Some Aspects of Nasal Disease in the Cat

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Abstract

The aim of this study was to describe the radiographic signs of cats with chronic nasal disease and to assess the level of agreement between two independent observers in identifying these features.

Nasal radiography of 85 cats were reviewed retrospectively by two independent observers. Computed Tomography and Magnetic Resonance Imaging were also performed in five and one cases respectively. Individual review was followed by consensual evaluation. The consensual radiological diagnosis was compared to the definitive diagnosis confirmed by histopathology. Seventy three cats were included in this part of the study, 55 (75%) cats had rhinitis and 18 (25%) had definitive diagnosis of neoplasia. The positive predictive values (PPV) were calculated for the diagnosis of each disease. The agreement between observers was also evaluated. The signs with higher PPV for nasal neoplasia were invasion of bony case (PPV= 88.8%) and vomer destruction (PPV=86.6%). Generalized unilateral location of the lesion had a PPV of 46.7%, whereas both loss of turbinate detail and soft tissue opacity showed a PPV of 42.8%. When these signs occurred together in an animal with nasal neoplasia, the PPV reached 80%. Radiographic signs for rhinitis were more variable. The presence of a mixed pattern (PPV=84%), and nasal cavities within normal limits (PPV=18.2%) were the features frequently found. A high level of agreement between observers as to the final radiographic diagnosis (k=0.94). With regard to specific features of nasal neoplasia and rhinitis, the agreement was very good in tumour cases; but in rhinitis was moderate, which confirms the variability of the rhinitis lesions. In summary, this study indicates a high degree of accuracy in the differentiation of radiographic features of neoplasia and chronic rhinitis in cats with chronic nasal disease.

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Dedication

To my father

To all my family

Declaration

I, Inés Carrera, declare that the work in this thesis is original, was carried out solely by myself or with due acknowledgements. It has not been submitted in any form for another degree or professional qualification.

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This MVM has been an unforgettable experience given all I have learned, and overall, to have had the opportunity of doing research at the University of Glasgow and have shared this time with the wonderful people at the Small Animal Hospital.

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1 Introduction

1.1 Overview

Diseases of the feline upper respiratory tract are frequently encountered in companion animal practice and represent a diagnostic and management challenge. Although these can range from viral infections to neoplasia, nasal disease is frequently characterised by sneezing and a non-descript nasal discharge (Demko and Cohn 2007). The definitive aetiology is, in most of the cases, very elusive and difficult to elucidate. The optimum diagnostic approach for cats with chronic nasal disease remains to be determined. Potentially useful diagnostic techniques such as brush cytology (Caniatti, Roccabianca, Ghisleni et al. 1998), rhinoscopy (Johnson, Clarke, Bannasch et al. 2004), radiography (O'Brien, Evans, Wortman et al. 1996, Lamb, Richbell and Mantis 2003), and computed tomography (Tromblee, Jones, Etue et al. 2006) have been described. However, even when invasive or expensive testing is performed, a specific aetiology for chronic nasal disease may be identifiable in less than half of the cases (Michiels, Day, Snaps et al. 2003, Henderson, Bradley, Day et al. 2004).

Radiography is an inexpensive, relatively easily accessible diagnostic imaging technique. It has been reported as a good first diagnostic step in the diagnosis of nasal disease in cats (O'Brien, Evans, Wortman et al. 1996, Lamb, Richbell and Mantis 2003). However, both of these studies found considerable overlap between the radiographic signs of chronic rhinitis and neoplasia. Radiography therefore, must be accompanied by further diagnostic tests to search for the primary causal agent. However, as stated previously, even when all possible diagnostic techniques are used, it may be still difficult or impossible to identify the cause.

The aim of this study was to compare the radiographic interpretation of two independent observers, in order to determine if significant differences between them could vary the decision on the final radiological diagnosis, and correlate the radiographic findings with the definitive diagnosis when known.

1.2 Categories of disease in the nose and nasal sinuses

A– Infectious rhinitis

A.1– Viral

Feline Herpes virus (FHV)

Feline Calicivirus (FCV)

A.2– Bacterial

A.2.1– Primary bacterial rhinitis

Bordetella bronchiseptica

Chlamididophila felis

A.2.2– Secondary pathogens

Staphylococus spp

Streptococcus spp

Pasteurella spp

Coliforms

A.3– Mycotic rhinitis

A.3.1– Cryptococcosis

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B– Inflammatory rhinitis

B.1– Nasopharyngeal polyps

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Deformity of the nasal cavity

Foreign body

Haemophilus felis

Oral disease

Palate defects

Stenotic nares

A– Infectious rhinitis

A.1– Viral

Within the spectrum of feline respiratory disease, viral upper respiratory disease is clearly the most prevalent and most severe. Infection rates within a population of cats can approach 100%. Profoundly varied clinical signs, high morbidity and mortality amongst kittens, inconsistent responses to therapy, and chronic infection amongst young and adult cats characterize clinical features and disease progression. At least 80% of cases of feline viral respiratory disease are caused by one or two viral groups: FHV and FCV (Gaskell and Dawson 1994). Numerous agents have been isolated, such as reovirus and cowpox virus, but the clinical importance of these is minor (Gaskell and Dawson 1994).

Feline Leukaemia Virus (FeLV) and Feline Immunodeficiency Virus (FIV) infection is reported to be a common concomitant or predisposing infection in cats infected by a range of micro organisms. However, some studies have suggested that the association between retroviral infection and chronic nasal diseases may be less important than previously thought (Cape 1992, Michiels, Day, Snaps et al. 2003).

FHV is a typical herpes virus, containing double-stranded DNA with a glycoprotein-lipid envelope. The fragility of the envelope limits the survival of FHV in the environment to 18 hours in damp and 12 hours in dry conditions, making it highly susceptible to destruction by common disinfectants (Kadoi, Kiryu, Iwabuchi et al. 1997). On the other hand, FCV is a small, non-enveloped, single-stranded RNA virus that infects both domestic cats and other Felidae. Unlike FHV, there are a large number of different strains of FCV with varying antigenicity and pathogenicity. However, there is sufficient cross-reactivity to group all the serotypes into a single one, based on nucleotide sequence analysis (Glenn, Radford, Turner et al. 1999). Although both viruses are relatively short lived outside the cat, FCV is slightly more resistant than FHV surviving for up to one week, or possibly longer if the environment is damp. Fomite spread is therefore likely to be of more significance for the transmission of FCV than FHV. FCV is inactivated by iodine, hypochlorite and glutaraldehyde, but not by quaternary ammonium products, anionic detergents, and ethanol (Doultree, Druce, Birch et al. 1999, Sykes 2001)

Pathophysiology

a) Natural infection with FHV takes place via the nasal, oral or conjunctival routes. The virus primarily targets the mucosa of the upper respiratory tract including soft palate, tonsils, and turbinates, and also the conjunctivae. The upper trachea may sometimes be involved. Viraemia is rare because virus replication is normally restricted to areas of lower body temperature such as the respiratory tract. Infection with FHV leads to multifocal epithelial necrosis with neutrophilic infiltration and fibrin exudation. Intranuclear inclusion bodies are present in infected cells. Replication of the virus can also lead to osteolytic changes in the turbinate bones. Acute lesions normally take between 2 and 3 weeks to resolve, although turbinate destruction may be permanent, predisposing affected animals to chronic rhinitis. Primary lung involvement may occur, but it is rare. Secondary bacterial infection can enhance the onslaught leading to, for example, bacterial pneumonia and sinusitis (Gaskell and Dawson 1994).

b) The natural routes of infection for FCV are nasal, oral or conjunctival. Replication occurs mainly in the oral and respiratory tissues, although there are slight differences between strains of FCV in tissue tropism and pathogenicity. Thus some strains have a predilection for the lung, and others have been found within macrophages of the synovial membrane of joints (Bennett, Gaskell, Mills et al. 1989). Oral ulcers are the predominant pathological feature of FCV infection. These begin as vesicles that subsequently rupture, with necrosis of the overlying epithelium and infiltration of neutrophils at the periphery and base. The ulcers generally heal over a period of 2-3 weeks. Pulmonary lesions occur less frequently and appear to result from an initial focal alveolitis, leading to areas of acute exudative pneumonia and subsequent development of a proliferative interstitial pneumonia (Gaskell and Dawson 1994).

Clinical signs

a) Feline Herpes virus infection typically causes a severe upper respiratory disease, particularly in young susceptible animals. The incubation period is usually 2-6 days, but may be longer. A lower dose is generally associated with a longer incubation period and milder clinical signs. Initial signs include depression, marked sneezing, inappetance and pyrexia, followed rapidly by serous ocular and nasal discharges. Conjunctivitis typically develops and the ocular and nasal discharges change from serous to mucopurulent. In severe cases, dyspnoea and coughing may

also be present. Oral ulceration can occur, but this is less common if compared with FCV infection, where it is a characteristic feature. Occasionally, primary viral pneumonia or generalised disease may occur, particularly in young or debilitated animals. Other manifestations of infection include ocular disease such as ulcerative or interstitial keratitis (Gaskell and Dawson 1994).

b) Different spectra of clinical signs may be seen due to the large number of strains of FCV. Most strains induce a fairly characteristic, mild upper respiratory tract syndrome with pyrexia, oral ulceration and mild respiratory and conjunctival signs. In contrast, some strains appear to be non-pathogenic, whereas other strains are more virulent and capable of inducing more severe disease. Recently, an outbreak of severe haemorrhagic fever has been described, caused by a highly virulent strain of FCV (Pedersen, Elliott, Glasgow et al. 2000). Ulcers may also be seen on the lips and the nose. Some of the more virulent strains of FCV may cause pneumonia with associated dyspnoea. FCV has been reported in occasional cases of abortion. A feature of some FCV strains is a lameness and pyrexia syndrome (Pedersen, Bitsch, Knox et al. 1981, Dawson, Smyth, Bennett et al. 1991, TerWee, Lauritzen, Sabara et al. 1997). This lameness, which may or may not be associated with respiratory disease, is commonly seen as shifting lameness accompanied by pyrexia. Affected cats are dull and anorexic. Lameness, with or without respiratory disease, has also been described after vaccination (Church 1989, Dawson, McArdle, Bennett et al. 1993).

Although clinical and epidemiologic features of infectious upper respiratory disease are well defined, clinical signs associated with one organism can be remarkably similar to those produced by another. However, sneezing is the hallmark of acute infectious upper respiratory disease (Demko and Cohn 2007).

A chronic carrier state exists if virus persists in a complete or partial form beyond elimination and normal recovery from the acute infection. It is important to note that as many as 80% of cats that recover from acute viral upper infection are likely to become chronic carriers and are therefore able to infect susceptible cats and kittens (Reubel, Ramos, Hickman et al. 1993). The nature of chronic feline herpes virus infection differs from that of chronic feline calicivirus. In the FHV carrier state, the virus enters a non-replicative state that persists for the life of the animal (Gaskell and Dawson 1994). Reactivation of virus shedding occurs with or without concurrent clinical signs, and it may occur spontaneously or after natural or artificial (corticosteroid-induced) stress

(Sykes 2001). In contrast, FCV is excreted continuously from the oropharynx of carrier cats and it is not caused by stress (Wardley 1976).

Two mechanisms have been proposed that may induce chronic disease (Cape 1992). First, as explained above, carrier states may lead to chronic clinical signs. Second, FHV causes bony and mucosal injury to the turbinates, which may predispose the nasal cavity to secondary bacterial infection, leading to chronic rhinitis and secondary sinusitis.

A.2–Bacterial Infections

A.2.1–Primary

Bordetella bronchiseptica

This is an aerobic Gram-negative coccobacillus, the pathogenicity of which is determined by the presence of several virulence factors.

In the past, *B. bronchiseptica* was considered to play only a secondary role in feline respiratory disease, but is now established as a primary pathogen. Respiratory disease has been reproduced in specific pathogen-free cats following both aerosol and nasal challenge (Jacobs, Chalmers, Pasman et al. 1993, Coutts, Dawson, Binns et al. 1996), and a number of field cases associated with *B. bronchiseptica* have also been reported (Willoughby, Dawson, Jones et al. 1991, Welsh 1996, Binns, Dawson, Speakman et al. 1999). These studies showed that infection is widespread in the cat population and found a significant association between the presence of *B. bronchiseptica* and respiratory disease in rescue catteries. In recent epidemiological studies (Dawson, Jones, McCracken et al. 2000), contact with dogs with respiratory disease was identified as a significant risk factor for infection with *B. bronchiseptica* in the cat; since dog and cat isolates from the same household often appeared similar.

Pathogenesis

The pathogenesis of B. *bronchiseptica* is determined by the presence of several virulence factors such as fimbrae, which mediate adhesion to host cells; and flagellae, which make the organism motile (Gaskell and Dawson 1994). The primary route of infection appears to be initiated via the oronasal cavity where the organism colonises mucosal surfaces. The release of toxins from *B. bronchiseptica* following colonisation

is responsible for focal and systemic inflammatory damage (Speakman, Dawson, Binns et al. 1999).

Clinical signs:

A range of clinical signs has been reported in infected cats (Willoughby, Dawson, Jones et al. 1991, Welsh 1996, Binns, Dawson, Speakman et al. 1999), varying from severe dyspnoea, cyanosis and death due to bronchopneumonia to milder signs of sneezing, oculonasal discharge and coughing. In general, coughing appears to be much less marked in cats than in dogs.

Young kittens appear to be most susceptible to *B. bronchiseptica* respiratory disease, particularly bronchopneumonia. In the field, it is possible that factors such as hygiene and overcrowding, may contribute to a heavy burden of infection and increased severity of clinical signs (Willoughby, Dawson, Jones et al. 1991).

Even though *B. bronchiseptica* is considered a primary pathogen in nasal disease, it can play a secondary role as well. Welsh (1996) reported a 13-year old castrated male domestic short hair, with unilateral, purulent nasal discharge. A papillary adenocarcinoma was diagnosed and additionally, *B. bronchiseptica* was isolated from a nasal wash, thought to be secondary infection.

Chlamydophilia felis

Chlamydiae are obligate intracellular Gram-negative bacteria with rigid walls. These bacteria have a tendency to produce chronic or relapsing infections, suggesting that the host immune response is only partially effective. *Chlamydia psittaci* has a number of different strains, infects a wide range of veterinary species and has a worldwide distribution. A single strain is thought to infect cats and has recently been renamed *Chlamydophilia felis* (Everett, Bush and Anderson 1999). *C. felis* is recognised primarily as an ocular pathogen, being responsible for up to 30% of cases of conjunctivitis in the UK (Wills, Howard, Gruffydd-Jones et al. 1988).

Pathogenesis

Much remains unknown regarding the pathogenesis of chlamydial infections in cats. The organism appears to have predilection for the conjunctival epithelial cell. Natural transmission of *C. felis* presumably occurs by close contact with other infected cats and their aerosols, via fomites. Mutual grooming and self-grooming are probably important means of natural inoculation. The incubation period in experimentally infected cats is

approximately 3-5 days. The chlamydial development cycle involves an alternation between the predominantly extracellular, infectious elementary body (EB), and the intracellular, metabolically active reticulate body (RB). Infections caused by chlamydiae tend to follow a chronic, insidious course, often progressing through asymptomatic stages. *Chlamydiae* may be capable of passing through periods of delayed development interspersed with production of new crops of infectious EBs (Greene 1998).

C. *felis* may also be capable of entering a persistent state within tissues. Conjunctivitis associated with *C. felis* may persist for 8 months following infection, despite signs of chronic conjunctivitis only being apparent for approximately 2 months (Wills, Howard, Gruffydd-Jones et al. 1988). Systemic therapy is often required to eliminate shedding (Sparkes, Caney, Sturgess et al. 1999). Elimination of infection may also have public health significance, as it has been suggested that *C. felis* could be transmitted to people (Yan, Fukushi, Matsudate et al. 2000)

Chlamydial disease may be exacerbated by superinfection with other microorganisms. In one study, 8% of cats had both chlamydial and either FCV or FHV infection (Wills, Howard, Gruffydd-Jones et al. 1988). Cats with concurrent FCV infection had additional signs, such as oral ulceration, in addition to conjunctivitis. Dual infection with FCV appears to be more common than with FHV, although this may relate to the ease of FCV detection compared with FHV (Wills, Howard, Gruffydd-Jones et al. 1988). Co-infections with FIV (feline immunodeficiency virus) prolong the duration of conjunctivitis and chlamydial shedding; and in cats with FIV infection, superinfection with *C. felis* may accelerate the clinical progression of FIV infection (O'Dair HA, Hopper CD, Gruffydd-Jones TJ et al. 1994).

Clinical signs

C. felis is primarily a conjunctival pathogen capable of causing acute to chronic conjunctivitis, with blepharospasm, chemosis and congestion, and a serous to mucopurulent ocular discharge, but no dyspnoea or coughing. Transient pyrexia, reduced appetite and weight loss may occur shortly after infection. Clinical signs improve after a few weeks, but mild conjunctivitis persists for several months. Nasal discharge and sneezing may be present in some cats. The strain and/or the route of infection may influence the extent of respiratory tract involvement. Sneezing and nasal discharge without concurrent ocular involvement is highly unlikely to be associated with *C. felis* infection (Sykes, Anderson, Studdett et al. 1999).

A.3– Mycotic Rhinitis

A.3.1–Cryptococcosis

In the United States, cryptococcosis is the most frequently encountered systemic fungal infection in cats, accounting for 46.1% of all mycotic infections (Davies and Troy 1996). Unlike other fungal infections, cryptococcosis does not occur in a defined geographic region. Although there are several different species of the genus cryptococcus in the environment, only one, *C. neoformans*, causes disease (Medleau and Barsanti 1998)

C. neoformans is a saprophytic round yeast-like fungus that does not take up common cytological stains. Buds can break off at different stages of growth, resulting in organism size variation in tissues. Most likely environmental sources are locations near avian habitats or in leaf and bark litter of eucalyptus trees. The pigeon is considered to be the most important vector as the elevated body temperature is thought to protect it from the disease (Medleau and Barsanti 1998).

Pathogenesis and clinical signs

The exact mode of infection of cryptococcosis is unknown, but most evidence points towards inhalation of aerosolised basidiospores. In cats, the nasal cavity is usually the primary site of infection. Once inhaled, the organism regenerates its capsule, lodges in the nasal passages, and begins to initiate a mycotic rhinitis. If the rostral part of the nasal cavity is involved, clinical signs such as sneezing, wheezing and nasal discharge are prevalent. When the caudal nasal structures are affected, nasopharyngeal involvement may be possible. Signs of stertor, inspiratory dyspnoea and upper airway obstruction may be also present (Malik, Martin, Wigney et al. 1997). Although the mechanism of extension to the central nervous system is unknown, it has been suggested that it is the result of invasion of the cribriform plate or along the optic nerves (Jacobs, Medleau, Calvert et al. 1997). Cerebral cryptococcal granulomas in cats have been increasingly reported (Beatty, Barrs, Swinney et al. 2000, Foster, Charles, Parker et al. 2001, Mandrioli, Bettini , Marcato et al. 2002).

The establishment and spread of infection are highly dependent on host immunity. In cats, infection with FeLV or FIV may be a predisposing factor for feline cryptococcosis (Malik, Martin, Wigney et al. 1997).

A.3.2– Aspergillosis

Aspergillus species are ubiquitous in the environment and are considered opportunistic invaders. Two distinct manifestations of aspergillosis in dogs and cats occur; a localized nasal form and disseminated disease.

Infection with Aspergillus *spp* in cats is rare with reports of three cases of sinusitis with orbital involvement and seven cases of nasal aspergillosis (Wilkinson, Sutton and Grono 1982, Goodall, Lane and Warnock 1984, Hamilton, Whitley and McLaughlin 2000, Tomsa, Glaus, Zimmer et al. 2003, Whitney, Broussard and Stefanacci 2005).

Disseminated aspergillosis is apparently opportunist in immunosuppressed cats and tends to be secondary to immunosuppresive disorders such as diabetes mellitus, FeLV, FIV and feline panleukopenia, or prior use of glucocorticoids or antibiotics (Davies and Troy 1996).

In animals with a localized nasal fungal infection, an adequate, predominantly cellular, immune response may prevent systemic spread. Some defects of local defence mechanisms (previous trauma), or other underlying disease (previous FHV) may permit persistence of the infection. However, in the most recent report of feline aspergillosis the four cats were healthy, middle-aged, retrovirus negative with no previous history of glucocorticoids or antibiotic therapy, or trauma (Whitney, Broussard and Stefanacci 2005).

Most cases of canine aspergillosis occur in mesaticephalic and dolicocephalic breeds. Albeit on limited data so far, it has been theorized that brachycephalic cats are susceptible to fungal infections because of alterations in nasal airflow and mucociliary clearance, as Persian cats seem predisposed (Davies and Troy 1996, Whitney, Broussard and Stefanacci 2005).

Signs of fungal rhinitis include epistaxis, sneezing, mucopurulent nasal discharge and exophthalmus.

B– Inflammatory Rhinitis

B.1– Nasopharyngeal Polyp

Nasopharyngeal polyps are non-neoplastic, inflammatory growths that originate from the middle ear or the eustachian tube and extend to the pharynx and nasal cavity (Lane, Orr, Lucke et al. 1981, Bradley 1984). Often arising from a stalk, they consist of a

loosely arranged fibrovascular tissue covered by a stratified squamous to ciliated columnar epithelial layer (Lane, Orr, Lucke et al. 1981)

The causes of inflammatory polyps in cats are unknown. It has been hypothesised that they are congenital defects arising from remnants of branchial arches (Baker 1982), a response to irritation from chronic viral infections (Rogers 1988), or chronic inflammation secondary to otitis media (Cook, Bergman, Bahr et al. 2003). A recent study (Veir, Lappin, Foley et al. 2002), found that neither calicivirus nor herpesvirus could be detected by polymerase chain reaction in fresh or formalin-fixed polypoid tissue, and concluded that these agents were not responsible for the growth of nasophraryngeal polyps, or that they were cleared by immunologic defense by the time of polyp removal.

Clinical signs associated with nasopharyngeal polyps include:

i. Sneezing: may occur if the nasal turbinates are irritated or if the disease also affects the rostral nasal cavity
ii. Nasal discharge
iii. Stertorous respiration with or without concurrent signs of otitis media and externa, phonation changes and weight loss
iv. Episodes of acute respiratory distress with cyanosis and syncopal attacks can be attributed to upper airway obstruction
v. Involvement of the middle ear manifested by Horner's syndrome or facial nerve paralysis, whereas signs of head tilt, ataxia and nystagmus indicate involvement of the inner ear

No breed or sex predisposition has been identified. It has traditionally been thought that nasopharyngeal polyps primarily occur in younger animals, but Veir, Lappin, Foley et al. (2002) suggested that the disease should be on the differential diagnosis list for middle-aged to older cats with aural and nasal signs as well.

B.2– Idiopathic Chronic Rhinosinusitis

Idiopathic chronic rhinosinusitis is inflammation of the nasal cavity and sinuses that has been present persistently or intermittently for four weeks or longer, in which a specific or primary aetiology cannot be identified. (Bradley 1984, Cape 1992, Michiels, Day, Snaps et al. 2003). The term non-specific rhinitis has also been used (Michiels, Day, Snaps et al. 2003). It has been suggested that a previous viral infection may play a role in the chronically inflammed and reactive nasal cavity (Michiels, Day, Snaps et al. 2003, Johnson, Foley, De Cock et al. 2005). However, it is difficult to assess the present

or past involvement of viral infection in all cases of feline chronic rhinosinusitis. Therefore, even isolation of virus from the nasal cavity of a cat with chronic rhinosinusitis does not prove its involvement in the current disease process; but on the other hand, it must be kept on mind that a previous viral infection may have caused serious and chronic injuries to the turbinates (Michiels, Day, Snaps et al. 2003).

C– Neoplasia of the Nose and Nasal Sinusitis

Tumours of the nasal cavity and sinuses are uncommon in cats. Early studies indicated that feline nasal and paranasal tumours comprised approximately 1% of all feline tumours reported (Moulton 1990). A later study indicated an increase to about 8.4% (Cox, Brawner, Powers et al. 1991). Generally, feline nasal and paranasal sinus tumours are malignant (Cox, Brawner, Powers et al. 1991, Mukaratirwa, van der Linde-Sipman and Gruys 2001), most are locally invasive, and with distant metastasis rare (Legendre, Krahwinkel and Spaulding 1981).

Numerous types of cells may give rise to neoplasia of the nose and paranasal sinuses. The normal nasal cavity is lined by a thick keratinised squamous epithelium on its rostral cutaneous part of the nasal cavity (vestibule). At mid-vestibule the epithelium is thinner and non-keratinised. The submucosa of the vestibule contains vessels, numerous free cells including mast cells, plasma cells, lymphocytes, macrophages and granulocytes. Bundles of collagen fibres, large blood vessels and serous glands are located deep in the submucosa. The caudal two thirds of the nasal cavity, and paranasal sinuses, except the olfactory region are lined by a pseudo-stratified epithelium, interposed with goblet cells. In older animals there is metaplasia of some areas to squamous epithelium (Patnaik 1989). The olfactory epithelium comprises the dorso-caudal portion of the nasal cavity, and contains neurosecretory cells. The supporting tissue, bone and cartilage, must also be considered as sites of origin of nasal and paranasal sinus tumours (Mukaratirwa, van der Linde-Sipman and Gruys 2001).

A histological classification of tumours of the nasal cavity has been provided by Mukaratirwa, van der Linde-Sipman and Gruys (2001):

Epithelial tumours	**Non-epithelial tumours**
adenoma	malignant lymphoma
basal cell tumour	mastocytoma
adenocarcinoma	plasmacytoma
squamous cell carcinoma	fibrosarcoma
undifferentiated carcinoma	chondrosarcoma
olfactory neuroblastoma	osteosarcoma
	haemangiosarcoma
	neurofibroma
	melanoma
	malignant mesenchymal

There appear to be few studies on feline nasal tumours (Cox, Brawner, Powers et al. 1991, O'Brien, Evans, Wortman et al. 1996, Patnaik 1989, Mukaratirwa, van der Linde-Sipman and Gruys 2001), but all agree that certain tumours predominate: adenocarcinoma, squamous cell carcinoma, anaplastic carcinoma, malignant lymphoma and fibrosarcoma.

Mukaratirwa, van der Linde-Sipman and Gruys (2001) found those of epithelial origin accounted for 43.1% in a large histopathological series, with adenocarcinomas and squamous cell carcinomas predominating. The remaining 56.9% were non-epithelial with malignant lymphomas accounting for half.

Presenting signs include chronic sneezing, an initial unilateral nasal discharge, intermittent epistaxis and inspiration dyspnoea. Facial distortion and swelling, and bony lysis may also occur. Neurological signs, such as seizures, can be present in cats affected with olfactory neuroblastomas (Smith, Turrel, Bailey et al. 1989, Mukaratirwa, van der Linde-Sipman and Gruys 2001).

The vast majority of feline nasal tumours have been reported in old cats, but they can also occur in young animals. It has been found that castrated male cats are predisposed to intranasal tumours (Cox, Brawner, Powers et al. 1991, Mukaratirwa, van der Linde-Sipman and Gruys 2001). The reason is unknown, though it may be related to a hormonal influence.

1.3 Diagnostic Approach to Nasal Disorders

1.3.1 Initial Investigations

Clinical history and physical findings

Signalment: in younger cats, nasal or nasopharyngeal polyps, infectious upper respiratory tract disease and foreign bodies are more likely, while neoplasia is more common in older animals.

Animal husbandry: various management factors may be associated with specific diseases, including the animal's use (foreign bodies), the environment, home or travel history and exposure history.

Medical history: vaccination history and response to previous medical treatments, past skull trauma or surgery, dental problems, etc.

Sneezing: the onset and duration of the problem may be important; sneezing often lessens with chronicity (although nasal discharge usually persists); whereas an acute onset of violent sneezing suggests that a foreign body should be considered.

Nasal discharge: the type of discharge (serous, mucoid, purulent, bloody, or food materials), onset, duration, and response to therapy should be ascertained, and if the discharge was unilateral or bilateral initially.

Abnormal sounds: wheezing sounds are produced by air flowing through a narrowed lumen and are commonly reported in animals with dried secretions at the nostrils or a stenotic airway. Stertor may be encountered secondary to anatomic disorders or in animals with secretions in the nasopharynx. Stridor refers to an inspiratory wheeze and is associated most frequently with narrowing or obstruction of the upper airway.

Bony involvement: animals suffering from diseases associated with periosteal involvement (tumour, fungal infection) may demonstrate pain when petted or touched. Gross swelling or facial distortion is most often due to tumour growth.

Tissue growth: in addition to gross facial distortion, an expansile growth within the nasal cavity may be detected in the oral cavity or at the external nares.

Oral examination: attention should be given to hard palate, soft palate, tonsils, teeth, and periodontia, and the oral mucosa in general.

Eyes: presence of conjunctivitis, epiphora, corneal ulceration, exophthalmus, protrusion of the third eyelid.

Regional lymph nodes: should be critically examined.

1.3.2 Further Investigations

Laboratory tests: routine blood testing is rarely helpful, but may be indicated for pre-anaesthetic purposes. Biochemical and haematological findings are non-specific, but the latter may indicate the presence of inflammation.

Infectious disease screening may be useful in order to detect viral agents (FHV, FCV, FeLV and FIV). Bacterial culture, serology and fungal culture may also be performed.

Rhinoscopy: enables inspection of the internal structures of the nasal chambers. It requires the use of an otoscope or endoscope, flexible or rigid, to explore and visualize the nasal cavity, and should be always performed after obtaining skull radiographs, Computed Tomography (CT), or Magnetic Resonance Imaging (MRI).

An otoscope can be used to evaluate the nasal cavity of cats; but because of the relative rigidity and size of the ostoscope speculum, only the most rostral aspect of the nasal cavity can be assessed. Rigid fibreoptic endoscopes can provide a deeper view of the nasal cavity. However, despite the increased visibility afforded by a rigid scope relative to the otoscope, nearly 50% of the caudal portion of the nasal cavity still remains inaccessible. The flexible fibreoptic endoscope permits the most visualisation of the nasal cavity, but is the most expensive. Bronchoscopes are generally too large for cats. Paediatric bronchoscopes can be used in cats, but the enclosed biopsy channel is generally too narrow to accommodate biopsy instruments (Elie and Sabo 2006).

Biopsy: is required to gain a definitive diagnosis in many cases. Significant haemorrhage may be encountered, so blood-clotting times should be evaluated prior to biopsy. An endotracheal tube must be in place, and the pharynx should be packed with gauze swabs for the duration of the procedure (Harcourt-Brown 2006).

Biopsy collection via direct visualization is preferred whenever feasible; however, this approach may be difficult due to the anatomic limits of the patient's nasal cavity as well as the indwelling instrument in use. Frequently it is necessary to consider blind biopsies. In these instances proper placement of the biopsy is determined indirectly. Cup forceps are preferred to obtain nasal specimens. The images of the nasal cavity, whether by means of radiography, MRI or CT, allow aiming the biopsy instrument toward the lesion. Alternatively, a polypropylene or similarly rigid catheter may be used to obtain

biopsies. Attachment of a 6 to 12 millilitre syringe to the catheter can be used to apply negative suction (Elie and Sabo 2006).

Nasal flush: is the least traumatic of the biopsy methods, but often does not yield diagnostic samples. A urinary catheter should be used and cut short to avoid penetration beyond the medial canthus. Sterile saline can then be flushed rostrocaudally or caudorostrally (from the nasopharynx). The sample is collected by aspiration and centrifuged. Any deposits can be smeared and stained for examination (Harcourt-Brown 2006).

Rhinotomy: exploratory rhinotomy and biopsy should only be used where no other approach is appropriate, such as where complete nasal obstruction is encountered or surgical management of neoplasia or mycotic infection is being considered. Rhinotomy is generally not well tolerated by cats (Willoughby and Coutts 1995, Bregazzi, LaRue, McNiel et al. 2001).

1.3.3 Diagnostic Imaging of the Nasal Cavity

Diagnostic imaging of the nasal cavity and paranasal sinuses is important in evaluating cats with signs of nasal disease. The objective of imaging is to permit evaluation of the extent and involvement of the calvarium, dental structures, nasal turbinates, air passages, and paranasal sinus cavities, as well as determining if the lesion has extended into the brain cavity or retrobulbar space. Survey radiography, CT, and MRI can all be used to image the nasal cavity and paranasal sinuses. Each modality has its relative merits. Survey radiography is universally available and relatively inexpensive, but provides a limited appreciation of regional anatomy. CT is available at some academic veterinary hospitals and large referral practices. CT produces images that represent thin, cross-sectional slices of the skull, avoiding the problem of superimposition inherent with survey radiography. CT, relative to survey radiography, also provides better tissue contrast, permitting improved delineation of the bony structures. In contrast, MRI has excellent soft tissue contrast, but poor bone detail.

Survey Radiography

Several technical factors determine the diagnostic quality of radiographic studies of the nasal cavity and paranasal sinuses in cats and dogs. All studies must be performed with the animal under general anaesthesia to ensure proper positioning, to avoid motion artefacts, and to allow proper radiation safety practices. Close attention must be paid to

radiographic positioning and exposure for comparison of structures in the right and left sides of the skull, and to ensure that the full extent of the nasal cavity and the sinuses have been included on the various views. On all views it is important to prop the mouth open and to keep the endotracheal tube and tongue away by binding them to the mandible. The proper exposure should be one that uses a relative low kV and appropriate mAs for the film-screen system being used. In a properly exposed view, one should be able to easily visualize soft tissues along the outside of the nasal cavity (lips and nasal planum) as well as the ethmoidal turbinates in the caudal part of the nasal cavity. Overexposure will tend to diminish visualization of subtle lesions in the nasal cavity; in contrast, underexposure will tend to lead to a false impression of fluid or swelling of the nasal mucosa. Finally, because of the delicate and intricate nature of the turbinates, a high-detail film-screen combination or non-screen mammography film should be used (Pownder, Rose and Crawford 2006).

Projections

The most commonly used radiographic views for evaluation of the nasal passages are intraoral dorsoventral and lateral views. The rostro-caudal skyline view is useful for the evaluation of the frontal sinuses (Farrow 1994, Burk and Feeney 1996).

• **Intraoral Dorsoventral view:** This view is obtained by placing the patient in ventral recumbency and then inserting a plastic film cassette or a non-screen film into the mouth. The x-ray beam is directed through the incisive bone perpendicular to the plate.

• **Lateral view:** positioning the skull in the true lateral recumbency, results in superimposition of the paired structures (e.g. mandibles & tympanic bullae). Positioning is accomplished by elevating the nose rostrally and rotating the head dorsally using radiolucent supporting material, such as wedge-shaped piece of radiolucent foam placed under the mandibles.

• **Rostro-Caudal Skyline view of the frontal sinus:** is obtained by placing the patient in dorsal recumbency with the head flexed into a position perpendicular to the spine. The angle of the x-ray beam or degree to which the head is flexed varies with the shape of the skull and prominence of the sinuses. Alignment of the frontal sinuses relative to the x-ray beam should not result in superimposition over other structures. If properly positioned, this view permits the comparison of the right and the left sides.

Interpretation

Every report describing the radiographic features of nasal disease has stressed the importance of evaluating the integrity of the nasal conchae (turbinates). Loss of the integrity of the so-called normal turbinate pattern is regarded as a sign of aggressive nasal disease such as neoplasia or destructive rhinitis. However, the striated pattern created by the turbinates and the interposed air passages will be compromised by the presence of fluid. The ethmoidal turbinates in the caudal nasal cavity have much coarser bony conchae and create bone dense radiographic shadows that cannot be obliterated by fluid alone. Whereas there is a general symmetry of structures in the two halves of the nasal cavity, there will not be a perfect correspondence in shape or position of individual turbinates. This lack of perfect symmetry is particularly apparent in cats and in dogs with short noses.

There have been numerous reports describing the radiographic features of nasal disease in the dog (Gibbs, Lane and Denny 1979, Sullivan, Lee, Jakovljevic et al.1986, Russo, Lamb and Jakovljevic 2000, Saunders, Clerx, Snaps et al. 2004, Windsor, Johnson, Herrgesell et al. 2004) but few in the cat (O'Brien, Evan Wortman et al. 1996, Lamb, Richbell and Mantis 2003). Most authors have chosen to divide these diseases into three basic categories, and the common or typical radiographic findings for these are:

Non-destructive nasal disease:

- Patchy increase in opacity throughout most of the nasal cavity; usually bilateral involvement
- Loss of turbinate pattern (obliteration of air spaces) in the mid to rostral portion of the nasal cavity
- Frontal sinuses usually unaffected
- No evidence of bony destruction involving caudal turbinates, vomer bone, or surrounding facial bones
- No evidence of external soft tissue swelling or mass

Destructive rhinitis:

- Areas of decreased opacity (turbinate destruction) within the nasal cavity; lesions can be unilateral or bilateral (if bilateral extent of involvement is usually asymmetric)
- Poorly circumscribed mass lesions possible in the caudal nasal cavity and frontal sinuses (aspergillomas)

- Frontal sinus involvement common in chronic or severe cases
- Facial bone lysis and production (osteomyelitis) possible in severe cases

Neoplasia:

- Soft tissue mass with the associated turbinate, vomer bone, hard palate, and facial bone destruction
- Punctate to geographic areas of decreased opacity associated with destruction of the hard palate and/or overlying facial bones
- Frontal sinus involvement
- External soft tissue swelling or mass

These guidelines are general and by no means perfect. There is considerable overlap between the radiographic signs in cats with rhinitis and nasal neoplasia (Cox, Brawner, Powers et al. 1991, Cape 1992, O'Brien, Evans, Wortman et al. 1996, Lamb, Richbell and Mantis 2003). Displacement of the vomer, unilateral generalized loss of turbinate detail, evidence of bone invasion and unilateral nasal lesions have been associated with neoplasia, but the predictive value has a range of between 56-73%. Radiographic signs in cats with rhinitis are more variable and less specific than those for nasal neoplasia. The presence of lucent foci is an important sign of destructive rhinitis in dogs (Sullivan, Lee, Jakovljevic et al. 1986, Russo, Lamb and Jakovljevic 2000). However, these punctate lesions have only been observed in a few cats, and may be associated with foreign body (Bright and Bojrab 1976) or aspergillosis (Goodall, Lane and Warnock 1984, Sullivan, Lee, Jakovljevic et al. 1986).

Computed Tomography

CT offers several advantages relative to survey radiography, the most important being the ability to produce cross-sectional tomographic slices that avoid the problem of superimposition of structures inherent in radiography. Because CT generates digital images, it is possible to adjust the contrast scale to the entire nasal cavity/paranasal sinus region. Manipulation of the contrast scale also allows better discrimination of soft tissue structures from those that are only faintly mineralised, which improves visualization of even the fine turbinate structures in the rostral part of the nasal cavity.

Nasal CT is most easily performed with the animal in ventral recumbency with the head secured in such a way that the hard palate is parallel to the table. It is important to attempt to keep the sagittal plane of the head perpendicular to the plane of the gantry. It

is also important to avoid using endotracheal tubes with metal fittings or radiopaque markers because these can cause significant image artefacts. Other technical considerations include the slice thickness and the size of the field-of-view. Choice of the slice thickness is a compromise between the superior image quality of thinner slices and the practical time limitations for acquiring, processing, and reviewing studies that contain large number of slices. Most CT scanners offer a limited selection of slice thickness, typically 1.5 mm, 3 or 5 mm, and 10 mm. One approach is to determine the distance to be imaged for each patient and choose a slice thickness that will cover that distance in 20 to 40 slices. With spiral CT scanners, image data are acquired for an entire volume. Thickness of slices is chosen after the study is acquired and can be altered to suit different portions of the anatomy (Kuehn 2006). CT of the normal feline nasal cavity and paranasal sinuses has been described (Losonsky, Abbott and Kuriaskin 1997).

It has been shown that CT is superior to radiography in defining the degree of involvement of nasal lesions (Thrall and Robertson 1989). CT was more accurate at determining whether they were unilateral or bilateral; whether the lesions involved the paranasal sinuses; whether lesions had caused bony lysis of the hard palate, surrounding facial bones, sphenoid bone, or cribriform plate; and whether lesions had extended into the cranial cavity, retrobulbar space, or oral cavity. By giving a more accurate representation of the extent of involvement, CT was deemed to be more valuable in staging tumours, predicting treatment-related complications, and planning either surgery or radiation therapy.

Magnetic Resonance Imaging (MRI)

MRI provides superior soft tissue contrast if compared to CT (Saunders, Clerx, Snaps et al. 2004), and by using multiplanar images, it is possible to map the extent of a sinonasal infection or neoplasia into either the orbit or cranial cavity (Kneissl, Konar, Fusch-Baumgartinger et al. 2007). With the use of different sequences, MRI substantially improves relative contrast between normal and abnormal soft tissue and may therefore aid in the identification of diseases in the nasal cavity and frontal sinuses (Saunders, Clerx, Snaps et al. 2004). Normal sinonasal secretions show low signal in T1-weighted sequences, and high signal intensity in T2-weighted images, due to the high content in water. When the frontal sinus and nasal cavity are obstructed, the normal secretion become dehydrated and it may appear as low signal intensity in both T1 and T2- weighted sequences (Saunders, Clerx, Snaps et al. 2004).

The use of Gadolinium (Gd-DTPA) has been proposed as a method for differentiating sinonasal neoplasm from infection (Kubal 1999).

Moore, Gavin, Kraft et al. (1991) and Voges and Ackerman (1995) evaluated five dogs and one cat with nasal tumours that had invaded the brain cavity and the retrobulbar space. CT and MRI were both available and the authors concluded that MRI studies were superior in demonstrating the anatomic features of the primary tumour masses as well as secondary features of brain pathology (oedema) in response to tumour invasion.

There are, however, some disadvantages to MRI compared with CT; amongst them, tissues that have minimal hydrogen protons, such as bone or calcification, will have no signal, and therefore will appear as a signal void. Therefore, subtle aggressive bony lesions or areas of mineralization may be missed on MRI images.

As described above, there are multiple possible aetiologies which may cause nasal disease in the cat; and there are also a great number of diagnostic tools that may be helpful to orientate the clinician to the final diagnosis. Radiography is one of the first diagnostic tools used by both first opinion and referral veterinarians; and we wished in this study to investigate the value of radiography in feline chronic nasal disease. The main aim of this study was to describe the radiological features of cats with chronic nasal disease and to assess the level of agreement of two independent observers in identifying these features. These radiological findings were correlated with other diagnostic modalities associated with a definitive aetiological diagnosis for chronic nasal disease in cats.

2 Materials & Methods

The radiology database from the University of Glasgow Small Animal Hospital, was searched to identify cats in which radiography was performed for evaluation of chronic nasal disease for the period 1986-2006.

Medical records were examined with respect to age, breed, sex, and presence of clinical signs referable to nasal disease.

a) Nasal discharge: unilateral/bilateral, serous/mucopurulent
b) Epistaxis
c) Sneezing
d) Facial deformity
e) Exophthalmos
f) Ocular discharge
g) Stertor
h) Dyspnoea
i) Anorexia
j) Seizures
h) Head tilt

Complete blood count, serology for FCV, FHV, FIV, and FeLV were recorded. Testing fro C. *felis* and fungi (cryptoccocosis and aspergillosis), were also noted when performed.

Radiographic evaluation included in each case dorsoventral-intraoral (DViO) or ventrodorsal-intraoral (VDiO) views of the nasal cavity. Lateral views of the skull, and/or rostro-caudal skyline views of the frontal sinuses (RCd skyline) were additionally included in some cases. Intraoral (DViO/VDiO) views were taken using non-screen films in the early years of this study. Latterly, screen/films held in a flexible plastic envelope were used in order to show fine detail. Lateral and RCd skyline of the frontal sinuses views were obtained using screen/films in conventional cassettes.

The techniques for positioning cats for these views were as described by Farrow (1994) and Burk and Feeney (1996).

To aid interpretation, the intra-oral views were divided into rostral and caudal regions. The rostral limit of the ethmoidal conchae was considered at the level of the third upper premolar (O'Brien, Evans, Wortman et al. 1996). Right and left nasal chamber were defined by the vomer bone (Gibbs, Lane and Denny 1979).

Radiological findings were recorded using a custom-designed form that included the following features:

a) Lesion location:

a.1) Unilateral

a.2) Bilateral

a.3) Rostral

a.4) Caudal

b) Soft tissue opacity:

b.1) Focal

b.2) Multifocal

b.3) Generalized unilateral

b.4) Generalized bilateral

b.5) Generalized unilateral and focal involvement on the contralateral side

b.6) Degree: mild, moderate, severe

c) c) Turbinate destruction:

c.1) Focal

c.2) Multifocal

c.3) Generalized unilateral

c.4) Generalized bilateral

c.5) Generalized unilateral and focal involvement on the contralateral side

d) Mixed pattern: areas of conchal destruction and superimposed soft-tissue opacity, interspersed with areas of conchal destruction alone

e) Vomer destruction, vomer deviation, mineralization, invasion of surrounding bony structures, frontal sinus involvement, facial deformity, dental disease

On the basis of the radiographic signs, cats were also assigned a score using the scheme of nasal radiographic patterns:

1 Normal radiographic appearance of both nasal passages

2 Areas of increased soft tissue opacity superimposed on a normal conchal pattern

3 Areas of increased soft tissue opacity superimposed over areas of turbinate destruction

4 Areas of decreased opacity owing to conchal destruction without accompanying soft tissue opacity

5 A mixed pattern with areas of conchal destruction and superimposed soft tissue opacity, accompanying areas of turbinate destruction alone.

Cats were anaesthetised and placed in ventral recumbency. CT scans were performed using a third generation scanner (Elscint Twin), operating at 120 kV and 135 mAs. Slice thickness was 1.2 mm and serial transverse sections were obtained beginning at the incisor teeth and extending caudally to the olfactory lobe of the brain. Using OmniPro software, sagittal, dorsal and paraxial images were reconstructed.

Scans following contrast medium administration were not carried out in these cats.

Recorded CT findings included:

a) Presence, location (rostral, caudal, focal, generalized), and laterality (unilateral, bilateral) of abnormal soft tissue within the nasal cavity, frontal sinus, sphenoid sinus, retrobulbar space, and nasopharynx

b) Presence and location of bony destruction of the dorsal, lateral, or ventral aspect of the maxilla, palatine bone, vomer bone, nasal septum, maxillary turbinates, cribriform plate, frontal bone, and orbital lamina

The ventral aspect of the maxilla was defined as the hard palate rostral to the level of the fourth premolar, and the palatine bone was considered the hard palate caudal to the fourth premolar (Tromblee, Jones, Etue et al. 2006). Exophthalmus and facial asymmetry were also recorded.

MR imaging was performed using a 1.5 Tesla scanner (Gyroscan NT 1.5 Tesla, Philips Medical System, Eindhoven, The Netherlands). An extremity coil was used to improve signal-to-noise ratio. The T1-weighted images were obtained with a TR 400 and TE 18. The T2-weighted images were obtained with TR of 2500 and TE of 124. Postcontrast T1-weighted images were obtained after the administration of Dimeglumine gadopentetate[1] ($0.2 mlkg^{-1}$). Contiguous 4mm-thick sections were obtained.

[1] ***Magnevist***, Schering Plough Health Care Ltd, Burgess Hill, West Sussex

MRI data recorded were:

a) Presence, location (rostral, caudal, focal, generalized), and laterality (unilateral, bilateral) of abnormal soft tissue within the nasal cavity, frontal sinus, sphenoid sinus, retrobulbar space, and nasopharynx, and brain and meningeal involvement

b) Signal intensity of the abnormal soft tissue in T1, T2 and T1 after contrast medium administration

c) Evidence of bony destruction of the dorsal, lateral, or ventral aspect of the maxilla, palatine bone, vomer bone, nasal septum, maxillary turbinates, cribriform plate, frontal bone, and orbital lamina

The criteria for a definitive diagnosis were rhinoscopic biopsy, surgical biopsy, or necropsy. Diagnosis of nasal neoplasia was only made on the basis of histological examination of nasal biopsy or necropsy, and observation of neoplastic cells. Diagnosis of rhinitis was based on presence of inflammatory cells, and absence of other primary causes, such as neoplastic cells, nasopharyngeal polyps, primary bacterial agents (B. *bronchiseptica*, C. *felis*), and fungi (cryptoccocosis, aspergillosis).

This study was divided into two parts. The first part was aimed at a pure imaging diagnosis; nasal radiographs, CT and MRI scans were examined independently by two observers (A + B), who were unaware of any patient information, apart from the identification number. Individual review was followed by a consensual evaluation of the radiographs. Secondly, the consensual evaluation reached by the independent observers was compared to the definitive diagnosis.

The statistical study included Kappa Statistical analysis using kappa value in order to measure the agreement between the two observers with respect to specific radiological signs in cats with confirmed rhinitis and neoplasia. Kappa results range from 0 to 1. The higher the value of kappa, the stronger the agreement. Kappa values greater than 0.9 are considered excellent. If $k>0.6$, the agreement is good; values of kappa between 0.4 and 0.6 are considered moderate, and if $k<0.4$, the agreement is poor. Kappa values were calculated separately for rhinitis and tumours.

Chi-Square Statistical analysis using Chi square value was done in order to compare if two different samples (rhinitis and tumour), are different enough in some characteristic of their behaviour. $P<0.01$ is considered statistically significant. The radiological consensual evaluation by observers A and B was compared to the definitive diagnosis.

The software used was Sigma Stat and Microsoft Excel 2by2.

Positive predictive value (PPV) was calculated from cats which had definitive diagnosis of neoplasia or rhinitis. The PPV is the proportion of patients with positive results who are correctly diagnosed. It is computed as: PPV= true positives/total number of positives ×100.

3 Results

Eighty-five cats in which nasal radiography was done for investigation of chronic nasal disease were included in the first part of the study. Seventy three out of 85 cats had definitive diagnosis of rhinitis and neoplasia based on histopathology (55 and 18 cats respectively) or clear identification of the primary cause of the chronic nasal disease (Figure 1).

Twelve cats did not have a definitive diagnosis based on histopathology, but despite of this, they were included in the radiological part of this study. A presumptive diagnosis was made based on the radiographic findings (based on the consensual evaluation).

The range age of cats with confirmed neoplasia and rhinitis were similar: from 0.62-16 years in neoplasia, and from 0.33-15.3 years in rhinitis (Table 1, Figure 2). However, cats with neoplasia (mean 9.7 years) were older than cats with rhinitis (mean 6.4 years). Within the neoplasia group, cats with epithelial tumours were older than cats with non-epithelial tumours, with mean ages of 13 and 7 years respectively (Figure 3).

The prevalence of females was higher in the neoplasia group (72%) compared to rhinitis (54.5%) (Figure 4).

A variety of breeds were represented over the 73 cats with confirmed chronic nasal disease (Table 1), including 50 Domestic Short Hair, 4 Domestic Long Hair, 9 Siamese, 4 Burmese, 3 Persian, 1 Chinchilla, 1 Russian Blue, and 1 Abyssinian. The proportion of purebred in cats with confirmed neoplasia was 22.2%, whereas in cats with confirmed rhinitis was 27.2%.

3.1 Clinical findings

Similar clinical signs were recorded in cats with rhinitis and nasal neoplasia; although more cats with neoplasia showed unilateral nasal discharge, facial deformity and ocular discharge (Table 2). Signs of anorexia and weight loss were also more common in cats with nasal tumours. Two cats had a history of seizures (in addition to sneezing and nasal discharge), thought to be due to bony case destruction and consequent brain involvement. One cat showed head tilt, nasal and aural discharge caused by a nasopharyngeal polyp.

Chronic rhinitis (Table 3) was diagnosed in 55 cats on the basis of clinical, radiological and histological findings. Rhinitis associated with primary causes was as followed: nasopharyngeal polyps (3), previous trauma (2 cats), and foreign body (3). Ten cases of

non-nasal diseases were associated with nasal discharge, and therefore included in this study. These ranged from pharyngitis to pneumonia and soft palate tumours. Idiopathic chronic rhinitis was based on the lack of evidence of primary causes of rhinitis and lack of neoplastic cells and presence of inflammatory cells in histopathology, and 37 cats met the criteria. Evidence of fungal disease was not found in any of the cases included in this study. Secondary bacterial infection was found in either cats affected with tumours or rhinitis. There was evidence of *Pasteurella multocida* (9), *Pseudomonas aerunoginosa* (1), *Staphylococus intermedius* (2), *Acinetobacter lwoffi* (1), *Corynebacterium* spp (1), *Flavobacterium* spp (1), *Pleisomonas shigelloides* (1), *Proteus* spp (1) and *Bramhella* spp (1). Primary bacterial pathogens *Bordetella bronchiseptica* and *Chlamydia felis* were not isolated in any of the cats.

Thirty-two cats were tested for the presence of FHV, FCV, FeLV and FIV. Only one cat had high titre to FCV and just two cats were positive for FeLV. None of the cats showed evidence of FHV or FIV.

Eighteen biopsy or necropsy specimens revealed 6 lymphomas, 4 undifferentiated carcinomas, 2 squamous cell carcinomas, 2 osteosarcomas, 2 fibrosarcomas, 1 adenocarcinoma and 1 melanoma (Table 4). Six cats were presumptively diagnosed with nasal tumours, although biopsy or necropsy was not carried out, based on the high suspicion of neoplastic disease.

3.2 Radiographic findings

3.2.1 Interobserver evaluation

Individual review of the radiographic findings in all 85 cats with nasal radiography was performed by each observer (Tables 5A and 5B). The comparison between observers is summarized in Table 6.

3.2.1.1 Nasal Neoplasia

Agreement between observers for nasal neoplasia was excellent (k>0.9) for the recognition of turbinate destruction, vomer destruction, mineralization, frontal sinus involvement, facial deformity, and overall score. Agreement for invasion of bone was nearly excellent, with kappa= 0.857. Good agreement (k=>0.6) was apparent for lesion location, soft tissue opacity and degree of this soft tissue opacity. Moderate agreement (0.6>k>0.4) was apparent for mixed pattern and deviation of the vomer.

3.2.1.2 Rhinitis

Excellent agreement (k>0.9) for rhinitis was evident for the recognition of normal nasal cavities, deviation of the vomer and frontal sinus involvement. Agreement was good (k>0.6) for lesion location, degree of soft tissue opacity and vomer displacement. Moderate agreement (0.6>k>0.4) was apparent for soft tissue opacity. Lesion score had a kappa value of 0.468. Poor agreement (k<0.4) was shown for mixed pattern.

3.2.2 Consensual evaluation and comparison with definitive diagnosis:

The incidence of radiographic signs on which the observers agreed in 73 cats with definitive diagnosis are summarized in Table 7. Examples of the range of radiographic features for rhinitis and nasal tumours are illustrated in Figure 5.

All cats with confirmed neoplasia were interpreted as abnormal radiographically (Figure 6). In those with definitive diagnosed rhinitis, 18.8% had nasal cavities considered to be within normal radiological limits (Figure 7A).

Unilateral involvement of the nasal cavity was the most common radiographic finding in cats with neoplasia (77.7%). In cats with rhinitis, the lesion location was more variable. Unilateral involvement was the most common, but it only accounted for 29.1% of the cases. Bilateral and rostral involvement was found in 25.4% and 21.8% of the cats respectively.

Opacification of one nasal cavity by soft tissue was frequently seen in cats with neoplasia (50%), followed by generalized unilateral involvement accompanied by focal contralateral opacification (22.2%). On the other hand, in cats with rhinitis the commonest feature was focal soft tissue accumulation (29.2%).

The degree of soft tissue opacity was classified into mild, moderate and severe. Severe accumulation of soft tissue was commonly found in neoplasia (55.5%), while in the rhinitis group, mild was seen in 21.8% of cats, and moderate degree in 61.8%. Severe opacification was not found in the rhinitis group. Mild opacification was not observed in cats suffering from neoplastic disease.

Turbinate destruction was always present in cats with neoplasia. However, turbinate destruction was identified in 65.3% of the rhinitis cases. The location of this loss of turbinate detail was often seen in tumours affecting only one chamber (50%), whereas in rhinitis the pattern of destruction was more variable: multifocal and focal destruction accounted 21.8% and 16.3% respectively, and unilateral turbinate destruction was seen in 21.8% of the cats.

Mixed pattern was observed in 21 cases (38.2%) affected with rhinitis, and only four with nasal neoplasia (22.2%).

Destruction of the vomer, invasion of the bony case and frontal sinus involvement were more prevalent in tumours. Mineralization and facial deformity were not seen in any of the rhinitis cases.

Thoracic radiographs were available for review in all cats with nasal neoplasia. Evidence of metastatic spread was found in only one case, which was confirmed on necropsy.

Positive predictive values (PPV) for various radiographic signs are summarized in Table 8. The radiographic signs with the highest PPV for neoplasia were invasion of bones (PPV=88.8%) and vomer destruction (PPV=86.6%), followed by unilateral lesion location (PPV=46.7%), and unilateral loss of turbinate detail (PPV=42.8%). When all signs occur together in one cat, the PPV for neoplasia was 80%.

Based on definitive radiological diagnosis of rhinitis, nasal neoplasia or nasal cavity considered within normal limits, there was excellent interobserver agreement (k=0.941) (Table 9).

There were a number of identified diagnostic errors. Both observer A and B interpreted four cats (two cats each) with rhinitis when the confirmed diagnosis was tumour. Observer A interpreted two cats with nasal neoplasia and the biopsy revealed rhinitis. Observer B considered one nasal radiograph to be within normal limits and but was found to be a case of rhinitis.

There were also a few consensual diagnostic inaccuracies. Both A and B observers reached an agreed radiological diagnosis of neoplasia in two cats, but the biopsy concluded chronic non-specific rhinitis. Further, there were another two cases in which the observers consensually diagnosed rhinitis and the biopsy returned a diagnosis of tumour (Figure 8).

3.3 Computed Tomography & MRI

CT scans were performed on five cats, four of which also had nasal radiography (Table 10). Three of these cats had a definitive diagnosis of rhinitis: cat 1 had rhinitis due to foreign body, cat 4 had chronic destructive rhinitis and cat 5 had chronic non-specific rhinitis. CT images of cats 1 and 5 showed that the turbinates were bilaterally thickened and distorted, rather than obscured by a homogeneous opacity. The retrobulbar space and sphenoid sinus were affected in cat 1, whereas the nasopharynx was obliterated by

soft tissue in cat 5. Neither CT studies showed turbinate destruction. When comparing CT images with nasal radiographs, DViO views of cat 1 did not show clearly the bilateral soft tissue opacity (Figure 9). Radiographs were not available in cat 5.

Cat 4, diagnosed with chronic destructive rhinitis, showed bilateral and severe soft tissue opacity within the nasal cavity, frontal sinuses, sphenoid sinus, and nasopharynx. Bony destruction was extensive, and involved the turbinates, ventral palatine bone and lateral maxilla. On DViO views of the nasal cavity, it was not possible to identify the palatine and maxilla destruction (Figure 10).

Cats 2 and 3 had confirmed diagnosis of nasal neoplasia. Cat 2 showed bilateral involvement, with multifocal opacification within the nasal cavity, as well as sphenoidal and nasopharyngeal soft tissue opacities. Bony destruction was seen involving the palatine bone, vomer bone, nasal septum and turbinates. All these signs were appreciated on DViO views, apart from the palatine invasion (Figure 11).

The scan performed in cat 3, revealed homogeneous soft tissue opacity on the left side, with a faint mineralization embedded within it. Turbinates were destroyed rostral and caudal to the soft tissue mass. The ipsilateral frontal sinus showed a lining of soft tissue.

MRI was performed in only one cat, which had a definitive diagnosis of rhinitis. MRI images revealed soft tissue opacity within the right nasal cavity, which had high signal intensity on T2-weighted images. This same area was isointense with respect to brain grey matter on T1-weighted images. The sphenoid sinus was filled by soft tissue and it showed a hyperintense rim on T2-weighted images and it also had rim-enhancement after the administration of contrast medium (Figure 12). Integrity of the cribriform plate and frontal bone could not be fully assessed since bone presents a signal void, but the presence of faint enhancement of the meninges, indirectly made the suspicion of bony destruction possible.

4 Discussion

A broad range of identifiable primary conditions have been associated with chronic nasal disease in cats including viral, bacterial and mycotic infections, nasal parasites, allergic rhinitis, neoplasia, nasopharyngeal polyps, foreign bodies, dental disease, congenital defects, and trauma (Van Pelt and Lappin 1994). The referral nature of the population of cats in this study probably influenced the occurrence of different diagnoses, excluding some such as dental disease or oronasal fistulae, which may be readily diagnosed in first opinion practice. Consequently, the cats included in this study were considered representative of those referred for investigation of chronic nasal signs. This study was performed in two different steps; firstly, two independent observers analyzed radiographs of cats with chronic nasal disease, without knowledge of the definitive diagnosis. In the second part of this study, the radiological diagnosis was compared to the definitive diagnosis of nasal disease. In the first part of the study 85 cats were evaluated. In the second part, 73 cats had confirmed diagnosis of chronic nasal disease, 58 (75%) had a definitive diagnosis of chronic rhinitis, and 18 (25%) were diagnosed with neoplasia. The population of cats in this study and the distribution of diseases were similar with those reported in previous studies of feline sinonasal disease (Lamb, Richbell and Mantis 2003, Henderson, Bradley, Day et al. 2004).

Cats with confirmed rhinitis tended to be younger than cats with nasal neoplasia (rhinitis mean=6.4 years and nasal neoplasia group= 9.7 years). However, the age range of cats affected by either of these conditions is wide. The youngest cat with rhinitis was 4 months old and with neoplasia 7 months old. The oldest cats were 16 years with neoplasia and 15.3 years with rhinitis.

It has been suggested that male sex hormones play a role in the development of nasal tumours (Cox, Brawner, Powers et al.1991), and is responsible for a male predominance previously reported in cats with neoplasia (Cox, Brawner, Powers et al. 1991, Mukaratirwa, van der Linde-Sipman and Gruys 2001). This is at odds with this study, where females were predominant. Other studies (O'Brien, Evans, Wortman et al. 1996, Schoenborn, Wisner, Kass et al. 2003, Henderson, Bradley, Day et al. 2004), failed to identify any gender predisposition. These conflicting results might be due to a small population size in most of the studies.

No breed predisposition was identified in this study, concurring with previous studies reported (O'Brien, Evans, Wortman et al. 1996, Lamb, Richbell and Mantis 2003)

The clinical signs found in this study were not thought to be pathognomonic for any individual disease, but certain features can be useful and increase the index suspicion for a particular condition. Unilateral nasal discharge, ocular discharge, facial deformity and exophthalmus were more common in cats with neoplasia than in cats with rhinitis. The common observation of unilateral nasal discharge in cats with tumours is in agreement with other studies (Hawkins 1988, Henderson, Bradley, Day et al. 2004, Demko and Cohn 2007). Exophthalmus and unilateral ocular discharge seemed to be always associated with neoplasia, as none of the cats with rhinitis suffered from exophthalmus, and if ocular discharge was present, this tended to be bilateral. These findings are supported by those of Tromblee, Jones, Etue et al. (2006) where unilateral ocular discharge was significantly associated with neoplasia. The presence of unilateral epiphora has been reported as an indicator of nasolacrimal duct occlusion and should be considered suspicious of an intranasal mass in cats with current signs of nasal disease (Legendre, Krahwinkel and Spaulding 1981, Theon, Peaston, Madewell et al. 1994). Exophthalmus has been also reported in a cat with aspergillosis (Hamilton, Whitley and MacLaughin 2000). Two cats in our study showed neurological signs of seizures, accompanied by sneezing and nasal discharge. Few reports have described neurological signs due to nasal neoplasia (Smith, Turrel, Bailey et al. 1989), or fungal (cryptococcosis) infection (Beatty, Barrs, Swinney et al. 2000, Foster, Charles, Parker et al. 2001, Mandrioli, Bettini, Marcato et al. 2002). Seizures in the cats included in this study were caused by infection. One cat had osteomyelitis in addition to chronic rhinitis. It was affecting the frontal sinus and eroding the bone case with consequent brain involvement. The second cat, suffering from seizures, had chronic rhinitis confirmed by MRI and histopathology.

Chronic rhinitis was definitive diagnosis in 55 cats in our study; 18 of these had evidence of primary causes of chronic nasal discharge and nasal disease, such as nasopharyngeal polyps, foreign bodies, choanal stenosis, and non-primary nasal disease as penumonia. However, in 37 cats with complete diagnostic work-up including histopathology, a primary cause could not be identified; therefore the diagnosis of chronic non-specific rhinitis was made. Chronic non-specific or idiopathic rhinitis is generally considered a consequence of prior infection with either FHV-1, FCV, *C. felis*, or some combinations of these agents (Maggs 2005). Although viral (especially FHV-1) or Chlamydia infection are often implicated as the initial cause of acute rhinitis, the pathogenesis of idiopathic chronic rhinitis is unknown and it is uncertain whether acute rhinitis is related to the chronic syndrome (Johnson 2003). It is possible, however, that

the underlying pathogenesis of nasal damage is initiated by FHV-1-mediated cytolysis or induced by virally directed, inmuno-mediated destruction and perpetuation of the inflammation in the absence of ongoing viral infection (Johnson, Foley, De Cock et al. 2005).

Virus isolation, immunofluorescent antibody assays, and serum neutralizing, ELISA antibody titres and PCR have been used to confirm exposure to or presence of FHV-1, but the correlation between test results and disease is low (Maggs, Lappin, Reif et al. 1999, Johnson, Foley, De Cock et al. 2005). In addition, a role for active viral infection in naturally occurring chronic rhinitis in cats could not be established (Johnson, Foley, De Cock et al. 2005). In our study, 32 cats had virus isolation. None were positive for FHV-1, and only one had a FCV antibody titre of 80, but isolation in feline cell culture was not performed.

B. *bronchiseptica* is known as a primary cause of feline upper respiratory tract disease (Binns, Dawson, Speakman et al. 1999, Sykes, Anderson, Studdett et al. 1999). A recent study, (Helps, Lait, Damhuis et al. 2005) has shown a high prevalence of antibodies of B. *bronchiseptica* in European cats. That study highlighted that the prevalence of B. *bronchiseptica* was significantly higher in multi-cat household with active upper respiratory tract disease than in multi-cat households without evidence of upper respiratory disease. Yet in this study we did not find any case positive for B. *bronchiseptica*. This bacteria may be very difficult to isolate (Speakman, Dawson, Binns et al. 1999), and PCR techniques may be more effective than bacterial culture (Helps, Lait, Damhuis et al. 2005). PCR isolation was not performed on samples from the cats reported here.

None of the cats included in this study suffered from C. *felis* infection. C. *felis* is primarily an ocular pathogen and has been reported from 0 to 32% of cases of upper respiratory disease (Wills, Howard, Gruffydd-Jones et al. 1988). The association with FHV and FCV is unclear and probably poor (Sykes, Anderson, Studdett et al. 1999), although concurrent C. *felis* infection may severely exacerbate the clinical signs (Bannasch and Foley 2005). The isolation of this agent appears to be higher if PCR techniques are used (Owen, Sturgess, Harbour et al. 2003). However, PCR techniques were not used for the cats selected in our study, and bacterial cultures were used instead.

Recent work has revealed that potentially pathogenic bacteria and a wider variety of bacterial species can be isolated from cats with idiopathic chronic rhinitis than from cats without nasal disease (Johnson, Foley, De Cock et al. 2005). *P. multocida* was the most

common bacteria found in this study. This bacteria is considered a commensal of the upper respiratory and digestive tracts of cats. However, a toxigenic strain of this organism has been implicated in the development of nasal turbinate destruction in pigs (Pedersen and Elling 1984, Kamp and Kimman 1988). Whether bacterial species are causally related to disease or accumulate secondary to nasal inflammation and damage has not been determined in the studies carried out to date (Maggs, Lappin, Reif et al. 1999, Sykes 2001, Johnson, Foley, De Cock et al. 2005). Experimental studies might be required to determine the role of bacteria in chronic nasal disease.

FeLV in our study was isolated in two cases and FIV in none. This low prevalence correlates well with data presented by Cape (1992) and Michiels, Day, Snaps et al. (2003), which showed poor association between retroviral infection and chronic nasal disease.

Histopathological findings in idiopathic chronic rhinitis may include moderate to severe neutrophilic, lymphocytic or pleiocellular inflammation with epithelial ulceration, fibrosis, necrosis, glandular hyperplasia, turbinate destruction and remodelling. There may be considerable discordance between macroscopic abnormalities and those detected histologically (Johnson, Foley, De Cock et al. 2005). It must be understood that the appearance of the nasal cavity does not necessarily reflect the presence or absence of underlying pathology (Kuehn 2006). The lack of neoplastic cells or another primary cause of infection, such as nasopharyngeal polyps or the identification of fungi, supports the diagnosis of non-specific rhinitis.

Non-specific or idiopathic rhinosinusitis is therefore a very difficult entity to fully understand. A primary cause cannot be found, and sometimes it is considered a diagnosis of exclusion. However, it must be taken into account that previous or current viral infection and concurrent secondary bacterial infection may be the most likely cause for the chronic and refractory nasal disease.

Eighteen cats were diagnosed with nasal neoplasia confirmed by either nasal biopsy or necropsy. Non-epithelial tumours were found in eleven cases, of which six were malignant lymphoma. The most frequent epithelial tumour was undifferentiated carcinoma (4).

The preponderance of specific tumour types varies between different studies. This may be due to the fact that some researchers discuss all types of nasal and paranasal tumours arising from nasal and paranasal epithelium together (Madewell, Priester, Gillette et al. 1976, Moulton 1990) whilst others separate tumours arising externally from the

epithelium of nasal planum from those arising from intranasal structures (nasal cavity and paranasal sinuses) (Legendre, Krahwinkel and Spaulding 1981).

Just as the preponderance of specific tumours varies between studies, so also does the ratio of epithelial to non-epithelial tumours (Bright and Bojrab 1976, Madewell, Priester, Gillette et al. 1976, Levy and Ford 1994) In dogs, epithelial tumours predominate (Patnaik 1989). However, in cats a predominance of non-epithelial tumours is found (O'Brien, Evans, Wortman et al. 1996, Mukaratirwa, van der Linde-Sipman and Gruys 2001, Lamb, Richbell and Mantis 2003). Amongst these, malignant lymphoma had the highest occurrence. The results of this study, where non-epithelial tumours accounted for 61% and lymphoma was the most common (54.6%) concurs with previous investigations. Previous reports and the present study, indicate that cats are subject to a variety of nasal and paranasal tumours. Definitive cell typing requires inmmunohistochemical staining. Correct diagnosis is very important, since most tumours appear to have different prognosis and treatment options.

Evidence of metastasis from nasal neoplasia has been reported as very rare (Legendre, Krahwinkel and Spaulding 1981, Moulton 1990, Cox, Brawner, Power et al. 1991). One reason for this may be that nasal tumours are more locally invasive and metastasize late in the disease. Only one case of metastatic spread to the lungs was identified in this study, being a carcinoma.

The prevalence of abnormal nasal radiographs in cats with chronic nasal disease is very high (O'Brien, Evans, Wortman et al. 1996, Lamb, Richbell and Mantis 2003). Hence, the principal question facing the radiologist is whether rhinitis or nasal neoplasia is the most likely diagnosis.

This study was based on examination of dorsoventral-intraoral (DViO) or ventrodorsal-intraoral (VDiO) views of the nasal cavity. In some cases, additional views such as rostroventral-caudodorsal view of the frontal sinus and lateral view of the skull were included.

Intraoral views are particularly useful because there is minimal superimposition of the nasal cavity by other structures and provide opportunities to compare left and right sides, which aids recognition of any asymmetrical lesions. In order to achieve this, accurate positioning was important, but minor tilting did not detract from interpretation of the films. If there was a marked tilting (easily seen by comparing the symmetry of the canine teeth), the radiographs were repeated.

Lateral views aid identification of lesions breaching the nasal bones, and was a feature noted in some tumours (Figure 6). Lateral radiographs are also useful for identifying lesions involving the nasopharynx, such as polyps or laryngeal masses.

A rostro-caudal skyline view is required for examining the frontal sinuses. However, it is difficult to obtain a satisfactory view of the frontal sinus in breeds such as Persians due to anatomical conformation.

The radiographic findings in this series of cats with rhinitis and nasal neoplasia were similar to those previously reported (Cox, Brawner, Power et al. 1991, Cape 1992, O'Brien, Evans, Wortman et al. 1996, Lamb, Richbell and Mantis 2003). They are also similar to those reported in dogs with chronic nasal disease (Sullivan, Lee, Jakovljevic et al. 1986, Russo, Lamb and Jakovljevic 2000).

There is a considerable overlap in the radiographic signs in cats and dogs with rhinitis or nasal neoplasia. As described by Russo, Lamb and Jakovljevic (2000), differentiation of rhinitis and nasal neoplasia should be based on finding combinations of radiographic features that together have a high predictive value. The highest positive predictive values for nasal neoplasia in the present study were evidence of bone invasion and vomer destruction; followed by the presence of unilateral lesion, generalized unilateral soft tissue opacity, and generalized unilateral loss of turbinate detail. PPV ranged from 42.8% to 88.8%. When all this signs occurred together in one cat, the PPV was 80%. Lamb, Richbell and Mantis (2003) found a PPV of similar signs in cats with neoplasia, with a range of 56-73%, but when combining all together in one cat, the PPV reached 86%.

Only 12.3% of the cats in this study showed involvement of the frontal sinus; which is in accordance with the low proportion of frontal sinusitis found by Lamb, Richbell and Mantis (2003). However, only a small number of cats in this study had frontal sinus views taken. Frontal sinusitis has been reported as a common sequel to chronic rhinitis in cats (Bradley 1984, Cape 1992), which means that the radiographic signs of frontal sinus involvement have a poor predictive value.

In this study, and in agreement with previous ones (O'Brien, Evans, Wortman et al. 1996, Lamb, Richbell and Mantis 2003), the radiographic appearance in cats with rhinitis was more variable and less specific than those of nasal neoplasia. We only found a high positive predictive value in the recognition of a mixed pattern (PPV=84%). The recognition of nasal cavities considered within normal limits had a PPV of 18.2%. Mixed pattern (defined as areas of conchal destruction and superimposed soft-tissue

opacity, interspersed with areas of conchal destruction alone), was more commonly found in cats with rhinitis (21 cats with rhinitis and 4 cats with nasal neoplasia). This mixed pattern feature was only recognized in a few cases by Lamb, Richbell and Mantis (2003) in their study of 64 cats, and explained by the lack of rhinitis cases due to foreign body or aspergillosis. We did not find any cases of aspergillosis, and only three cats had foreign body-associated rhinitis. The presence of lucent foci can be explained as soft tissue/fluid tends to have a patchy distribution in rhinitis, whereas in tumours it tends to fill the nasal cavity uniformly or accumulate as a mass. These findings were also reported in CT studies (Schoenborn, Wisner, Kass et al. 2003, Tromblee, Jones, Etue et al. 2006). The presence of lucent foci has been perceived as an important feature in dogs with destructive rhinitis (Sullivan, Lee, Jakovljevic et al. 1986, Russo, Lamb and Jakovljevic 2000).

Deviation of the vomer was a frequent finding in the radiographs of the cats studied, and it was defined as a normal anatomical variation; whereas destruction or lysis of the vomer was considered a pathological finding (Figure 13). No radiographic studies were found to substantiate deviation of the vomer as a normal feature. However, a recent CT study found that vomer deviation can be seen in normal cats as well as in cats with nasal disease (Reetz, Mai, Muravnick et al. 2006). One radiographic report of cats with neoplasia and rhinitis (O'Brien, Evan, Wortman et al. 1996) had differentiated nasal septum deviation from vomer lysis, but they considered both findings to be abnormal in rhinitis and neoplasia. The largest study describing radiographic findings in cats with nasal disease (Lamb, Richbell and Mantis 2003) only commented on displacement of midline structures. We found deviation of the vomer in both neoplasia and rhinitis groups. On the other hand, lysis of the vomer was more common in cats with neoplasia. When destruction of the vomer was seen in cats with rhinitis, it was related to severe rhinitis.

Agreement between observers was in general moderate for rhinitis, which confirms the variability of features seen. Agreement was excellent in the recognition of nasal cavity within normal radiographic limits, and frontal sinus involvement. Good agreement was achieved for lesion location, and the severity of accumulation of soft tissue. Agreement was moderate for the recognition of distribution of soft tissue opacity and the presence of turbinate destruction. Observer A did not recognize unilateral soft tissue and turbinate destruction, with partial involvement of the contralateral side. Differences in perceiving the extent of nasal lesions and signs of bone invasion could be due to

differences in the threshold for abnormality used by the two observers, or by the influence of co-existing radiographic features. However, in tumour cases, the agreement was good. Lytic areas might be more consistently visualized when superimposed on a relatively uniform soft tissue background, as occurs with many cats with nasal neoplasia. The presence of mixed pattern makes it difficult to recognize the exact location of turbinate destruction and soft tissue opacity. Observer A identified mixed pattern in 27 cats with rhinitis, whereas observer B considered mixed pattern in only 9 cats. This poor agreement confirms the variability and difficulty of assessing the extent and exact location of the lesions, but also that both observers could have a different perception of mixed pattern despite prior agreement on definitions.

Regarding the lesion score, the agreement was barely moderate (k=0.468). There are several radiographic scales, which can be divided into qualitative and quantitative ones. A quantitative scale attributes to radiographic abnormalities a numeric score according to their perceived severity (Scruton, Baxter, Cross et al. 2005). Zubrod, Schneider, Hague et al. (2005), proposed a dichotomous rating scale according to the presence of radiographic changes. When assessing an abnormal radiographic sign in terms of presence or absence of the lesion, there is a very high accuracy and agreement between observers. On the other hand, when scale rates are necessary to define a lesion, the results between observers are frequently discordant. It is very important to first assess the rating of the scale and its repeatability in order to obtain similar results within observers. Our poor agreement might be due to the lack of exact definition of the scale. Each observer was able to recognize the presence of the lesion, but when setting a scale rate, it was very different in the case of rhinitis. Here lesions can appear very variable, therefore a rating scale for their definition should be comprehensively assessed and settled before trying to fix a score which could define such different lesions.

On the other hand, agreement for nasal tumours was excellent for turbinate destruction, vomer destruction, mineralization, facial deformity, and score. Good agreement was apparent for lesion location, soft tissue opacity, and bony case invasion. This data showed a direct correlation with the highest positive predictive values for nasal neoplasia. It was surprising that the agreement for the score in tumours was excellent in contrast with the poor agreement on score achieved with rhinitis cases. A possible explanation for this is that neoplasia induces features that are not as variable as rhinitis lesions, and even though the rating score was not perfectly defined, both observers scaled the neoplastic features similarly.

Poor agreement was only shown for mixed pattern and the recognition of wavy vomer. The disagreement over the mixed pattern seen in nasal tumours tends to confirm that the two observers had a different concept of this feature. Observer A identified wavy vomer in eight cats with neoplasia, whereas observer B only four. However, they were in complete agreement on the recognition of vomer deviation/destruction. It may be that wavy vomer or septal deviation can occur together with nasal septum destruction, and observer B might have given more weight to lysis of the vomer, overlooking the deviation of the nasal septum. Also, the correct positioning of the animal influences the appearance of the vomer bone. It is particularly true on ventrodorsal- intraoral views, where slight obliquity can mask the real appearance of the nasal septum.

These results reaffirm that differentiation of rhinitis and nasal neoplasia should be based on finding combinations of radiological signs that together have a very high PPV. Individual signs can be interpreted differently by different radiologists, so the diagnosis should be based on other signs which have better agreement. This is supported by the high degree of agreement and accuracy reached by the two independent observers on the final diagnosis of rhinitis or neoplasia. Kappa reached an excellent 0.941, and the correlation between radiological diagnosis and histopathology diagnosis was also very good.

Nasal CT and MRI are powerful tools that greatly enhance the ability to reach a diagnosis in cases of chronic nasal disease. It has been reported that CT is no more sensitive than radiographs for detecting nasal cavity abnormalities in cats and dogs with referable clinical signs, but is more sensitive at localizing these changes and determining the extent of disease (Thrall and Robertson 1989, Schoenborn, Wisner, Kass et al. 2003). Although on a smaller scale, the ability to assess the location and extension of the lesion was confirmed in our study. There were four cats that had undergone CT investigation in addition to nasal radiographs. These 4 cats showed abnormalities on DViO views of the nasal cavity, but the involvement of the sphenoid sinus (3 cats), nasopharynx (2 cats) and retrobulbar space (1 case), could only be seen with CT. In one cat, on radiographs, only one side on the nasal cavity seemed to be affected, but CT demonstrated bilateral involvement. Previous reports found that soft tissue in nasal neoplasia tends to be on the dorsal aspect of the nasal cavity or to have a mass effect with displacement of midlines structures, whereas chronic rhinitis often had a ventral or patchy distribution of fluid or soft tissue (Schoenborn, Wisner, Kass et al. 2003, Tromblee, Jones, Etue et al. 2006). Given the small number of CT scans in our

study, we are not able to assess this, as an overlap of these features was found in cats with rhinitis and neoplasia. We had a similar problem with bony destruction. Tromblee, Jones, Etue et al. (2006) reported a strong association between lysis of the ventral maxilla and neoplasia. We found two cats, both with ventral maxilla destruction (with severe destruction of turbinates and vomer). One was histologically confirmed as chronic destructive rhinitis and the other as nasal neoplasia. Hopefully in the future more cases will be available to extend this study.

Another possible advantage of CT imaging is to differentiate fluid from a soft tissue mass. Previous reports have indicated that even CT attenuation characteristics are of little value in differentiating obstructive sinusitis from soft tissue because as the secretions desiccate they enter the same range of Hounsfeld units as soft tissue (Codner, Lurus, Miller et al. 1993, Kubal 1999). The difficulty in differentiating secretions from mass lesions can often be overcome by including contrast enhanced images, but there are as yet no reports of contrast studies in cats. However, the distinction between soft tissue and fluid can be straightforward with MRI. An acute obstruction shows a low signal in T1-weighted images and very high signal intensity in T2-weighted sequences. Most tumours can have a high signal in long TR sequences (T2), but commonly they are not as bright as in obstructions. Confidence can be higher, if the high signal intensity area completely conforms to the shape of the sinus. As the obstruction becomes chronic, the protein concentration increases. It results in higher signal intensity in T1, and yet still be as bright in T2. Greater increases in the protein concentration cause gradual decrease in signal intensity on both T1 and T2. When the protein concentration reaches 35%, there is signal void, which can simulate air. The appearance of a non-neoplastic abnormal sinus can be complicated by the presence of haemorrhage. Intravenous contrast is very useful to distinguish an obstructed sinus from neoplasia. With an obstructed sinus, there is normally rim-enhancement, whereas with tumours a general enhancement is a common expectation. There are no studies at the moment defining MRI imaging for chronic nasal disease in cats. Unfortunately, we only had one cat that underwent a MRI study. It was a very interesting case which showed chronic rhinitis with meningeal involvement. MRI was extremely useful to distinguish obstructive sinus from neoplasia and to recognize meningeal enhancement. MRI study in this case provided a definitive answer to explain the nasal discharge and seizures of this cat. This would suggest that a comparative study would be of great value.

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5 Tables

Table 1. Age and sex distribution in 73 cats with confirmed nasal disease:

Diagnosis	n	Age	Sex	Breed
Rhinitis	55	Mean 6.4 years (0.33 years to 15.3years)	23 Female 22 Male	36 Domestic Short Hair 4 Domestic Long Hair 6 Siamese 3 Burmese 3 Persian 1 Chinchilla 1 Russian Blue 1 Abyssinian
Nasal tumour	18	Mean 9.7 years (0.62 years to 16years)	13 Female 5 Male	14 DSH 3 Siamese 1 Burmese

Table 2. Prevalence of clinical signs in 73 cats with confirmed rhinitis or nasal neoplasia:

Sign	Rhinitis (n=55)		Tumour (n=18)	
	n	%	n	%
Nasal discharge				
Unilateral	17	27	10	47.6
Bilateral	19	30.16	2	9.5
Mucopurulent	9	14.3	5	7.9
Serous				
Epistaxis	12	19	6	28.5
Sneezing	24	38	12	57
Facial deformity	6	9.5	6	28.5
Exophthalmus			1	4.8
Ocular discharge	5	8	6	28.5
Ear discharge	2	3.17		
Stertor	8	12.7	3	14.3
Dyspnoea	5	8	2	9.5
Anorexia	2	3.2	4	19
Seizures	2	3.18		
Head tilt	1	1.58		

Table 3. Definitive diagnosis in 73 cats with chronic disease

Definitive daignosis	n	Type
Rhinitis	55	37 Non-specific rhinitis 3 Nasopharyngeal polyp 3 Foreign body associated 2 Old trauma 10 Primary non-nasal disease
Nasal neoplasia	18	4 Carcinoma 1 Adenocarcinoma 2 Squamous cell sarcoma 6 Lymphoma 2 Fibrosarcoma 2 Osteosarcoma 1 Melanoma

Table 4. Histomorphological classification, sex and age distribution in 18 feline nasal tumours

Tumour type	No of cases	%	Age range
Epithelial tumours			
Undifferentiated carcinoma	4	23.6	5 to 14.6
Squamous cell carcinoma	2	11.8	years
Adenocarcinoma	1	5.8	
Non-epithelial tumours			
Malignant lymphoma	6	54.6	0.6 to 16
Fibrosarcoma	2	18.2	years
Osteosarcoma	2	18.2	
Melanoma	1	9	

Table 5A. Summary of radiological interpretations of 85 cats with nasal radiography interpreted by observer A

Radiological signs	Rhinitis (n=59)		Nasal tumour (n=26)	
	n	%	n	%
Nasal Cavity within normal limits	14	23.7		
Lesion location				
Unilateral	21	35.5	19	73
Bilateral	8	13.5	6	23
Rostral	15	25.4	1	4
Caudal	1	1.6		
Soft tissue opacity				
Focal	16	27.1	1	4
Multifocal	4	6.5		
Generalized unilateral	14	23.7	18	69.2
Generalized bilateral	3	5	4	15.3
Generalized unilateral+ focal contralateral			3	11.5
Degree:				
Mild	13	22	1	4
Moderate	12	20.3	9	34.5
Severe			16	61.5
Turbinate destruction				
Focal	10	17.2	1	4
Multifocal	14	24.14		
Generalized unilateral	9	15.5	18	69.2
Generalized biltareral	4	6.5	4	15.3
Generalized unilateral+ focal contralateral			3	11.5
Mixed pattern	27	45.7	2	7.7
Vomer destruction	3	5	11	42.3
Vomer deviation	14	23.7	8	30.8
Mineralization	0	0	2	7.7
Invasion bony case	0		7	27
Frontal sinus involvement	3	5	6	23
Facial deformity	1	1.6	3	11.5
Score				
1	16	27.1		
2	16	27.1		
3	4	6.5	22	84.6
4	15	25.4	4	15.4
5	8	13.5		

Table 5B. Summary of radiological interpretations of 85 cats with nasal radiography examined by observer B

Radiological signs	Rhinitis (n=62)		Nasal tumour (n=23)	
	n	%	n	%
Nasal Cavity within normal limits	16	25.8		
Lesion location				
Unilateral	12	19.3	14	60.8
Bilateral	12	19.3	7	30.5
Rostral	19	30.6	2	8.7
Caudal	3	4.8		
Soft tissue opacity				
Focal	19	30.6	2	8.7
Multifocal	8	12.9	1	4.3
Generalized unilateral	9	14.5	12	56.5
Generalized bilateral	4	6.4	2	8.7
Generalized unilateral+ focal contralateral	6	9.6	5	21.8
Degree:				
Mild	11	17.7		
Moderate	15	24.2	9	39.1
Severe	1	1.6	14	60.9
Turbinate destruction				
Focal	12	19.3	3	13
Multifocal	8	12.9	1	4.4
Generalized unilateral	8	12.9	14	60.9
Generalized biltareral	3	4.8	2	8.7
Generalized unilateral+ focal contralateral	2	3.2	3	13
Mixed pattern	9	14.5	1	4.4
Vomer destruction	4	6.4	12	52.2
Vomer deviation	13	20.9	4	17.4
Mineralization	0	0	2	8.7
Invasion bony case	1	1.6	6	26
Frontal sinus involvement	3	4.8	6	26
Facial deformity	0	0	3	13
Score				
1	16	25.8		
2	14	22.6		
3	21	35.4	22	95.6
4	2	3.2		
5	8	12.9	1	4.3

Table 6. Comparison of radiological interpretation of 85 cats by two independent observers A and B.

Radiological signs	Rhinitis (n=61)			Nasal Tumours (n=26)		
	A	B	kappa	A	B	kappa
Nasal cavity within normal limits	14	16	0.967			
Lesion location						
Unilateral	21	12		19	14	
Bilateral	8	12	0.649	6	7	0.840
Rostral	15	19		1	2	
Caudal	1	3				
Soft tissue opacity						
Focal	16	19		1	2	
Multifocal	4	8			1	
Generalized unilateral	14	9	0.488	18	12	0.714
Generalized bilateral	3	4		4	2	
Generalized unilateral+ focal contralateral		6		3	5	
Degree:						
Mild						
Moderate	13	11		1		
Severe	12	15	0.604	9	9	0.783
		1		16	14	
Turbinate destruction						
Focal	10	12		1	3	
Multifocal	14	8			1	
Generalized unilateral	9	8		18	14	0.95
Generalized biltareral	4	3		4	2	
Generalized unilateral+ focal contralateral		2		3	3	
Mixed pattern	27	9	0.33	2	1	0.5
Vomer destruction	3	4	0.75	11	12	0.91
Comer deviation	14	13	0.929	8	4	0.5
Mineralization	0	0		2	2	1
Invasion bony case	0	1		7	6	0.857
Frontal sinus involvement	3	3	1	6	6	1
Facial deformity	1	0		3	3	1
Score						
1	16	16				
2	16	14				
3	4	21	0.468	22	22	0.913
4	15	2		4		
5	8	8			1	

Table 7. Summary of radiological consensual interpretation by observers A&B of 73 cats with definitive diagnosis of rhinitis or nasal tumour (NS=not significant, P<0.1 = significant)

Radiological signs	Rhinitis (n=55)		Nasal tumour (n=18)		p
	N	%	n	%	
Nasal cavity within normal limits	10	18.8			p=0.121
Lesion location					
Unilateral	16	29.1	14	77.7	p<0.01
Bilateral	14	25.4	4	22.3	NS
Rostral	12	21.8			NS
Caudal	3	5.4			NS
Soft tissue opacity					
Focal	16	29.2	1	5.5	NS
Multifocal	11	20	2	11.1	NS
Generalized unilateral	12	21.8	9	50	NS
Generalized bilateral	5	9.1	2	11.1	NS
Generalized unilateral+ focal contralateral	1	1.8	4	22.2	P<0.05
Degree:					
Mild	12	21.8			P=0.072
Moderate	34	61.8	8	44.4	NS
Severe			10	55.5	P<0.01
Turbinate destruction					
Focal	9	16.3	1	5.5	NS
Multifocal	12	21.8	2	11.1	NS
Generalized unilateral	12	21.8	9	50	P<0.05
Generalized biltareral	2	3.6	2	11.1	NS
Generalized unilateral+ focal contralateral	1	1.8	4	22.2	NS
Mixed pattern	21	38.2	4	22.2	NS
Vomer destruction	2	3.6	13	72.2	P<0.01
Vomer deviation	21	38.2	8	44.4	NS
Mineralization			3	16.6	NS
Invasion bony case	1	1.8	8	44.4	P<0.01
Frontal sinus involvement	3	5.4	6	33.3	P<0.01
Facial deformity			1	5.5	NS
Score					
1	10	18.2			NS
2	9	16.3			NS
3	12	21.8	14	77.7	P<0.01
4	3	5.4			NS
5	21	38.2	4	22.2	

Table 8. Positive predictive values in 73 cats with confirmed rhinitis and nasal neoplasia

	Positive predictive value	
	Individuals signs	**Signs in combination**
Signs of rhinitis		
Nasal cavity within normal limits	10/55 (18.2%)	
Presence of mixed pattern	21/25 (84%)	
Signs of nasal neoplasia		
Unilateral lesion	14/30 (46.7%)	
Generalized unilateral soft tissue opacity	9/21 (42.8%)	
Generalized unilateral loss of turbinate detail	9/21 (42.8%)	8/10 (80%)
Vomer destruction	13/15 (86.6%)	
Invasion of bones	8/9 (88.8%)	

Table 9. Comparison of definitive radiological diagnosis by two independent observers in 73 cats

	Observer A	**Observer B**	**Definitive diagnosis**	**kappa**
Rhinitis	47	45	45	0.941
Nasal tumour	16	17	18	
Nasal cavity within normal limits	10	11	10	

Table 10. Computed Tomographic (CT) findings and comparison with nasal radiograph in five cats with chronic nasal disease. (ST= soft tissue)

	CT Findings	**Radiological findings**	**Definitive diagnosis**
Cat 1	Bilateral lesion location Lining of ST opacity on the sphenoid sinus, obliteration of the retrobulbar space, and multifocal soft tissue opacity within the nasal cavity. No evidence of turbinate destruction	Very mild increase of ST opacity on the right nasal cavity, on its caudal part	Rhinitis due to foreign body
Cat 2	Lesion location: bilateral ST opacity: multifocal within the nasal cavity, sphenoid sinus and nasopharynx. Bony destruction: ventral palatine bone, vomer bone, nasal septum, and turbinates	Lesion location: bilateral ST opacity: bilateral multifocal Bony destruction: multifocal loss of turbinates, and vomer deviation	Tumour
Cat 3	Lesion location: unilateral ST opacity: lining of ST on the left frontal sinus, and multifocal opacity within the left nasal chamber. Bony destruction: generalized loss of turbinates Mineralization within ST	Lesion location: unilateral ST opacity: multifocal Bony destruction destruction: unilateral generalized loss of turbinates Mixed pattern	Tumour
Cat 4	Lesion location: bilateral ST opacity: generalized bilateral within the nasal cavity, bilateral involvement frontal sinus, sphenoid sinus and nasopharynx. Bony destruction: generalized loss of turbinates, ventral palatine bone, lateral maxilla (right side)	Lesion location: bilateral ST opacity: generalized bilateral Bony destruction: generalized loss of turbinates. Mixed pattern	Chronic destructive rhinitis
Cat 5	Lesion location: bilateral ST opacity: rostral, bilateral, and nsaopharynx No turbinate destruction	None	Rhinitis

Figures

Figure 1: Pie chart showing causes of chronic nasal disease in 73 cats

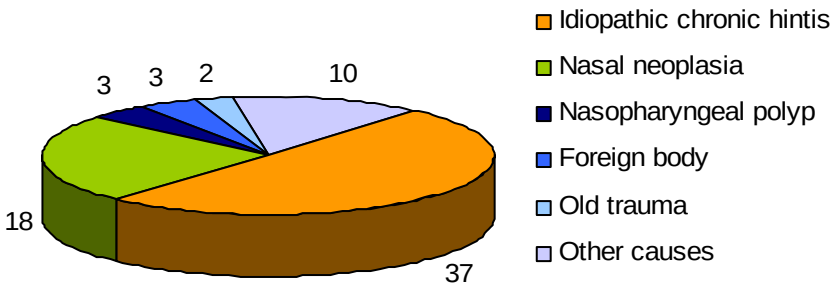


Figure 2: Bar graph showing age range in 73 cats with confirmed nasal neoplasia and chronic rhinitis

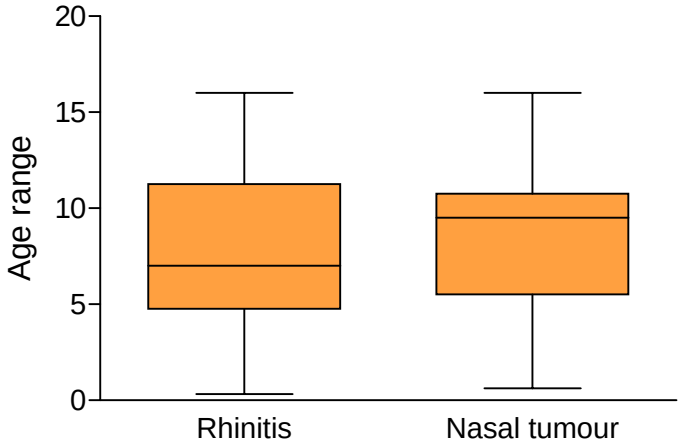


Figure 3: Bar chart showing age range in 18 cats with epithelial and non-epithelial nasal tumours (NA: please note that the mean age of the epithelial tumour group is 13 years old and it is at the top of the orange box. The mean age of the non-epithelial group is 7 years old and it is highlighted within the orange box).

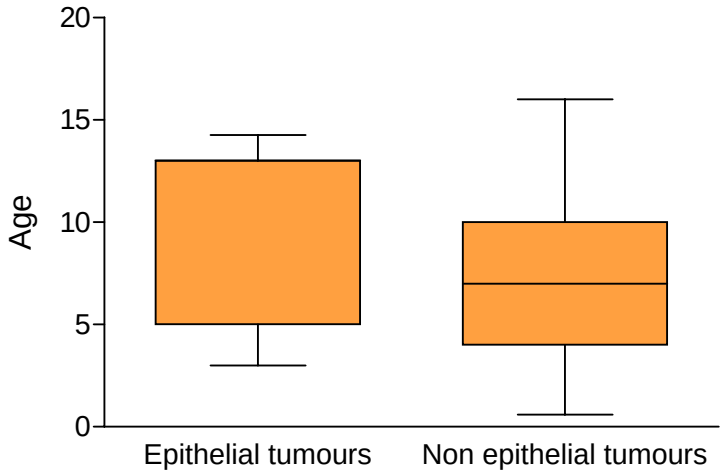


Figure 4: Bar graph of gender in 73 cats with chronic rhinitis and nasal tumours

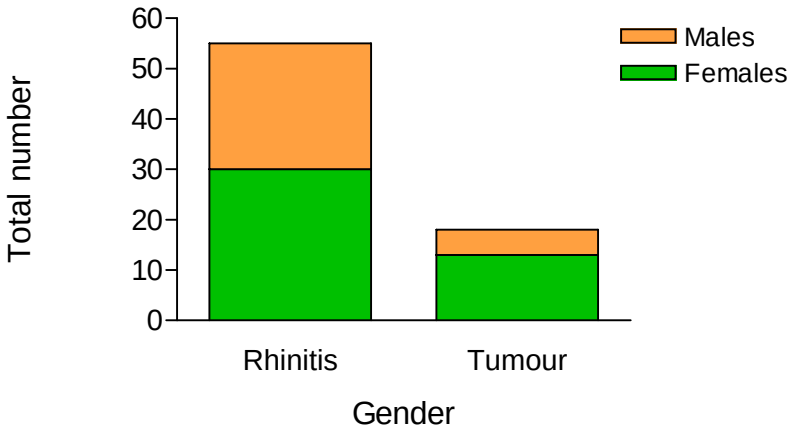


Figure 5: Bar graph of selected radiographic changes in 73 cats with confirmed chronic rhinitis and nasal tumours

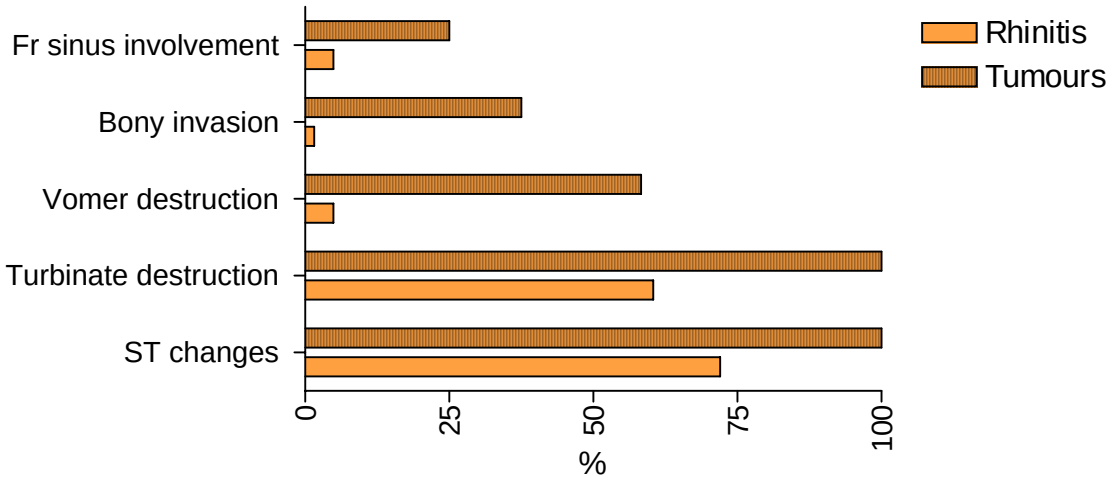
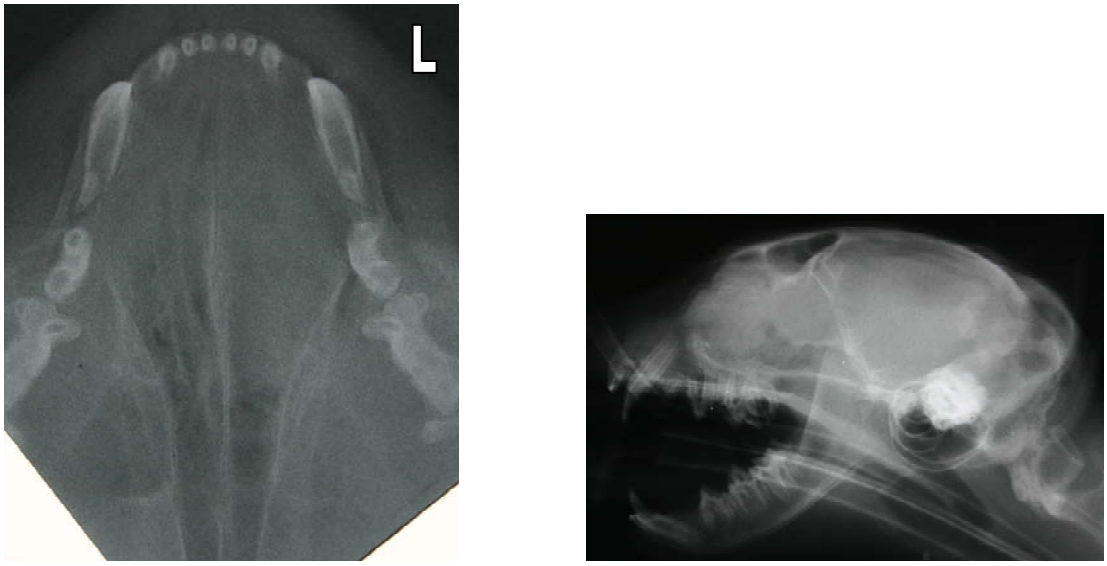
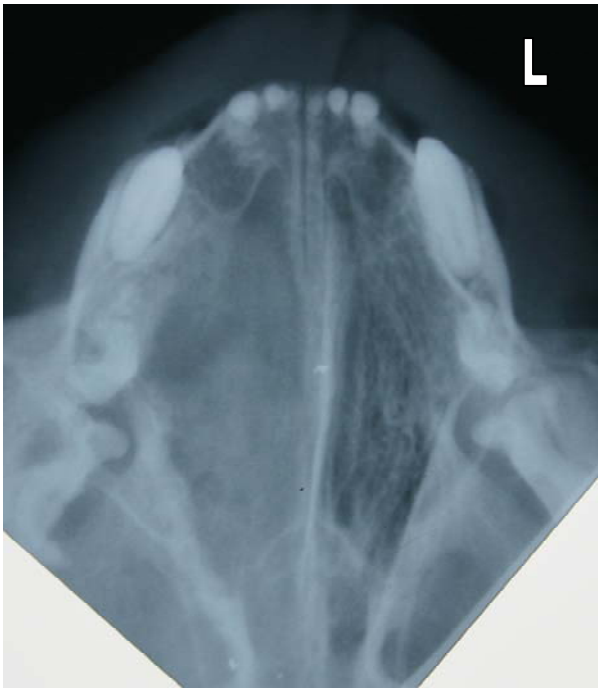


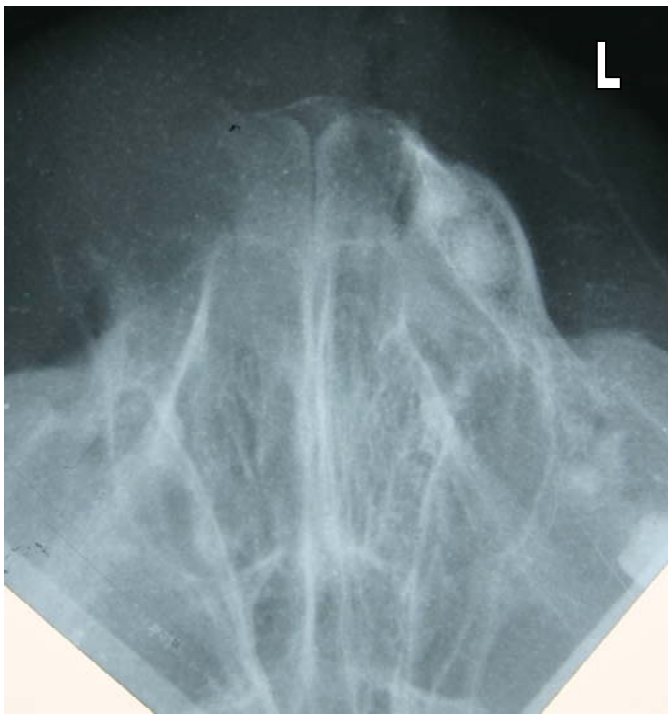
Figure 6: DViO radiographic views of examples of feline nasal tumours (A-D)



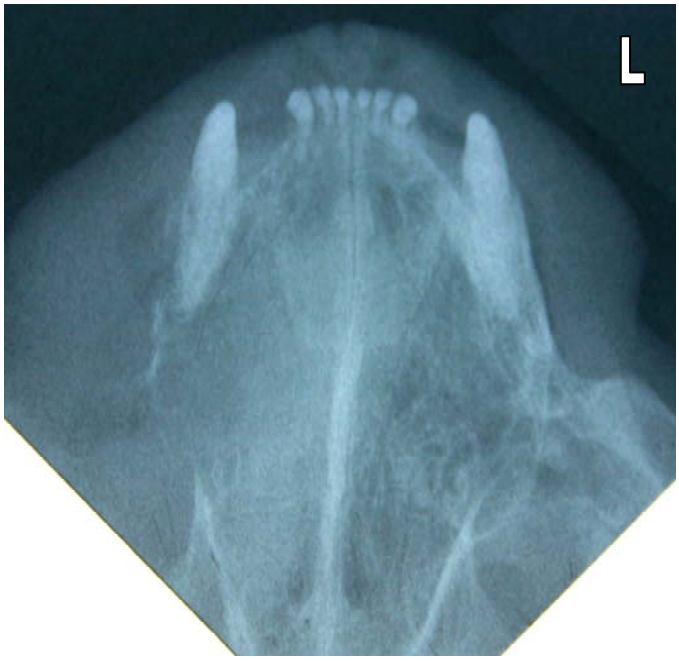
A. DViO and lateral skull radiograph of a 7-month-old cat with nasal lymphoma. There is generalized bilateral turbinate destruction. Note the vomer destruction on the DViO view. On the lateral view breach of the cribriform plate can be appreciated.



B. Nasal lymphoma in a 7 year-old castrated male. There is right unilateral nasal involvement, with generalized and severe increase in soft tissue opacity and loss of normal nasal turbinates. Bony case and vomer destruction are evident.

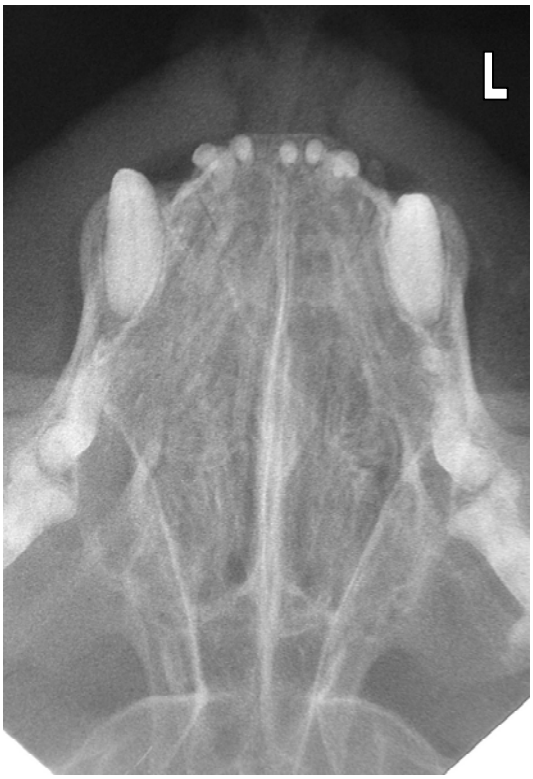


C. Fibrosarcoma with massive right rostral maxilla destruction. There is some is some increase in soft tissue opacity within the right nasal cavity

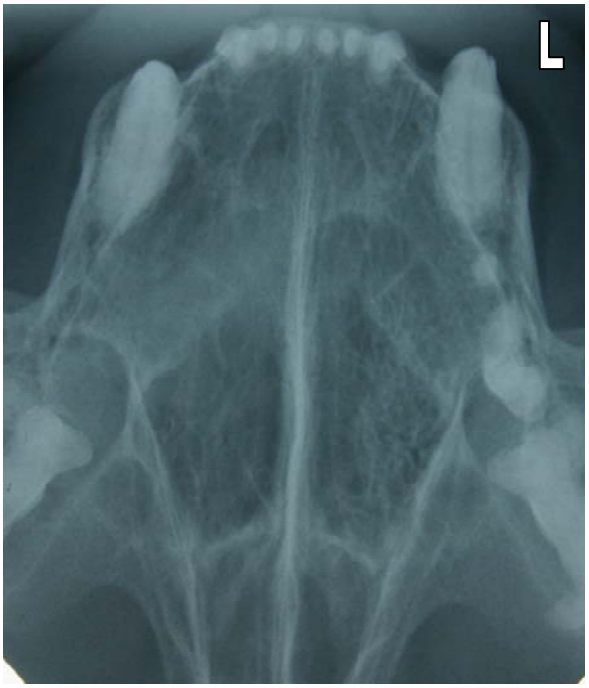


D. Squamous cell carcinoma in an 11 year-old Domestic Short Hair female. Note The extensive bony case destruction and facial asymmetry.

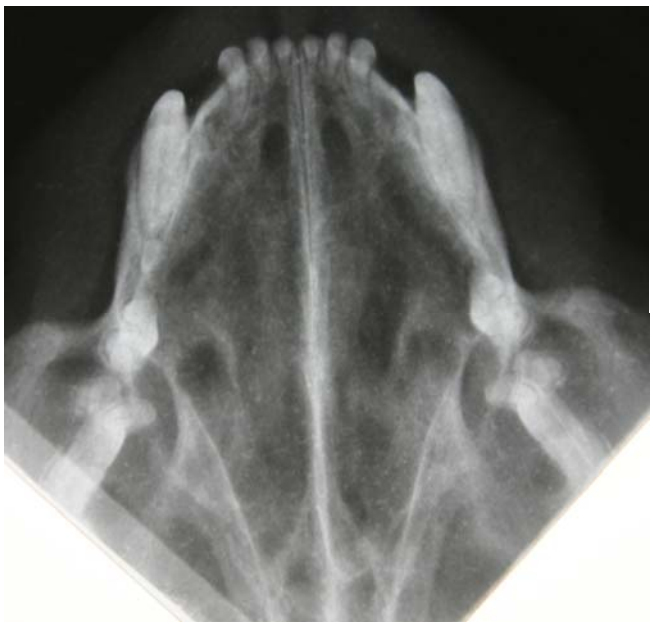
Figure 7: DViO views of some radiographic features in cats with chronic rhinitis. (A-D)



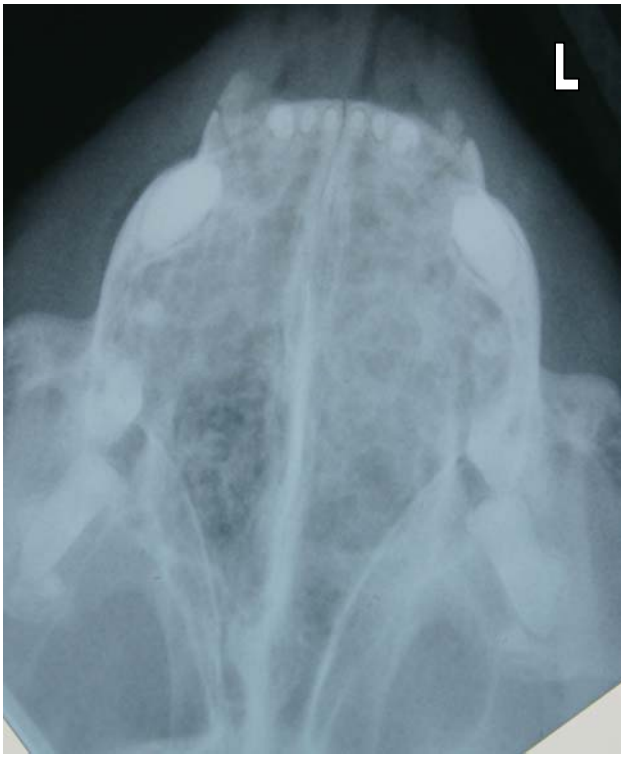
A. DViO view of a cat with chronic rhinitis. The nasal radiograph can be considered within normal limits.



B. Unilateral rhinitis. There is an increase in soft tissue opacity affecting the right nasal cavity.

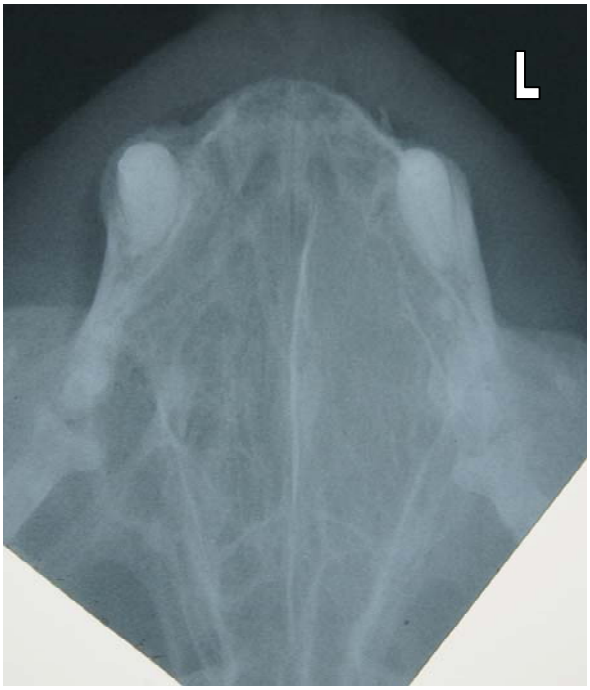


C. Chronic hyperplastic rhinitis. There is bilateral generalized loss of turbinate detail and increase of soft tissue opacity. There are focal areas of turbinate alone producing an increase of radiolucency, which results in mixed pattern.

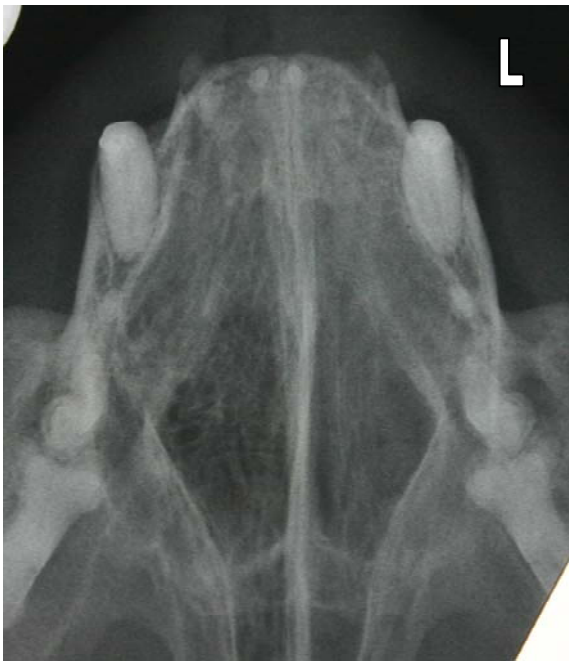


D. Example of chronic non-specific rhinitis with secondary bacterial infection. There is bilateral soft tissue opacity, more marked on the left side. There is mild loss of turbinate detail. Note the wavy appearance of the vomer.

Figure 8: DViO views of examples of incorrect radiological diagnosis (A,B)

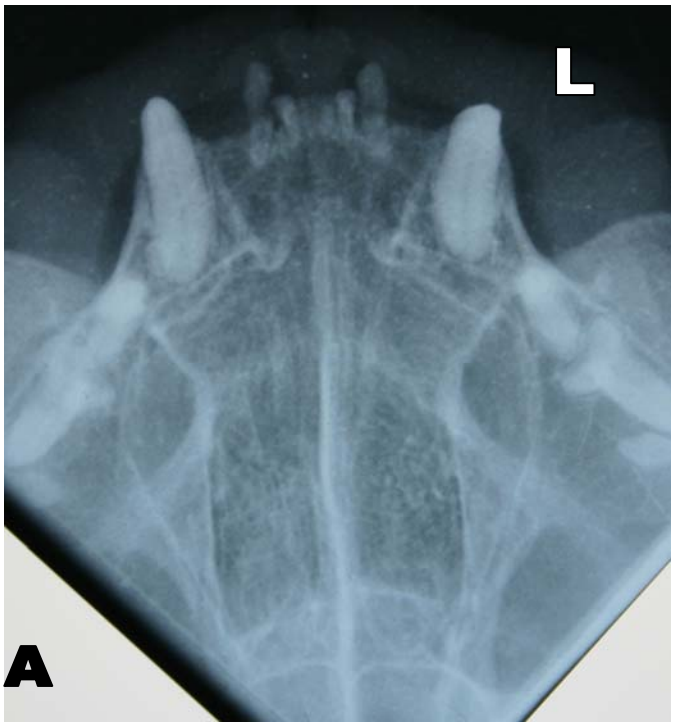


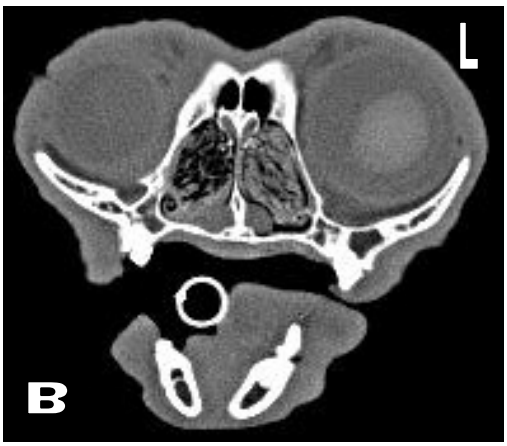
A. The severe degree of soft tissue opacity and loss of turbinate detail, mainly affecting the left nasal cavity, in addition to vomer destruction and bony case involvement were misinterpreted as neoplasia.



B. Nasal carcinoma misinterpreted as rhinitis in an 8 year-old cat with chronic nasal discharge. Note the unilateral and moderate increase of soft tissue opacity on the left. The turbinate destruction is not severe and there are no signs of bony case involvement. The vomer is deviated (normal anatomical variation), but it is not destroyed.

Figure 9: DViO radiograph (A) and transverse CT images (B and C) of a cat with chronic rhinitis due to foreign body. (A) There is a subtle increase of soft tissue opacity on the right caudal nasal cavity. (B,C) There is mucosal thickening with patchy accumulation of soft tissue/fluid within the turbinates. These changes on CT are seen affecting the caudal nasal cavity and extending rostrally. The nasopharynx is occluded by this soft tissue/fluid. The foreign body is not visible (it was confirmed by endoscopy)





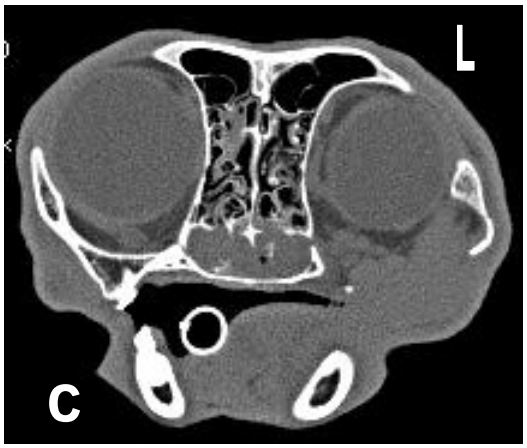


Figure 10: DViO view (A), and transverse CT images (B,C) of a cat with chronic destructive rhinitis confirmed by hystopathology. (A) There is bilateral and severe soft tissue opacity and generalized turbinate destruction. There is an area of mixed pattern on the left cranial nasal cavity (black arrow). (B, C) CT confirms the severe soft tissue accumulation within the nasal cavity. The turbinates are destroyed, as well as the right lateral and ventral maxilla. The area of mixed pattern seen on A is also observed on CT images.

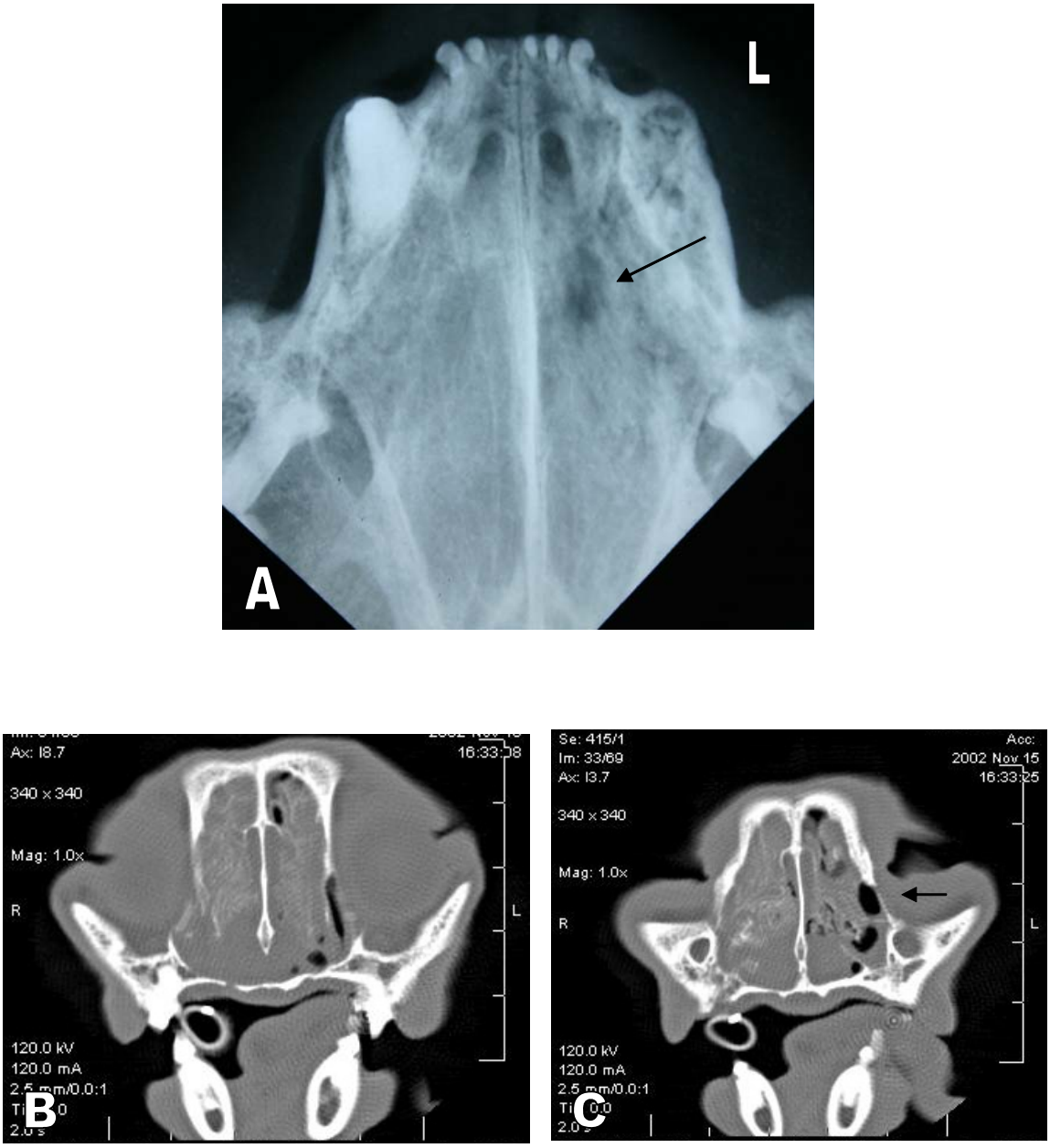


Figure 11: DViO (A) and transverse CT images (B, C, D, E) of a cat with nasal neoplasia. (A) DViO shows bilateral patchy soft tissue opacity and multifocal turbinate destruction. The most rostral part of the vomer bone is destroyed. Transverse CT images reveal occlusion of the right sphenoid sinus and nasopharynx. Apart from the turbinate and vomer destruction, CT scan clearly shows lysis of the ventral maxilla.

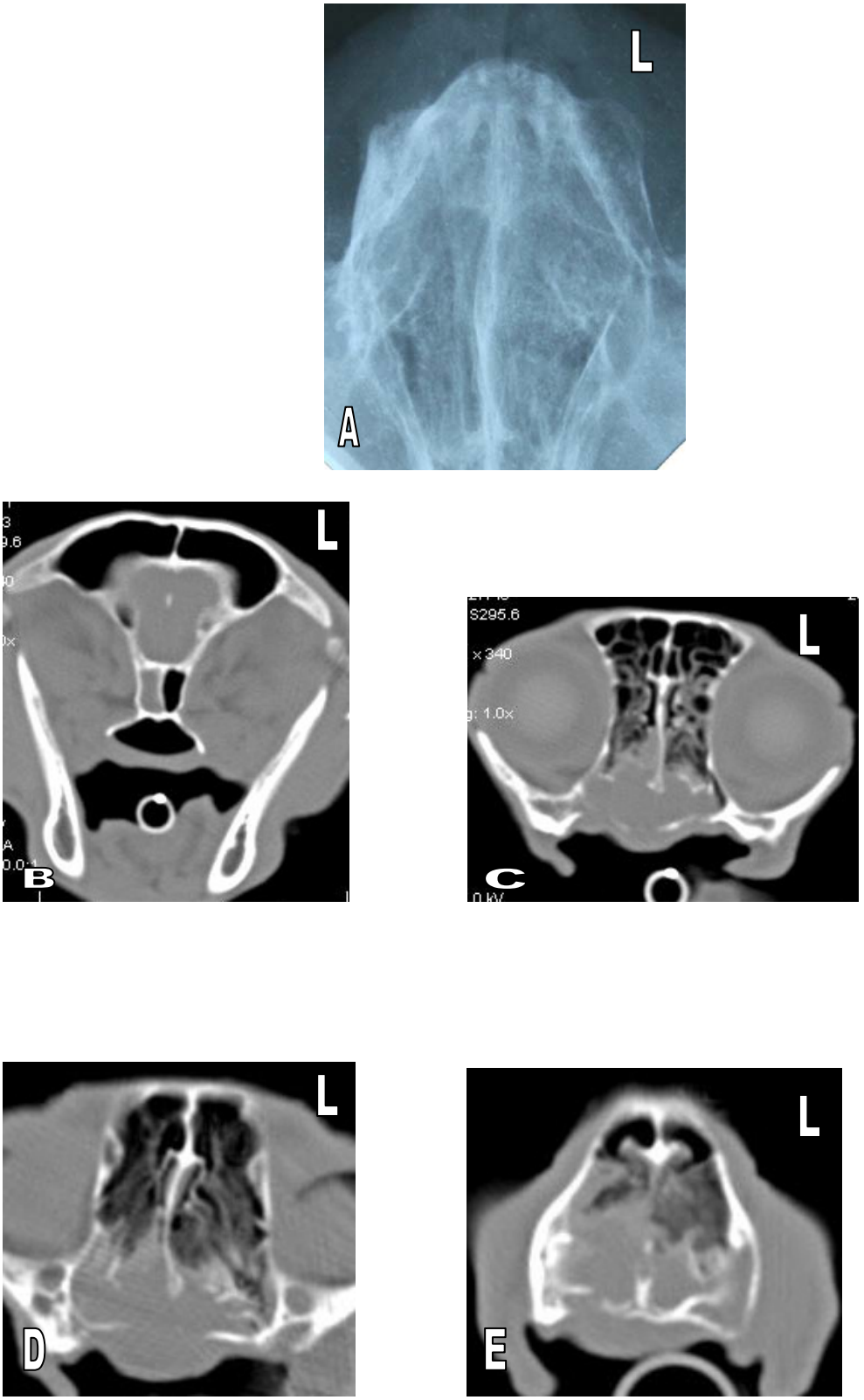


Figure 12: Dorsal MRI T1 images after Gadalonium administration in a cat with chronic rhinitis: There is contrast enhacement within the nasal cavity, more marked on the right side. The right sphenoid sinus shows rim enhancement. Note the subtle enhancement of the meninges (black arrow). These findings are compatible with rhinitis which was confirmed by biopsy.

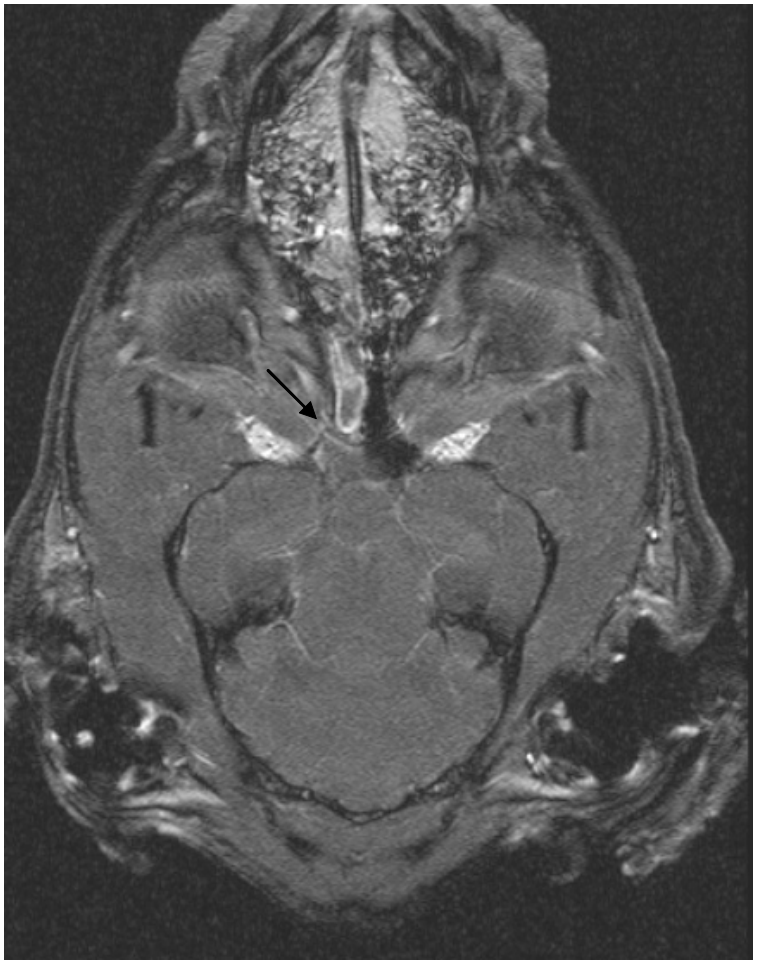
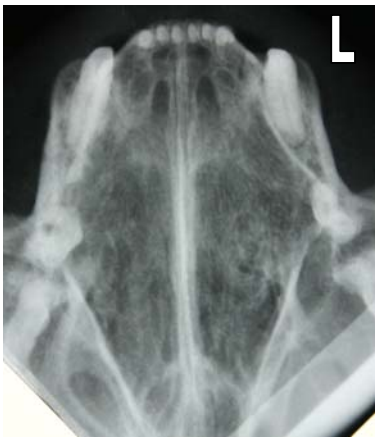
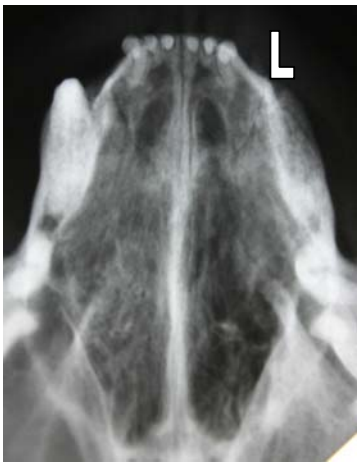
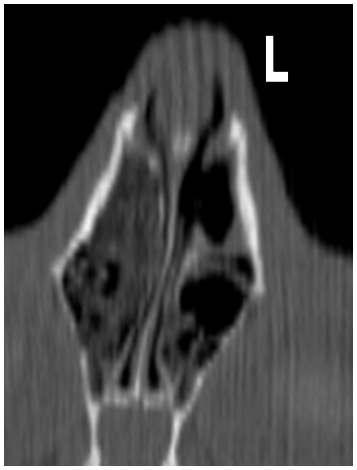


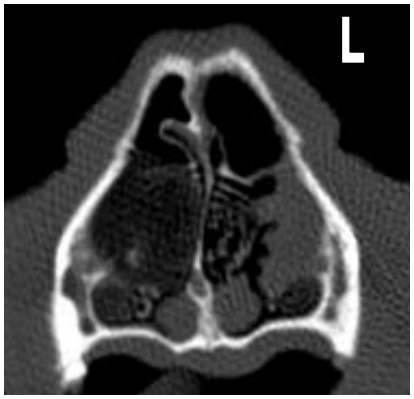
Figure 13: Examples of anatomic and pathologic variations in the feline nasal septum (A-D)



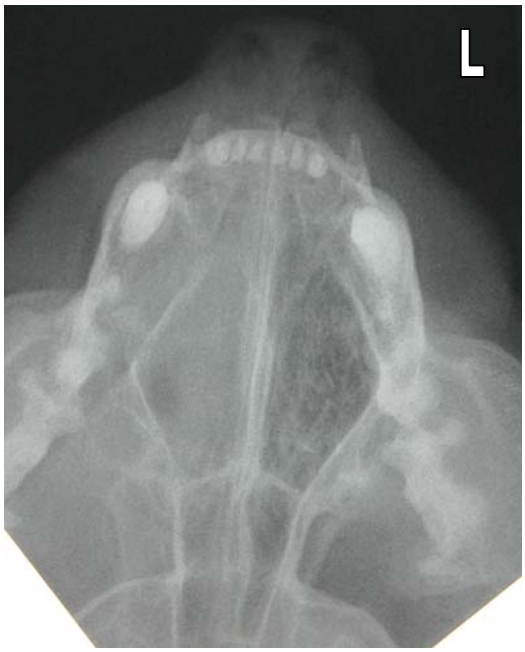
A. Normal nasal septum

B 

C 

D 

B-D: DViO view (B), dorsal reconstructed CT (C), and transverse CT (D) images showing deviation of the nasal septum to the left. It represents a normal anatomical variation, as there is no obvious vomer destruction.



E. Destruction of the nasal septum is evident in this case of nasal neoplasia