

PHYSIOLOGIC MUCOSAL CHANGES WITHIN THE NOSE AND ETHMOID SINUS: IMAGING OF THE NASAL CYCLE BY MRI*†

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ABSTRACT

Magnetic resonance studies frequently demonstrate increased T₂-weighted signal in the nasal area. To further evaluate this phenomenon, several MRI examinations of the nasal cavity were performed within an 8- to 12-hour period. The study demonstrated that changes alternated from side to side and were interrupted by the administration of topical vasoconstriction, confirming imaging of the normal nasal cycle. Changes were also observed within the ethmoid sinuses. Signal intensity on T₂-weighted images during the congested phase was similar to inflammatory mucosa. Occasionally, these changes make interpretation of the extent of pathology difficult in patients with sinus disease, and raise the possibility of inflammatory pathology in asymptomatic patients. Awareness of MRI imaging of nasal cycle should reduce the likelihood of diagnostic errors and provides another method for study of this physiologic phenomenon.

The phenomenon of alternating congestion and decongestion of nasal mucosa was first described by Kayser in 1895.¹ The cycle was further investigated by Heetderks, who systematically studied 60 volunteers by anterior rhinoscopy in a test chamber.² He demonstrated that a nasal cycle occurred in approximately 80% of the study group. Changes were accentuated by cold and high humidity and were generally less marked in older individuals. Each cycle lasted between 50 minutes and 4 hours. Stoksted studied the nasal cycle using serial rhinomanometry and noted that, as a result of reciprocity between the two sides of the nose, overall nasal resistance remained essentially unchanged.³ Hasegawa and Kern studied the nasal cycle by rhinomanometry in 50 people, demonstrating a cycle of between 1 and 6 hours, occurring in 72% of their patients.⁴ Other studies have demonstrated cycles in awake patients occurring between 2 and 7 hours.^{5,6} The cycle remains following the application of local anesthesia, but is absent in laryngectomees.⁵

Cole and Haight have extensively studied the effect of posture on the normal nasal cycle.⁷⁻⁹ Using a 'head out' body plethysmograph, they showed that recumbency accentuated the amplitude of the cycle. They also demonstrated increased nasal resistance on the dependent side in lateral recumbency and on the ipsilateral side with unilateral body support during dorsal recumbency. The total nasal resistance at rest, however, appears to be remarkably constant in adults.

In children, the nasal cycle appears to be less well defined. Although there is cyclical fluctuation in nasal resistance, it is not clearly associated with reciprocal changes on the contralateral side, and there are greater variations in total nasal resistance over time.¹⁰

There is evidence that the nasal cycle is regulated by autonomic tone and is under the control of a center in the hypothalamus. When an individual is placed in a controlled environment, there appears to be temporal constancy to the cycle, with the change-over occurring at relatively fixed times during the day. It is also possible that the higher centers may influence the cycle and that there is the potential to achieve some degree of voluntary control.¹¹⁻¹⁴

In addition to rhinomanometry and plethysmography, the nasal cycle has also been demonstrated by using flexible liquid crystal thermography.¹⁵ Early experience with MRI demonstrated unilateral changes suggesting pathology within the nose and paranasal sinuses of patients who were otherwise asymptomatic. The absence of clinical or endoscopic correlation in these patients suggested that changes might represent the nasal cycle, and it was decided to study the phenomenon further.

MATERIALS AND METHODS

Seven healthy volunteers with no prior history or current symptoms of sinus disease were studied. Two volunteers were eliminated when significant asymptomatic sinus disease was identified on MRI. The final study group of five volunteers (2 men, 3 women) ranged in age from 26 to 42 years. T₁- and T₂-weighted MRI images were performed three to four times over a period of 8 hours. Between studies the volunteers were allowed to undertake normal daily activities. A topical nasal decongestant spray (0.05% xylometazoline) was administered to the congested side of the nose of two volunteers following the last examination. The study was then repeated within 1 hour.

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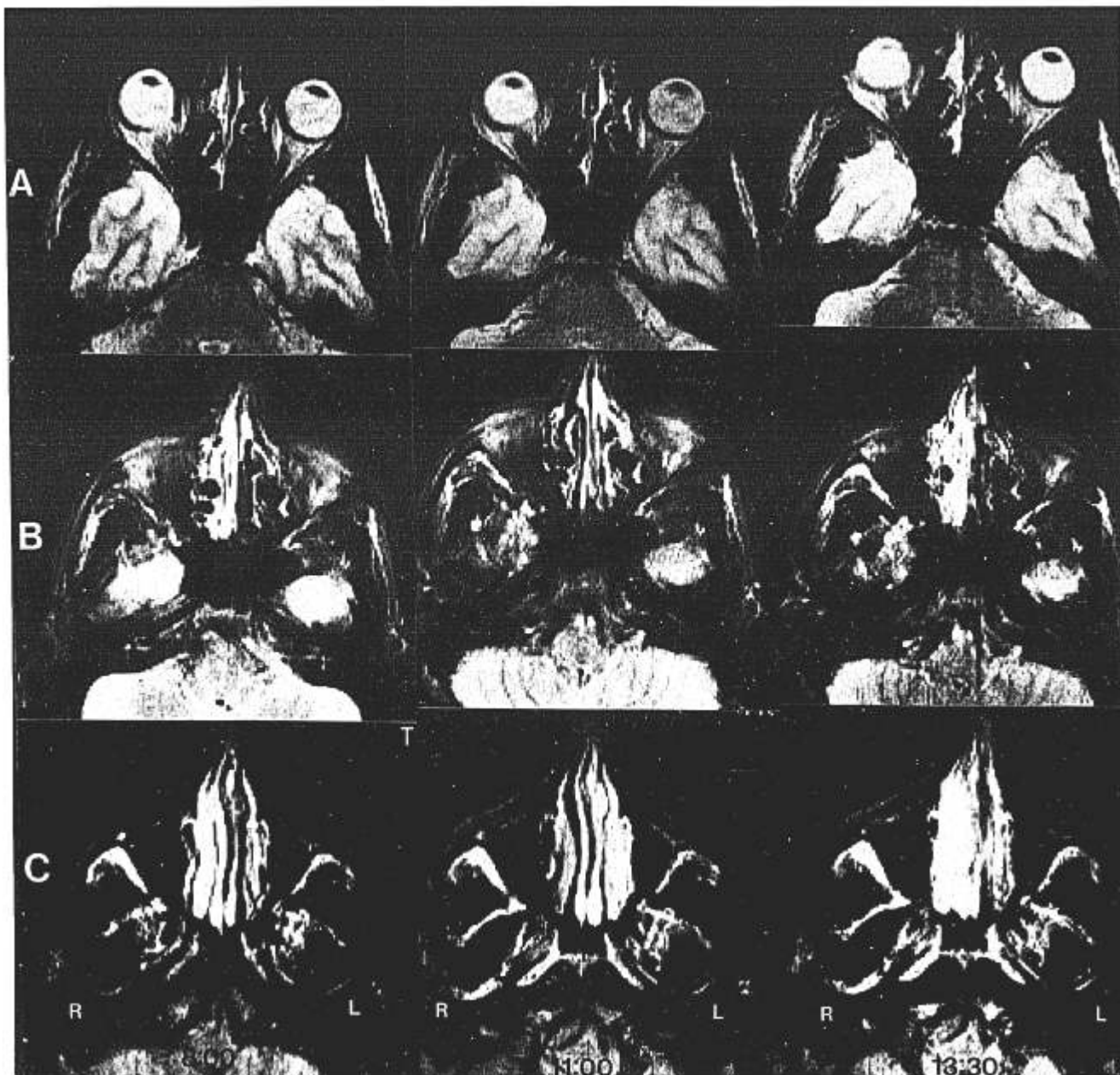


Fig. 1. Demonstration of the nasal cycle by MRI in a normal volunteer. Sequential T2-weighted images in the axial plane showing alternating intensities and volumetric changes in the turbinates. At 8:00 AM the signal intensity is more dominant within the right ethmoid sinus (A&B) and right turbinates (C).

Fig. 2. Demonstration of the nasal cycle by MRI in a normal volunteer. Sequential T2-weighted images in the axial plane showing alternating intensities and volumetric changes in the turbinates. At 11:00 AM the dominant signal intensity is in the left ethmoid sinus (A&B) and turbinates (C).

Fig. 3. Demonstration of the nasal cycle by MRI in a normal volunteer. Sequential T2-weighted images in the axial plane showing alternating intensities and volumetric changes in the turbinates. At 13:30 PM the greater signal intensity has now returned to the Rt ethmoid sinus (A&B) and turbinates (C).

All volunteers were studied in the supine position on either a 1.5 Tesla unit (Signa, General Electric) or a 0.6 Tesla unit (Technicare) with head coils and fields of view of 20 to 24 cm. The T1-weighted images were performed using a short repetition time (TR) (600 to 800 msec) with short echo times (TE) (20 to 40 msec). The T2-weighted images were performed using long repetition times (TR) (2,000 to 3,000 msec) with long echo times (TE) (60 to 80 msec). Images were reconstructed using a 256 x 128 data matrix acquired with either two or four excitations. The scan thickness was 5 mm, with a gap interval between 1 and 2 mm.

Increased signal activity within each area of the nasal cavity and the paranasal sinuses was then evaluated. Optical densities were measured from the inferior turbinates on both sides and on similar sections on subsequent examinations.

RESULTS

The T1- and T2-weighted MRI images from the five volunteers included in the study were analyzed. On

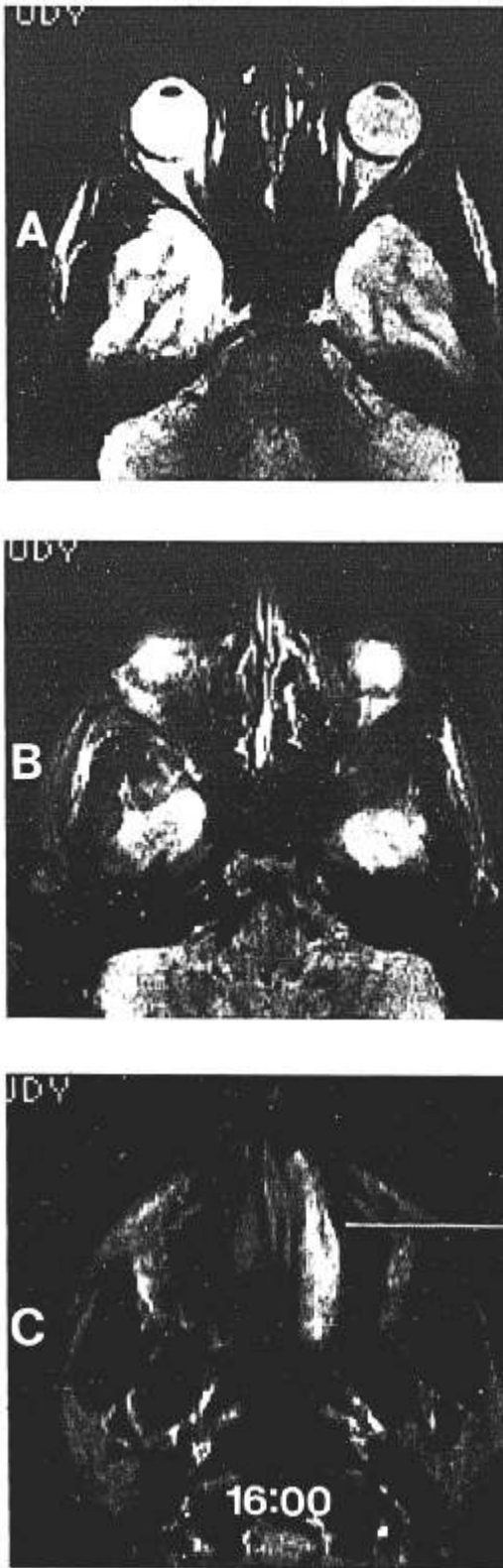


Fig. 4. Demonstration of the nasal cycle by MRI in a normal volunteer. Sequential T₂-weighted images in the axial plane showing alternating intensities and volumetric changes in the turbinates. At 16:00 PM the signal intensity is again slightly greater in the left ethmoid (A&B) and turbinates (C).

the T₁-weighted images it was only possible to detect mucosal volume changes of the turbinates. On the T₂-weighted images, however, the volume changes noted on the T₁-weighted images were accompanied by a change in signal intensity. The side demonstrating turbinate congestion uniformly demonstrated increased signal intensity. Over the course of the study period, each volunteer demonstrated at least one change in dominant signal intensity from one side to the other. The number of cyclical changes observed in the 8-hour study period varied between one and three. Cyclical changes in signal intensity were also noted in the mucosa of the nasal septum, lateral nasal wall, and sphenoidal recess (Figs. 1 through 4). Both volunteers in whom a decongestant spray was administered to the congested side of the nose demonstrated reversal in the side of increased signal intensity following administration (Fig. 5).

By measuring the optical densities of the inferior turbinates, it was possible to quantify the change in signal intensities. For each volunteer the optical densities noted on each side were graphed separately over time (Fig. 6). A composite graph was also created to demonstrate cyclical changes on one side of the nose (Fig. 7).

In all volunteers a significant increase in signal intensity was noted in the ethmoid sinus during the congested phase. This was also observed to alternate sides along with the changes in the turbinates. No changes in signal intensity were noted in the frontal, maxillary, and sphenoid sinus mucosa.

DISCUSSION

Under most circumstances MRI examinations are performed with T₁- and T₂-weighted imaging. The T₁-weighted images define the regional anatomy, whereas T₂-weighted images are more accurate in defining pathology. Our initial experience with head MRI examinations demonstrated that a significant number of patients had increased signal intensity in the nasal area on T₂-weighted images. These changes appeared similar to changes created by inflammation, sometimes causing confusion with regard to both identification of limited pathology and extent of established disease (Fig. 8).

This study demonstrated that alternating increase and decrease in signal intensity and turbinate size occurred over time, and that the time frame was consistent with the nasal cycle. Reciprocal changes were observed on the opposite side of the nose, and changes were reversed by the use of a nasal decongestant. The study, therefore, identifies that changes observed in signal intensity result from the imaging of physiologic changes associated with the nasal cycle. It would appear, therefore, that this aspect of MRI, in addition to its inability to directly visualize bone, limits the current usefulness of this

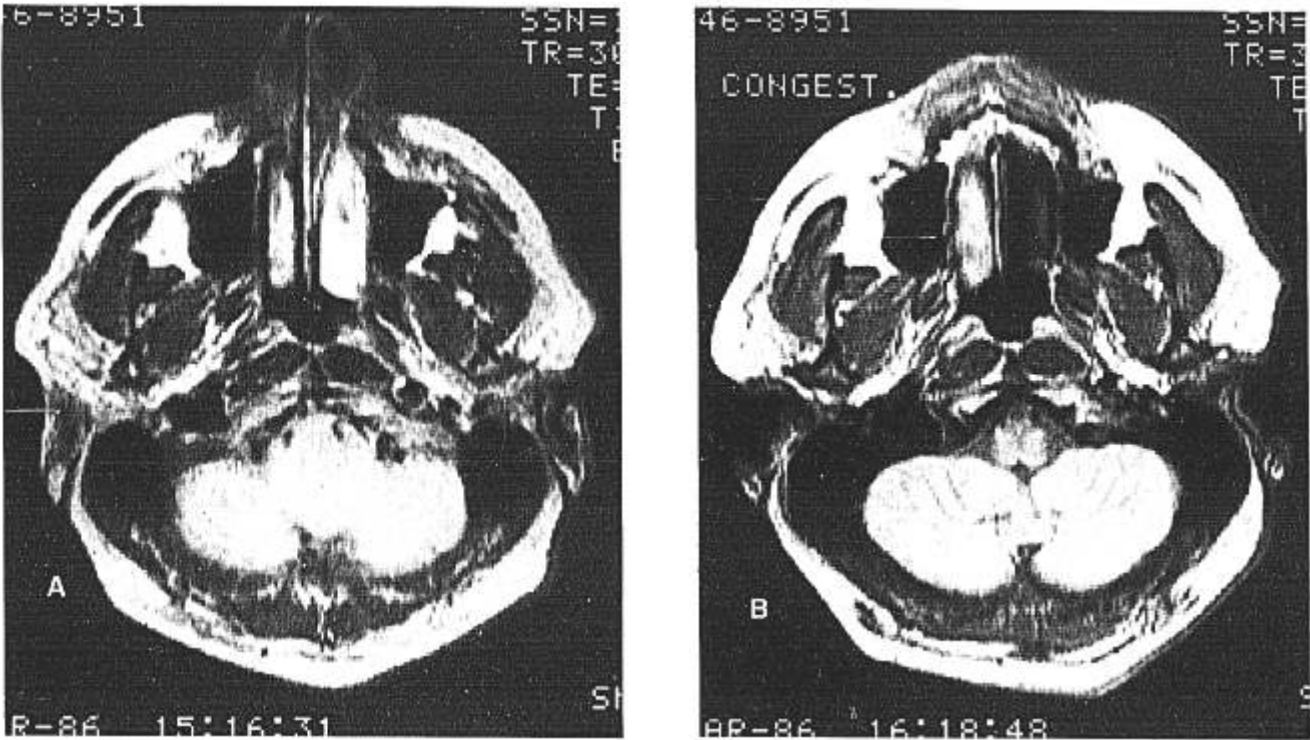


Fig. 5. Axial MRI images of a study volunteer at the level of the inferior turbinate. A. Before decongestion, the left inferior turbinate is larger and demonstrates greater signal intensity. B. One hour later, following administration of 0.05% xylometazoline spray to the left side of the nose, the right inferior turbinate is larger and demonstrates the greater signal intensity.

modality in imaging nasal pathology.

In this study, no attempt was made to time the length of each cycle. Times for the images were based on previous rhinomanometric studies demonstrating a normal cycle time of between 1 and 7 hours. The limited number of scan times during the day makes it unlikely that all cycles were identified. Currently, it is impractical to attempt precise demonstration of all phases of the nasal cycle by this modality due to the prolonged time required for examination. With shorter scan times, however, it may

be feasible to study the time factors further and to estimate volumetric changes that occur during the nasal cycle. None of the volunteers studied in this series were acyclic.

Cyclical changes within the ethmoid sinuses have, to our knowledge, not been previously described. It is also interesting to note that increased signal intensity during the congested phase only occurred within this sinus, and not within the maxillary, frontal, or sphenoid sinuses. The most likely cause would ap-

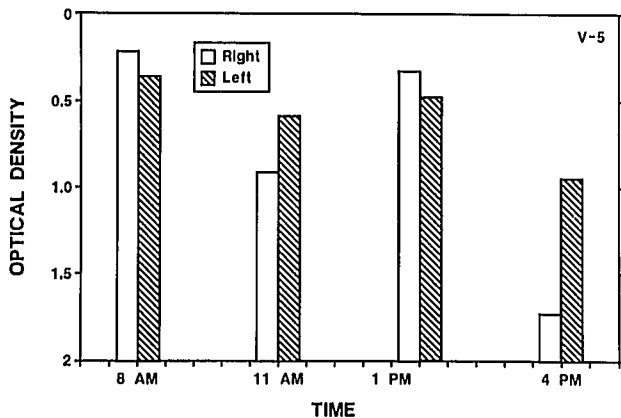


Fig. 6. Graphic representation of the changes seen in Figures 1 through 4. Optical densities were measured from the inferior turbinate and the scale inverted to provide signal intensity. In this patient the dominant side changed at each study.

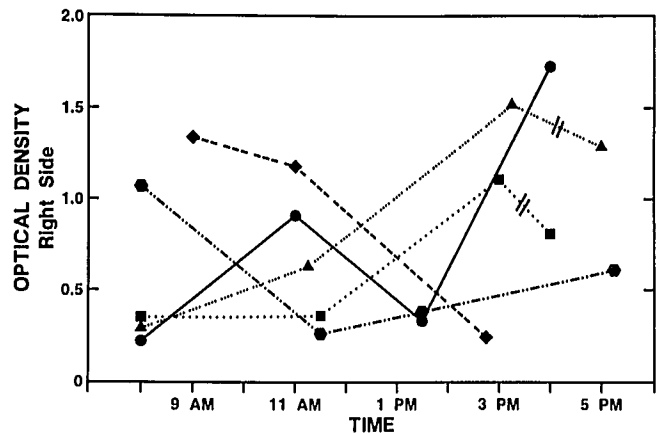


Fig. 7. Composite graph demonstrating the change in optical density of the right inferior turbinate of each of the five patients. The parallel lines indicate the point of administration of nasal decongestant in two patients.

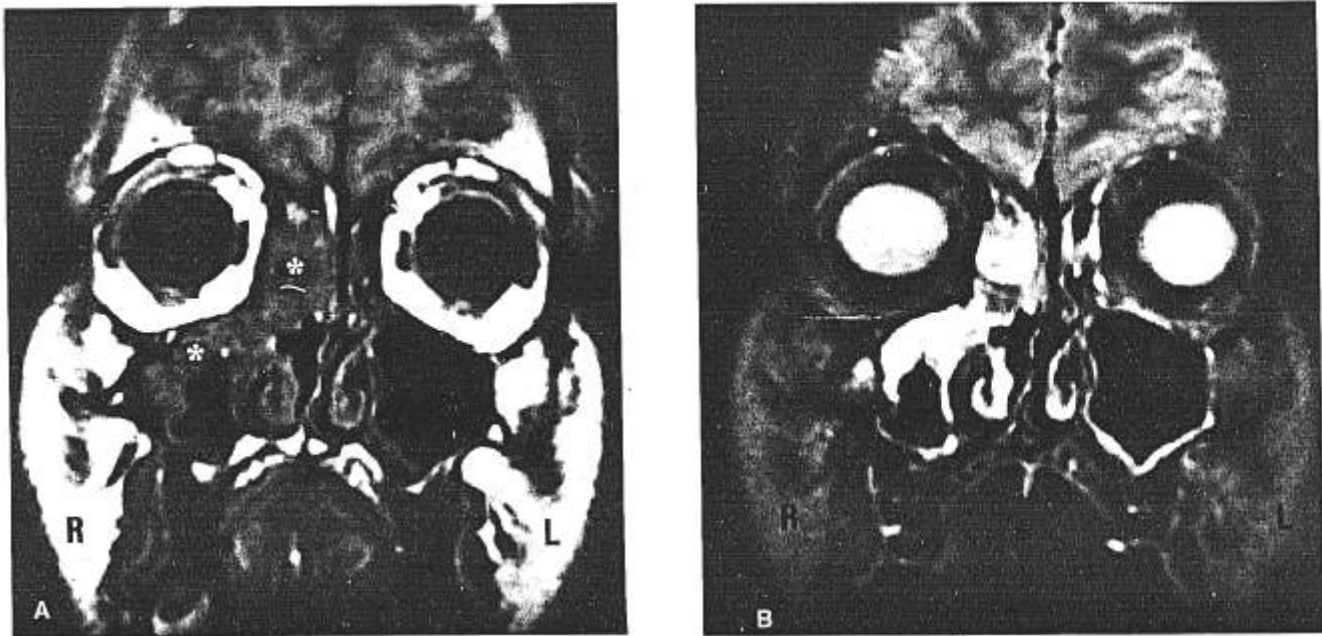


Fig. 8. Coronal MRI images of a patient with chronic inflammatory disease. A. The T1-weighted image demonstrates a mass within the right ethmoid and maxillary sinuses (asterisks). There is some mucosal thickening in the left ethmoid sinus and of the floor of the left maxillary sinus. B. The T2-weighted image demonstrates increased signal intensity of the soft tissue mass and thickened mucosa. There is also increased signal intensity from both inferior turbinates (Rt>Lt). Diffuse increased signal intensity within the nose and ethmoid area makes delineation of the extent of disease difficult.

pear to be increased vascular congestion of the ethmoid sinus mucosa, but the possibility that this could represent a change in secretion within the sinus cannot be entirely ruled out. Studies by Doyle and van Cauwenberge have suggested that mucociliary clearance within one side of the nose is maximal during the decongested phase of the cycle.¹⁶ It is conceivable, therefore, that the increased signal intensity in the ethmoid during the congested phase could represent a change in character or thickness of the mucociliary blanket. Since all observations in this study were, of necessity, performed in the recumbent position, it remains to be seen whether similar findings are also present with the more attenuated changes that occur in the erect position.

The recognition of changes within the ethmoid sinus during the nasal cycle suggests a greater role for neural control in the functioning of the paranasal sinuses than was previously recognized. If these changes are indeed functionally significant, this is a potential mechanism by which central factors, autonomic instability, and stress may play a part in the pathogenesis of sinus disease.

CONCLUSIONS

The nasal cycle is imaged with T2-weighted MRI. An increased signal intensity was demonstrated in the turbinates and in the mucosa of the lateral nasal wall, the nasal septum, and sphenoidal recess during the congested phase. Changes due to the

nasal cycle were also identified within the ethmoid sinus, but not within the frontal, maxillary, or sphenoid sinus. Thus increased signal intensity on the T2-weighted image in the nose or ethmoid sinus does not necessarily denote pathology. This finding appears to represent a limitation for MRI imaging of this area.

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