An investigation into the usefulness of a rostrocaudal nasal radiographic view in the dog

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ABSTRACT

A rostrocaudal (RCd) nasal view was developed in large breed mesaticephalic dogs using a complete, subsequently sectioned, skull and cadaver specimens to optimise the radiographic technique and evaluate normal anatomic features. Gelatin was placed in one nasal passage of the cadaver specimens to mimic the effects of nasal pathology. The latter specimens and 18 clinical cases with suspected nasal disease were evaluated to determine the usefulness of the RCd view compared to standard nasal views. An optimal RCd view was obtained with the dog in dorsal recumbency and the head symmetrically positioned with the hard palate perpendicular to the table using a table top technique with 8:1 grid, collimating to the nasal region and centring the primary beam on the philtrum. The dorsolateral aspects of the maxillary bone, the nasal bones, septal sulcus of the vomer, mucosa lined nasal septum and conchae could be seen. A centrodorsal more radiolucent area representing the ethmoid bone region was also visible. Gelatin soft tissue opacification of the nasal passage could be seen more clearly in RCd nasal view than in occlusal dorsoventral view. In clinical cases the RCd view was useful to build up a 3-dimensional image of nasal passage pathology as well as to detect nasal septum and osseous nasal border pathology not visible in other views. This view is particularly useful in cases where cross-sectional imaging modalities are not available or where the nasal investigation is limited by cost considerations.

Key words: dog, nasal radiography, rostrocaudal nasal view.

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INTRODUCTION

The occlusal (intraoral) dorsoventral view of the nasal passages (or alternatively the ventro-15°-rostral-caudodorsal oblique view (open mouth) of the nasal cavity), lateral and rostrocaudal (RCd) frontal sinus views are currently the standard views used for radiographic nasal evaluation[2,5,7]. Non-screen films for occlusal views have been shown to be more accurate than screen-film combinations to allow visualisation of nasal conchal patterns[6] but non-screen film is no longer readily available. Standard nasal views do not always identify all pathology present or its exact delineation and computed tomography (CT) or magnetic resonance (MR) imaging are required for further evaluation.

In this study an additional radiographic view, the RCd nasal view, was investigated. It is hypothesised that this view allows for the end-on visualisation of nasal structures which will improve 3-dimensional localisation of nasal pathology, particularly in its dorso-ventral location. In addition, it may allow greater visibility of the nasal septum with its mucosal covering and the osseous nasal borders.

Diagnostic imaging modalities allow for assessing the size and extent of lesions, localisation of biopsy sites and attempt differentiation of nasal diseases[6]. Differential diagnoses for nasal pathology include fungal, bacterial, viral, parasitic, allergic and non-specific rhinitis, foreign bodies and neoplasia. Computed tomography has traditionally been used to build up cross-sectional images of the nasal passages[1,11]. The CT images of the more rostral aspects of the nasal passage appear similar to RCd nasal radiographs that initiated this study. Although the latter represents the full length of the nasal passage, similar benefits to CT may be obtained. Computed tomography is also advantageous to guide insertion of a biopsy needle through a nostril to the region of abnormal tissue. This is because of CT's ability to distinguish bilateral from unilateral and ventral from dorsal disease more accurately than routine radiography. It is hypothesised that the RCd nasal view will also differentiate dorsal from ventral and bilateral versus unilateral disease and assist in guiding biopsy instruments more accurately making the procedure more precise and less traumatic in cases were CT or MR imaging are unavailable or beyond the financial means of the client.

The nasal cavity is separated into left and right nasal fossae by the nasal septum. The perpendicular plate of the ethmoid bone forms a middle osseous nasal septum with the dorsal part of this septum formed by the septal plates of the frontal and nasal bones[3]. Ventral to this osseous septum is a narrow cartilaginous septal band which is continuous with the more rostral cartilaginous septum. The osseous septum extends rostrally to approximately the caudal border of the third maxillary premolar tooth and from there it continues rostrally as a cartilaginous septum[3]. In the region of the bony nasal aperture the septum is membranous for about 1 cm and then continues rostrally again as cartilage[3]. The ventral aspect of the nasal septum is held in position by the bony septal sulcus of the vomer bone and the incisive bone rostrally to the second premolar teeth. This bony septal sulcus is the only radiographically visible septal segment in standard nasal views, and is only seen in the occlusal view[4]. It is hypothesised that the proposed RCd nasal view will allow better evaluation of the rostral cartilaginous septum due to the soft tissue opacity of its mucosal lining as well as the caudal osseous septum. The nasal conchae are cartilaginous or slightly ossified scrolls covered with nasal mucosa and form the dorsal, middle, ventral and common nasal meatuses. The conchal trabecular pattern is visible in good quality occlusal views but it is impossible to distinguish at which level the concha is involved when turbinate destruction is present. The RCd nasal view may be able to identify the

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level of turbinate destruction.

The objective of this study was to develop a RCd nasal passage view in the dog, to determine the normal osseous radiographic anatomy from skull specimens, and its value in evaluating simulated nasal pathology in necropsy specimens and in clinical cases with nasal disease, and to compare the value of the RCd nasal view with the other standard nasal views.

MATERIALS AND METHODS

Part 1 of the study was designed to optimise the radiographic technique and determine normal radiographic anatomy. In addition, the effect of placing gelatin in a nasal passage was evaluated. The heads of one German shepherd dog and a Border collie (dogs recently euthanased for reasons other than nasal disease) were removed at C2–3, and a German shepherd dog skull with its osseous turbinates and remnants of the cartilaginous nasal septum still present, but without the mandible, were used. The heads or skull were placed in dorsal recumbency with the nose pointing upwards using positioning aids and a perspex head holder. Various positions of the hard palate relative to the cassette and centring the primary beam in the region of the nostrils were performed to obtain optimal positioning. The primary beam was collimated to the external nasal borders to limit the effects of scatter. Optimal radiographic technique was determined by comparing 8:1 grid bucky table exposures to table top non-grid and table top 8:1 grid exposures. Part 2 of the study utilised the optimal RCd nasal view in a limited number of dogs with nasal disease in order to determine its sensitivity to detect pathology in a clinical setting. Brachycephalic prognathic dogs were excluded as it was believed that anatomical conformation would render the RCd nasal view unreadable.

All lateral and RCd nasal radiographs were made with detail screens and standard film. All occlusal views were made with thin plastic envelope flexi-cassettes with detail screens. Routine radiation safety procedures were followed.

Part 1

The skull specimen and 2 heads had the standard lateral and occlusal views made followed by the RCd nasal view. The skull specimen was then placed in water and frozen prior to being sectioned transversely to prevent splintering of the turbinates. This specimen was sectioned transversely at 2 locations; the rostral aspect of the first premolar tooth (about the rostral extent of the osseous turbinates) and at the caudal border of the third premolar tooth (about at caudal edge of the ventral nasal concha and rostral extent of osseous septum). This resulted in a ~4-cm section of cranial nasal passage, ~3.5 cm mid-nasal passage and the remainder of the head with the ethmoidal conchae and caudal aspect of dorsal nasal concha. These 3 sections were radiographed rostrocaudally, first individually and then in combinations of 2 adjacent sections. The right nasal passages of the 2 cadaver specimens were completely filled with about 20 mℓ gelatin (10 g in 500 mℓ warm water[8]) to mimic pathology. It has been shown that there is no difference in the X-ray attenuation of blood, purulent material and gelatin[8]. The nasopharynx was obstructed with a cotton ball, the heads positioned upright in dorsal recumbency and the warm gelatin fluid instilled into the right nasal cavity through the external nares, followed by 24-hour refrigeration. Lateral, occlusal and RCd nasal views were made followed by freezing the cadaver specimens and then sectioning and radiographing them as described for the skull specimen.

Normal anatomical structure, location and radiographic visibility on the intact and sectioned skull (aided by wire markers) and cadaver heads were evaluated and the gelatin-filled side compared with the normal side.

Part 2

Eighteen cases of suspected clinical nasal disease, including 4 Bull or Staffordshire terriers, 3 Maltese poodles (a popular local breed) and 3 Border collies, with the remainder being single breeds only, underwent routine radiography. The ages of the 18 dogs ranged from 3–13 years with a mean of 8.5 years. In addition to the 3 standard nasal views, the RCd nasal view was made. The dogs were already under general anaesthesia and positioned correctly for the RCd frontal sinus view and the additional view required minimal repositioning. Each of the dogs had well positioned optimal quality radiographs made and a final diagnosis was obtained by means of biopsy or necropsy histopathology and/or culture.

Each of the radiographic views were grouped together and reviewed independently by the authors blinded to the radiographic diagnosis in the other 3 views or of the final diagnosis of the case. Radiological changes evaluated on applicable views included location, size and opacity of any lesion, conchal effacement or lysis, vomer deviation or lysis, lysis or new bone production of the bones surrounding the nasal passages and frontal sinus involvement. Evidence of radiological changes compatible with pathology in each view were graded as follows: 0, normal; 1, suspect pathology; 2, mild changes; 3, moderate changes; and 4, severe changes. This was followed by evaluating the 4 radiographs of each individual dog together to make a radiological diagnosis. Evaluations were then correlated and where differences of opinion existed between researchers, consensus was obtained. Results were compared to the final diagnosis. The value of the RCd nasal view in making a diagnosis was compared with the other views. All clinical cases were under the supervision of the attending clinician and standard hospital procedures were followed.

RESULTS

Part 1

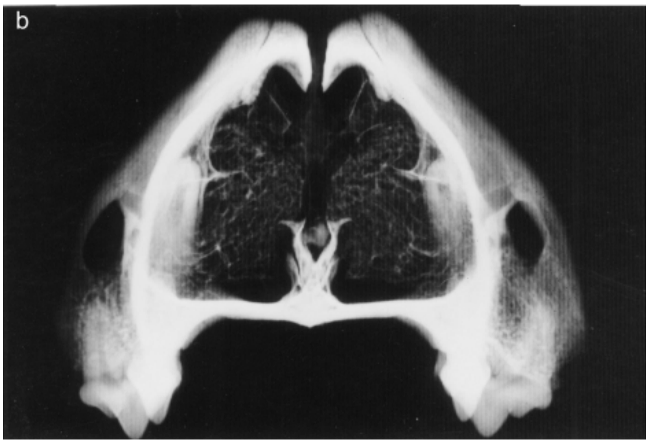
Optimal positioning was obtained with the hard palate perpendicular to the cassette, ensuring absolute symmetry of the left and right sides and the primary beam centred on the philtrum, midway between the ventral aspect of the nostril and edge of the lip and parallel to the hard palate. Table top techniques using a grid and a 65–75 kVp range in large-breed dogs were found to be optimal.

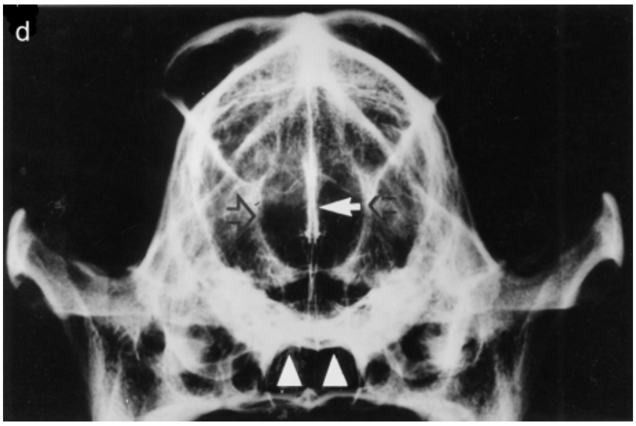
On the skull specimen (Figs 1, 2) optimal positioning was evidenced by the hamuli pterygoidei protruding just ventral to the osseous palate as well as the ventral aspect of the bullae tympanicae being just visible or absent. Detailed descriptions aided by evaluating the 3 subsections individually or as adjacent blocks are given in the figure legends.

On the intact and sectioned cadaver specimens similar structures were visible (Fig. 3) but less clearly defined due to the addition of the soft tissue components which resulted in thicker conchal structures and septum. In the rostral 2 sections the cartilaginous septum became visible as a soft tissue opacity due to the adjacent mucosal lining. The added gelatin (Fig. 4) could not be visualised in the lateral views, but was evident as a slightly increased opacity in the occlusal view of one dog. The gelatin was clearly seen on RCd nasal radiographs as a soft tissue opacity of the air-filled meati without a marked effect on the visibility of the conchal structures. This included the individual and adjacent sections as well as the intact specimens.

Part 2

The final diagnosis was malignant neoplasia in 9 dogs, bacterial rhinitis in 4 dogs, 1 allergic rhinitis, 1 polyp and 1 periapical molar abscess. One dog had





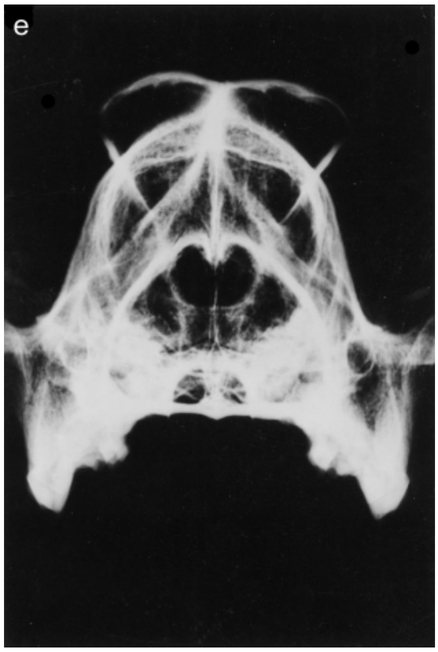


Fig. 1: **Nasal RCd views of sections of German shepherd dog skull.**

a) **Rostral section. Note absence of nasal bone, turbinates and bony septum. V-shaped septal sulcus of the incisive bone indicates the position of the radiolucent cartilaginous septum.**

b) **Mid section. Note the presence of the separate medially curving nasal bones dorsally, infraorbital canal and vomer bone. Some dehydrated and shrivelled remnants of the septum can still be seen in the vomer sulcus. The ventral 70 % of the nasal passage is taken up by the poorly defined ventral nasal concha originating laterally from the conchal crest. Dorsally the small dorsal concha is just visible. Note absence of cribriform plate region and choanae.**

c) **Combined rostral and mid-nasal sections. Note how the canine tooth roots of the rostral section obliterate the lateral aspects of the mid-nasal section making localised pathology in this region undetectable.**

d) **Caudal nasal section. Note the absence of the previously prominent nasal and maxillary bones and the presence of the hamuli pterygoidei and bullae tympanicae, the choanae** (white arrowhead) **dorsal to the palatine bones and dorsal to this the very opaque ventral bones of the cranium. Note the oval central more radiolucent cribriform plate region** (black arrows) **with the central very radio-opaque dorsal osseous septum** (white arrow) **formed by the septal processes of the frontal and caudal nasal bones. Ventral to this is the thin osseous nasal septum of the ethmoid bone. Specific conchal structures are difficult to visualise in this view.**

e) **Combined mid- and caudal nasal sections. Note the fairly thick curved nasal bone borders superimposing on the dorsal aspect of the cribriform plate region and the caudal aspect of the nasal region with its bony nasal septum extending dorsally to the nasal bones.**

Fig. 2: **Nasal RCd view of complete skull of same dog as in Fig. 1. The radiolucent infraorbital canal** (short open arrow) **is seen laterally, with the lateral aspects of the maxillary bone clearly seen dorsomedially to it. The V-shaped septal sulcus of the vomer and incisive bones** (arrowhead) **has a thin osseous nasal septum extending dorsally, which is formed by the ethmoid bone. Dorsally, the clearly seen thin curved bone** (short arrow) **is the inner table of the rostral aspect of the right frontal bone. Ventral to these bones is a fairly round, markedly radiolucent area, the ventrolateral bony borders of which are indicated by long, thin, white arrows. The borders of this area represent the caudal circumferential edge of the ethmoid bone and the adjacent frontal and presphenoid bones which surround the caudal aspect of the cribriform plate. The caudodorsal aspect of the nasal passage extends dorsally beyond the curved inner tables of the frontal bone and centrally has a very radio-opaque line representing the osseous septal processes of the frontal and nasal bones.**

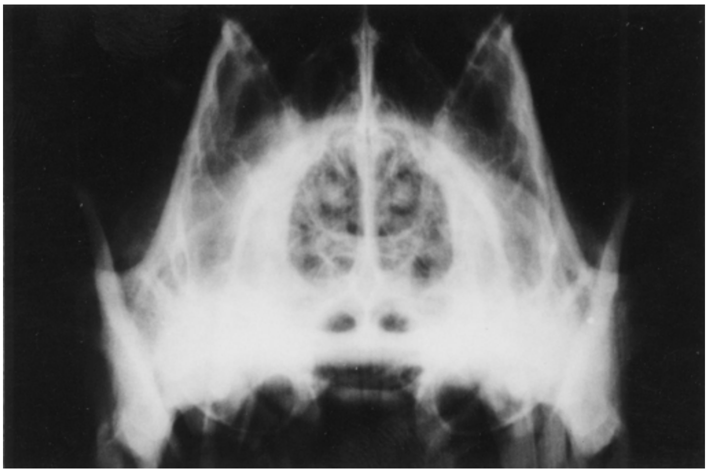


Fig. 3: **Nasal RCd view of Border collie cadaver head. Note, compared to Fig. 2, the poor definition of bony structures and the soft tissue opacity thickening of the conchae and nasal septum. There is still good visibility of the nasal passages, choanae and caudal ethmoid bone borders.**

epistaxis which resolved and the other had a mild nasal discharge of unknown aetiology. The latter 2 dogs showed no radiological changes in any of the views.

The lateral nasal view showed suspected pathology in only 2 dogs. Seven dogs showed changes in the RCd frontal sinus view, 6 were due to neoplasia and 1 was a case of bacterial rhinitis. The occlusal view revealed pathology in 16 dogs of which in 3 the pathology was only suspected. The RCd nasal view had pathology seen in 15 dogs with only 1 suspect case. One dog with chronic rhinitis had a normal RCd nasal view with suspect pathology in the occlusal view. In the remaining dogs with pathology evident in both the RCd nasal and occlusal views, 7 dogs had an equal pathology grading (Fig. 5), in 5 dogs the RCd nasal view gave more information than the occlusal view and in 3 dogs it gave less information. In both the latter groups there never was a grading difference greater than 1 between the RCd nasal and

Fig. 4: **German shepherd dog cadaver after the addition of 20 mℓ gelatin to the right nasal passage.**

a**) Nasal RCd view. Note markedly increased opacity of right nasal passage as compared to the left nasal passage. The right choana is also partially opacified.**

b**) Occlusal view. Note poorly defined slightly increased opacity of right nasal passage** (left side of radiograph).

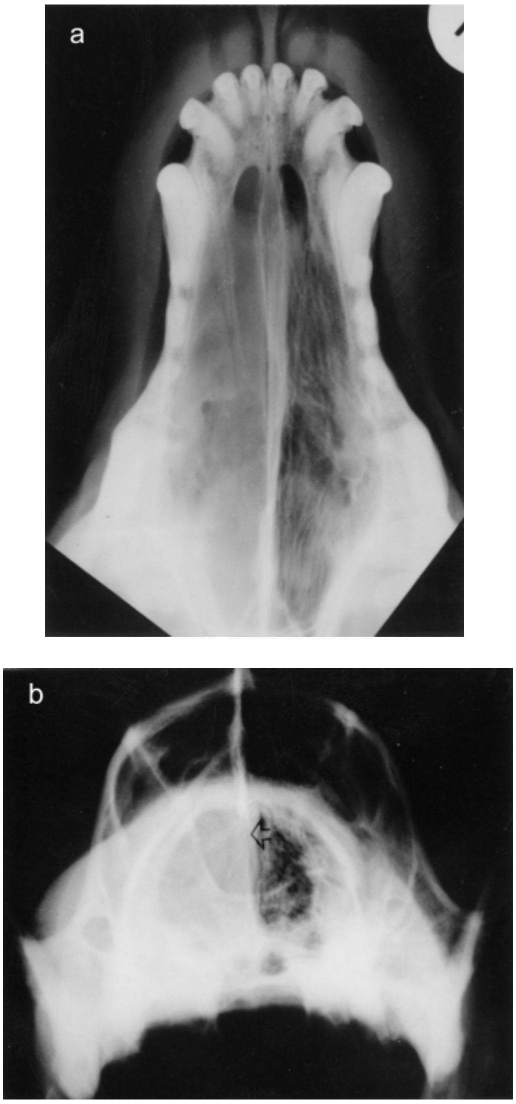


Fig. 5: **Nine-year-old Husky with advanced adenocarcinoma of right nasal passage.**

a) **Occlusal view. Note increased soft tissue opacity and turbinate destruction of right nasal passage** (left side of radiograph) **with suspect lytic areas in the palatine or maxillary bone.**

b) **Nasal RCd view. Note marked increased soft tissue opacity of the right nasal passage, destruction of turbinates, dorsal bony nasal septum** (open arrow) **and palatine or maxillary bone ventral to the opacified affected choana.**

occlusal views.

Changes seen in the RCd views demonstrated unilateral and bilateral disease as well as the cross-sectional locations (dorsal, middle, ventral, lateral or medial) of pathology within the affected nasal passage. In addition to these changes, all dogs with neoplasia showed other abnormalities in this view. These included conchal destruction, septum displacement, erosion, or destruction and maxilla erosion. Occlusive views showed vomer erosion or destruction in 3 dogs. One of these had nasal septum erosion in the RCd nasal view. The RCd nasal view showed septal erosion or destruction in an additional 3 dogs.

DISCUSSION

Precise centring, accurate positioning (including bilateral symmetry) and adequate exposure factors are essential prerequisites for optimal information from the RCd nasal view. If RCd frontal sinus views are part of the standard radiographic evaluation then the additional RCd nasal view requires minimal extra effort. The view allows good visualisation and definition of the mucosa covered cartilaginous and osseous septum, vomer, conchae, choanae and outline of the caudal aspect of the ethmoid bone region which is seen as a relatively round radiolucent area in the dorsal aspect of the nasal passage. The dorsal edge of the latter is either a thin mineral opacity representing the inner table of the frontal bone or a thicker mineral opacity when part of the nasal bone superimposes on it. The cribriform plate *per se* is not visible. The bony borders however allow visualisation of the region. The olfactory bulbs lie immediately caudal to this region. The RCd nasal view thus allows for markedly improved spatial orientation of intranasal structures and pathology. Parts of the rostral nasal osseous borders formed by the maxilla, and nasal bones can also be readily evaluated for possible pathology. Extranasal structures such as the infraorbital canal and hamuli pterygoidei are visualised clearly in the RCd nasal view. The limited number of gelatin studies showed that abnormal increases in nasal soft tissue opacity can readily be identified in the RCd view, even if the occlusal view appears radiographically normal. This is confirmed by another study using ultrasonographic gel to mimic soft tissue defects[8]. However, it should be realised that the length of gelatin to be penetrated in the RCd view was much greater than its dorsoventral height in the occlusal view and this factor could result in its increased visibility. Focal nasal masses are therefore less likely to be seen more readily in the RCd view. However, more advanced nasal soft tissue masses are likely to expand according to the conformation of the nasal passage and could therefore be seen more easily in a RCd nasal view. Destructive rhinitis cases are rare in South Africa and none were included in the study. It is however believed that the RCd nasal view may well be more sensitive in the early stages of this disease. In a study of the radiographic anatomy of the cribriform plate[9] the RCd nasal view was unfortunately not used. The same authors in another study determined the radiographic visibility of nasal boundary defects using a variety of different views in 13 cadaver specimens divided into 3 groups[10]. Defects of the cribriform plate were deemed to be not visible in the RCd nasal view but this view was only performed in 1 dog of each group. However, we also believe that defects here would be difficult to detect unless there was destruction of the caudal peripheral borders of the ethmoid bone or adjacent frontal and sphenoid bones which would enlarge the roundish radiolucent region seen in this area. In our study the naso-orbital wall was not visible in the RCd view because this boundary runs at an angle to the RCd directed primary beam. We did evaluate the osseous borders surrounding the nose and in 2 dogs with neoplasia, maxilla destruction was seen, 1 of which was only seen in the RCd view and in the other in all views except the frontal sinus view. We thus believe that the RCd nasal view is beneficial in detecting asymmetry of osseous nasal borders due to pathological new bone formation or bone loss.

In this limited study of clinical cases, the RCd nasal view allowed about the same amount of pathology to be detected as in the occlusal views but allowed additional nasal septum pathology to be seen. Vomer and/or septum changes were seen in 6 dogs, 3 only in the occlusal view (vomer only) and in 4 dogs in the RCd nasal view. This, and its ability to contribute to an improved overall 3-dimensional understanding of the pathology, as well as being able to assess some of the osseous nasal boundaries, makes it a worthwhile view to perform. It should also allow better patient management in cases requiring biopsy. Additional studies are required in larger numbers of specific nasal conditions to determine its exact value in differentiating the causes of nasal pathology. The RCd nasal view should certainly be made in preference to the lateral nasal views which provided minimal additional information in this study. Although CT and MR imaging provide exact planar cross-sectional images of pathology, their expense and limited availability make the RCd nasal view a worthwhile consideration in the routine radiographic evaluation of nasal disease.

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