgeon (JC) at a private referral facility (WestVet Emergency and Specialty Center) between January 2011 and October 2020. All pre- and postoperative exams and procedures were performed by a single board-certified surgeon and 2 board certified radiologists interpreting CT images and radiographs. Patients undergoing the procedure were required to have an anconeal process large enough to accommodate the width of the cannulated screw (Arthrex 4.0 mm partially threaded [1/2 shaft length] screws and Wright Medical 3.5 and 4.0 mm partially threaded [1/3 shaft length] screws were utilized for patients). Owner consent was acquired prior to procedures but was not collected for inclusion in the study given its retrospective nature.

An anesthetized survey CT (Toshiba Aquilion 16 CT Scanner; Toshiba Medical Systems Corporation [now Canon] Medical Systems USA Inc) of the elbows was performed for surgical planning and to characterize concomitant elbow pathology (CT settings: Helical acquisition, mA500, kVp 120, 2 mm slice thickness, soft tissue and bone reconstruction algorithms with 0.5 mm volume bone reconstructions, 512 X 512 image matrix; window width and window level were adjusted as needed on the CT image viewing station). The patient was placed in dorsal recumbency with both thoracic limbs extended cranially and fixed with bandaging tape to facilitate access to the caudal olecranon. The patient's head was situated toward the anesthesia machine, which was located on the opposite side of the CT gantry, and the surgeon stood adjacent to the patient at the level of the elbows. The assistant stood on the other side of the CT table and the surgical table was positioned at the caudal aspect of the patient. The surgeon, assistant and anesthesia technician moved out of the CT suite while scans were performed. Based on planning images, the angle of k-wire placement was estimated. The patient remained in dorsal recumbency with the thoracic limbs extended cranially, with the elbow in an approximately 60-degree flexion angle, for the procedure. The surgical site was draped and prepared using aseptic technique. A 1 cm stab incision was made over the caudal aspect of the olecranon. Free-hand placement of a guidance k-wire (Arthrex or Wright Medical Cannulated Screw System) into the tuber olecranon was performed (Figure 1). The size of the guidance k-wire was determined based on the planned size of the cannulated screw. Focused, sequential region of interest (ROI) CT imaging of the tuber olecranon to the anconeal process was performed to guide k-wire placement into the ununited fragment (Figure 2). Multiplanar reconstruction (MPR) was generated of each ROI in the sagittal, axial, and coronal planes. Adjustment of the k-wire trajectory was performed as needed. When k-wire placement was deemed satisfactory, based on MPR, a glide hole was drilled over the k-wire in the cis-ulnar bone using a cannulated drill bit. A glide hole was created to prevent threads from engaging the cis-ulnar bone, as engagement of the cis fragment would have negated the lag effect. Additionally, the glide hole helped prevent stripping of the screw head during insertion into sclerotic bone. Use of lavage during drilling was case dependent. An Arthrex or Wright Medical self-drilling, self-tapping cannulated bone screw and washer were applied in lag fashion to secure the anconeal process fragment. Because the cannulated screws are self-drilling, self-tapping was not necessary to pre-drill the trans-ulnar (UAP) fragment. However, partial drilling of the trans segment did aid in screw engagement, while maintaining fixation of the k-wire in the distal aspect of the segment. The elbow was held in flexion while the screw was hand-tightened. The length of the screw was estimated based on preoperative radiographs and the correct screw length was confirmed intraoperatively using a depth gauge (Wright Medical or Arthrex Cannulated Screw System) that accommodates measurement over a k-wire. Focused, sequential region of interest CT imaging was used to guide screw placement and a final survey scan was utilized to check screw placement and confirm appropriate screw length. Bone wax was placed in the screw head in the more recent patients to prevent joint fluid

Figure 1—Pre- and intraoperative images of CT-guided lag screw placement. A—K-wire placement in the tuber olecranon. B—Cannulated lag screw placement.
migration, as some screws slightly entered the joint dorsal to the UAP above the articular surface. The site was closed routinely. In cases where a static, negative radioulnar step was appreciated a dynamic proximal ulnar osteotomy (DPUO), with the osteotomy oriented obliquely to the long access of the ulna, or a bi-oblique DPUO\textsuperscript{14} was performed; elbow arthroscopy and subtotal coronoidectomy was performed in patients with a fragmented medial coronoid process (FMCP). Pins were not placed as part of the ulnar osteotomy. Patients were moved to the operating room for the arthroscopy and osteotomy procedures.

All patients were hospitalized overnight and discharged the following day with a combination of pain medication and anti-inflammatories. Antibiotic prophylaxis differed between patients, with 4 out of 7 patients being discharged with 10 days of oral antibiotic treatment. If an osteotomy was performed a splint or soft-padded bandage was placed for 1 to 2 weeks. Strict activity restriction was advised for 2 weeks; leash walks were then introduced over the next 6 to 8 weeks depending on the patient’s clinical progress. Patients were rechecked at approximately 1, 2, 4, and 8 weeks and further rechecks were performed if complications occurred. Radiographs were taken at 6 to 8 weeks postoperatively to determine if fusion of the anconeal process had occurred, and later if complications arose. Patients were then returned to regular activity over a 3- to 4-week period.

Breed, sex, affected limb, age at surgery, concomitant elbow pathology, screw placement time, radiographic follow-up and complications were recorded for each patient (Table 1). Recorded data regarding historic lameness scores (ie, lameness grade reported by owner or primary veterinarian), presenting lameness score, and pain on elbow range of motion were retrospectively reviewed. Lameness was scored out of 5 as previously described.\textsuperscript{15} The degree of elbow arthrosis was scored pre- and postoperatively at 8 weeks and with the most recent radiographs using criteria previously defined by Guthrie\textsuperscript{16} (Table 2). Radiographic union was defined as any osseous bridging (partial or complete) between the anconeal process and the ulna; as previously defined.\textsuperscript{17} Radiographic union was accessed at 8 weeks postoperatively and with the most recent follow-up radiographs. Complications were categorized as catastrophic, major I, major II, or minor and were also grouped in relation to the time postoperatively as outlined by Cook.\textsuperscript{18} Catastrophic complications were those causing permanent unacceptable function, major I complications required further surgical treatment, major II complications required further medical treatment and minor complications did not require additional treatment. Analyzed time frames included perioperative (0 to 3 months postoperatively), short-term (> 3 to 6 months), mid-term (> 6 to 12 months), and long-term (> 12 months).
Data analysis

Summary statistics of mean and median values were reported and were calculated using Microsoft Excel (version 14.5.4).

Results

Ten dogs were initially identified and 7 met the inclusion criteria with a total of 8 elbows treated surgically. Breeds included German Shepherd Dog (n = 4), Mastiff (1), South African Boerboel (1) and Irish Wolfhound (1). Neuter status included female intact (n = 1), female spayed (3) and neutered male (3). The mean age at the time of surgery was 14.2 months (range, 6.83 to 32.03 months). Six dogs were diagnosed with unilateral UAP (3 left; 3 right) and 1 with bilateral UAPs. CT imaging revealed concurrent degenerative joint disease in all 8 affected elbows. Six of the diseased elbows had appreciable cubital joint incongruity, 2 had a concurrent FMCP and 1 patient had evidence of humeral panosteitis (Table 1).

Median lag screw placement time was 62.8 minutes (range, 39 to 95 minutes). For patients in which CT images were available for review, screws were placed within 1 mm of the center of the UAP in the transverse plane in 1/4 joints, within 2 mm of center in 2/4 joints and within 4 mm of center in 1/4 joints. Cannulated screws were used for fixation in 8/8 elbows. A routine DPUO or bi-oblique DPUO was performed in all 6 elbows with evidence of incongruency. The 2 patients with a FMCP had an arthroscopic explore and subtotal coronoidectomy.

Data regarding the preoperative historic and physical exam lameness scores and pain on range of motion was available for 7/8 joints (Table 2). All dogs presented for the chief complaint of forelimb lameness, and all dogs with historical lameness recorded had a history of lameness of the affected limb(s). On gait evaluation, the mean preoperative lameness exam score was 0.75/5, 5/6 of the dogs with data recorded were painful on range of motion and 5 dogs had palpable joint effusion. Preoperative flexion and extension angles of the affected elbow joints were not recorded. At the time of the most recent follow-up, the lameness score remained static in 3/6 dogs, decreased in 2/6 dogs, and increased in 1/6 dogs when comparing the preoperative lameness score and the score on the most recent follow-up gait evaluation. Data on lameness grade was not reported in 1 patient. All patients were comfortable on range of motion at the most recent follow-up postoperatively.

Table 1—Patient signalment, age at surgery, concurrent elbow disease, and surgical treatment performed.

<table>
<thead>
<tr>
<th>Patient ID</th>
<th>Joint ID</th>
<th>Breed</th>
<th>Sex</th>
<th>Age at surgery</th>
<th>Affected side</th>
<th>Concomitant elbow pathology</th>
<th>Anesthesia time</th>
<th>Lag screw placement time</th>
<th>Treatment</th>
<th>Ulnar osteotomy performed/ type performed</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Mastiff</td>
<td>FS</td>
<td>8.33 mo</td>
<td>Left</td>
<td>Left elbow incongruency, DJD</td>
<td>228 min</td>
<td>53 min</td>
<td>Cannulated lag screw fixation</td>
<td>Yes, DPUO</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>German Shepherd Dog</td>
<td>MN</td>
<td>32.03 mo</td>
<td>Right</td>
<td>DJD</td>
<td>220 min</td>
<td>39 min</td>
<td>Cannulated lag screw fixation</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>South African Boerboel</td>
<td>MN</td>
<td>15.67 mo</td>
<td>Left</td>
<td>Left elbow incongruency, DJD</td>
<td>270 min</td>
<td>74 min</td>
<td>Cannulated lag screw fixation</td>
<td>Yes, not specified</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>German Shepherd Dog</td>
<td>FS</td>
<td>8.5 mo</td>
<td>Left</td>
<td>Left elbow incongruency, DJD</td>
<td>NR</td>
<td>58 min</td>
<td>Cannulated lag screw fixation</td>
<td>Yes, DPUO</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>German Shepherd Dog</td>
<td>FS</td>
<td>11.36 mo</td>
<td>Right</td>
<td>Right FMCP, right elbow incongruency, DJD</td>
<td>269 min</td>
<td>60 min</td>
<td>Cannulated lag screw fixation</td>
<td>Yes, BODPUO</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>German Shepherd Dog</td>
<td>MN</td>
<td>16.67 mo</td>
<td>Right</td>
<td>Right FMCP, right elbow incongruency, DJD</td>
<td>305 min</td>
<td>95 min</td>
<td>Cannulated lag screw fixation, subtotal coronoidectomy</td>
<td>Yes, DPUO</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>Irish Wolfhound</td>
<td>FI</td>
<td>6.83 mo</td>
<td>Right</td>
<td>DJD</td>
<td>404 min</td>
<td>50 min</td>
<td>Cannulated lag screw fixation</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>Irish Wolfhound</td>
<td>FI</td>
<td>6.83 mo</td>
<td>Left</td>
<td>Left elbow incongruency, DJD</td>
<td>404 min</td>
<td>74 min</td>
<td>Cannulated lag screw fixation</td>
<td>Yes, DPUO</td>
</tr>
</tbody>
</table>

BODPUO = Bi-oblique dynamic proximal ulnar osteotomy. DJD = Degenerative joint disease. DPUO = Dynamic proximal ulnar osteotomy. FI = Female intact. FMCP = Fragmented medial coronoid process. FS = Female spayed. MN = Male neutered. NR = Not recorded

Table 2—Preoperative, 8-week postoperative, and most recent recheck patient evaluations.

<table>
<thead>
<tr>
<th>Patient ID</th>
<th>Joint ID</th>
<th>Reported historic lameness</th>
<th>Lameness on gait evaluation</th>
<th>Pain on ROM</th>
<th>Guttie score</th>
<th>Follow-up (d)</th>
<th>Guttrie score</th>
<th>Radiographic union</th>
<th>Follow-up (d)</th>
<th>Lameness on gait evaluation</th>
<th>Pain on ROM</th>
<th>Guttie score</th>
<th>Radiographic union</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2–3/5</td>
<td>4/5</td>
<td>Yes</td>
<td>2</td>
<td>58</td>
<td>2</td>
<td>Complete</td>
<td>99</td>
<td>2/5</td>
<td>No</td>
<td>2</td>
<td>Complete</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2/5</td>
<td>0/5</td>
<td>Yes</td>
<td>3</td>
<td>44</td>
<td>3</td>
<td>Partial</td>
<td>828</td>
<td>1/5</td>
<td>No</td>
<td>3</td>
<td>Partial</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>NR</td>
<td>NR</td>
<td>No</td>
<td>3</td>
<td>79</td>
<td>3</td>
<td>Partial</td>
<td>252</td>
<td>NR</td>
<td>No</td>
<td>3</td>
<td>Partial</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>4–5/5</td>
<td>2/5</td>
<td>Yes</td>
<td>2</td>
<td>70</td>
<td>2</td>
<td>Complete</td>
<td>97</td>
<td>1/5</td>
<td>No</td>
<td>2</td>
<td>Partial</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>2–3/5</td>
<td>0/5</td>
<td>Yes</td>
<td>2</td>
<td>62</td>
<td>2</td>
<td>Partial</td>
<td>173</td>
<td>0/5</td>
<td>No</td>
<td>2</td>
<td>Partial</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>4–5/5</td>
<td>0/5</td>
<td>No</td>
<td>3</td>
<td>62</td>
<td>3</td>
<td>Partial</td>
<td>146</td>
<td>0/5</td>
<td>No</td>
<td>3</td>
<td>Partial</td>
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<tr>
<td>7</td>
<td>7</td>
<td>0/5</td>
<td>0/5</td>
<td>Yes</td>
<td>1</td>
<td>58</td>
<td>1</td>
<td>Partial</td>
<td>85</td>
<td>0/5</td>
<td>No</td>
<td>1</td>
<td>Partial</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>2/3/5</td>
<td>0/5</td>
<td>Yes</td>
<td>1</td>
<td>58</td>
<td>1</td>
<td>Partial</td>
<td>85</td>
<td>0/5</td>
<td>No</td>
<td>1</td>
<td>Partial</td>
</tr>
</tbody>
</table>

NR = Not recorded. ROM = Range of motion.
Modified Guthrie scores were assigned to all patients preoperatively; 1/7 patients (2/8 joints) had a score of 1, 3/7 patients (3/8 joints) had a score of 2, and 3/7 patients (3/8 joints) had a score of 3. Modified Guthrie scores remained static for all patients for both the 8-week recheck and most recent radiographic recheck (mean, 221 days; range, 85 to 828 days).

Radiographic union was present in 7/7 patients (8/8 joints) at both the 8-week recheck and most recent radiographs. At 8 weeks postoperatively, the bridging was further categorized as complete (2/7 patients; 2/8 joints) or partial (5/7 patients; 6/8 joints). The most recent radiographs revealed complete healing in 3/7 patients (3/8 joints) and partial healing in 4/7 patients (5/8 joints) (mean, 221 days postoperatively; range, 85 to 828 days).

Perioperative and short-term data was available for 7/7 patients (8/8 joints), mid-term data was available for 3/7 patients (3/8 joints) and long-term data was available for 1/7 patients (1/8 joints). Median follow-up time was 14 days (range, 85 to 828 days). Perioperative minor complications included seroma formation in 1 patient. Major perioperative complications developed in 2 patients (patients 2 and 4), characterized by incisional infections requiring implant removal at 44 and 82 days postoperatively. Implant removal, even in the perioperative period (patients 2 and 4) did not appear to impact radiographic union, as all patients still achieved bridging.

No complications were recorded in the short- or mid-term periods; however, follow-up was not standardized and therefore complications cannot be excluded. One patient had a major II long-term complication with radiographic evidence of persistent incomplete bridging in an operated elbow and a grade I lameness. The patient with the persistent incomplete bridging was 32.03 months old at the time of surgery, which may have contributed to the outcome. Regardless, the owner reported rare lameness 7 years postoperatively and no further intervention was required. The 2 patients that developed surgical site infections (SSI) necessitating implant removal were German Shepherd Dogs. The 2 patients that were discharged without oral antibiotics developed incisional infections within the perioperative period and required implant removal.

Discussion

In patients with negative radioulnar incongruency the radial head is proximally displaced, leading to an abnormal force on the developing anconeal process; therefore a proximal ulnar osteotomy acts to pull the ulna proximally to off-load the force on the anconeal process and allow union. Previous work by Meyer-Lindenberg showed that fusion occurs in all patients using ulnar osteotomy alone if the anconeal process is connected with fibrous tissue preoperatively. Sjöström published a case series of 22 dogs that underwent osteotomy of the ulna for treatment of UAP, with 15/22 dogs achieving radiographic union.4 Given that all patients do not achieve union with ulnar osteotomy alone, the addition of lag screw fixation was proposed. A small case series, published by Krotscheck, documented complete radiographic union and excellent clinical outcome for patients that underwent lag screw placement and ulnar osteotomy. Pettitt found a significant difference in radiographic outcome in favor of patients treated with proximal ulnar osteotomy and lag screw fixation compared to proximal ulnar osteotomy alone. A limitation to the present study is that fibrous bridging of the anconeal process to the ulna was not determined arthroscopically prior to lag screw fixation, therefore, the absolute necessity of lag screw fixation in the reported cases is unknown. An alternative method would have included preoperative MRI or arthroscopy to determine the presence of fibrocartilaginous bridging. If present, a staged procedure with a proximal ulnar osteotomy could have been performed. Staging would allow time for the triceps muscle to pull the proximal ulnar fragment proximally. A CT scan could then be performed 6 to 8 weeks later to determine if congruency had been corrected and if UAP bridging occurred as a result. If the UAP was still present, lag screw fixation via CT-guidance (or other method) would be indicated. This alternative might potentially require more than one anesthetic event and thereby increase the overall expense and postoperative recovery time but may also offer a simpler and less invasive but effective option for treating UAP.

Prognosis has been reported to be dependent on the age at which surgery is performed. In the majority of cases in the present study, patients underwent surgery after the ideal 4- to 6-month range that has been reported. Future studies should stratify outcomes following CT-guided screw placement based on age to determine the effect on prognosis.

The authors found that CT-guided lag screw placement is more difficult on patients with loose fragments; therefore, preoperative arthroscopy would also allow evaluation of fragment mobility and aid in patient selection. In patients with loose fragments, the k-wire was noted on serial CT scans to push the fragment slightly cranial until it engaged the fragment. Subjectively, the use of the end-threaded guidewire (k-wire) provided in the cannulated screw set aided in “capturing” the loose fragment compared to a standard smooth k-wire. Additionally, the loose fragment would typically push against the adjacent humeral surface to minimize displacement and subsequently allow for k-wire engagement. After drilling the glide hole, the self-drilling, self-tapping cannulated screw engaged the UAP fragment, and was noted on serial CT scans to pull the loose fragment into place in lag fashion during tightening.

SSI necessitating implant removal occurred exclusively in German Shepherd Dogs. McDougall reported a 7.4-fold increased odds of deep SSI requiring implant removal among German Shepherd Dogs undergoing TPLO procedures. Additionally, Lopez found an approximately 9 times increased risk of SSI in German Shepherd Dogs undergoing TPLO procedures compared to all other breeds in the study.
Owners should be aware of the possible increased likelihood of complications in German Shepherd Dogs with CT-guided lag screw placement; however, further studies would be necessary to define odds ratios.

Technical experience with the procedure may have impacted patient outcome; the 2 patients that developed SSI were among the first 4 patients that underwent the procedure. Lavage during drilling was not consistently utilized; therefore, thermally induced osteonecrosis contributing to the development of infection cannot be ruled out. Additionally, the 2 patients discharged without postoperative antibiotics developed surgical site infections; however, routine postoperative antibiotics use is not recommended with this technique, as likely several other factors (ie, risk of orthopedic infections in German Shepherd Dogs, loss of asepsis in the older CT suite) lead to the increased rate of infections. Slight placement of the cannulated screw within the joint space may have also contributed to seroma formation, with synovial fluid movement through the screw into the subcutaneous space. Bone wax was placed in the screw head in the more recent patients to prevent joint fluid migration and a subsequent decline in seroma formation was noted. In cases where the lag screw slightly breached the joint surface, the determination of whether to leave it or change the screw length was based on several subjective criteria. Many of the UAP fragments measured <10 mm in height. Therefore, engagement of screw threads within the fragment was minimal, and stabilization, lag effect, and stripping of the screw hole were all weighed when determining if changing to a shorter screw was necessary. All screws that breached the joint did so dorsal to the UAP articular surface within the intercondylar foramen, which tends to have fibrous tissue and fat pad present, and no screw was more than approximately 2 mm longer than the fragment. While appropriate screw length was the goal, range of motion was not reduced and patients with longer screw lengths were not subjectively evaluated to have increased discomfort postoperatively. Countersinking of the screw was not performed but would distribute forces against the screw head evenly to reduce the risk of head fracture, and should be considered in future cases. Additionally, countersinking could potentially reduce soft tissue irritation and seroma formation.

Performing lag screw placement within the CT suite has several disadvantages, as the level of asepsis that can be achieved is not comparable to the operating room, specifically the ventilation and flow of personnel cannot be equally controlled. The number of surgical site infections was lower within the more recent cases, however, these cases were performed in a new hospital with a larger CT room; therefore differing risk of nosocomial infections created by room design cannot be ruled out. One example is the difference in ventilation and air conditioning between the 2 CT suites. In addition, the number of support staff allowed in the CT room during the procedure and the positioning of the patient table differed in the later cases and may have led to a decreased rate of infection. Additional surfaces that could potentially lead to contamination of the surgical field were also covered with sterile draping in latter cases.

Limitations include the retrospective nature of the data and the lack of long-term follow-up for all patients. Four of the 7 patients had less than 6 months of follow-up, which would limit the ability to access the true clinical outcome of the procedure. Objective outcome parameters such as validated lameness scoring systems (eg, Canine Brief Pain Inventory/Liverpool Osteoarthritis in Dogs [LOAD]) or force plate analysis and repeat CT scans would be ideal to further elucidate the utility of this technique in comparison to other procedures. Additionally, comprehensive measurements could be made in future studies to determine the accuracy of CT-guided screw placement compared to other techniques. An ulnar osteotomy was performed in 6/8 treated elbows and the significance of performing both techniques as related to the outcome and complication rate was not investigated. A retrospective study by Pettitt comparing a proximal ulnar osteotomy versus a proximal ulnar osteotomy and lag screw placement demonstrated that the lag screw procedures in 50% of patients that had ulnar osteotomies alone and fused in 84% of patients with anconeal process fixation and ulnar osteotomy. A significant association was found between radiographic union and treatment method in favor of the osteotomy with fixation of the anconeal process, however the degree of anconeal fusion was not accessed in the study. The present study is confounded by treatment of multiple elbow diseases, as those with concurrent incongruity or FMCP had secondary procedures performed and the effect of the secondary procedure was not investigated. Follow-up CT imaging would have been ideal to access bridging and should be considered in future studies.

In addition, the level of radiation exposure to the patient was not measured for each case and given the multiple ROI scans that were performed to guide k-wire placement the total dose of radiation may have been high. The effect of radiation on neoplastic transformation is well established in human medicine; however, similar causation has not been elucidated in veterinary patients. Owners should be warned of the unknown risk of neoplastic development following this procedure.

Prolonged anesthetic time is a significant downside to CT-guided lag screw placement. It is expected that the anesthetic times should decrease with the initial learning curve for the procedure, as the cases presented were the first 7 cases in which this technique was performed.

In conclusion, it was deemed feasible to use CT-guidance for cannulated lag screw placement within UAPs. Additionally, the subjective, descriptive data revealed that pain on range of motion decreased postoperatively for patients in which data was available both pre- and postoperatively. The lameness scores improved postoperatively in 6/6 patients for whom data was recorded, when comparing the historical lameness grade and the postoperative gait evaluation. Patient 7 was diagnosed with bilateral UAPs; however, the patient exhibited unilateral lameness,
which is suspected to be due to compensation of the less affected limb. The degree of elbow arthrosis remained static when comparing pre- and postoperative radiographs at 2 time points using the Modified Guthrie scoring method.\textsuperscript{16} However the qualitative scoring criteria was broad, therefore subtle progression of arthrosis may have been missed. All patients achieved radiographic union of the anconeal process to the proximal ulna, defined in this study as partial or complete bridging, at both the 8-week and most recent radiographic recheck. Given these findings, CT-guided cannulated lag screw placement is a feasible option for treatment of UAP in canine patients; however, future work is needed to assess the technique in relation to other published procedures.

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### References


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