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[Original Articles]

Rhinoscintigraphy: A Simple Radioisotope Technique To Study the Mucociliary System

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Abstract

Purpose: This was a radioisotope study of nasal mucociliary clearance of total and subtotal nasal obstruction.

Methods: Rhinoscintigraphy was performed by insufflating 1.85 MBq (69 mCi) Tc-99m MAA in 20 patients. Six cases were regarded as the control group, because the presence of small spurs does not affect nasal patency. The remaining 14 patients had various rhinopathic conditions. Two regions of interest were selected, one in the nasal cavity and one in the pharynx. Mucociliary transport speed was calculated.

Results: This parameter appeared to be a sensitive index for the assessment of the degree of mucociliary alteration. It showed that polyposis impairs mucociliary transport most severely, thus confirming the results of other published studies.

Conclusions: Rhinoscintigraphy proved to be a reliable, easily reproducible, and harmless method, so it may be used for follow-up examinations in patients who have had surgery of the nose and paranasal sinuses, and for drug therapy of rhinopathic conditions.

The mucociliary transport system is a sound, nonspecific mechanism that protects respiratory pathways from extraneous inhaled particles, microbic agents, and hypersecretion. The ciliary activity of respiratory epithelium and the peculiar properties of epithelial mucus are responsible for trapping and eliminating these substances.

Various well-established techniques to study the ciliary activity of nasal mucosa are

available. Direct methods such as stroboscopy, roentgenography, and photoelectron techniques are performed to assess the ciliary activity and the frequency of ciliary beat, but they are expensive and unsuitable for routine studies (1–6).

Indirect methods use soluble, insoluble, or radioactive substances to assess nose-to-pharynx transport times. Saccharine and vegetal-carbon powder testing is the easiest and most inexpensive technique to evaluate nasal ciliary function. It is based on the simultaneous use of soluble and insoluble substances (6).

Radiopharmaceuticals may play a significant role if detailed information is needed, because semiquantitative parameters are available (7,8). The aim of this study was to determine whether rhinoscintigraphy can assess the ciliary clearance of the nasal mucosa in various rhinopathic conditions.

Materials and Methods

We examined 20 nonsmoking patients (13 men and 7 women ranging in age from 22 to 56 years) who were referred to the Otorhinolaryngology Clinic of the Catholic University of the Sacred Heart. Little spurs with no obstacles to nasal patency were present in six patients, so they were regarded as the control group. Various rhinopathic conditions were diagnosed in the remaining 14 patients. The degree of nasal obstruction was assessed based on subjective reports, clinical examination, anterior and posterior rhinoscopy, endoscopy, anterior active manometry, and a nasal decongestive test. According to the results of these examinations, a total of 7 patients with nasal obstruction were studied. All patients underwent rhinoscintigraphy in the nostril with the highest degree of impaired patency.

A gamma camera with a low-energy high-resolution collimator was used. Patients were positioned sitting in front of the gamma camera, with the involved nostril touching the collimator. Tc-99m (1.85 MBq; 69 mCi) was insufflated into the nostril while the patients held their breath. A spray applicator (nominal ejection volume, 50 µl) with a 2% aqueous solution of propylene glycol was used. The acquisition was immediately started, storing 30 thirty-second frames for a total 15 minutes per study. Two radioactive markers were placed on the mastoid and external acoustic meatus and then recorded. If no activity appeared in the pharynx, late static scintigraphy was performed 1 hour after radiopharmaceutical insufflation.

Regions of interest were selected in the nasal cavity and pharynx. With the aid of radioactive markers, the separation between the palate and the pharynx was identified; here the radioactivity appeared as a downward and backward inclined area at the “end” of the scintigraphic pattern (Fig. 1A). Time-activity curves were obtained from each region of interest (Fig. 1B). The exact time when the radioactivity entered the pharynx was individualized using external markers, sequential images, and time-activity curves. The length of the radioactivity path from the hyperactive area corresponding to the insufflated radiopharmaceutical to the end of the nasal activity was displayed directly by the computer, transforming the number of pixels into millimeters. Mucociliary

transport speed was then calculated by dividing length by exact time.

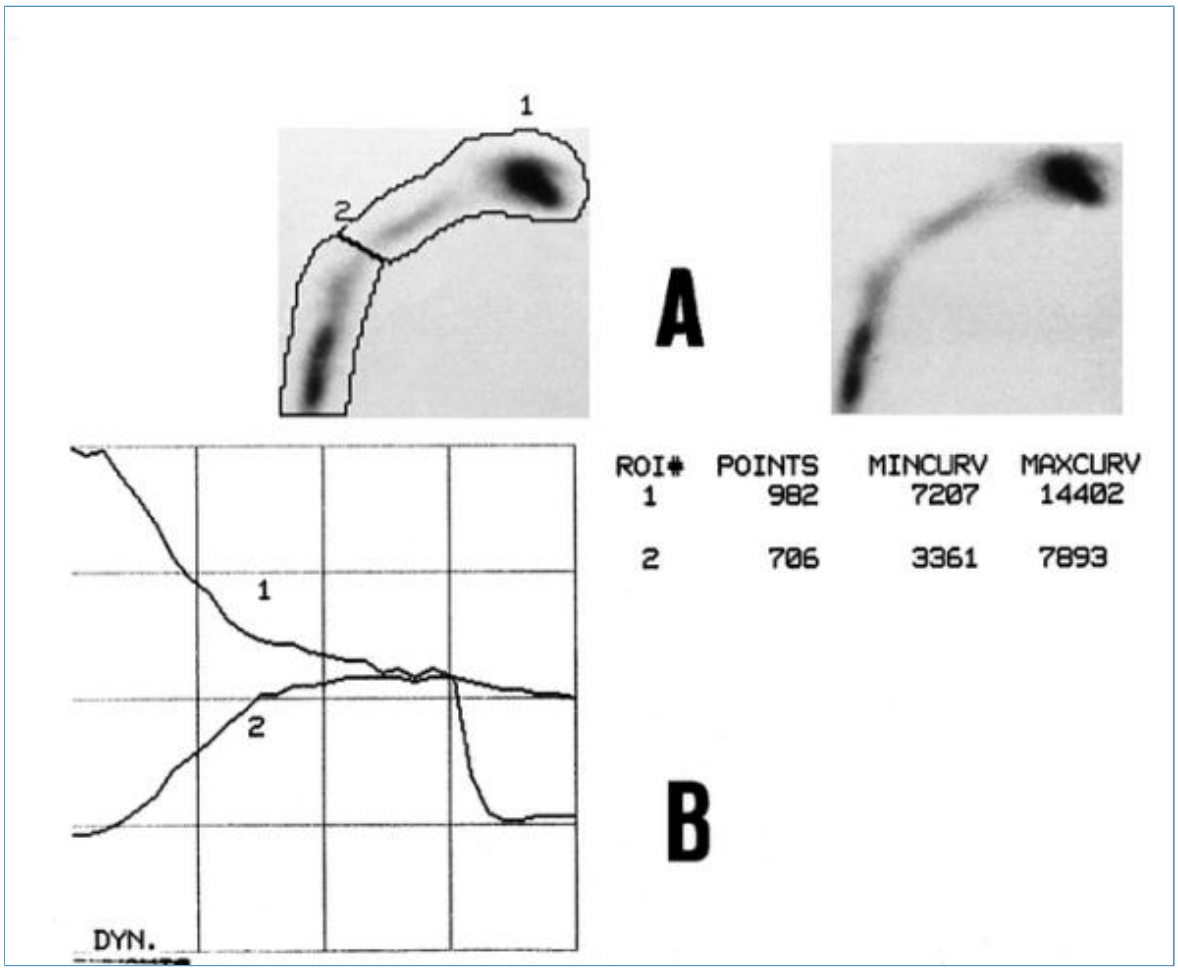

Fig. 1. (A) Normal rhinoscintigraphic patterns with selected regions of interest. (B) Corresponding time-activity curves of the nasal cavity (1) and pharynx (2).

The results obtained in the control group and subtotal obstuctions are shown in Table 1; total obstructions are shown in Table 2. The Student's *t* test was chosen for statistical comparison, with p = 0.001 as the significance limit, because of the small number of patients studied.

TABLE 1. *Rhinoscintigraphic Semiquantitative Parameters*

Control Group		Subtotal Nasal Obstruction		
Patient No.	MTS (mm/min)	Patient No.	Pathology	MTS (mm/min)
1	6.44	1	S+T	4.30
2	8.07	2	S+T	4.09
3	7.77	3	S+T	4.28
4	7.37	4	S+T	4.02
5	7.60	5	P	3.96
6	5.60	6	P	3.00
		7	S+T+P	2.26
Mean ± SD	7.14 ± 0.94			3.70 ± 0.77

$t = 7.20$ $p < 0.0005$.
MTS, mucociliary transport speed; S, septal deviation; T, turbinate hypertrophy; P, polyposis.

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TABLE 2. *Total Nasal Obstruction*

Patient No.	Pathology
1	P
2	P
3	P
4	P+S
5	S+T
6	S+T
7	S

S, septal deviation; T, turbinate hypertrophy; P, polyposis.
Note: There was no early or late appearance of the tracer in the pharynx for all patients.

Table 2. Total Nasal ObstructionS, septal deviation; T, turbinate hypertrophy; P, polyposis.Note: There was no early or late appearance of the tracer in the pharynx for all patients.

Results and Discussion

Various radiopharmaceuticals (colloidal solutions, resin particles, and albumin microspheres) labeled with ^{51}Cr (9) or I-131 have been proposed for rhinoscintigraphy. Tc-99m MAA is preferred by most authors.

The first published reports of the technical features of rhinoscintigraphy were practically identical: A droplet of radioactive solution was placed 1 cm behind the head of the inferior turbinate. According to the suggestion of Ingels et al. (10), we chose a spray applicator. It allows a widespread and physiologic distribution of the tracer throughout the nostril, so fully exhaustive information on ciliary clearance is available (Fig. 2).

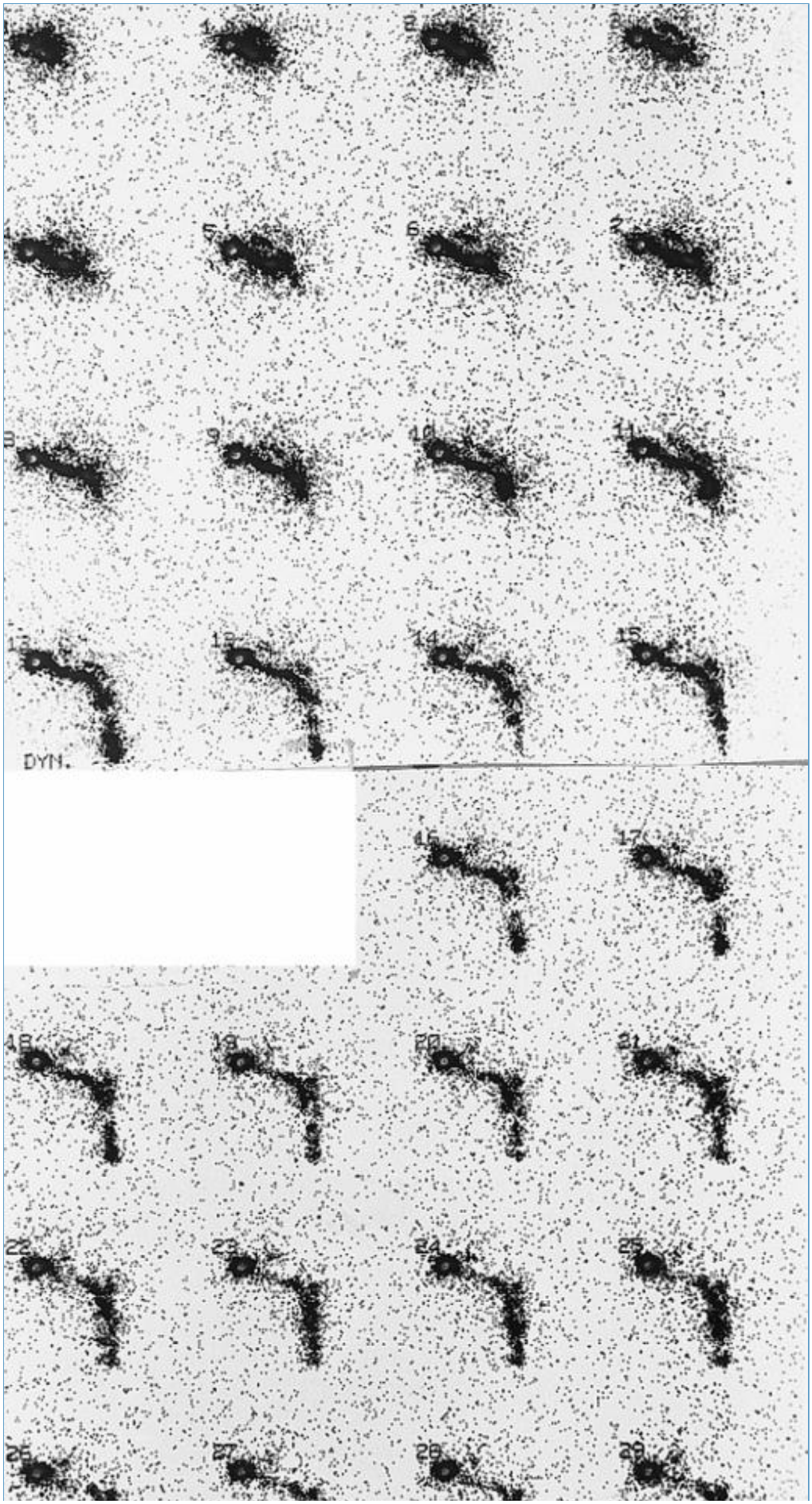
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Fig. 2. Normal dynamic sequential rhinoscintigraphy.

Mean values of mucociliary transport speed in our control group (Table 1) correspond closely with normal rhinoscintigraphy results reported in the literature (from 5.69 to 8.07 mm/min). A comparison between mucociliary transport speed and the corresponding data obtained with soluble and insoluble substances is difficult, because most studies refer to mucociliary transport time. The reported values show a high range of variability (i.e., from 4.6 to 12.3 mm/min for the saccharine test; from 3.4 to 7.8 mm/min for the vegetal-carbon powder (7,11).

In the article by Ingels et al. (10), all patients underwent duplicate rhinoscintigraphy and saccharine-dye tests in the same nostril, with a time interval of at least 1 week. A more consistent agreement was found for rhinoscintigraphy rather than saccharine test duplicate results. This may be a result of the uniform albumin clearance by the gel phase of the mucus, because Tc-99m MAA particles rest on the top of the epithelial cilia.

No semiquantitative parameter is reported in Table 2, because the radioactivity never reached the pharynx, including delayed imaging (Fig. 3).

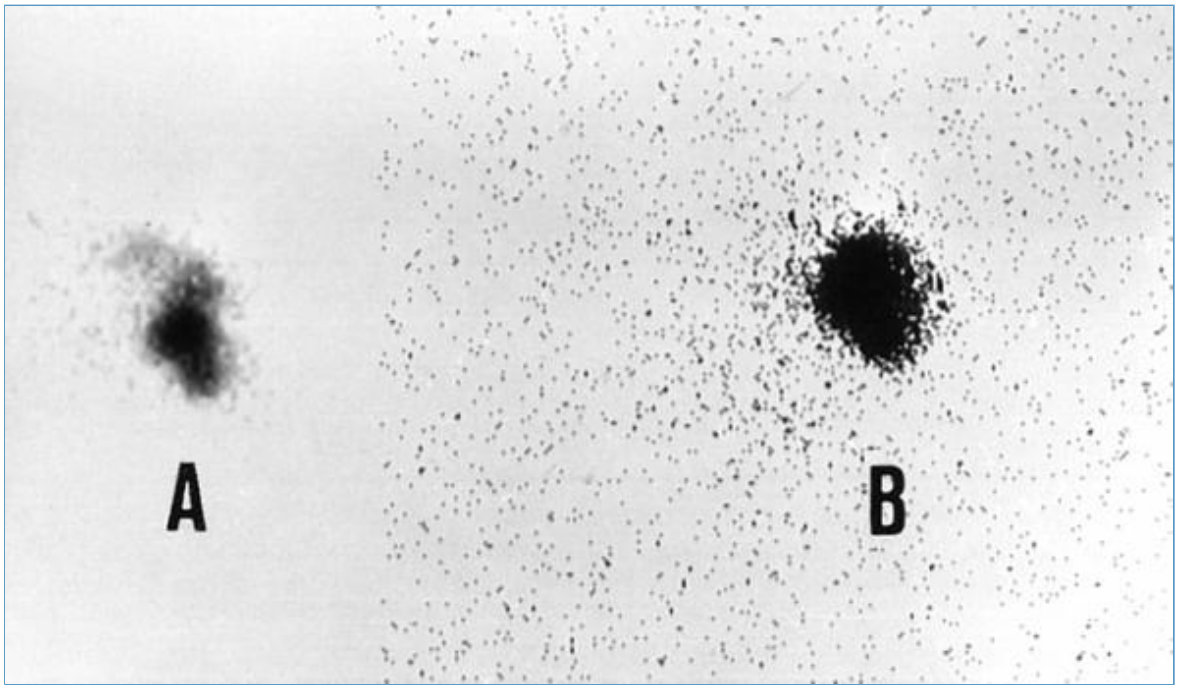

Fig. 3. Rhinoscintigraphic pattern in total nasal obstruction. No pharyngeal activity appears in (A) early and (B) late imaging.

From the data of Table 1, we may infer that mucociliary transport speed is a sensitive index of nasal patency, because its values are markedly decreased compared with those of the control group, as confirmed by statistical evaluation ($t = 7.20$; $P < 0.0005$). According to this parameter, nasal polyposis impairs mucociliary transport more severely than does septal deviation and turbinate hypertrophy. These results correspond with saccharine or methylene blue tests in nasal polyposis (12–14). Structural

modification of the ciliary epithelium, hypersecretion, or alteration of mucous rheology direct compression of the cilia by muciparous cells or nasal polyps are the possible and suggested causes of the slow mucous flow (13) (Figs. 4 and 5).

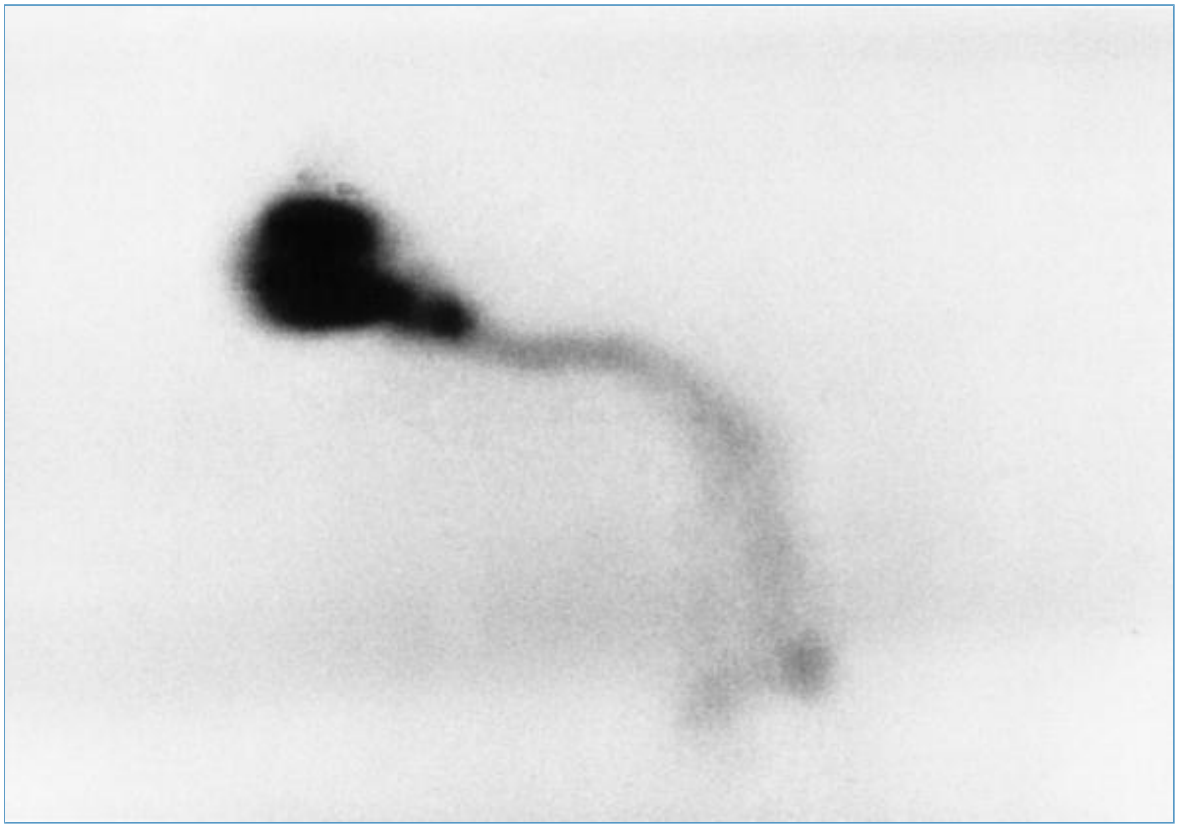

Fig. 4. Subtotal nasal obstruction (case 2, Table 1). Moderately delayed mucociliary transport speed with fair radioactivity in the pharynx is shown at 15 minutes.

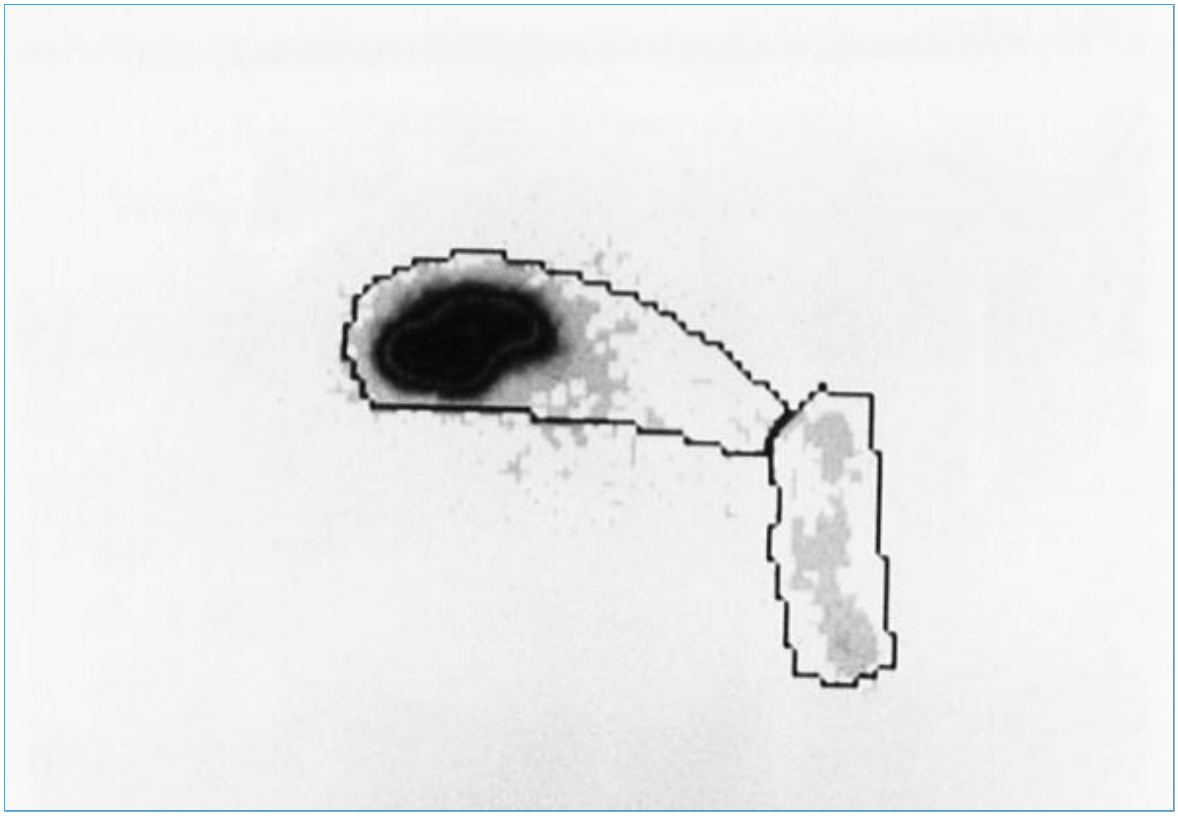

Fig. 5. Subtotal nasal obstruction (case 6, Table 1). Highly delayed mucociliary transport speed with markedly reduced radioactivity in the pharynx is shown at 15 minutes.

Conclusions

Although a limited number of patients was studied, rhinoscintigraphy appears to accomplish some significant goals in research on the ciliary system of the nasal mucosa. The insufflated tracer diffuses throughout the nasal fossa, enabling the mucosa to be studied as a whole. The distance from the nose to pharynx is assessed exactly, and thus a precise evaluation of mucociliary transport speed is possible. Sequential images show the motion pathway of the radiopharmaceutical from the nasal cavity to the pharynx as clearly as possible. A semiquantitative assessment of mucociliary clearance is determined. Mucociliary transport speed may be compared easily with post-therapy results, because it is a highly reproducible parameter.

Thus, rhinoscintigraphy may be suggested as a sensitive method for a morphologic and functional follow-up in surgery of the nose and paranasal sinuses and in the course of drug therapy for various rhinopathic conditions.

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Key Words: Mucociliary Transport Speed; Nasal Polyposis; Rhinoscintigraphy.

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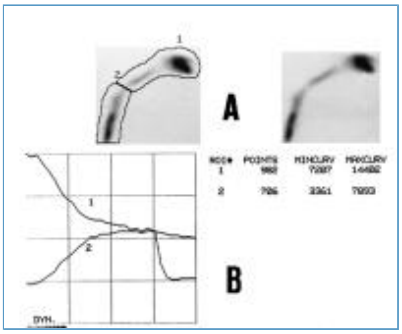

Fig. 1

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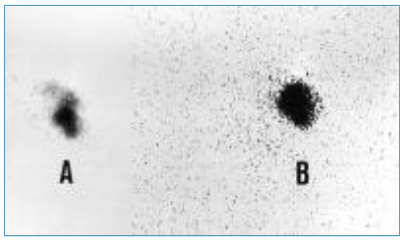
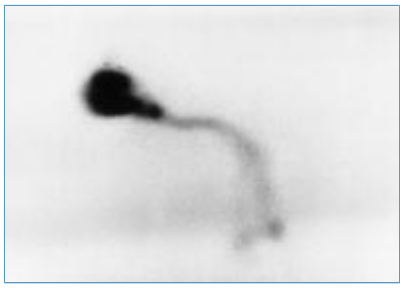


Fig. 3



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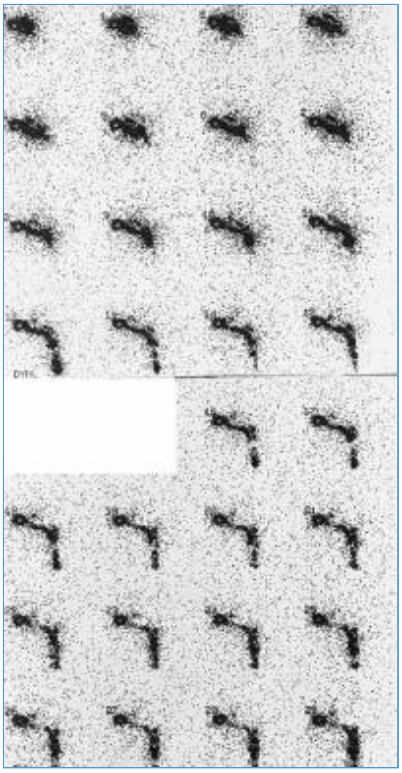

Fig. 2

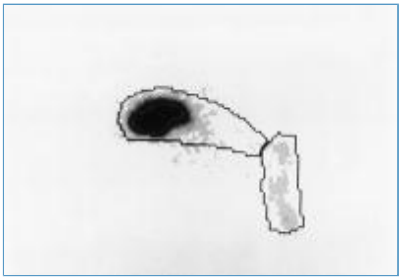

Fig. 5

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