Artykuł przeglądowy *Review*

CT review of upper respiratory disorders in domestic cat

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Summary

Upper respiratory tract (URT) diseases are remarkably common in cats, and can be both challenging in the acute state and frustrating in the chronic state. The imaging of the feline nasal cavity and paranasal sinuses by conventional radiography is still common. However, information obtained by this technique is limited, primarily because of superimposition of anatomic structures. Radiographic findings from conventional radiography can be vastly extended with computed tomography (CT). In this article, we discuss the application of CT and the typical radiographic features of feline viral and fungal rhinitis, nasal neoplasia, inflammatory polyps, nasopharyngeal stenosis, soft palate dysgenesis, and nasal foreign bodies.

Keywords: Upper respiratory tract diseases, computed tomography, polyp, nasal neoplasia

Diagnosing diseases of the feline upper respiratory tract (URT) remains a challenge for the radiologist because of the complex anatomy of the carnivore skull. The aim of this paper is to describe frequent causes and the computed tomography appearance of typical URT diseases in the domestic cat.

Anatomy

The upper respiratory system, or the upper respiratory tract (URT), consists of the nose, nasal cavities, pharynx, and larynx. Nasal cavities extend from the rostrally located nostrils to the cribriform plate and nasopharynx as a caudal edge. There are two nasal passages and a septum between them. The nasal septum is osseous and fuses with the cribriform plate, where it becomes cartilaginous and extends rostrally. Each nasal cavity contains mucosa-covered turbinate bones (conchae), separating the cavity into passages referred to as the common, dorsal, middle, and ventral meatus. The nasal cavity is surrounded by sinuses. Cats have frontal sinuses, narrow lateral maxillary recesses, and small sphenoidal sinuses. The pharynx is a cavity behind the oral cavity, through which both food and air are transported further. The portion of the pharynx that is part of the respiratory tract is referred to as the nasopharynx, and has connection with the larynx, located directly behind the base of the tongue and the soft palate, extended into trachea. The nasal cavities are bilaterally limited by the incisive, nasal, maxillary, lacrimal, zygomatic, palatine, vomer, presphenoid, and ethmoid bones. The brachycephalic skull conformation in cats, though not considered as a disease, may lead to similar URT abnormalities as it does in dogs. The most popular cat breeds described as "brachycephalic" are Persian, Exotic, Himalayan, and Burmese cats. The skull of brachycephalic cats is round because of the reduced length of the splanchnocranium and neurocranium. Due to the head conformation and the shortening of nasal cavities, the soft tissue structures of URT may obstruct air flow and cause secondary lesions, such as the collapse of the laryngeal cartilages (10).

Computed tomography

For decades, radiography has been the gold standard in the canine and feline URT diagnostics. The imaging of the feline nasal cavity and paranasal sinuses by conventional radiography is still common.

However, information obtained by this technique is limited, primarily because of the superimposition of anatomic structures. Radiographic findings from conventional radiography can be vastly extended with computed tomography (CT). High-resolution, thin-slice transverse CT provides optimal bone detail (27). Considering the possibility of adjusting window length and width, this modality offers wide possibilities for applications in imaging soft tissue and bony

structures. Routine use of i.v. contrast agents may afford additional diagnostic value by demonstrating blood vessels, increasing contrast in different types of soft tissues, and revealing areas of excessive or prolonged enhancement, which may contribute to the inflammatory process (27). It is also possible to convert data acquired in a certain plane into another plane. This process is called multiplanar reformation or reconstruction (MPR). CT technology also makes it possible to recalculate the contribution of each voxel and reconstruct it as a 3-dimensional volume render image (3-dVR). MPR and 3dVR are helpful tools, especially in presurgical planning and for education purposes. It is also worth mentioning that modern thin-slice CT scanners can reconstruct data as a virtual endoscopy image (VE). Using soft tissue and bone algorithms is a helpful tool in standard tomogram evaluation (13).

All CT scans described in the present article were performed with a 16-slice helical CT unit (Brivo CT 385 GE Healthcare) with animals in sternal recumbency. The cats were under pharmacological sedation with butorphanol 0.3 mg/kg (Torbugesic VET 10 mg/ml, Zoetis) and medetomidine 5-20 μg/kg i.m. (Sedator 1 mg/ml, EUROVET) during the CT examination. In some cases, when sedation was not sufficient, propofol 1 mg/kg was administered to obtain general anesthesia (Propofol-Lipuro 10 mg/ml, B. Braun). Helical CT images were acquired with a slice thickness of 0.625 mm, the tube rotation was 1 s, with a current ranging from 120 to 140 mA and a voltage of 120 kVp. The matrix dimensions were 512 × 512. All studies also included images obtained pre- and post-intravenous administration of contrast, iohexol (Omnipaque; GE Healthcare Inc, Princeton, NJ, USA), at a dose of 2.2 mL/kg of body weight (concentration of 350 mg iodine/mL). The contrast agent was injected manually through an i.v. catheter placed in the cephalic vein.

Computed tomography appearance of URT diseases

Common clinical signs of URT infections include nasal and ocular discharge, epistaxis, URT noise, sneezing, and dyspnea (26). The biggest retrospective study on the causes of nasal diseases in cats (22) indicates that the most common causes include: 1) viral and/or bacterial infections, often leading to chronic rhinosinusitis; 2) anatomical changes, such as stenosis; 3) foreign bodies; 4) nasal or nasopharyngeal polyps; 5) dental issues; 6) various forms of neoplasia, of which lymphoma is the most common diagnosis.

Many researchers (6, 11, 15) argue that viral rhinosinusitis and neoplastic diseases are the most frequent causes of URT diseases. Determining the exact cause of the disease is vital for correct diagnosis and treatment. CT offers a useful tool for effective differentiation between these two causes (23). Therefore, a CT examination is an important step in the diagnostic process.

The other common diagnoses include fungal rhinitis and foreign bodies, which are discussed separately below.

Although dental disease is commonly described as a cause of rhinitis in cats, it is rarely reported. Tooth root abscesses should be considered as a differential diagnosis for cats with URT signs, especially with unilateral discharge and other evidence of dental disease (6).

Feline chronic rhinitis

Feline chronic rhinitis can be defined as an inflammation of the nasal cavity that has been present for at least one month. Because frontal sinuses are usually involved as well, the condition may also be described as chronic rhinosinusitis (6, 11). It has been proven that in most cases, the primary cause of inflammation is a viral infection combined with an impaired immune response (6, 11). The most common pathogen isolated from rhinitis patients is feline herpesvirus-1 (FHV-1). The pathogenesis of FHV-1 has been well described (12). The virus enters the cat's body via the nasal, oral, or conjunctival routes. It replicates in the nasal epithelium and spreads to the conjunctiva and the other parts of the respiratory system, causing multifocal epithelial necrosis. Viral infection starts 24 h after exposition and lasts 1-2 weeks. After this time, acute disease resolves. Like the other members of *Herpesviridae* family, FHV-1 is able to produce latent infections, particularly in the trigeminal ganglia (25). Almost all infected cats become lifelong carriers (25). Because the virus is sensitive to environmental factors, antiseptics, and detergents, pathogen shedding from infected cats is the main source of infection (25).

The other viral types detected with polymerase chain reaction (PCR) technique are feline calicivirus (FCV) and reovirus. Altogether, these three types of pathogens are responsible for approximately 90% of all feline URT infections (26). It is important to consider the outcomes of a study (16) that demonstrated little difference in the isolation rate of viruses between cats with rhinosinusitis and a healthy control group. This suggests that viral presence itself may be less important in disease manifestations than factors such as immunosuppression, bacterial co-infection, and structural damage (17). Although bacterial infection has been shown in 80-90% of cases, primary bacterial infection is thought to be rare. The onset of rhinosinusitis is marked by fever of up to 40.5°C, frequent sneezing, conjunctivitis, rhinitis, and often salivation. Initially, a serous nasal and ocular discharge occurs, but it may become mucopurulent in more chronic states. Depression and anorexia may also develop (25). Because acute or chronic idiopathic rhinosinusitis are typically considered a diagnosis of exclusion, it is important to thoroughly evaluate cats (especially adults) with URT signs.

The other primary causes of chronic rhinitis may be parasitic infections (*Cuterebra* spp.) and allergen exposure (pollen, house dust, molds) (15).

Described clinical changes correspond with computed tomography findings detectable during examination. Due to increased epithelial permeability, free fluid accumulation might be observed, mostly in the dependent portion of the nasal cavity. Not always inflammatory exudate can be easily distinguished from a soft tissue mass, because protein-containing fluid may exhibit similar x-ray attenuation as soft tissue (12). This is one of the reasons why contrast studies are routinely performed. This type of studies may strongly enhance blood vessels within soft tissue structures, thus increasing the attenuation of x-rays in a specific area (33). Attenuation might be objectively measured with the Hounsfield Unit scale. Although no imaging findings are pathognomonic for inflammation, some imaging characteristics have been found to be helpful in differentiating between nonspecific rhinitis and nasal neoplasia. Different studies have identified a large group of radiological signs that might be suggestive in distinguishing inflammatory processes. The most suggestive has been gathered in the bracket:

Tab. 1. Comparison of CT features of neoplastic and inflammatory diseases of URT

Inflamatory	Neoplasia
– lack of maxilloturbinate destruction, – fat attenuating hilus of medial retropharyngeal lymph nodes on pre- and postcontrast images (23), – absence of paranasal bone changes (5)	– maxilloturbinate destruction, – bone destruction involving maxilla, palatine, lacrimal bone, – presence of homogeneous space-occupying mass, – nasal septum destruction (29), – lack of fat attenuating hilus of medial retropharyngeal lymph nodes on pre- and postcontrast images (23)

Although many of the previously mentioned findings may be useful in clinical practice, it should be pointed out that biopsy remains the gold standard in differentiating between inflammatory and neoplastic processes (23).

Fungal rhinitis

Signs of fungal rhinitis include epistaxis, sneezing, mucopurulent nasal discharge, exophthalmos, and mandibular lymphadenopathy. The most characteristic CT findings in fungal rhinitis are severe turbinates and paranasal bone lytic changes. Other findings include abnormal soft tissue attenuation in the nasal cavity, turbinate thickening, fluid accumulation, and lymphadenopathy (17). Because nasal flushing is a treatment of choice for fungal rhinitis, it is crucial to assess the cribriform plate before the procedure. The reason for this is that the lytic process may be extended, and if the cribriform plate is involved, nasal flushing is con-

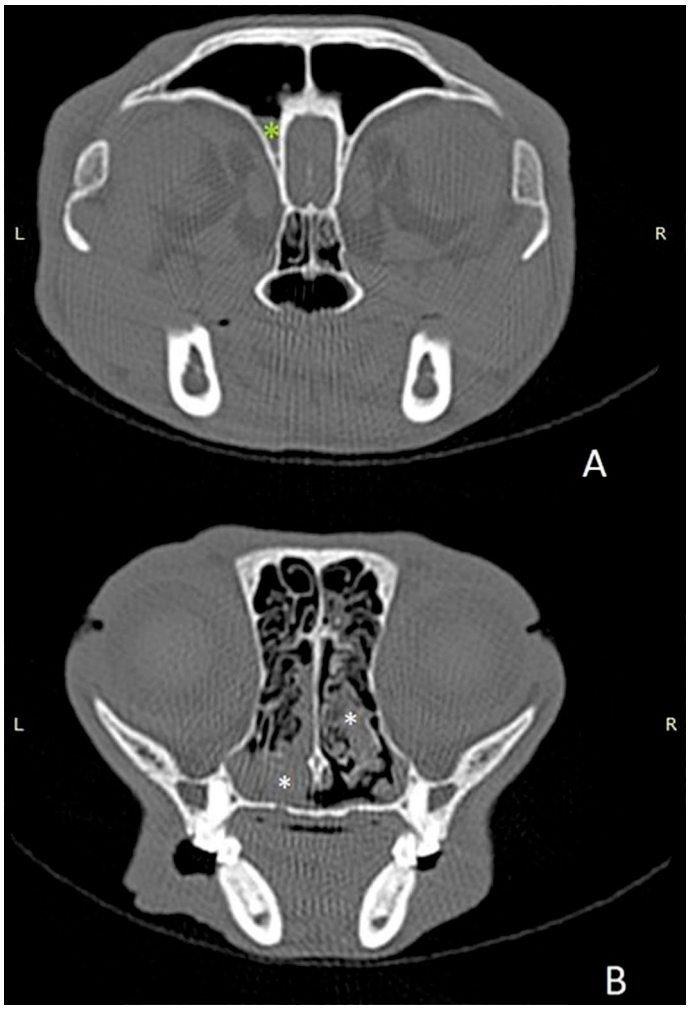

Fig. 1. Transverse CT images of the nasal cavity and frontal sinuses of a cat diagnosed with rhinitis. Note the bilateral soft tissue/fluid opacification of the nasal cavities (B, white asterisks) and the soft tissue/fluid opacification of the ventral part of right frontal sinus (A, green asterisks)

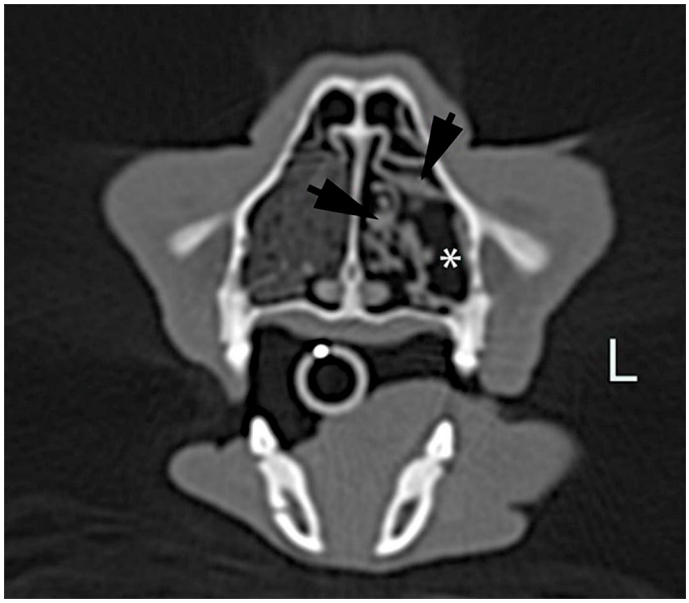

Fig. 2. Transverse CT images of the nasal cavity and frontal sinuses of a cat diagnosed with fungal rhinitis (aspergillosis). The image shows conchal destruction in the left nasal cavity creating hypoattenuating areas (white asterisks) and a thickening of the remaining conchal structures (black arrows)

traindicated because of the high risk of intracranial damage (20). The most common mycotic pathogens causing rhinitis in cats are *Cryptococcus neoformans* and *Aspergillus* sp. Other fungal diseases affecting the nasal cavity in cats include hyalohyphomycosis and phaeohyphomycosis (17). Differentiating between fungal rhinitis and nasal neoplasia remains challenging because of the similar computed tomography appearance and the lack of literature data.

Neoplastic disease

Neoplasia is the second most frequently diagnosed cause of URT diseases in cats (24). The median age is 11 years (range 2-20 years). Factors predisposing to neoplasia, including the sex, breed, and skull conformation, have been identified in several feline studies.

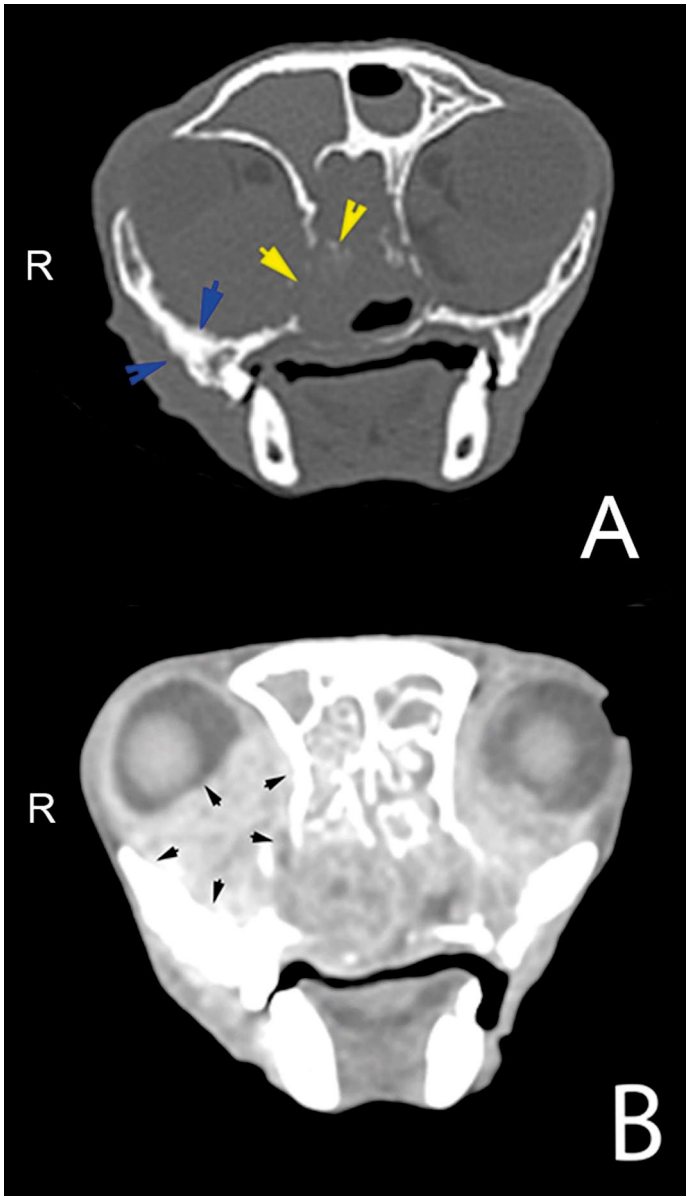

Fig. 3. Transverse CT images of the nasal cavity and frontal sinuses of a cat diagnosed with nasal lymphoma. Note the paranasal bones and turbinate lysis (yellow arrows), periosteal reaction (blue arrows), and the retrobulbar mass leading to exophthalmos (black arrows)

Tab. 2. Comparison of CT features of nasal lymphoma and carcinoma

Carcinoma	Lymphoma
– extension of the tumor into the orbit (29), – more subtle contrast enhancement, – more heterogeneous contrast enhancement (21), – unilateral nasal changes, – intralesional calcification, – extension of the mass lesion within the frontal sinus (5), – absent or mild lymphadenopathy (20)	– minor mass effect (29), – abnormal perinodal fat, – abnormal hilus of medial retropharyngeal lymph nodes, – lymphadenopathy (23)

Lymphoma is the most frequent neoplasia of the feline nasal cavity (21, 23), with a median age of 9 years (range 2-16 years). The median age for the second most frequently diagnosed nasal tumor, malignant epithelial neoplasia (adenocarcinoma and carcinoma), is 12.5 years (range 5-20 years) (21, 23). Benign tumors, such as adenomas, fibromas, fibropapillomas, hemangiomas, and chondromas, have been described in various case reports (22).

Clinical signs can be similar for both neoplastic and inflammatory diseases. Therefore, an early accurate diagnosis followed by proper therapy is essential for the optimal clinical outcome. Several computed tomography findings have been shown to be reliable in differentiating between neoplastic disease and rhinosinusitis. These include process laterality (bilateral vs. unilateral), paranasal bones and turbinate lysis, presence of a mass effect, and appearance of regional lymph nodes (21, 23).

Although, no imaging findings are pathognomonic for certain types of neoplasia, some imaging characteristics have been found to be helpful in differentiating between the most common neoplasia.

Nasopharyngeal polyps

Feline nasopharyngeal polyps (FNPs) are a common cause of URT disorders. They reportedly account for 20% of nasopharyngeal diseases (22). They are non-neoplastic, inflammatory-derived nodules that arise from the middle ear or the Eustachian tube and extend into the pharynx. The exact etiology of nasopharyngeal polyps remains unclear. Although chronic otitis media, respiratory tract infections, nasopharynx infections, and congenital origin have been investigated as potential causes, the relationship has not been proven (18). Young adult cats are an overrepresented group (2 years median). In this group, a congenital origin has been suspected, in which the polyp is thought to develop from branchial arch remnants (26). Cats with FNPs may have a chronic history, which may include clinical signs typical of URT infection, such as nasal discharge, sneezing, and rhinitis or sinusitis, secondary to the obstruction of normal air flow. Other clinical signs may include dyspnea, stridor, weight

loss, epistaxis, voice change, and dysphagia. Cats with large polyps obstructing the nasopharynx may present with cyanosis and syncopal episodes. Cats with FNPs may present with signs of otitis externa, otitis media, or otitis interna (24, 25).

Computed tomography findings in cats with nasopharyngeal polyps include a soft tissue mass within the nasopharynx and/or the tympanic cavity and/or the external ear canal, and a thickening of the tympanic bulla. The mass can be described as isoattenuating to soft tissue, homogeneous and with ill-defined borders on precontrast images. After contrast medium administration, the polyps are homogeneous, oval-shaped, with well-defined borders, and with rim enhancement. Additionally, a mass effect may be observed (24). A postcontrast rim enhancement of nasopharyngeal polyps is reported to be a common finding in CT images. This regular pattern may help distinguish a nasopharyngeal polyp from a collection of exudate or a neoplastic mass. The extent of increased attenuation in the outer zone is correlated with the histologic grade of inflammation in the superficial layers. The medial retropharyngeal lymph node lateral to the polyp tends to be larger than the contralateral node in over half of cases (24). Most FNPs extend from the tympanic cavity (68%), nasopharynx (18%), and external ear canal (14%) (19).

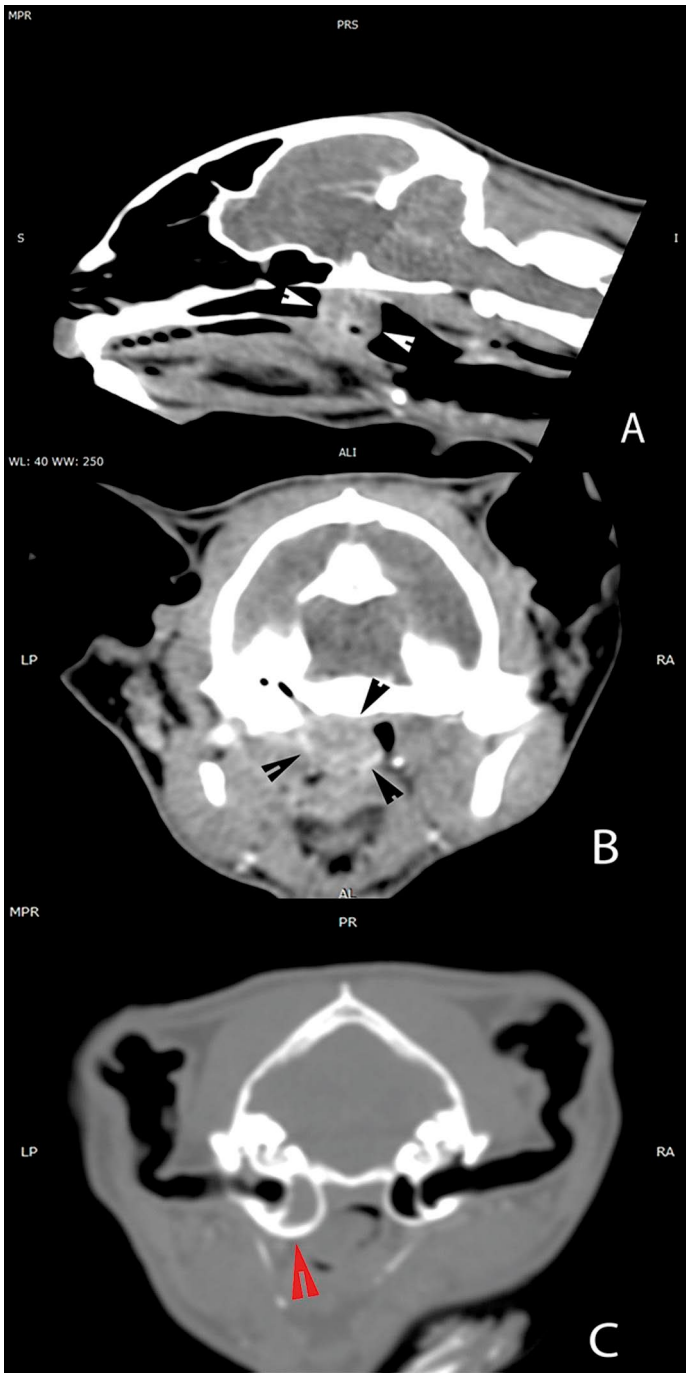

Fig. 4. 2-year-old domestic short haired cat with a nasopharyngeal polyp. Images A and B obtained using a soft tissue algorithm in a postcontrast exam. The soft tissue attenuating mass in the nasopharynx has been visualized. Note the characteristic hyperattenuating peripheral rim (white and black arrows). Image C was obtained using a high-frequency reconstruction algorithm, note the tympanic bulla thickening and expansion (red arrows)

Nasopharyngeal stenosis

Nasopharyngeal stenosis (NPS) is a pathologic narrowing within the nasopharynx. It results in inspiratory and expiratory stertor, open mouth breathing, nasal and ocular discharge, and even dyspnea in more severe cases. This can occur as a congenital anomaly, such as choanal atresia, or, more commonly, it may be secondary to an inflammatory condition, such as chronic rhinitis, trauma, or a tumor/polyp (31). Both

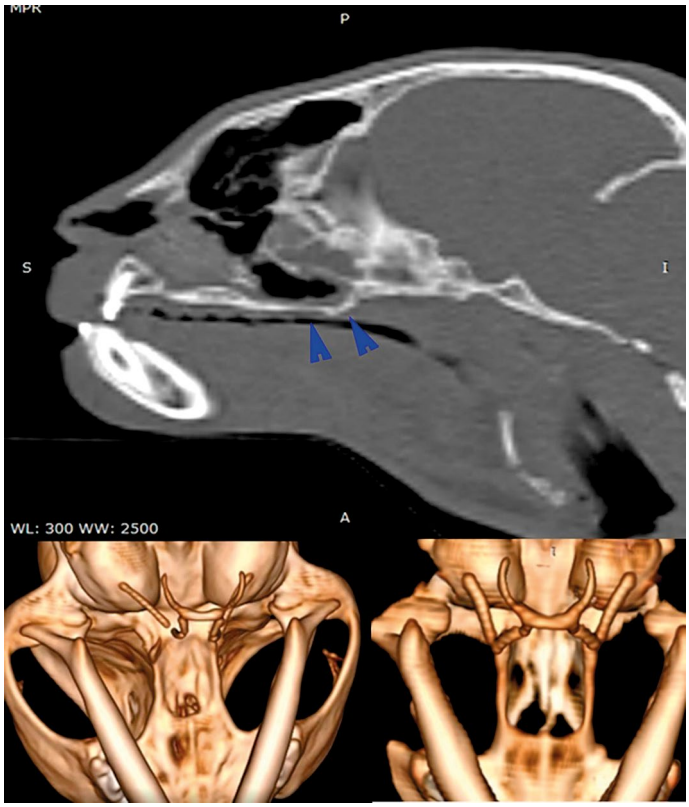

Fig. 5. 3-year-old domestic short haired cat with bilateral choanal atresia. Note the total occlusion of the choanae caused by abnormal bone. 3d reconstruction has been attached to visualize morphological differences between atretic (left) and normal (right) choanae

computed tomography and recurrent endoscopy are excellent tools for establishing a diagnosis (11). The computed tomography appearance depends on the primary cause. NPS secondary to chronic rhinitis may be shown as a narrowing of the nasopharynx, bilateral fluid accumulation in nasal cavities, and turbinate thickening (*). Choanal atresia is an uncommon congenital condition in which the choana (the nasal passage into the nasopharynx) is blocked by abnormal bone or soft tissue uni- or bilaterally (28).

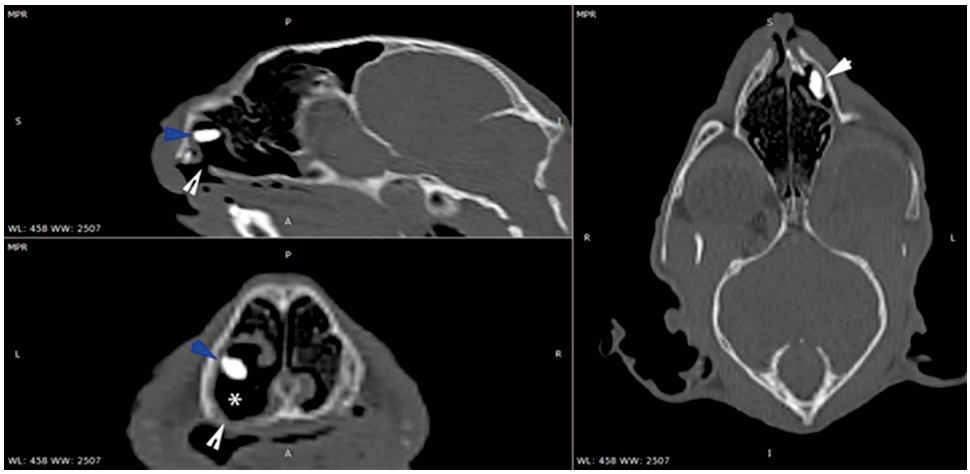

Fig. 6. Foreign body (tooth) in the left nasal cavity of a cat. Note the oronasal fissure (blue arrow) and turbinate lysis (white asterisks)

Foreign bodies

Plant material is the most common type of foreign bodies found in URT. This includes grass blades, grass seeds, sticks, pieces of wood, and conifer material. In outdoor cats, with a sudden onset of clinical signs, a foreign body should always be considered. Sneezing and unilateral mucopurulent nasal discharge are typical findings. The diagnosis and treatment of nasal foreign bodies usually include a combination of rhinoscopy and imaging techniques, such as CT (12). According to the literature, the prevalence of nasal foreign bodies as a cause of chronic nasal disease ranges from 5 to 20% for dogs (2-4, 8) and from 2.6 to 10% for cats (6, 9). The visibility of foreign bodies varies depending on their nature. In one study (22), a grass seed was visible in CT images in 19% of cases. Secondary lesions were visible in CT images in 96% of cases, including a collection of exudate (37%), abscess (24%), and enlarged lymph nodes (22%). A unilateral, focal, linear, homogeneous soft tissue attenuating lesion (20-60 HU) is the most typical CT appearance of a nasal foreign body of plant origin. It is also important to note that fluid accumulation is present in over 90% of cases. Another common sign is the presence of turbinate destruction and mucosal thickening. Skull bone lysis has not been reported. Other foreign bodies reported in the nasal cavity are teeth, which can be easily diagnosed because of their very high x-ray attenuation (1800-2200 HU) (14).

Conclusion

Thanks to the lack of superimposition of anatomic structures, multiplanar reformation, and routine use of i.v. contrast agents, computed tomography provides a greater amount of information about the disease processes of URT. Since no CT findings can be considered pathognomonic for a specific URT disease or tumor tissue type (29), nasal biopsies remain the gold standard for a definitive diagnosis.

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