ORIGINAL ARTICLE

Veterinary Research Forum. 2026; 17 (5): 345 - 351

doi: 10.30466/vrf.2025.2049407.4611

Journal Homepage: vrf.iranjournals.ir

Veterinary Research Forum

A 5-year retrospective epidemiological and compositional study of canine and feline uroliths in Tehran, Iran (2019 - 2024)

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Article Info

Article history:

Received: 01 January 2025
Accepted: 27 August 2025
Available online: 15 May 2026

Keywords:

Cat
Dog
Epidemiology
Urinary bladder stones
Urolithiasis

Abstract

This study provided a comprehensive analysis of 145 urinary bladder stone cases diagnosed in dogs and cats over a 5-year period at a private veterinary hospital. The aim was to evaluate demographic patterns, urolith composition, and species-specific trends to enhance understanding and improve management of urolithiasis in companion animals. A retrospective study was conducted on clinical records, including patient demographics (species, breed, age, sex), urolith composition, and stone size. Chemical composition of uroliths was determined using qualitative chemical analysis. Statistical analyses were performed to identify significant associations between patient demographics and urolith composition. Of the 145 cases, 80 were dogs (55.17%) and 65 were cats (44.82%). In dogs, calcium oxalate stones predominated (65.00%) followed by struvite stones (30.00%) and mixed compositions (5.00%). Conversely, cats exhibited a higher prevalence of struvite stones (55.00%), with calcium oxalate accounting for 40.00% and mixed stones for 5.00%. Larger stones (10.00 - 20.00 mm) were more common in female dogs, while cats generally presented with fewer and smaller stones. No statistically significant temporal trend in urolith composition was observed for either species during the study period. Stone color distribution varied by species including cream and brown stones being most common in dogs and cats, respectively. This study established baseline epidemiological data on urolithiasis for this region, revealing significant species-specific differences in stone composition. The high prevalence of calcium oxalate in dogs and struvite in cats highlighted the need for tailored clinical management and provides a crucial benchmark for future regional and global comparative studies.

Introduction

Urinary bladder stones, uroliths, are among the most common disorders of the lower urinary tract in veterinary medicine, particularly in companion animals such as dogs and cats.[1] These stones form due to a complex interplay of dietary, genetic, metabolic and environmental factors leading to the precipitation of mineralized components in the urinary tract.[2-5] This condition is not only a major cause of discomfort and morbidity but also poses significant challenges for effective diagnosis, treatment, and prevention. The increasing prevalence of urolithiasis in companion animals necessitates a deeper understanding of its etiology, pathophysiology and epidemiology.

The clinical presentation of urolithiasis varies widely from asymptomatic cases to severe manifestations including hematuria, dysuria and complete urinary obstruction which can become life-threatening if not promptly managed.[6-8] The quality of life in affected pets is significantly impaired by recurring episodes of pain and urinary distress. Furthermore, chronic urolithiasis may contribute to progressive renal dysfunction and other systemic complications emphasizing the critical importance of timely detection and effective management strategies to alleviate suffering and prevent long-term sequelae.[9]

The chemical composition of uroliths in dogs and cats is influenced by species-specific metabolic processes. Calcium oxalate and struvite are the most commonly observed urolith types in both species, however, their relative prevalence differs.[10] In dogs, calcium oxalate uroliths are becoming increasingly prevalent, often associated with diets high in calcium or oxalate content and genetic predispositions in breeds such as Miniature Schnauzers and Yorkshire Terriers.[11,12] In contrast, struvite stones in cats are typically sterile and linked to factors such as reduced water intake, urinary stasis and

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diets promoting alkaline urine pH.[6] These differences underline the necessity of species-specific approaches to prevention and treatment.

Dietary management plays a pivotal role in the prevention of urolithiasis. Studies suggest that increased water intake and the use of specialized therapeutic diets can significantly reduce the recurrence of uroliths. For example, diets designed to control urine pH and reduce dietary precursors such as magnesium and oxalates are effective in minimizing struvite and calcium oxalate crystalluria.[13] However, knowledge gaps persist regarding the long-term effectiveness of these dietary interventions particularly in cases involving mixed or less common urolith compositions

Environmental and geographic factors further complicate the epidemiology of urolithiasis. Higher incidences of certain stone types have been reported in specific climates potentially due to variations in hydration and dietary habits.[14] Additionally, the increasing popularity of processed and commercial pet foods, which may vary in mineral content and acidifying agents, has been linked to changes in the prevalence of specific urolith types. These factors suggest that urolithiasis is not merely a biological phenomenon but also a consequence of anthropogenic influences.[15,16]

Despite advances in veterinary diagnostics, including ultrasonography and cystoscopy, urolithiasis remains a complex and multifaceted condition in companion animals. Previous studies provided valuable insights into urolith composition and prevalence, yet much of the literature focuses on specific populations or limited datasets. Continuous, region-specific analyses are essential to capture trends in stone composition and prevalence across diverse settings helping address gaps in our understanding of species-specific differences.

This study contributed to the growing knowledge of urolithiasis by analyzing 5 years of cases from a private veterinary hospital, focusing on dogs and cats. By examining patterns in urolith composition and prevalence, this research aimed to provide actionable insights that enhance diagnostic and treatment protocols. While the general epidemiology of urolithiasis is well-documented globally, there is a notable lack of specific data for companion animals in Iran. Therefore, this study provided a crucial regional benchmark, allowing for valuable comparisons with international findings and contributing to a more complete global picture of the disease. Such findings can support evidence-based approaches to the prevention and management of urolithiasis, ultimately improving the welfare of companion animals.

Materials and Methods

Study design and data collection. A retrospective analysis was conducted on 145 cases of urinary bladder stones diagnosed in dogs and cats at a private veterinary hospital over a 5-year period. Data were retrieved from clinical records, including patient demographics (species, breed, age, and sex) and urolith composition. Of the total cases, 80 were dogs and 65 cats. The canine cohort included 42 males and 34 females, while the feline cohort comprised 39 males and 23 females. Cases with incomplete or ambiguous records were excluded to ensure the reliability of the analysis.

Diagnostic criteria and urolith analysis. The diagnosis of urolithiasis was confirmed based on clinical signs, imaging findings (ultrasonography or radiography) and retrieval of uroliths via surgical or non-surgical procedures. When available, urine samples were analyzed prior to stone removal. Urinalysis included macroscopic assessments including color, turbidity, and specific gravity using a handheld refractometer (Atago Co., Tokyo, Japan), dipstick testing for pH, protein, glucose, ketones, bilirubin, and blood (Roche Diagnostics, Mannheim, Germany), and microscopic sediment evaluation for crystals, red and white blood cells, and bacteria. Following retrieval, uroliths were rinsed with sterile saline and dried at room temperature. For compositional analysis, a portion of the urolith was powdered and analyzed using a qualitative chemical analysis kit (SABA Chemical Industries Co., Tehran, Iran). According to the manufacturer's protocol, a series of reagents was used to detect the presence of specific ions including calcium, oxalate, phosphate, magnesium, ammonium, urate, and cystine. The resulting color changes or precipitate formations were compared against a standardized chart to qualitatively identify the primary mineral constituents of the uroliths.

Data organization. The data were systematically organized in a spreadsheet with separate records for dogs and cats. Each entry included variables such as species, breed, age, sex and detailed urolith characteristics (*e.g.,* composition, size, and number). A unique identifier was assigned to each case for consistent tracking during analysis. This study was conducted as a retrospective analysis of anonymized clinical data. No additional interventions were performed beyond standard veterinary care. Data collection and usage adhered to ethical standards for veterinary clinical research, ensuring patient and client confidentiality.

Statistical analysis. Descriptive statistics were employed to summarize the data focusing on the prevalence and composition of uroliths by species, sex,and other demographic factors. Trends in urolith composition over the 5 years were also examined. Statistical analyses were conducted using SPSS Software (version 29.0; IBM Corp., Armonk, USA). To assess the statistical significance of observed differences between groups, a Chi-square test was used to analyze the association between categorical variables (predominant urolith type and sex), and an independent samples *t*-test was used to compare the mean age between the two predominant urolith groups. For all statistical tests, a *p*-value of < 0.05 was considered statistically significant. The results were interpreted to identify patterns in the occurrence and characteristics of urolithiasis.

Results

Study population and demographics. A total number of 145 cases of urolithiasis, collected over a 5-year period (2019 - 2024), were included in this study, comprising 80 dogs (55.17%) and 65 cats (44.82%). The canine cohort consisted of 44 males and 36 females, with a mean age of 7.20 ± 3.20 years (range: 1 to 15 years). The age distribution was as follows: 5.00% were young (< 2 years), 40.00% were adult (2 - 7 years) and 55.00% were senior (> 7 years). The most frequently represented dog breeds were Terrier, Shih Tzu and Pomeranian. The feline cohort included 41 males and 24 females, with a mean age of 5.00 ± 2.50 years (range: 1 to 11 years). The age distribution was as follows: 11.00% were young (< 2 years), 63.00% were adult (2 - 7 years) and 26.00% were senior (> 7 years). Persian and domestic shorthair were the most common cat breeds. Detailed characteristics for the most common breeds are provided in Table 1.

Urolith compositions. In dogs, calcium oxalate was the predominant component in 65.00% of cases while struvite was the predominant component in 30.00%. In cats, struvite was the predominant component in 55.00% of cases while calcium oxalate was the predominant component in 40.00%. Analysis of the urolith constituents revealed that mixed-composition stones were overwhelmingly more common than pure, mono-mineral stones in both species. Among dogs, 96.25% (77/80) of the uroliths were of mixed composition with only 3.75% (3/80) being pure. Similarly, in cats, 95.38% (62/65) of uroliths were of mixed composition,while only 4.61% (3/65) were mono-mineral. To visualize this species-specific difference in stone composition, the average mineral composition for dogs and cats is presented in Figure 1. The gross morphological diversity of these uroliths is illustrated in Figure 2.

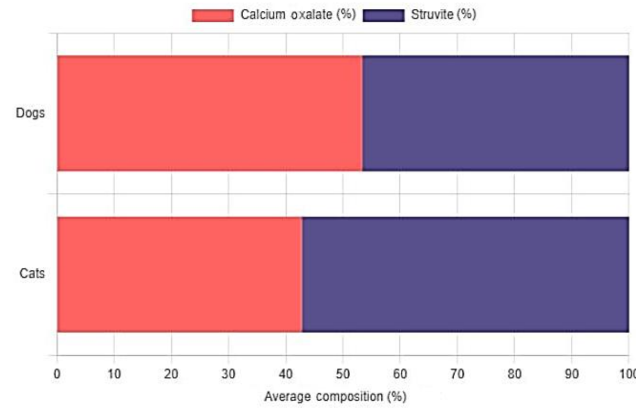

Fig. 1. Average mineral composition of uroliths in dogs and cats.

To investigate the association between sex and urolith composition, stones were categorized by their predominant mineral type. A Chi-square test was performed on these categories. In dogs, no statistically significant association was found between sex and the predominant stone type ($p = 0.15$). Similarly, no significant association was observed in cats ($p = 1.00$).

An independent samples *t*-test was used to compare the mean age of animals between the two predominant urolith types. In dogs, the mean age of those with predominantly calcium oxalate uroliths (7.85 years) was not significantly different from those with predominantly struvite uroliths (6.59 years), ($p = 0.11$). Similarly, in cats, no significant difference was observed between the mean age of the oxalate group (5.03 years) and the struvite group (4.97 years; $p = 0.92$).

Size and number of uroliths. In dogs, the number of stones *per* case ranged from 1 to 20 with most stones measuring 2.00 - 3.00 mm. Larger stones (10.00 - 20.00 mm) were identified in 15.00% of cases, predominantly composed of calcium oxalate. Female dogs had larger stones (mean size: 13.25 mm) compared to males (mean size: 3.40 mm). In cats, typically fewer stones *per* case (1 - 3 stones) with struvite stones often larger (some exceeding 5.00 mm) were observed. Female cats had slightly larger stones on average (mean size: 4.21 mm) compared to males (mean size: 2.82 mm).

Table 1. Demographic and urolith characteristics for the most common dogs and cats breeds in the study population. Data are presented as mean ± SD.

Species	Breeds	No.	Age (years)	Age range	Male (%)	Stone size (mm)	Most frequent type	Most common color
Dog	Terrier	15	7.90 ± 3.10	3 - 14	67.00	5.20 ± 4.10	Oxalate	Brown
	Shih Tzu	12	8.10 ± 2.90	4 - 13	42.00	8.10 ± 6.50	Equal	Brown
	Pomeranian	10	7.30 ± 2.50	4 - 11	60.00	4.50 ± 3.80	Oxalate	Brown
	Shih Tzu Terrier	10	6.50 ± 3.40	1 - 12	40.00	6.70 ± 5.90	Equal	Cream
	Spitz	5	5.40 ± 2.10	3 - 8	80.00	3.80 ± 1.70	Oxalate	Cream
	Chihuahua	4	9.00 ± 1.40	8 - 11	50.00	9.50 ± 8.70	Oxalate	Brown
	Pekingese	4	7.50 ± 2.40	5 - 10	75.00	2.50 ± 0.60	Equal	Cream
Cat	Persian	41	5.10 ± 2.30	1 - 11	59.00	3.70 ± 2.10	Struvite	Cream
	Domestic Shorthair	15	4.80 ± 2.80	2 - 10	60.00	2.90 ± 1.50	Struvite	Cream
	Scottish Fold	4	4.30 ± 1.50	3 - 6	50.00	3.50 ± 1.30	Struvite	Cream

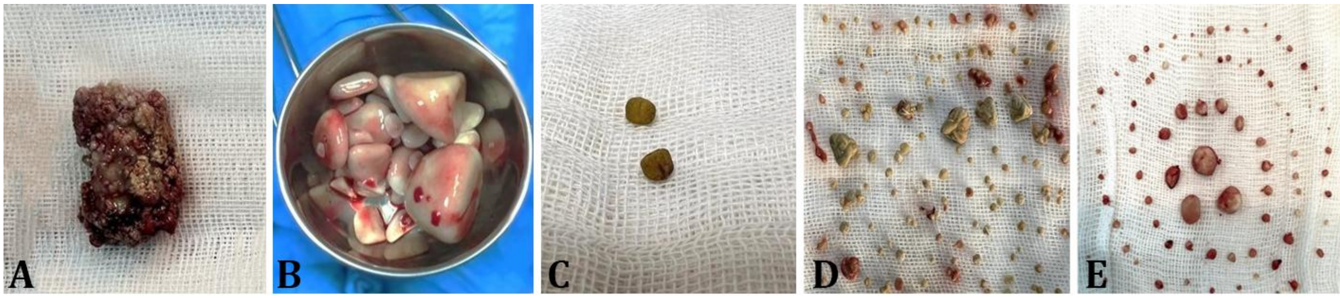

Fig. 2. Gross morphological diversity of uroliths recovered from the study population. **A)** A large, nodular, brown calcium oxalate urolith. **B)** Multiple large, smooth, white struvite stones. **C)** Two small, rounded, brown uroliths of mixed composition. **D)** Numerous small, irregularly shaped, cream-colored uroliths of mixed composition. **E)** Multiple small, smooth, cream and white struvite uroliths.

Trends over time. A Chi-square test was used to analyze the proportion of predominant stone types across the 5-year study period. The analysis found no statistically significant temporal trend in urolith composition for either dogs (p = 0.31) or cats (p = 0.55).

Stone color. Stone color distribution revealed notable differences between dogs and cats. Among dogs, the most common stone colors were cream (24 cases, 30.00%) and brown (22 cases, 27.50%) followed by white (four cases, 5.00%) and yellow (one case, 1.25%). Cats exhibited a similar pattern with cream-colored stones being the most frequent (40 cases, 61.53%), followed by brown (11 cases, 16.92%) and white (four cases, 6.15%). Rare variations in color such as yellow stones were observed only in dogs.

Discussion

This study provided a comprehensive analysis of 145 cases of urolithiasis in dogs and cats over a 5-year period, shedding light on demographic trends, urolith composition and species-specific differences in Tehran. The primary value of these findings were not in identifying novel urolith types, but in establishing a critical epidemiological baseline for this specific geographic region, which has been underrepresented in the veterinary literature. These findings offered valuable insights into the clinical characteristics of urolithiasis in this population, which could inform both prevention and management strategies and allow for direct comparison with global data.

This study identified calcium oxalate as the most common urolith in dogs (65.00% of cases) and struvite as the predominant composition in cats (55.00% of cases). These findings were consistent with general global trends but also showed notable regional variations when compared to large-scale international studies, as detailed in Table 2.[11,12,14,16,17] In dogs, the dominance of calcium oxalate mirrors trends was observed in the retrospective analysis of 2,735 canine uroliths in Spain and Portugal,[17] where calcium oxalate was the most common urolith type (38.10%), followed by struvite (32.90%). This study reported a closer distribution between calcium oxalate and struvite compared to our finding which could be due to regional differences in diet and veterinary care practices. In dogs, the high prevalence of calcium oxalate uroliths in our cohort, which was composed of many small breeds like Terriers and Shih Tzus, consisting with the well-documented genetic predisposition for this stone type in small-breed dogs reported in the wider literature.[11,12,18,19]

The distinct species-specific prevalence of urolith types observed in our study was consistent with established pathophysiological differences between the species. The formation of these stones is indeed multifactorial. In dogs, the high prevalence of calcium oxalate uroliths is often linked to factors such as hypercalciuria (excess calcium in urine), diets that promote acidic urine and well-documented genetic predispositions, particularly in small breeds.[11,20] Conversely, struvite urolithiasis in dogs is frequently associated with urinary tract infections caused by urease-producing bacteria, which raise urine pH and promote struvite crystal precipitation.[6] In cats, the dynamic is different. The high prevalence of struvite uroliths is primarily driven by non-infectious causes.[21] Key factors include highly concentrated urine due to cats natural tendency for lower water intake, diets rich in precursors like magnesium and phosphorus and a urine pH that is often in the alkaline range. Unlike in dogs, feline struvite stones are typically sterile.[22] This fundamental difference in the underlying cause of struvite formation is a critical factor in the species-specific trends observed in our study and in the literature worldwide.

Interestingly, while many long-term studies from North America and Europe have documented a significant increase in the prevalence of calcium oxalate uroliths over time,[11,12,23] our analysis did not reveal a statistically significant temporal trend in either dogs (p = 0.31) or cats (p = 0.55). The stable prevalence of urolith types in our study population over this 5-year period might suggest that the epidemiological factors present in our region, such as common dietary practices, differed from those in other parts of the world. It is also possible that a 5-year timeframe is too short to detect a slower-moving trend. Further long-term, multi-center studies would be valuable to clarify if the epidemiology of urolithiasis in Iran is following global patterns or has a unique, stable profile.

Table 2. Comparison of predominant urolith prevalence (%) in dogs and cats across different geographic regions.

Study	Region	Species	Calcium oxalate	Struvite
Current study	Iran	Dog	65.00	30.00
		Cat	40.00	55.00
Burggraaf *et al.* [20]	The Netherlands	Dog	30.80	40.90
		Cat	68.80	24.20
Houston and Moore [22]	Canada	Dog	45.50	39.10
		Cat	49.10	43.10

The predominance of struvite stones (55.00%) in cats observed in this study was consistent with global findings. In a retrospective analysis of feline uroliths submitted to the Canadian Veterinary Urolith Centre, struvite stones consistently accounted for the majority followed by calcium oxalate.[22] However, this study noted a gradual increase in calcium oxalate prevalence over time, attributed to changes in dietary formulations promoting urinary acidification. A study analyzing 7866 feline and canine urolith submissions in the Netherlands found struvite as the most prevalent urolith type in cats. The researchers emphasized dietary factors, reduced water intake, and lower activity levels in indoor cats as key contributors.[20] These closely mirrored the trends observed in this study, particularly the higher prevalence of struvite stones in feline urolithiasis cases.

In this study, mixed-composition uroliths were accounted for 10.00 - 20.00% of cases in both dogs and cats, often involving combinations of calcium oxalate and magnesium ammonium phosphate (MAP; struvite). This prevalence was in agreement with findings by Defarges *et al.*, who reported that mixed uroliths were common, particularly in chronic cases, and posed unique diagnostic and therapeutic challenges.[6] The complexity of mixed stones, arising from multifactorial etiologies, underscores the need for individualized management strategies.

Rare uroliths such as cystine and urate stones were identified in < 5.00% of cases, consistent with other studies. Houston and Moore reported that urate and cystine uroliths together constituted less than 10.00% of analyzed uroliths in dogs and cats, with cystine being almost exclusively found in male dogs due to genetic predispositions.[22] Similarly, Stevenson emphasized the rarity of these stones, noting that urate stones were often linked to liver dysfunction or breed-specific predispositions such as in Dalmatians.[24] Rare urolith compositions including urate and cystine stones accounted for < 5.00% of cases in this study consistent with Cannon *et al.*, which reported urate stones in approximately 9.00% and cystine stones in only 0.13% of feline uroliths over a 20-year period.[23]

In this study, stone sizes in dogs ranged from 2.00 - 3.00 mm for the majority, with larger stones (10.00 - 20.00 mm) found in 15.00% of cases. Female dogs had larger stones on average (mean size: 13.25 mm) than males (mean size: 3.40 mm). In cats, stone sizes were smaller on average with struvite stones often exceeding 5.00 mm. Female cats also had slightly larger stones (mean size: 4.21 mm) than males (mean size: 2.82 mm). These findings were consistent with observations in a study analyzing 7,866 urolith submissions in the Netherlands which reported that stone size varied significantly based on composition and species, with struvite stones generally being larger than calcium oxalate stones.[20]

Lulich *et al.* observed that female dogs and cats were more likely to develop larger stones, possibly due to differences in urine flow dynamics and anatomical factors, which was consistent with the gender-specific trends observed in this study.[18]

The finding that calcium oxalate stones in dogs are generally smaller and denser compared to struvite stones is supported by several studies. For instance, Nykamp observed that calcium oxalate uroliths typically exhibited higher density and compact structure, contrasting with the larger, less dense struvite uroliths in dogs, which were often influenced by infection-related factors and dietary compositions.[25] Similarly, Defarges *et al.* emphasized the differing characteristics of calcium oxalate and struvite stones, with calcium oxalate stones being harder and more radiopaque, while struvite stones were often larger due to infection-driven growth dynamics.[6]

In this study, the most common stone colors in dogs were cream and brown, accounting for 30.00 and 27.50% of cases, respectively. This was different from the findings of Weichselbaum *et al.* who identified light tan as the most prevalent color, accounting for 64.80% of canine urocystoliths. In their study, light tan was predominantly associated with MAP urocystoliths, with 84.90% of MAP stones being light tan in color.[26] While our study did not explicitly link cream-colored stones to MAP, struvite stones were common in dogs which might share some compositional overlap with MAP stones, potentially explaining the color similarities.

Weichselbaum *et al.* also observed that gray, green or gray-green stones were primarily associated with ammonium acid urate urocystoliths with 84.70% of ammonium acid urate stones showing these colors.[26] In contrast, in our study, yellow stones were identified in dogs, although in much smaller proportions (1.25%), and no significant association with urate stones was made. White stones, observed in 5.00% of dog cases in our study, were also less common in Weichselbaum *et al.* where white was the least common color, representing less than 0.30% of cases.[26]

These differences in color distribution might reflect regional variations, differences in dietary practices and distinct diagnostic methods used in both studies. While Weichselbaum *et al.* highlighted the potential of stone color as an aid in identifying the urolith type, particularly in MAP and ammonium acid urate cases, the color distribution observed in our study suggested that further research is needed to link stone color more closely to specific mineral compositions in a broader population.[26]

A significant finding of this study was the overwhelming prevalence of mixed-composition uroliths with over 95.00% of stones containing both calcium oxalate and struvite components. The formation of mixed uroliths was a recognized clinical phenomenon, often attributed to changes in the urinary environment over time such as shifts in urine pH or the presence of infection which could cause a new mineral layer to form on an existing nidus.[6] The high frequency of mixed stones in our population highlighted the complexity of urolithiasis and underscored the challenge in implementing a single, targeted preventive strategy.

The relative rarity of other common urolith types such as purine (urate) and cystine stones in our cohort was also noteworthy, although they were not entirely absent. This finding could be attributed to the specific breed distribution within our single-center study population. For instance, breeds with a high genetic predisposition for urate stones, such as Dalmatians, were not present in our cohort.[24] Furthermore, the qualitative chemical analysis kit used, while effective for identifying major components, might be less sensitive to detecting trace minerals compared to quantitative methods like spectroscopy. This analytical characteristic may explain why the vast majority of stones were identified as combinations of the most common and easily detectable minerals, calcium oxalate and struvite and it was an important consideration when interpreting our results.

The nature of the uroliths is also intrinsically linked to the animals diet, a factor that was not assessed in this study but was critical in the management of this disease. Diets that promote alkaline urine and are high in protein, magnesium, and phosphorus are known to increase the risk of struvite formation. Conversely, diets high in calcium and oxalates, particularly those that acidify the urine can increase the risk for calcium oxalate uroliths.[2] The widespread use of therapeutic diets designed to dissolve or prevent struvite stones may have inadvertently contributed to the rise in calcium oxalate prevalence seen in many global studies.[11] This highlights the pivotal role of carefully tailored nutritional management in both preventing recurrence and managing urolithiasis in companion animals.

The findings of this study provided several key clinical recommendations for veterinary practitioners in Iran. First, the high prevalence of mixed-composition uroliths (> 95.00%) underscored the necessity of performing compositional analysis on all retrieved stones to guide appropriate long-term management and avoid ineffective therapy. Second, our data confirmed that global species-specific trends were present in this region. Practitioners should, therefore, apply established international guidelines for the prevention of calcium oxalate uroliths in at-risk dogs and sterile struvite urolithiasis in cats, which primarily involve promoting urine dilution and tailoring diets to mitigate specific urolith risks.

While this study provided valuable regional data, its findings should be interpreted in the context of several important limitations.

The study retrospective nature inherently limited control over data consistency and its single-center design might not fully represent the broader companion animal population in Iran.

Furthermore, critical data on potential confounding variables including detailed dietary histories and underlying metabolic conditions were not consistently available in the clinical records. The absence of the information precluded a comprehensive analysis of their influence on urolith formation.

The qualitative chemical analysis kit used for urolith composition was another key consideration. This method, while practical for clinical settings, lacks the quantitative precision of advanced techniques like spectroscopy or crystallography. This was a significant factor when comparing our prevalence data to studies that employed such methods and might explain the high proportion of mixed stones identified.

Finally, the lack of long-term follow-up data means that recurrence rates and the efficacy of management strategies were not evaluated.

Conflict of interests

The authors declare no conflict of interest.

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