

Article

Frequency and Coexistence of Ununited Anconeal Process with Other Primary Elbow Dysplasia in Dogs

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Abstract

Background: Ununited anconeal process (UAP) is one of the four primary causes of elbow dysplasia (ED). Radiography (X-ray) and computed tomography (CT) are commonly employed imaging techniques for the diagnosis of elbow dysplasia. The objective of this retrospective study was to evaluate the frequency and distribution of UAP in dogs referred for elbow imaging and to analyze the coexistence of this disorder with other primary causes of ED, such as medial coronoid process disease (MCPD), osteochondritis dissecans (OCD), and joint incongruity (IC). **Methods:** The study population comprised 108 dogs of both sexes, aged between 3 and 15 months, of breeds predisposed to ED: 69 German Shepherds, 23 Labrador Retrievers, and 16 Golden Retrievers. All dogs underwent both radiographic and CT examinations of the elbow joints. Categorical data were analyzed using Fisher's exact test to evaluate breed-related findings and lesion coexistence, with significance set at 5%. Inter-method reliability was assessed using Cohen's kappa coefficient (κ). **Results:** Based on radiographic and CT findings, elbow dysplasia was diagnosed in 53 dogs and 58 dogs, respectively. UAP was identified in 9 cases and only in German Shepherds. Among the 9 UAP-positive dogs, coexistence with other ED lesions (most commonly medial coronoid process disease and joint incongruity) was observed in 8 cases. For specific UAP detection, both imaging modalities demonstrated perfect diagnostic agreement ($\kappa = 1.0$). **Conclusions:** UAP was the rarest diagnosed primary etiology of elbow dysplasia in the study population. This disorder has been found only in German Shepherds; however, this observation should be interpreted with reservation due to the unequal breed distribution within the study population. Radiography and computed tomography demonstrated equivalent diagnostic agreement for UAP identification; this result should also be interpreted cautiously due to the limitation of the small number of identified cases of this disorder. Furthermore, UAP occurred more frequently as a concomitant lesion—most commonly in association with medial coronoid process disease and joint incongruity—rather than as a solitary finding.

Keywords: ununited anconeal process; dog; elbow dysplasia; radiology; computed tomography



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1. Introduction

Orthopedic diseases of the thoracic limb in dogs, particularly elbow dysplasia (ED), are a frequent cause of motor activity impairment in companion animals. Elbow dysplasia is a polygenic, multifactorial condition classified as a juvenile-onset disease. It comprises a complex of disorders resulting from one or more primary conditions, such as medial coronoid process disease (MCPD), with or without a fragmented medial coronoid process (FMCP); ununited anconeal process (UAP); incongruity (IC); and osteochondritis dissecans (OCD). These conditions inevitably lead to the development of irreversible changes in the form of degenerative joint disease (DJD) [1–8]. Elbow dysplasia is most commonly diagnosed in dogs aged between 4 and 6 months, typically belonging to medium, large, and giant breeds characterized by rapid growth rates. The most predisposed breeds include German Shepherds, Golden Retrievers, Labrador Retrievers, Rottweilers, and Bernese Mountain Dogs [1,9–15]. It is noteworthy that among the mentioned breeds, UAP is most frequently diagnosed in German Shepherds [16]. Furthermore, it has been demonstrated that males are affected approximately twice as frequently as females; this is attributed to both the accelerated growth rates of male individuals and sex-linked factors [1,4,6,17].

One of the primary causes of ED is the ununited anconeal process of the ulna. Typically, the anconeal process develops as an integral part of the ulna; however, in large and giant breed dogs, this process arises from a separate ossification center. Consequently, in healthy puppies of these breeds, its fusion with the remainder of the olecranon of the ulna may not occur until between 20 and 24 weeks of age. This age, therefore, determines the appropriate timeframe for implementing diagnostic procedures to detect the presence of UAP. In cases of ununited anconeal process, the cartilaginous layer located between the secondary ossification center and the rest of the process fails to unite, leading to the partial or complete detachment of the anconeal process. Such lesions result in elbow joint instability and displacement of the process relative to the ulna, which subsequently leads to the development of secondary degenerative joint disease [1,13,18–20].

As mentioned above, an ununited anconeal process is one of the primary causes of canine elbow dysplasia; however, it is frequently not an isolated disorder but coexists with other primary lesions leading to ED. In such cases, accurate identification of these concurrent elbow joint pathologies is crucial for implementing appropriate therapeutic procedures, assessing disease progression, and determining the prognosis [7]. Although conventional radiography remains the baseline screening modality and is characterized by a relatively high efficacy in confirming UAP, its two-dimensional nature can result in the superimposition of anatomical structures, consequently hindering the detection of other coexisting causes of ED. Computed tomography overcomes these limitations by offering multiplanar cross-sectional imaging, which provides excellent visualization of the subchondral bone, joint incongruity, and medial coronoid process disease. Therefore, identifying the coexistence of UAP with other primary lesions is essential for establishing an accurate diagnosis and implementing appropriate management. Consequently, the objective of this study was to determine the frequency of ununited anconeal processes within a referral dog population, as well as to evaluate their coexistence with other primary causes of ED using imaging modalities such as radiography and computed tomography.

2. Materials and Methods

2.1. Animals

This retrospective study evaluated a total population of 108 dogs representing three breeds: 69 German Shepherds, 23 Labrador Retrievers and 16 Golden Retrievers, of different sexes (46 males and 62 females), aged 3 to 15 months, which were referred to the Imaging Diagnostics Laboratory of the Department and Clinic of Surgery at the Faculty of Veterinary

Medicine, Wrocław University of Environmental and Life Sciences, during the period from November 2017 to December 2019 for elbow imaging procedures due to thoracic limb lameness, joint pain, or for routine breed screening, in order to perform imaging diagnostics of the elbows.

Exclusion criteria applied to the study population involved individuals with a documented history of prior thoracic limb surgical interventions, as well as patients presenting with elbow pathologies such as fractures, luxations, neoplastic lesions, and abnormalities in hematological and biochemical blood parameters disqualifying them from anesthesia. Furthermore, dogs falling outside the targeted age range (younger than 3 months or older than 15 months) were omitted from the analysis. Cases characterized by deficient medical records, specifically those lacking paired, diagnostic-grade radiographic and CT sequences, were likewise rejected. Additionally, any animal whose owner withheld formal consent for participation was barred from inclusion in the study.

Based on the medical history, physical examination, and imaging findings, the animals were assigned to two groups:

Group I: 50 dogs (comprising 33 German Shepherds, 10 Labrador Retrievers, and 7 Golden Retrievers). This group included animals that were asymptomatic and showed no abnormalities on radiographic or computed tomography examination.

Group II: 58 dogs (comprising 36 German Shepherds, 13 Labrador Retrievers, and 9 Golden Retrievers). This group consisted of affected animals, defined as those exhibiting clinical signs and/or abnormalities on radiographic or computed tomography examination.

Animals presenting with clinical signs but negative imaging findings on both modalities were excluded from this study cohort to ensure maximum homogeneity of the groups.

2.2. Anesthesia Protocol

The following anesthetic protocol was used in the animals qualified for X-ray and computed tomography of the elbows:

1. Sedation: medetomidine (prep. Cepetor, 1 mg/mL, ScanVet Poland, Gniezno, Poland) at a dose of 10–20 µg/kg bw and butorphanol (prep. Butomidor, 10 mg/mL, ORION PHARMA/VetViva Richter GmbH, Wels, Austria) at a dose of 0.1 mg/kg bw administered in one intramuscular injection;
2. in the case when sedation was insufficient for the safe conduct of the above-mentioned examinations, the dogs were given general anesthesia in which the following medications were used: for premedication—medetomidine (prep. Cepetor, 1 mg/mL, ScanVet Poland, Gniezno, Poland) at a dose of 10–20 µg/kg bw and butorphanol (prep. Butomidor, 10 mg/mL, ORION PHARMA/VetViva Richter GmbH, Wels, Austria) at a dose of 0.1 mg/kg bw administered as one intramuscular injection, and for the main anesthesia—propofol (prep. Propofol-Lipuro, 10 mg/mL, Braun, Melsungen, Germany), intravenously at an initial dose of 2–4 mg/kg bw, and then according to the effect.

2.3. Radiographic Technique

In all the dogs, X-ray examination of the elbows was performed with the use of an indirect digital radiography system, using a Vertix 3D X-ray machine (Siemens Healthineers, Erlangen, Germany) with a Siemens Polydoros LX 30 lamp (Siemens AG, Erlangen, Germany). The exposure parameters were selected depending on the thickness of the X-rayed tissue and were as follows: lamp voltage from 60 to 70 kV and the product of time and amperage from 6.8 to 7.1 mAs. Taking images did not require the use of an anti-scatter grid.

Each elbow joint was screened separately. Radiological projections of the elbows in the examined dogs were made in accordance with the guidelines of the International Elbow Working Group [11] and comprised a mediolateral projection in an extended elbow position (Figure 1a), a mediolateral projection in flexion (Figure 1b), a craniocaudal projection (Figure 1c), an oblique projection craniolateral-15-caudomedial (Figure 1d).



Figure 1. *Cont.*

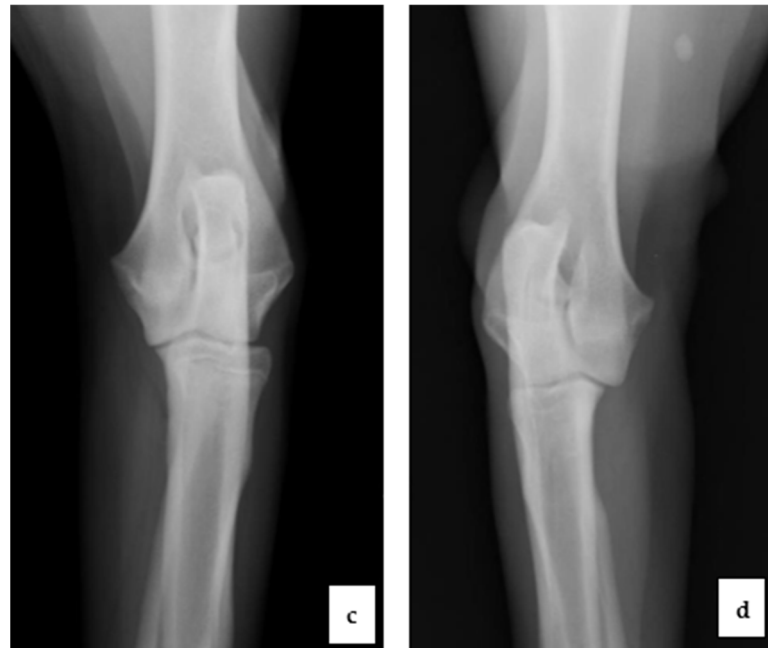


Figure 1. Radiographs of a normal canine elbow joint obtained in the following projections: (a) mediolateral in extension; (b) mediolateral in flexion; (c) craniocaudal; (d) 15° craniolateral-caudomedial oblique (d).

2.4. CT Technique

Computed tomography of the elbows was performed using a 16-slice Siemens Somatom Emotion Computed Tomograph (Siemens Healthineers, Erlangen, Germany). The examination was performed on the dogs in sternal recumbency in line with the long axis of the CT table. In addition, the animal was stabilized in a non-shadowing sponge positioner, and its head was tilted to the side and also stabilized with special belts on the CT table. In order to maximize the exposure of the elbows, the thoracic limbs were pulled out in the cranial direction and placed parallel to each other. Scanning was carried out along the long axis of the elbows, first in the cranial direction and then in the caudal direction. Both elbow joints were scanned simultaneously. The CT examination of the elbows was performed using the following exposure parameters: 60 mAs and 130 kV; the pitch factor was 0.75; the cross-section images were obtained using the bone filter: W 1400, C 300. The image of the elbows was obtained using the Siemens syngoMMWP software, version VE40A. Additionally, the function of the multiplanar reconstruction (MPR) image in the sagittal, dorsal and transverse sections and the three-dimensional image function were used.

2.5. Image Interpretation

All radiographic and CT images were evaluated by a single experienced investigator (a veterinary radiologist), ensuring complete consistency in the application of diagnostic criteria across the entire study population.

Each elbow joint was evaluated systematically for the presence or absence of primary ED lesions: ununited anconeal process, medial coronoid process disease, osteochondritis dissecans and joint incongruity, as well as secondary degenerative joint disease. A joint was classified as positive for a specific lesion if characteristic structural criteria were clearly identifiable on the respective imaging modality.

2.6. Statistical Analysis

Categorical data, including the frequency of UAP, the occurrence of concomitant ED lesions, and breed distributions, were expressed as frequencies and percentages. Differ-

ences in proportions between groups were analyzed using Fisher’s exact test. Due to the absence of UAP cases among Golden Retrievers and Labrador Retrievers, the Haldane–Anscombe method was applied to the odds ratio estimation to address the zero cases in some breed categories.

The detection rates of UAP were compared between radiography and computed tomography using descriptive frequency tables and Fisher’s exact tests where appropriate. Inter-method reliability between radiography and computed tomography for overall ED lesions and individual UAP detection was assessed using Cohen’s kappa coefficient (κ). Statistical significance for all tests was established at a 5% significance level.

3. Results

Based on the inclusion criteria, which comprised medical history, physical examination, hematological and biochemical blood analyses, radiography, and computed tomography of the elbow joints, 50 dogs were classified as healthy (18 males and 32 females). The mean age of the healthy animals was 8.23 ± 3.1 months.

Radiographic examination of the affected cohort ($n = 58$) identified elbow dysplasia with at least one detectable primary lesion in 38 dogs. In an additional 15 dogs, ED was diagnosed based on the presence of secondary degenerative joint disease changes without identification of a specific primary lesion. Five dogs showed no radiographic evidence of elbow dysplasia. In contrast, computed tomography identified ED with a detectable primary lesion in 52 dogs, whereas six dogs were diagnosed with ED based solely on secondary changes in DJD without a visible primary cause.

Radiography detected an ununited anconeal process (Figure 2) in 9 (17%) of the 53 dogs diagnosed with ED via this modality. Five dogs presented with bilateral involvement, while four dogs had unilateral disease (two left-sided and two right-sided cases), affecting a total of 14 elbow joints. Computed tomography identified UAP (Figure 3) in 9 (15.5%) of 58 patients and involving a total of 14 affected elbow joints. Similar to the radiographic findings, computed tomography revealed that five dogs presented with bilateral involvement, while four animals had unilateral disease (two left-sided and two right-sided cases).

All dogs diagnosed with UAP belonged to the German Shepherd breed, whereas no cases of UAP were identified in Golden Retrievers or Labrador Retrievers. Details regarding lesion prevalence according to breed are presented in Table 1. Regarding breed distribution, UAP was identified exclusively in German Shepherds, with a prevalence of 13.0% (9/69), whereas no cases (0%) were detected in Labrador Retrievers or Golden Retrievers. Due to the absence of positive cases in the retriever groups (zero-cell limitation), the odds ratio calculated with the Haldane–Anscombe correction was 12.41 (95% CI: 0.70–219.23).

Table 1. Breed distribution of ununited anconeal process (UAP) in the affected dog cohort in computed tomography and radiography.

Breed	Total	Computed Tomography			Total	Radiography		
		UAP (n, %)	Unilateral UAP (n)	Bilateral UAP (n)		UAP (n, %)	Unilateral UAP (n)	Bilateral UAP (n)
German Shepherd	36	9 (25.0%)	4	5	31	9 (29.0%)	4	5
Labrador Retriever	13	0	0	0	13	0	0	0
Golden Retriever	9	0	0	0	9	0	0	0
Total	58	9 (15.5%)	4	5	53	9 (17.0%)	4	5

Abbreviations: UAP, ununited anconeal process.



Figure 2. Radiograph of the elbow joint obtained in a flexed mediolateral projection. Elbow dysplasia is visible, secondary to an ununited anconeal process. The characteristic irregular radiolucent line separating the anconeal process from the remainder of the olecranon is indicated by a yellow arrow.

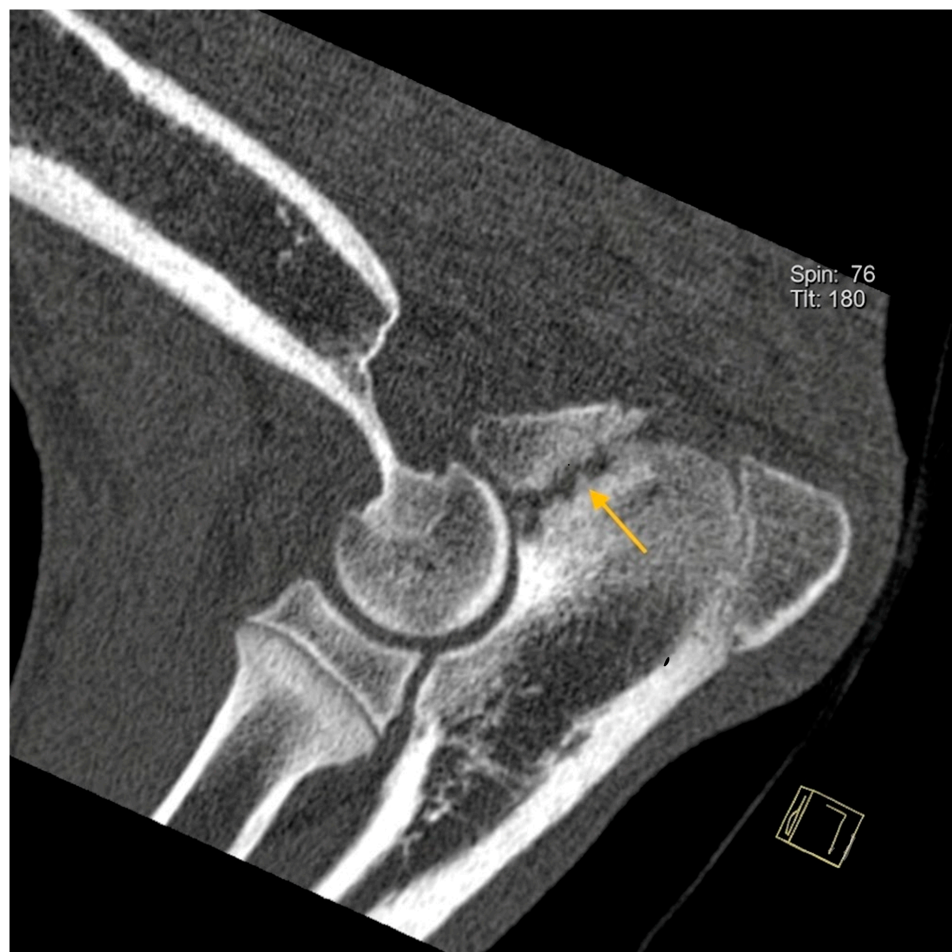


Figure 3. Multiplanar reconstruction image of the elbow joint in the sagittal plane. Elbow dysplasia is visible, secondary to an ununited anconeal process, as indicated by the yellow arrow.

Comparison of radiographic and CT findings revealed no statistically significant difference in the detection of UAP within the study population ($p > 0.999$). Both imaging modalities achieved 100% diagnostic agreement for the baseline identification of UAP, as presented in Table 2. For the overall detection of elbow dysplasia lesions, the inter-method reliability between radiography and computed tomography demonstrated a very high level of agreement, with a Cohen's kappa coefficient of $\kappa = 0.9076$. When specifically evaluating the detection of UAP, complete diagnostic agreement (100%) was achieved between the two imaging modalities, yielding a perfect Cohen's kappa coefficient ($\kappa = 1.0$).

Table 2. Diagnostic agreement between radiography and computed tomography for the detection of ununited anconeal process at the patient and joint levels.

Evaluation Level	Total Sample	Radiography Positive n = 53 * (n, %)	Computed Tomography Positive n = 58 * (n, %)	Observed Modality Agreement (%)
Patient Level (Group II)	58 dogs	9 (17.0%)	9 (15.5%)	100.0%
Joint Level (Group II)	116 joints	14 (13.2%)	14 (12.1%)	100.0%

* The number of dogs diagnosed with ED.

Regarding concomitant primary ED lesion pathologies, radiographic examination identified UAP as an isolated primary lesion in only one dog. In the remaining cases, UAP occurred in combination with other primary ED lesions, including OCD + UAP ($n = 2$), MCPD + UAP ($n = 1$), UAP + IC ($n = 2$), and MCPD + UAP + IC ($n = 3$). Computed tomography, likewise, identified one case of isolated UAP, whereas the remaining cases demonstrated the following complex lesion combinations: OCD + UAP ($n = 1$), MCPD + UAP ($n = 1$), MCPD + UAP + IC ($n = 4$), and MCPD + UAP + OCD + IC ($n = 2$). Across both imaging modalities, UAP most frequently coexisted with MCPD and joint incongruity. A comprehensive summary of isolated and combined lesions across both modalities is presented in Table 3.

Table 3. Frequency of isolated and combined primary ED lesions coexisting with UAP across imaging modalities ($n = 9$ dogs).

Lesion Combination	Radiography (Dog Count)	Computed Tomography (Dog Count)
UAP	1	1
UAP + MCPD	1	1
UAP + OCD	2	1
UAP + IC	2	0
UAP + MCPD + IC	3	4
UAP + MCPD + OCD + IC	0	2
Total UAP Cases	9	9

Abbreviations: UAP, ununited anconeal process; MCPD, medial coronoid process disease; OCD, osteochondrosis dissecans; IC, elbow joint incongruity.

4. Discussion

Owing to its widespread accessibility, cost-effectiveness, and the frequent viability of performing examinations without general anesthesia, radiography remains the frontline diagnostic tool in the clinical algorithms for canine elbow dysplasia.

The radiographic diagnosis of an ununited anconeal process is typically straightforward, owing to the presence of a distinct, occasionally irregular radiolucent line demarcating the anconeal process from the olecranon. This feature becomes diagnostic in dogs exceeding 20 weeks of age. For this specific pathology, radiographs obtained in a flexed mediolateral projection offer the highest diagnostic yield. The clinical utility of this view lies in its ability to mitigate the superimposition of the medial humeral epicondyle over the anconeal process. This is of particular significance in juvenile patients prior to the physal closure of the medial humeral epicondyle. In such cases, relying solely on an extended mediolateral projection may lead to diagnostic errors; the radiolucent line associated with the medial humeral epicondyle can be misidentified as the radiolucent gap of an ununited anconeal process [11,19,21].

Similarly to radiography, computed tomography provides high diagnostic certainty in identifying UAP. The optimal location for identifying an ununited anconeal process on multiplanar reconstruction (MPR) in the transverse plane is the proximal aspect of the trochlear notch; conversely, in the sagittal MPR view, the central portion of the notch provides the greatest clarity [10]. In CT imaging, UAP is diagnosed by the presence of a hypodense line situated between the anconeal process and the proximal ulna [19,21].

In the present study, ununited anconeal process was the least frequently diagnosed primary cause of elbow dysplasia among Group II dogs in both radiographic and computed tomographic examinations, occurring in 17.0% and 15.5% of animals, respectively. These observations are consistent with the findings of Komsta et al. [22], who identified UAP in 17.56% of a 40-dog cohort via radiography. Conversely, a substantially lower frequency of only 4.5% was reported by Remy et al. [23]. Notably, their study evaluated 154 elbow joints, albeit exclusively in German Shepherds. In contrast, Narojek et al. [24] demonstrated a higher radiographic frequency of UAP, reaching 38%.

Crucially, our findings revealed no statistically significant difference between radiography and computed tomography in the baseline detection of UAP ($p > 0.999$), with complete agreement observed in this study population. In the Authors' opinion, this consistency stems from the fact that UAP represents the most readily diagnosable primary cause of ED during routine radiographic screening. It must be emphasized, however, that to optimize the visualization of this lesion, a flexed mediolateral projection is imperative, particularly in patients nearing 20 weeks of age to avoid diagnostic pitfalls associated with skeletal immaturity.

Literature regarding the diagnosis of canine ED emphasizes the superiority of CT for the comprehensive evaluation of elbow dysplasia. However, no difference in UAP detection was observed between radiography and CT in the present study (Cohen's kappa coefficient was 1.0). This perfect Cohen's kappa coefficient demonstrates that both modalities are highly reliable and consistent in identifying these specific joint pathologies, eliminating potential diagnostic discrepancies that can often occur in clinical settings. Given the limited number of UAP-positive cases, these results should be interpreted with caution and should not be considered definitive proof of equivalent diagnostic performance between the two methods.

In the present study, an ununited anconeal process was identified exclusively in German Shepherds via both radiography and CT, with no cases recorded among Golden Retrievers or Labrador Retrievers. Although previous studies have reported a predisposition to UAP in German Shepherds [16,25], the breed-related findings in the present study should be interpreted with caution. This stems from the fact that German Shepherds constituted the majority of the affected study population ($n = 36/58$) compared to Labrador Retrievers and Golden Retrievers, meaning that this unequal breed distribution may have

influenced the observed frequency of UAP within the investigated cohort. Conversely, other authors have demonstrated that UAP occurs across a diverse range of breeds [22,24,26].

Primary causes of elbow dysplasia may manifest in isolation or in various combinations [3,5]. In the present study, the coexistence of multiple primary etiologies was observed more frequently than solitary lesions in both radiographic (63.16% vs. 36.84%) and CT (76.93% vs. 23.07%) evaluations. Among isolated primary causes, ununited anconeal process was the least frequently diagnosed disorder in both modalities, accounting for only 7.14% of cases. The discrepancy in the prevalence of UAP-associated combinations between radiography and CT stems from the inherent diagnostic limitations of radiography regarding MCPD, IC, and OCD. In these conditions, the superimposition of anatomical structures often precludes the detection of subtle abnormalities, rendering early-stage lesions occult. In contrast, computed tomography facilitates a definitive assessment by eliminating structural overlap and providing superior visualization of articular components. This is achieved through the evaluation of contiguous slices (0.6 to 1.0 mm in thickness), multiplanar reconstructions and three-dimensional volume rendering, which collectively reveal the true prevalence of these pathologies [11,21,27–30]. Comparative studies have demonstrated that the sensitivity of radiography for detecting elbow lesions (e.g., MCPD) is as low as 65% with a specificity of 93%, confirming a tendency for radiography to underestimate the prevalence of certain changes [31]. It should be emphasized that computed tomography is widely regarded as the reference imaging modality for the comprehensive evaluation of canine elbow dysplasia because of its superior ability to detect MCPD, OCD, IC, and associated osseous changes. Furthermore, discrepancies in the diagnosis of MCPD, OCD, and IC between conventional radiography and computed tomography may be attributable to the lower technical quality of radiographic projections and to interobserver variability in the interpretation of radiographic images among radiologists [17,21,28].

Two limitations should be considered when interpreting the findings of this study. First, the total number of confirmed UAP cases was relatively small ($n = 9$), limiting the statistical power of comparisons between imaging modalities and reducing the ability to identify potentially meaningful differences in diagnostic performance. Second, the study population was characterized by an unequal breed distribution, with German Shepherds representing the majority of examined dogs. Consequently, the observed breed-specific distribution of UAP should be interpreted cautiously.

5. Conclusions

The results of this study contribute to the understanding of the prevalence and lesion patterns associated with UAP in dogs predisposed to elbow dysplasia. Nevertheless, the results and subsequent conclusions were interpreted with due caution, fully accounting for the limitations of this study.

Based on the findings of this study, it was concluded that ununited anconeal process was the rarest diagnosed primary etiology of elbow dysplasia in the studied population. UAP was identified exclusively in German Shepherds; however, this observation should be interpreted with reservation due to the unequal breed distribution within the study population. No statistically significant difference in UAP detection was observed between radiography and computed tomography. However, given the limited number of UAP-positive cases, this finding should not be interpreted as strong evidence of equivalent diagnostic performance between the two imaging modalities. When evaluating the occurrence of UAP in isolation versus in combination with other primary causes, it was demonstrated that UAP more frequently occurred as a concomitant lesion and most commonly in association with medial coronoid process disease and joint incongruity.

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Informed Consent Statement: Informed written consent was obtained from owners.

Data Availability Statement: The data presented in this study are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

ED	Elbow dysplasia
DJD	Degenerative joint disease
UAP	Ununited anconeal process
OCD	Osteochondritis dissecans
MCPD	Medial coronoid process disease
FMCP	Fragmented medial coronoid process
IC	Incongruity
X-ray	Radiography
CT	Computed tomography
MPR	Multiplanar reconstruction
κ	Cohen's kappa coefficient

References

1. Kirberger, R.M.; Fourie, S.L. Elbow dysplasia in the dog: Pathophysiology, diagnosis and control. *J. S. Afr. Vet. Assoc.* **1998**, *69*, 43–54. [\[CrossRef\]](#) [\[PubMed\]](#)
2. Lavrijsen, I.C.M.; Heuven, H.C.M.; Voorhout, G.; Meij, B.P.; Theyse, L.F.H.; Leegwater, P.A.J.; Hazewinkel, H.A.W. Phenotypic and genetic evaluation of elbow dysplasia in Dutch Labrador Retrievers, Golden Retrievers, and Bernese Mountain Dogs. *Vet. J.* **2012**, *193*, 486–492. [\[CrossRef\]](#) [\[PubMed\]](#)
3. Robins, G.M. Some aspects of the radiographic examination of the canine elbow joint. *J. Small Anim. Pract.* **1980**, *21*, 417–428. [\[CrossRef\]](#) [\[PubMed\]](#)
4. Meyer-Lindberg, A.; Fehr, M.; Nolte, I. Co-existence of ununited anconeal process and fragmented medial coronoid process of the ulna in the dog. *J. Small Anim. Pract.* **2006**, *47*, 61–65. [\[CrossRef\]](#) [\[PubMed\]](#)
5. Samoy, Y.; Van Ryssen, B.; Gielen, I.; Walschot, N.; Van Bree, H. Review of the literature: Elbow incongruity in the dog. *Vet. Comp. Orthop. Traumatol.* **2006**, *19*, 1–8. [\[CrossRef\]](#) [\[PubMed\]](#)
6. Gemmill, T.J.; Clements, D.N. Fragmented coronoid process in the dog: Is there a role for incongruity? *J. Small Anim. Pract.* **2007**, *48*, 361–368. [\[CrossRef\]](#) [\[PubMed\]](#)
7. Vezzoni, A.; Benjamino, K. Canine Elbow Dysplasia: Ununited Anconeal Process, Osteochondritis Dissecans, and Medial Coronoid Process Disease. *Vet. Clin. N. Am. Small Anim. Pract.* **2021**, *51*, 439–474. [\[CrossRef\]](#) [\[PubMed\]](#)
8. Kubiak-Nowak, D.; Kielbowicz, Z.; Hebel, M.; Prządka, P.; Antończyk, A.; Jankowski, M. Assessment of Elbow Joint Incongruity as a Primary Cause of Canine Elbow Dysplasia: Comparative Imaging Analysis Using CT and Radiography in 108 Dogs—A Retrospective Study. *Life* **2025**, *15*, 1673. [\[CrossRef\]](#) [\[PubMed\]](#)
9. Janutta, V.; Hamann, H.; Klein, S.; Tellhelm, B.; Distl, O. Genetic analysis of three different classification protocols for the evaluation of elbow dysplasia in German Shepherd Dogs. *J. Small Anim. Pract.* **2006**, *47*, 75–82. [\[CrossRef\]](#) [\[PubMed\]](#)
10. Samoy, Y.; Gielen, I.; Van Bree, H.; Van Ryssen, B. Dysplastic elbow diseases in dog. *Vlaams Diergeneesk. Tijdschr.* **2011**, *80*, 327–338. [\[CrossRef\]](#)

11. Reichle, J.K.; Park, R.D.; Bahr, A.M. Computed tomographic findings of dogs with cubital joint lameness. *Vet. Radiol. Ultrasound* **2000**, *41*, 125–130. [[CrossRef](#)] [[PubMed](#)]
12. Janutta, V.; Hamann, H.; Klein, S.; Tellhelm, B.; Distl, O. Genetic evaluation of elbow angles as predictors of elbow dysplasia in German Shepherd Dogs. *J. Vet. Med. A Physiol. Pathol. Clin. Med.* **2005**, *52*, 254–261. [[CrossRef](#)] [[PubMed](#)]
13. Hazewinkel, H.A.W. Elbow Dysplasia; definitions and clinical diagnoses. In Proceedings of the 23rd Annual Meeting of the International Elbow Working Group, Dublin, Ireland, 20 August 2008; pp. 8–12.
14. Dallago, M.; De Bakker, E.; Coppeters, E.; Saunders, J.; Gielen, I.; Van Ryssen, B. Medial coronoid disease in an eleven-year-old Labrador Retriever. *Vlaams Diergeneesk. Tijdschr.* **2015**, *84*, 257–263. [[CrossRef](#)]
15. O'Neill, D.G.; Brodbelt, D.C.; Hodge, R.; Church, D.B.; Meeson, R.L. Epidemiology and clinical management of elbow joint disease in dogs under primary veterinary care in the UK. *Canine Genet. Epidemiol.* **2020**, *14*, 7. [[CrossRef](#)] [[PubMed](#)]
16. Grøndalen, J.; Røvik, A.M. Arthrosis in the elbow joint of young rapidly growing dogs. *IV Nord. Vet. Med.* **1980**, *32*, 212–218. [[PubMed](#)]
17. Hebel, M.; Panek, W.K.; Ruskowski, J.J.; Nabzdyk, M.; Niedzielski, D.; Pituch, K.C.; Jackson, A.M.; Kiełbowicz, M.; Pomorska-Mól, M. Computed tomography findings in a cohort of 169 dogs with elbow dysplasia—A retrospective study. *BMC Vet. Res.* **2021**, *17*, 296. [[CrossRef](#)] [[PubMed](#)]
18. Burton, N.; Owen, M. Canine Elbow dysplasia 1. Aetiopathogenesis and diagnosis. *Practice* **2008**, *30*, 508–512. [[CrossRef](#)]
19. Cook, C.R.; Cook, J.L. Diagnostic Imaging of canine elbow dysplasia: A review. *Vet. Surg.* **2009**, *38*, 144–153. [[CrossRef](#)] [[PubMed](#)]
20. How, K.L. Etiology of ununited anconeal process (UAP), osteochondritis dissecans (OCD) and elbow incongruity (EI). In Proceedings of the 33rd Annual Meeting of the International Elbow Working Group, Singapore, 24 September 2018; pp. 11–13.
21. Gasch, E.G.; Labruyère, J.J.; Bardet, J.F. Computed tomography of ununited anconeal process in the dog. *Vet. Comp. Orthop. Traumatol.* **2012**, *25*, 498–505. [[CrossRef](#)] [[PubMed](#)]
22. Komsta, R.; Debiak, P.; Twardowski, P. Radiographic evaluation of joints in dogs with elbow dysplasia—Clinical observations. *Bull. Vet. Inst. Pulawy* **2008**, *52*, 179–183.
23. Remy, D.; Neuhart, L.; Fau, D.; Genevois, J.P. Canine elbow dysplasia and primary lesions in German Shepherd Dogs in France. *J. Small Anim. Pract.* **2004**, *45*, 244–248. [[CrossRef](#)] [[PubMed](#)]
24. Narojek, T.; Fiszdon, K.; Hanyasz, E. Canine elbow dysplasia in different breeds. *Bull. Vet. Inst. Pulawy* **2008**, *52*, 169–173.
25. Guthrie, S. Some radiographic and clinical aspects of ununited anconeal process. *Vet. Rec.* **1989**, *24*, 661–662. [[CrossRef](#)] [[PubMed](#)]
26. LaFond, E.; Breur, G.J.; Austin, C.C. Breed susceptibility for developmental orthopedic diseases in dogs. *J. Am. Anim. Hosp. Assoc.* **2002**, *38*, 467–477. [[CrossRef](#)] [[PubMed](#)]
27. Reichle, J.K.; Snaps, F. The elbow. *Clin. Tech. Small Anim. Pract.* **1999**, *14*, 177–186. [[CrossRef](#)] [[PubMed](#)]
28. Moores, A.P.; Benigni, L.; Lamb, C.R. Computed tomography versus arthroscopy for detection of canine elbow dysplasia lesions. *Vet. Surg.* **2008**, *37*, 390–398. [[CrossRef](#)] [[PubMed](#)]
29. Lau, S.F.; Hazewinkel, H.A.W. Etiologies of medial coronoid disease. In Proceedings of the 33rd Annual Meeting of the International Elbow Working Group, Singapore, 24 September 2018; pp. 8–10.
30. De Rycke, L.M.; Gielen, I.M.; van Bree, H.; Simoens, P.J. Computed tomography of the elbow joint in clinically normal dogs. *Am. J. Vet. Res.* **2002**, *63*, 1400–1407. [[CrossRef](#)] [[PubMed](#)]
31. Samoy, Y.; Gielen, I.; Van Caelenberg, A.; Van Bree, H.; Duchateau, L.; Van Ryssen, B. Computed tomography findings in 32 joints affected with severe elbow incongruity and fragmented medial coronoid process. *Vet. Surg.* **2012**, *41*, 486–494. [[CrossRef](#)] [[PubMed](#)]

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