A Comparison of Owner-Assessed Long-Term Outcome of Arthroscopic Intervention versus Conservative Management of Dogs with Medial Coronoid Process Disease

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Abstract

Objectives The purpose of this study was to compare the long-term outcome of dogs with medial coronoid process disease (MCPD) treated with arthroscopic intervention versus conservative management.

Materials and Methods Medical records of dogs with MCPD treated by arthroscopic intervention or conservative management over an 8-year period were retrospectively reviewed. Long-term outcome (>12 months) was assessed via owner questionnaire including Liverpool Osteoarthritis in Dogs (LOAD) scores and Canine Brief Pain Inventory scores.

Results Data from 67 clinically affected elbow joints (67 dogs) diagnosed with MCPD on computed tomography were included. Forty-four dogs underwent arthroscopic intervention and 23 dogs were treated with conservative management. The median LOAD and Pain Severity Score (PSS) for dogs in the arthroscopic intervention group compared with the conservatively managed group were not significantly different ($p = 0.066$ and $p = 0.10$, respectively). The median Pain Interference Score (PIS) was significantly higher in the arthroscopic intervention group versus the conservative management group ($p = 0.028$). There was no significant difference after controlling for age. For LOAD, PSS and PIS, older age at diagnosis was all significantly associated with higher scores ($p = 0.048$, $p = 0.026$ and $p = 0.046$, respectively) and older age at time of questionnaire completion showed a stronger association with the scores ($p \leq 0.001$ for all).

Clinical Significance Arthroscopic intervention showed no long-term benefit over conservative management for dogs with MCPD.

Keywords
- medial coronoid process disease
- dogs
- arthroscopy
- conservative management
- clinical metrology instrument

* Dr. Dempsey conducted the study at the Institute of Veterinary Science, University of Liverpool, Wirral, United Kingdom of Great Britain and Northern Ireland.[1]

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Introduction

Elbow dysplasia is a major cause of osteoarthritis in the canine elbow.[1] Elbow dysplasia is a collective term describing several inheritable diseases, of which medial coronoid process disease (MCPD) is the most prevalent form and most common cause of thoracic limb lameness in medium, large and giant breed dogs.[1,2] While the underlying aetiopathogenesis of MCPD is not fully elucidated, various pathophysiological mechanisms have been postulated including failure of endochondral ossification,[3] repetitive mechanical overloading of the medial compartment leading to microdamage of subchondral bone,[4] fragmentation of bone and destruction of articular cartilage[5] and radioulnar incongruency causing mechanical overload within the medial compartment.[6]

The veterinary literature contains many treatment options for MCPD including medical and surgical interventions, which are aimed at ameliorating pain and slowing progression of osteoarthritis.[7–13] Historically, gait analysis[14] or activity monitoring[15] has been used to measure the efficacy of interventions aimed at decreasing chronic pain in dogs with osteoarthritis. While gait analysis is a gold standard measurement for lameness, it is time consuming and requires specialized equipment. Collection of kinetic data also relies on strict inclusion criteria including control of velocity and acceleration to limit variability of the gait and acquisition of valid trials. Gait analysis evaluates a dog contemporaneously, and weight bearing on an affected limb is only one part of chronic pain in dogs with osteoarthritis.[16] Methods of assessing chronic pain by owners are limited to clinical metrology instruments, which include Liverpool Osteoarthritis in Dogs (LOAD) and Canine Brief Pain Inventory (CBPI), hence their use in this study. The CBPI was designed to measure pain severity specifically related to osteoarthritis in dogs[17] and its impact on function, whereas LOAD evaluates pain related to osteoarthritis and ascertains a dog's ability and eagerness to exercise as well as function and stiffness.[18]

Both LOAD and CBPI have been validated for use in the assessment of canine osteoarthritis.[17,18] They are cost-effective and quantify the owners' behaviour-based assessment of pain, function and stiffness in their pets over extended periods of time.[17]

There are currently no studies that have used both LOAD and CBPI as clinical outcome measures for dogs undergoing arthroscopic intervention (AI) or conservative management (CM) for MCPD. The only study to directly compare long-term outcomes up to 12 months, of dogs with MCPD following AI with CM, used objective methods (inverse dynamic analysis). No difference was found between treatment groups.[19]

The purpose of our study was to evaluate owner-assessed long-term outcome of dogs with MCPD treated with AI or CM alone using a combined LOAD and CBPI questionnaire. We hypothesized that there would be no difference in long-term outcome between treatment groups.

Materials and Methods

Inclusion and Exclusion Criteria

The study was approved by the local institutional veterinary research ethics Committee (Veterinary Research Ethics Committee 108). Clinical records of the database of the Small Animal Teaching Hospital at the University of Liverpool were reviewed from January 2007 to January 2015 to identify dogs diagnosed with MCPD. Cases with incomplete medical records, dogs that had died since their treatment for MCPD or dogs with concurrent elbow joint pathology (ununited anconeal process, osteochondritis of the medial humeral condyle and flexor tendon enthesiopathy), were excluded. Dogs were eligible for participation in the study if their lameness was localized to one or both thoracic limbs based on subjective gait assessment, or the orthopaedic examination revealed signs of elbow pain, or there was a combination of these findings. In addition to this, computed tomography (CT) of the elbows supported a diagnosis of MCPD.[20] Inclusion into the study required a complete data entry for each patient and a completed combined owner questionnaire for LOAD and CBPI at least 12 months post-treatment. The data were entered into an electronic spreadsheet (Excel 2013, Microsoft), including patient identification number, age, breed, sex, weight, age at diagnosis of MCPD, clinically affected limb based on examination of the elbow joint and subjective gait assessment, lameness score out of 10 and grade of lameness at presentation. Treatment intervention (arthroscopy and type of intervention [inspection only, chondroplasty, fragment removal] or CM) was also included.

Computed Tomography

Computed tomography images of both elbow joints from each dog that met the inclusion criteria were scored retrospectively by a board-certified radiologist (T.W.M) who was blinded to the clinically affected elbow. Images were obtained (4-slice Siemens SOMATOM; Siemens Healthcare Diagnostics, Deerfield, Illinois, United States or 80-slice Toshiba Aquilion Prime; Toshiba Medical Systems, Japan) while the dogs were positioned in sternal recumbency.[21] Scanning parameters varied depending on bodyweight, but most images were obtained using 0.5-mm slice thickness, 120 kVp and 100 to 120 mAs. All images were reconstructed using sharp bone and smooth soft-tissue algorithms. The images were viewed using proprietary DICOM software (OsiriX Pixmeo, Geneva, Switzerland [versions 7.0]) in standard bone and soft-tissue display windows (soft tissue window level 50 HU/ window width 350 HU; bone window level 700 HU/window width 4000 HU). A scoring system modified from the International Elbow Working Group[22,23] was used to score both elbows on CT images (►**Supplementary Table 1**, available in online version only.). There were four variables measured in each elbow joint (conformation of the medial coronoid process, the size of the largest osteophyte in the joint on any reconstructed view, congruity by means of measurement of any step between the radius and ulna on the sagittal view and ulnar sclerosis ratio measured at the mid-medial coronoid process on the sagittal view). Each variable had a sub-score 0 to 3, with a total score of 12 per elbow.

Treatment Groups

All dogs had either AI (inspection only, chondroplasty of the MCP or fragment removal) or CM for MCPD. The decision whether AI was undertaken was due to surgeon preference, owner choice or financial considerations.

Arthoscopy[24] was performed by a board-certified surgeon or resident in-training under direct supervision. Conservative management consisted of weight reduction in dogs with a body condition score of 6/9 and above, a non-steroidal anti-inflammatory drug for 6 weeks, in some cases paracetamol/codeine for 1 to 2 weeks and increasing lead-restricted exercise for 8 weeks. Advice on long-term management was given via a telephone conversation or reassessment with the referral clinician after 6 weeks. Postoperative care of the AI group was identical to the CM group.

Questionnaire

Owners were sent an email summarizing the study aims and methodology with a link to the online questionnaire. A duplicate hard copy of the questionnaire was sent by mail if a completed online questionnaire had not been returned within 4 weeks of the original contact. The questionnaire comprised details on current medication, current type and average exercise per day, LOAD and CBPI scores—Pain Severity Score (PSS), Pain Interference Score (PIS) and quality of life score (QOL) (►**Supplementary Figs. 1** and **2**, available in online version only).

Statistical Analysis

Statistical analysis was performed using dedicated statistical software (SPSS 22.0, SPSS Inc, Chicago, Illinois, United States). Independent variables were derived from the signalment data, CT scores, arthroscopic records and patient follow-up. Variables assessed included those related to the dog (weight, breed, sex, age at diagnosis, lameness score at presentation, age at questionnaire completion), CT data (total score and individual sub-scores) and arthroscopic procedure (whether arthroscopy was performed and type of intervention [inspection only, chondroplasty, fragment removal]).

In dogs with bilateral lameness based on subjective gait assessment, only data relating to the elbow of the more severely lame thoracic limb were included in the analysis. If the more severely lame thoracic limb could not be ascertained in dogs with bilateral lameness on subjective assessment, then the elbow with the highest CT score was used. In dogs that were sound on the day of assessment, the clinically affected limb for analysis was based on a combination of findings from elbow examination or the documented lame limb in the referring veterinarians' and owners' history.

Medical treatment (no treatment, non-steroidal anti-inflammatory drug only, non-steroidal anti-inflammatory drug plus another drug) and average amount and type of exercise (mostly on or off lead, mostly walking gait or more active gait at exercise) at the time the owner completed the questionnaire were also assessed in the statistical analysis.

Descriptive statistics were generated for all variables; continuous data were summarized as median values with interquartile ranges (IQR), and categorical data were amalgamated into appropriate groups if required (due to small group sizes) and expressed as frequencies with 95% confidence intervals. For continuous variables (age, weight, LOAD, CBPI and CT scores), graphical assessment and a test for departure from linear trend were applied to determine the validity of assuming a linear association. Normality of distribution for continuous variables was also assessed via the Kolmogorov–Smirnov test. Difference in weight, age, age at questionnaire completion, CT score and initial lameness score between those dogs in the AI and CM groups were assessed using the Mann–Whitney U Test. The main dependent (outcome) variables considered for the main analyses were LOAD, PSS and PIS. Correlations between LOAD, total CBPI, PSS and PIS were assessed using the Spearman rank correlation coefficient. Initial univariable and subsequent multivariable linear regression analyses were performed to identify association between these outcomes and independent variables. All variables that showed some association with LOAD, PSS or PIS on initial univariable analysis ($p < 0.20$) were considered for incorporation into a final multivariable model. For any pair of variables with a correlation coefficient of ≥ 0.70, the variable with the smallest p-value was considered for further analysis. The models were constructed by manual backward stepwise procedures where variables with $p < 0.05$ were retained in the model. Potential confounding factors were assessed by examining parameter estimates for substantial changes following their removal.

Results

Altogether 149 dogs met the inclusion criteria, but 82 dogs were excluded due to failure of the owners to return the questionnaire leaving 67 dogs for the final analysis.

Arthroscopic Intervention Group

There were 44 dogs in the AI group. The Labrador Retriever was the most frequent breed (28 dogs) followed by the German Shepherd (6 dogs) with a total of 9 breeds (►**Table 1**). There were 14 males, 12 males neutered, 1 female and 17 females neutered dogs. Bodyweight ranged from 16.5 to 65.5 kg (median: 31.2 kg, IQR: 26.7–34.4). Age at diagnosis ranged from 5 to 64 months (median: 17 months, IQR: 10–33.2) and age at time of completion of the questionnaire ranged from 24 to 148 months (median: 87.5 months, IQR: 71–104). Two dogs were sound on both thoracic limbs at presentation, 5 dogs displayed bilateral lameness, 20 dogs were lame on the right and 17 dogs were lame on the left thoracic limb. Forty-one dogs presented with mild-to-moderate lameness and 1 dog was presented with severe lameness of the affected limb.

The majority of dogs (34/44) in the AI group were diagnosed with bilateral disease, 6 dogs had MCPD in the right elbow only and 4 dogs had MCPD in the left elbow only diagnosed on CT. The median total CT score for elbows at time of diagnosis for the AI group was 7/12 (IQR 6–8).

Table 1 Number of breeds affected with MCPD in the arthroscopic intervention and conservative management groups

Breed of dog	No. of dogs with MCPD Arthroscopic intervention group ($n = 44$)	No. of dogs with MCPD Conservative management group ($n = 23$)
Labrador Retriever	28	12
German Shepherd	6	0
Rottweiler	1	3
Labrador cross-breed	2	1
Boxer	3	0
Golden Retriever	1	1
English Springer Spaniel	0	2
Bull Mastiff	1	1
Bernese Mountain Dog	1	0
Staffordshire Bull Terrier	0	1
Shetland Sheepdog	1	0
Border Collie	0	1
Other Crossbreeds	0	1

Abbreviation: MCPD, medial coronoid process disease.

Forty-four clinically affected elbow joints in 44 dogs had AI and fragments were removed in 30 elbows, chondroplasty of the medial coronoid process only was performed in 10 elbows and 4 elbows had inspection only (medial coronoid process was probed and there were no loose cartilage or fragments). Twenty-four dogs had AI of both elbows. The most clinically lame elbow from each dog was analysed in our study.

Conservative Management Group

There were 23 dogs in the CM group. The Labrador Retriever was the most frequent breed (12 dogs) followed by the Rottweiler (3 dogs) with a total of nine breeds (►**Table 1**). There were 6 males, 5 males neutered, 2 females and 10 females neutered dogs. Bodyweight ranged from 15.3 to 70.2kg (median 31.1kg, IQR 24.3–33.9). Age at diagnosis ranged from 6 to 81 months (median 31 months, IQR 13–58) and age at the time of completion of the questionnaire ranged from 25 to 124 months (median 63 months, IQR 44–85.5). Seven dogs were sound on both thoracic limbs at presentation, 10 dogs were lame on the right and 6 dogs were lame on the left thoracic limb. Sixteen dogs presented with mild-to-moderate lameness of the affected limb.

The majority of dogs (16/23) in the CM group were diagnosed with bilateral disease, 6 dogs had MCPD in the right elbow only and 1 dog had MCPD in the left elbow only diagnosed on CT. The median total CT score for elbows at time of diagnosis for the CM group was 7/12 (IQR 6–8).

There was no significant difference in weight ($p = 0.99$), age ($p = 0.08$) or lameness score ($p = 0.17$) between dogs in the AI and CM groups at presentation. There was no significant difference between median total CT scores for elbows in the AI and CM groups ($p = 0.23$).

Questionnaires

The questionnaires were completed at a median of 56 months (IQR 23–71) post diagnosis. Dogs in the AI group were significantly older ($p = 0.004$) than the CM group at the time of questionnaire completion. At the time the questionnaire was completed, a larger proportion of dogs in the CM group were off lead (82.6% vs. 77.3%) and displayed a more active gait versus the AI group (69.6% vs. 63.6%) (►**Table 2**). A larger proportion of dogs in the CM group were no longer receiving medication (52.2% vs. 36.4%) and the median average distance covered per day was greater (2.5 miles vs. 1.5 miles). There was no significant difference between the AI and CM groups as to whether dogs were receiving any type of medication versus no medication ($p = 0.285$). There was no significant difference between the AI and CM groups for the average amount of exercise per day ($p = 0.058$), whether dogs were exercised on or off lead ($p = 0.505$) or whether the gait at exercise was mainly a walking gait or more active gait, that is, trotting, running or combination of gaits ($p = 0.547$). In both groups, owners were the main limiting factor for their dogs' willingness to exercise, accounting for 56.8 and 65.2% of the AI and CM groups respectively.

Overall for both groups, the median LOAD score was 14/52 (IQR 6–20) and median total CBPI was 11/100 (IQR 1–27). The median LOAD, PSS and PIS for dogs in the AI group (14/52, 4/40 and 5.5/60 respectively) were higher than the CM group (9/52, 3/40 and 3/60 respectively) (►**Fig. 1A–C**). This difference was not significant on linear regression for LOAD or PSS ($p = 0.066$ and $p = 0.10$ respectively) but was for PIS ($p = 0.028$). The specific type of AI (inspection, chondroplasty or fragment removal) undertaken was not significant for LOAD ($p = 0.32$), PIS ($p = 0.097$) or PSS ($p = 0.36$).

The type of medication the dog was being treated with at the time of completion of the questionnaire was not significantly associated with LOAD or PSS for both treatment groups ($p = 0.073$ and $p = 0.15$ respectively) but was significantly associated with PIS ($p = 0.016$), with dogs being treated with a non-steroidal anti-inflammatory drug ($p = 0.033$) or non-steroidal anti-inflammatory drug plus other drugs ($p = 0.014$) having lower scores.

In the AI group, owners rated their dog's QOL as 18 (40.9%) excellent, 18 (40.9%) very good and 8 (18.1%) as good. In the CM group, owners rated their dog's QOL as 12 (52.1%) excellent, 6 (26.0%) very good and (5) 21.7% good.

Correlation between LOAD and CBPI, PSS and PIS

There was good correlation between LOAD and total CBPI scores (Spearman rank correlation coefficient [ρ_s] = 0.86, $p < 0.001$), LOAD and PIS ($\rho_s = 0.87$, $p < 0.001$) and LOAD and PSS ($\rho_s = 0.76$, $p < 0.001$).

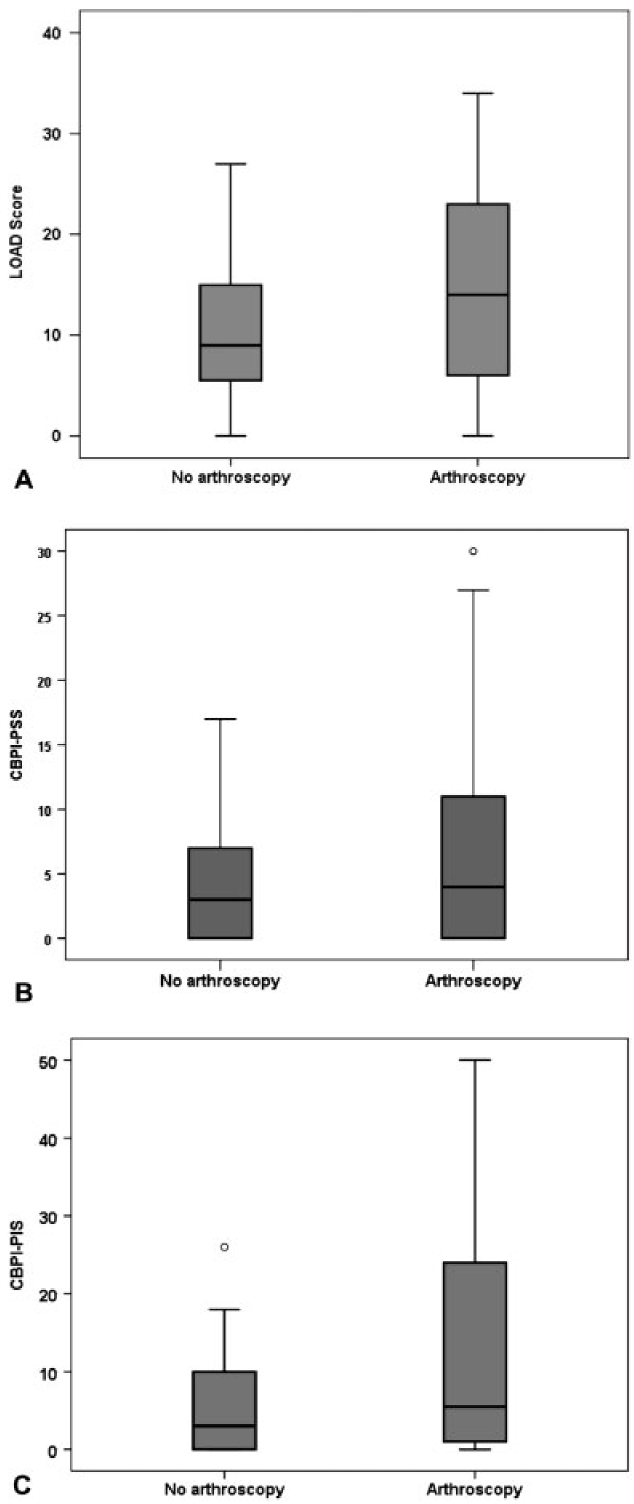

Fig. 1 (A–C) Box and whiskers plots comparing median Liverpool Osteoarthritis in Dogs score (LOAD), median Canine Brief Pain Inventory (CBPI) Pain Severity Score (PSS), and median Canine Brief Pain Inventory (CBPI) Pain Interference Score (PIS) for the conservative management of conservative management (CM) (no arthroscopy) and arthroscopic intervention (AI) groups. Each box represents the interquartile range, the horizontal line within each box represents the median, the whiskers represent the range and circles represent outliers. The median LOAD score was not significantly higher for the AI group versus the CM group, $p = 0.066$. The median CBPI PSS was not significantly higher for the AI group versus the CM group, $p = 0.10$. The median CBPI PIS was significantly higher for the AI group versus the CM group, $p = 0.02$.

Univariable Analysis

Univariable linear regression did not identify any significant associations between LOAD, PSS or PIS and breed, sex or weight (►**Table 3**). For LOAD, PSS and PIS, older age at diagnosis was all significantly associated with higher scores ($p = 0.048$, $p = 0.026$ and $p = 0.046$ respectively); however, for all of these, older age at time of questionnaire completion showed a stronger association with the scores ($p \leq 0.001$ for all).

Multivariable Analysis

Age, age at questionnaire, arthroscopy, type of AI and type of medication were all included in the initial multivariable models. However, for LOAD, PSS and PIS, only age at questionnaire completion remained significant in the final models, with none of the other variables being significant when controlling for age at questionnaire completion.

Discussion

We failed to reject our hypothesis that there was no overall difference in owner-assessed long-term outcomes, in dogs with MCPD treated either by AI or CM. LOAD scores, PSS and PIS for the AI group were higher than the CM group with the difference significantly higher for PIS but not for LOAD or PSS. No significant difference remained after controlling for age at questionnaire completion. This is currently the longest follow-up of dogs treated with AI versus CM for MCPD (median 56 months) and only one other study directly compares these two treatment modalities.[19] The long-term impact of various treatment modalities for dogs with MCPD is vital to establishing the best way forward to treat patients. Clinical metrology instruments are a useful tool for behaviour-based assessment of pain, function and stiffness of dogs in their home environment and during exercise over extended periods of time[17] in comparison to clinical evaluations based on 'a snapshot in time'.

Our results concur with that of a previous study directly comparing arthroscopy and CM,[19] which concluded there was no long-term benefit up to 52 weeks to removal of fragmented medial coronoid process or chondroplasty, using inverse dynamic analysis as an outcome measure. Other studies using force plate analysis and goniometry[25,26] found arthrotomy was not superior to medical treatment.[26] Despite AI, osteoarthritis progressed after 6 months.[25] An earlier meta-analysis[27] suggested arthroscopy was superior to medial arthrotomy and medical management, but arthrotomy was inferior to medical management with a follow-up of 6 to 9 months.[7,26,28,29] In our study, the type of AI, that is, whether a fragment was removed or not, was not significant for long-term outcome and is not reported in other studies.

The median age of 21 months of dogs at diagnosis and median weight of 31.1kg were similar to other studies.[23,30,31] Labrador Retrievers[8,23,31] and male dogs[6,8,23] were over-represented which is mirrored in other studies. Bodyweight was not associated with long-term outcome; however, body condition score may have been a better measure of actual obesity. This was not consistently entered

Table 2 Descriptive data for current medication, amount and type of exercise dogs with MCPD were receiving and limiting factors for exercise at the time the questionnaire was completed

Variable	Arthroscopic intervention (AI) group ($n = 44$)	Conservative management (CM) group ($n = 23$)
No. of dogs receiving NSAID plus another medication (paracetamol/codeine, gabapentin, tramadol, amantadine, nutraceutical)	12	3
No. of dogs receiving NSAID only	9	5
No. of dogs receiving another medication only (paracetamol/codeine, gabapentin, tramadol, amantadine, nutraceutical)	7	3
No. of dogs receiving no medication	16	12
Median (mean) exercise per day in miles	1.5	2.5
No. of dogs exercised mostly off lead	34	19
No. of dogs exercised mostly on lead	10	4
No. of dogs with mainly a walking gait at exercise	16	7
No. of dogs with mainly a trotting gait at exercise	3	3
No. of dogs with mainly a running gait at exercise	13	7
No. of dogs with a combination of gaits at exercise	12	6
No. of dogs where the owners are the main limiting factor to exercise	25	15
No. of dogs where they are the main limiting factor to exercise	18	6
No. of dogs where the owner and dog are both limiting factors to exercise	1	2

Abbreviation: NSAID, non-steroidal anti-inflammatory drug.

in the records and so could not be included in the analysis. Obesity is an etiological factor for osteoarthritis in people by increasing load on the joint and altering joint alignment.[32] A subclinical proinflammatory state with increased concentrations of adipokines leading to cartilage degradation is associated with obesity.[33]

Computed tomography is the imaging modality of choice for detecting fragmented medial coronoid process with a sensitivity and specificity of 71 to 100% and 85 to 93% reported respectively, when compared with arthroscopy or arthrotomy.[34–36] In our study, the CT scoring system was used as an attempt to establish that the degree of osteoarthritis was similar for the AI and CM groups at time of diagnosis and the initial management decision.

For LOAD, PSS and PIS, increasing age at diagnosis and questionnaire completion was significantly associated with higher scores, likely due to progressive osteoarthritis. Several studies have shown a correlation between radiographic arthrosis and cartilage pathology[8,35,37,38] and increasing age to be associated with more severe cartilage disease in MCPD.[37,39] Osteophytes signal significant joint morbidity in dogs affecting cartilage, synovium and subchondral bone.[8,38] Their formation with joint capsule fibrosis interferes with joint motion and function and is a source of pain in people.[40]

There were no significant differences between the AI and CM groups for dogs receiving any type of medication versus no medication or the average amount and type of exercise per day. Hence, no benefit of one treatment intervention over the other in the long term was supported. Some of these variables are owner dependent, which is supported by the questionnaire data that a larger proportion of owners in both groups influence their dogs exercise more than the dogs themselves. In the AI group, dogs were significantly older at the time of completion of the questionnaire and progression of osteoarthritis may have had an impact on their mobility. Across both treatment groups, the type of medication the dog was on at the time of questionnaire completion was significantly associated with PIS with dogs receiving non-steroidal anti-inflammatory drug plus other drugs having significantly lower scores, suggesting a benefit of analgesia in dogs with osteoarthritis secondary to MCPD. Despite progressive osteoarthritis, 81.8% of owners in the AI group and 78.3% in the CM group perceived their dogs to maintain a very good to excellent quality of life.

Limitations of the present study included a lack of an objective measurement as the primary outcome, although LOAD and CBPI have been validated with gait analysis. As our study was retrospective, there were no LOAD scores, PSS, or PIS available at time of diagnosis, which could have been compared with the follow-up scores. The retrospective nature of the data prohibited randomization of dogs into groups and therefore some selection bias is possible, although the similar

Table 3 Results of univariable analysis showing variables and their association with LOAD, CBPI PIS and CBPI PSS in 67 dogs with medial coronoid process disease

Variable	Category (units)	LOAD		CBPI pain interference score		CBPI pain severity score	
		β (95% CI)	p-Value	β (95% CI)	p-Value	β (95% CI)	p-Value
Age at diagnosis	(months)	0.11 (0 to 0.23)	0.048	0.16 (0.003 to 0.31)	0.046	0.11 (0.01 to 0.2)	0.026
Age at questionnaire completion	(months)	0.17 (0.11 to 0.23)	<0.001	0.21 (0.12 to 0.29)	<0.001	0.12 (0.07 to 0.17)	<0.001
Weight	(kg)	0.01 (−0.22 to 0.24)	0.92	0.02 (−0. 29 to 0.34)	0.88	−0.11 (−0.29 to 0.08)	0.27
Sex	MN	(Ref)	–	–	–	–	–
	M	0.23 (−5.89 to 6.35)	0.94	2.6 (−5.2 to 10)	0.50	0.43 (−4.3 to 5.1)	0.86
	FN	1.8 (−3.9 to 7.6)	0.52	−0.89 (−9.2 to 7.4)	0.83	−0.60 (−5.7 to 4.5)	0.81
	F	−7.1 (−19 to 4.5)	0.23	−5.0 (−21 to 10)	0.53	−4.3 (−14 to 5.3)	0.37
Breed	Labrador Retriever	(Ref)	–	–	–	–	–
	Crossbreed	6.6 (−3.1 to 16)	0.18	9.2 (−3.9 to 22)	0.17	2.7 (−5.2 to 10)	0.50
	German Shepherd dog	−6.3 (−14 to 1.8)	0.12	−0.97 (−8.9 to 7.0)	0.81	−2.8 (−7.5 to 2.0)	0.25
	Rottweiler	−0.45 (−10 to 9.2)	0.93	−6.7 (−18 to 4.2)	0.22	−5.8 (−12 to 0.78)	0.083
	Other breeds	−0.72 (−6.6 to 5.2)	0.81	−4.1 (−17 to 8.9)	0.53	−4.4 (−12 to 3.5)	0.27
Arthroscopy performed		4.3 (−0.29 to 8.9)	0.066	6.9 (0.78 to 13)	0.028	3.1 (−0.63 to 6.9)	0.10
Arthroscopic intervention	None	(Ref)	–	–	–	–	–
	Inspection	6.1 (−7.5 to 20)	0.37	−3.6 (−21 to 14)	0.69	1.0 (−10 to 12)	0.86
	Debridement	5.1 (−1.8 to 12)	0.15	7.5 (−1.5 to 17)	0.10	4.5 (−1.1 to 10)	0.12
Arthroscopic intervention	Fragment removal	3.9 (−1.1 to 8.9)	0.12	7.3 (0.78 to 13)	0.029	2.8 (−1.3 to 6.9)	0.17
CT score		−0.12 (−1.4 to 1.1)	0.84	−0.16 (−1.8 to 1.5)	0.85	−0.37 (−1.4 to 0.63)	0.47
Medical treatment	None	(Ref)	–	–	–	–	–
	NSAID only	−5.0 (−11 to 0.91)	0.095	−8.5 (−16 to −0.7)	0.033	−3.4 (−8.3 to 1.5)	0.17
	NSAID and another drug	−5.4 (−11 to 0.0)	0.05	−8.9 (−15 to −1.9)	0.014	−3.9 (−8.3 to 0.57)	0.087

Abbreviations: CBPI PIS, Canine Brief Pain Inventory Pain Interference Score; CBPI PSS, CBPI pain severity score; CI, confidence interval; CT, computed tomography; F, female; FN, female neutered; M, male; MN, male neutered; LOAD, Liverpool Osteoarthritis in Dogs; NSAID, non-steroidal anti-inflammatory drug; Ref, reference category.

distribution of variables across groups suggests that this may not have been a major factor. Small group sample sizes especially in the CM group could also lead to type II error.

Variability in experience and skill of the surgeon in performing the arthroscopy may have contributed to the outcome. Experienced surgeons may be better at differentiating between intact cartilage, chondromalacia or between superficial and deep cartilage lesions which have been found in human studies.[37] Experienced surgeons may also be more practiced with their intervention leading to better outcomes. However, residents were fully supervised by board-certified surgeons when performing arthroscopy to avoid this possibility. One veterinary study showed almost perfect interobserver agreement for grading cartilage arthroscopically.[37]

Another limitation was that there was no standardized arthroscopic grading system to assess the severity of cartilage lesions such as the modified Outerbridge scoring system[41] which is the 'gold standard' in veterinary medicine. This would have been interesting to compare severity of cartilage lesions to long-term outcome.

Dogs in the AI group were significantly older at the time of questionnaire completion. This may have resulted from surgeons choosing to treat patients with MCPD conservatively instead of arthroscopically in later years. Older age could impact the results due to progression of osteoarthritis, leading to higher outcome scores in the AI group. However, the multivariable analysis attempted to control for this.

Owner-assessed outcome scores observed the dog's overall function, rather than at the 'elbow level'. In our study, measurements and interventions were focused at the elbow joint. This is still relevant and important to the owner as LOAD and CBPI have been validated as clinical metrology instruments.[17,18]

Medial coronoid process disease is complex and the presentation of symptoms can be intermittent or constant. The functional deficit can range from mild stiffness but weight bearing through to severe non-weight bearing lameness. It is recognized that while bilateral changes may be seen radiographically with MCPD, radiographic findings may not correlate with clinical manifestations of musculoskeletal disease[25,29] and dogs most often present with unilateral symptoms, which were evident in our study. For consistency, we decided to use the clinically most affected limb in the data analysis. Our methodology in using a single limb for data analysis for those dogs with bilateral disease may have confounded our results. In those dogs with bilateral disease, the owner-assessed outcome scores may have been worse. One of the challenges when designing and interpreting any studies on the subject of MCPD is how to navigate the bilateral nature of the disease.

Conclusion

A general consensus of opinion is that the best prognosis is early surgical treatment in young dogs with MCPD, with minimal to mild osteoarthritis combined with postoperative rehabilitation and preventative measures against osteoarthritis.[42] More studies comparing treatment groups are required to identify whether younger dogs and those where osteoarthritis is minimally established benefit from AI, even if the discomfort is alleviated for a short period of time.

Our study has shown no significant benefit in long-term outcome for AI of dogs with MCPD compared with CM. Prospective randomized studies including larger populations of different ages of dogs, addressing subjective and objective parameters at diagnosis and long-term follow-up at standardized time intervals from treatment, are warranted. Without these studies, the decision-making process for the management of MCPD will remain, to a large extent, a matter of opinion and therefore of controversy.[42]

Author Contribution

All authors contributed to conception of study, study design, acquisition of data and data analysis and interpretation. All authors drafted, revised and approved the submitted manuscript.

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Conflict of Interest

None.

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