STRUVITE
The vast majority of canine struvite stones are caused by urinary tract infections with urease-producing bacteria such as *Staphylococcus* or *Proteus* (note: most *E. Coli* strains do not produce urease).³ Urease results in the metabolism of urea to ammonia. As ammonia reacts with water, the urine pH and urine ammonium levels rise resulting in supersaturation of ammonium magnesium phosphate (aka struvite). Thus, antibiotics are an essential part of therapy for struvite stones in dogs and should be based on urine culture and sensitivity results for best efficacy. In contrast to dogs, feline struvite stones primarily form in sterile urine, and antibiotic therapy is rarely indicated as a component of dissolution therapy in cats.²

According to the 2016 ACVIM consensus statement on uroliths in dogs and cats, both struvite cystoliths and nephroliths can and should be medically dissolved with antibiotics and a therapeutic dissolution diet.³ Nutritional goals for struvite dissolution are provided in Table 1.

**Exceptions:**
- Obstructing uroliths
- Massive solitary cystoliths (e.g. >85% of the bladder volume)
- Patient factors – Cannot administer diet or medications to patient or patient has comorbidities resulting in contraindications for medical dissolution

**Duration:**
- **In dogs**, dissolution takes an average of 3 months but is highly variable depending on the size and number of uroliths present.⁴
- **In cats**, dissolution takes an average of 1.5 – 2.5 weeks when fed Hill’s Prescription Diet s/d⁵ or Purina Pro Plan Veterinary Diet UR Urinary St/Ox⁶ and approximately 4 weeks when fed Hill’s Prescription Diet c/d.⁵

Table 1. Nutritional Recommendations for Struvite Dissolution.

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Method &amp; Therapeutic Diet Considerations (Hill’s s/d, Hill’s c/d, Royal Canin SO, Purina UR)</th>
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| Acidify urine  | - Hill’s s/d, Royal Canin SO, and Purina UR all target a urine pH at or below 6 when fed exclusively.  
                    - Hill’s c/d is also acidifying with a target pH of 6.2 – 6.4. |
| Increase urine volume | - All four dissolution diets are available as canned foods.  
                        - Restricting dietary protein → diuresis (reduced urea results in the loss of medullary concentrating gradient).  
                        - Hill’s s/d has the greatest protein restriction (8% protein on a dry matter basis), resulting in a USG 1.005 – 1.011 if fed exclusively. It is only appropriate for short-term use (<12 months). Royal Canin SO and Hill’s c/d are moderately protein restricted (<25%), and Purina UR is not protein restricted (37%). |
| Reduce phosphorus and magnesium | - Hill’s s/d and c/d have the greatest restriction in phosphorus and magnesium. Royal Canin SO is also restricted in magnesium. |
**Why not treat with surgery?**

While surgical removal of struvite uroliths is appealing because of its speed, this approach is not a simple solution and is not recommended as the first line of therapy for the following reasons:

- Cystotomies are invasive and painful with a 20% risk that stones are left behind and a 4% risk of other complications ranging from incisional infections to septic peritonitis. Studies have shown that patients with surgery may have a higher risk of postoperative complications such as incisional infections, sepsis, and death. It is important to consider the potential benefits and risks of surgery in the context of each patient.
- Surgery will not resolve bacterial cystitis and thus does not eliminate the need for antimicrobial therapy.
- Sutures can serve as a nidus for future stone formation. Studies have shown that sutures can contribute to calculi formation, especially in the presence of a urinary tract infection. It is crucial to take measures to prevent this issue.
- The expense of medical dissolution is often less than that of surgical stone removal.

**But will surgery relieve discomfort faster?**

In dogs with struvite, the greatest discomfort is associated with the infection rather than the stones. Therefore, relief of signs may be achieved rapidly with medical therapy. One approach is to start with a short term prescription of antibiotics and a dissolution diet. Non-steroidal anti-inflammatory drugs can also be considered if there is no concern for renal insufficiency. If the dog remains in significant discomfort after the first few days to weeks, surgery can be considered at that time. If the dog’s clinical signs diminish sufficiently, the antibiotics and diet can be continued for a full dissolution trial (see the Minnesota Urolith Center link for the protocol): [https://www.vetmed.umn.edu/sites/vetmed.umn.edu/files/canine_struvite_uroliths.pdf](https://www.vetmed.umn.edu/sites/vetmed.umn.edu/files/canine_struvite_uroliths.pdf)

Be aware of common reasons for a struvite dissolution trial failure:

- **Poor compliance with diet**
  - This can be monitored for by checking a urinalysis. When feeding Hill’s s/d exclusively, the urine pH should be ≤ 7, and the USG should be 1.005 – 1.011.
- **Inadequate antibiotic therapy (dogs)**
  - **Type** - Make sure to select an antibiotic based on a urine culture and sensitivity to avoid a scenario of ineffectual treatment due to antimicrobial resistance.
  - **Duration** – The antibiotic must be given the entire dissolution trial.
- **Wrong stone type**
  - If neither of the other reasons for failure is present, consider that the stones may have a non-struvite composition. See the CALCulator resource below for guidance on estimating a patient’s risk for various stone types.

**The role of nutrition in struvite prevention**

- **In dogs**, struvite stones rarely form in the absence of an infection and can thus be prevented by managing risk factors for urinary tract infections to eliminate their occurrence and by routine screening for infections to enable early detection and treatment. A long term therapeutic diet is not required.
- **In cats**, long-term feeding of a struvitolytic maintenance diet (Hill’s c/d, Royal Canin SO, or Purina UR) is recommended.

**CALCIUM OXALATE (CAOX)**

The factors influencing risk for CaOx uroliths are not well understood. Strong breed predispositions suggest that genetic factors play a major role in risk. Sex also influences risk, with the majority of CaOx stones occurring in males in both dogs and cats. Most dogs and cats with CaOx uroliths have increased urinary calcium excretion despite normal blood calcium
(i.e. idiopathic hypercalciuria). Other modifiable factors that likely influence CaOx risk, including diet, water intake, obesity, and voiding behaviors (e.g. incomplete bladder emptying predisposes to bladder stones in people). While CaOx stones cannot be dissolved, nutritional therapy can be used to reduce the risk of stone recurrence and are detailed in Table 2.

Table 2. Nutritional Recommendations for CaOx Prevention

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Method &amp; Therapeutic Diet Considerations (Hill’s u/d, Hill’s c/d, Royal Canin SO, Purina UR)</th>
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| Neutralize urine | - Acidic urine can result in hypercalciuria and hypocitraturia. High protein foods are often acidifying.  
- Hill’s u/d is the only non-acidifying diet formulated for the prevention of CaOx uroliths. It has a target pH of 7 – 7.7. |
| Increase urine volume | - All four dissolution diets are available as canned foods.  
- Restricting dietary protein → diuresis.  
- Hill’s u/d has the greatest protein restriction (13% protein on a dry matter basis). Royal Canin SO and Hill’s c/d are moderately protein restricted (<25%), and Purina UR is not protein restricted (37%). |
| Limit sodium | - There is controversy over the nutritional recommendations for sodium intake in dogs and cats with CaOx uroliths. Dietary sodium may promote water intake and thereby dilute urinary calcium and oxalate. However, sodium decreases urinary calcium resorption by the kidneys, resulting in increased calcium excretion. In short term trials in dogs, this effect appears to be canceled out by the increased urine volume, but it is unknown how dogs with idiopathic hypercalciuria respond to sodium supplementation, especially over time.  
- In rodent models of CaOx, a high sodium diet increases stone risk and low sodium diet decreases risk, despite increased diuresis in the higher sodium diets.  
- In people, sodium restriction decreases the risk of CaOx recurrence.  
- Canned and dry Hill’s u/d and c/d are low in sodium. Canned Purina UR is also low in sodium.  
- The dry formulations of Royal Canin SO and Purina UR contain supplemental sodium. |
| Prevent excessive calcium and oxalate excretion | - All four diets are formulated to have a low oxalate content, a moderate calcium content (low calcium is not recommended, as restriction will increase oxalate absorption), and an appropriate Ca:Phos ratio.  
- Vitamin B6 is needed for the metabolism of oxalate. All commercial dog foods should be formulated with sufficient B6, but supplementation is recommended for dogs on homemade diets. |
| Potassium citrate | - Citrate chelates calcium, which lowers supersaturation, inhibits crystal formation, and alkalinizes the urine (see above).  
- Potassium citrate is an ingredient in Hill’s u/d, Hill’s c/d, and Purina UR. For dogs with persistently acidic urine, potassium citrate may be provided as a supplement (75 mg/kg q12-24hrs). Avoid supplements containing cranberry extract, as they have been found to increase urinary oxalate excretion in people. |
GENERAL
Hill’s (S+OXSHIELD) and Royal Canin (SO Index) provide notations on their prescription diets about diets that should not promote struvite or calcium oxalate formation. These labels do not mean that the diets are equivalent to those specifically formulated for stone dissolution and/or prevention. Please contact individual pet food companies if you would like additional information on this subject.

RESOURCES
Recommendations for the management of canine and feline uroliths can be found on the Minnesota Urolith Center website:
https://www.vetmed.umn.edu/centers-programs/minnesota-urolith-center/recommendations

CALCulator
The Minnesota Urolith Center has developed a free app for veterinarians and veterinary support staff. You can download it from the Apple App Store (“MN Urolith”) for iPhones and iPads or from Google Play (“Minnesota Urolith Center”) for Android devices. This app contains a CALCulator function where you can input your patient’s signalment and receive data on the predicted stone type. If you have an online account with the Minnesota Urolith Center, you can also access information on the status of your patient’s stone analysis.

Calcium Oxalate Prevention-Diet Questions
The Minnesota Urolith Center now offers a handout that specifically addresses common questions about nutritional components that should be considered when selecting a diet for CaOx stone prevention:

ACVIM Small Animal Consensus Recommendations on the Treatment and Prevention of Uroliths in Dogs and Cats
In 2016, a group of experts published a consensus statement for the management of urolithiasis in small animals. This statement is publically available (open access) and contains information on the medical dissolution of uroliths and on nutritional considerations in the prevention of calcium oxalate uroliths.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5032870/

Dr. Fredric Coe, a renowned human kidney stone researcher and nephrologist at the University of Chicago, maintains a website that provides high quality summaries of data on various topics pertaining to kidney stones. The articles are easy to read and much of the information is likely applicable to canine uroliths as well:
https://kidneystones.uchicago.edu/
References