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# Primary atrophic rhinitis: a scanning electron microscopic (SEM) study

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## Introduction

THE term primary atrophic rhinitis was coined by Ruskin in 1942 to differentiate the idiopathic condition from atrophic rhinitis developing as a direct result of other conditions such as chronic nasal infection, radical nasal surgery or irradiation.

The disease has the same symptoms whatever its cause; the victim is distressed by a feeling of nasal obstruction and his associates by a characteristic foul odour.

On examination thin mucosa which bleeds easily is obscured by greenish crusts of thick secretion which dries in the nose. When these are removed the abnormal patency of the nasal fossa becomes obvious in advanced cases.

The sense of obstruction is associated with lack of sensory input from receptors in the mucosa; these are either atrophic, encrusted or simply too far from the main stream of tidal air to be stimulated. Crusts may reach a size such as to produce actual nasal obstruction which may become complete.

Anosmia results from atrophy of the neuro-epithelium in the roof of the nose and the first order neurones on the first cranial nerve pathway. This is often described as a merciful provision of nature in the odoriferous circumstances.

The histopathology of the mucosa in atrophic rhinitis has been well documented by Taylor and Young (1961). The use of the SEM has provided information additional to light microscopy in vasomotor rhinitis (Gray, 1979) and allergic rhinitis (Mygind, 1978). It is clear that clinically the surface of the nasal mucosa is abnormal in atrophic rhinitis and it therefore seemed worthwhile to investigate the condition using the SEM. This paper is a preliminary report on the results.

Taylor and Young (1961) have shown clearly the changes seen on light microscopy. These vary from loss of cilia with flattening of cells to a well-developed four-layered stratified squamous epithelium. Mitotic figures are seen in the deeper layers lying on an abnormally thin basement membrane and in places masses of keratin are found on the surface.

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There is a marked decrease in the number and size of compound alveolar glands.

The aetiology of primary atrophic rhinitis has been discussed many times with many theories proposed. Few of these have been established by scientific evidence. The subject is well reviewed by Taylor and Young (1961) and the reader is recommended to their paper. In summary, the following factors have been postulated.

A congenital aetiology was proposed by Fleishman (quoted by Girgis, 1966) where three sufferers in one family were found but no evidence of the precise nature of the inheritance or disease was given. Barton and Sibert (1980) have studied a family where 8 out of 15 children of an affected father were afflicted showing clearly an autosomal dominant Mendelian inherited pattern.

Acquired disease other than that secondary to surgery, infection and irradiation has been attributed to vascular, endocrine, nutritional and senescent factors. The fundamental vascular lesion was thought to be endarteritis and periarteritis in the terminal arterioles of the respiratory mucosa. Endocrine factors have received much attention with the oestrogen supply at puberty, parathyroid or pituitary disease the subject of inconclusive investigation. Parallels between Plummer-Vinson syndrome and atrophic rhinitis as a manifestation of iron deficiency have been drawn.

## Materials and methods

Seven patients with moderately severe atrophic rhinitis were thought suitable for and agreed to Young's procedure (Young, 1967) of closing the nasal fossa by vestibular skin flaps.

Biopsies were taken from each side at closure and again when the nose was reopened many months later.

Sixteen informative and photogenic samples of the nasal mucosa resulted from the work, the remainder of specimens being either unsatisfactory or lost to the study when the nose opened spontaneously.

Four patients were unrelated and three belonged to a family in whom the disease was shown to follow an hereditary Mendelian autosomal dominant pattern (Barton and Sibert, 1980).

By good fortune a fourth member of the family required reduction of a nasal fracture and sought help in the same E.N.T. department consenting to a biopsy at the same time. At this time no clinical symptoms or signs of the disease were present although they developed later.

Two of the eight patients had biopsies both before and after surgical closure of one or both nostrils and so microscopic comparison is possible.

Four of the patients were female and three male; their ages ranged from 16 to 60 years.

Biopsies were taken from the anterior or middle thirds of the inferior

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turbinates, some with and some without the use of 25 per cent cocaine paste.

Biopsies were fixed in 3 per cent glutaraldehyde in phosphate buffer pH 7·4 followed by post-fixation in 1 per cent osmium tetroxide ($OsO_4$) in phosphate buffer. They were then dehydrated through a graded series of ethanols, then an ethanol/freon series to absolute freon and 'critical point' dried from $CO_2$. They were then mounted on stubs with double-sided sellotape and sputter-coated with a thin layer of gold. All specimens

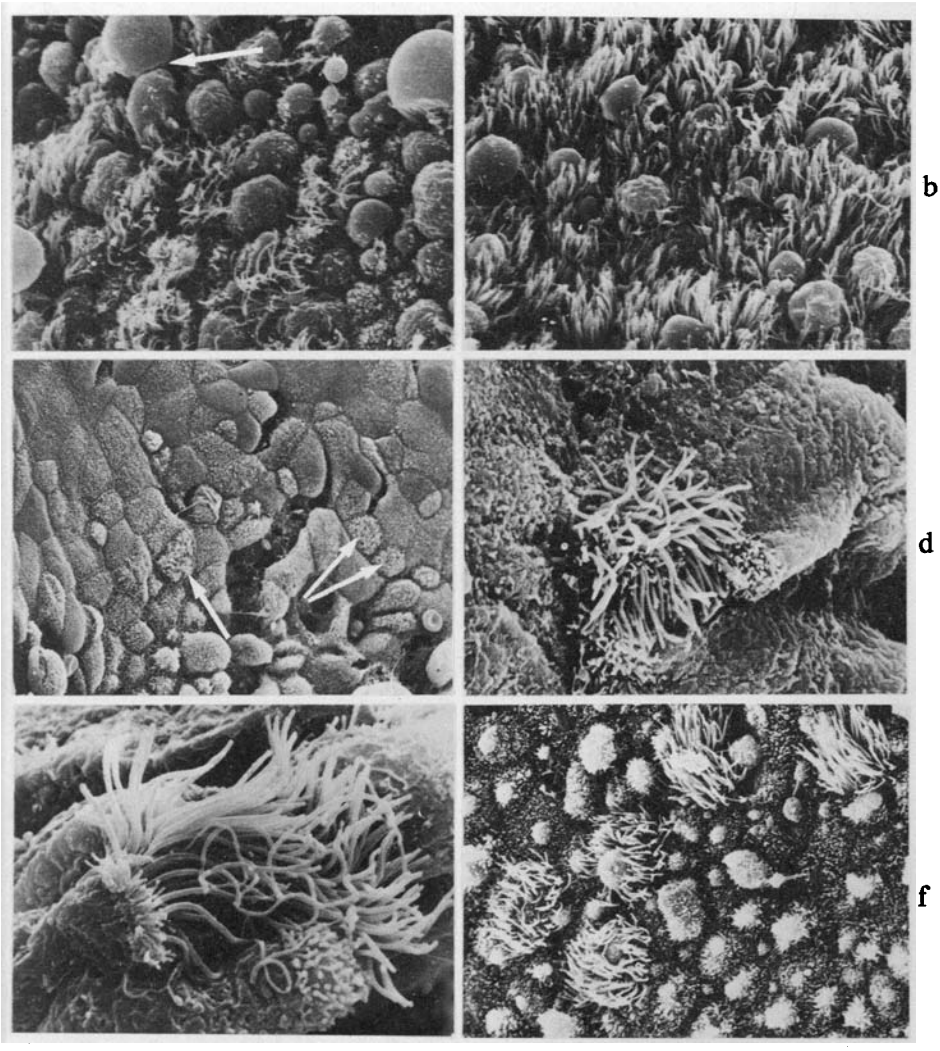



PLATE 1

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were examined in a Coates and Welter Field Emission Scanning Electron Microscope at 16 kV.

## Results

These are grouped into three sections: the general appearance of atrophic rhinitis (Plate 1(a) to (e) and Plate 2(a), (c) and (d)); a comparison between primary and familial disease (Plate 2(b) and (d)); and the effects of closure of the nose (Plate 2(f) and Plate 3(a) to (d)).

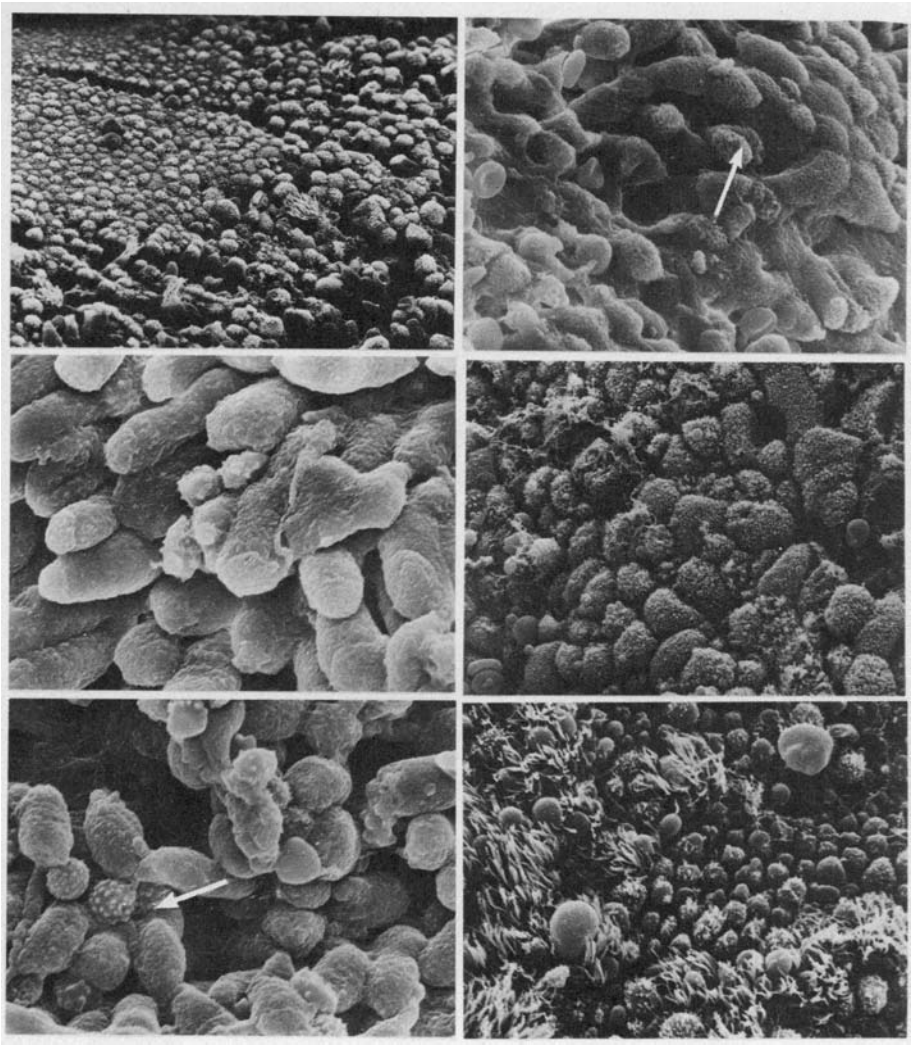



PLATE 2

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*The general features of atrophic rhinitis*

The blanket of mucus is absent and those drops of mucus exuding from the mouths of compound alveolar glands seem to repel each other and the surface for they remain discrete and have not cohered (Plate 1(a) and (b)).

The cilia are sparse, absent or dwarf-like; short cell surface excrescences like microvillae are evident bearing a dubious relationship to cilial genesis and maturation (Plate 1(c), (d), (e) and (f)).

The fate of the most superficial cells is clearly seen in Plate 2(a), (c)

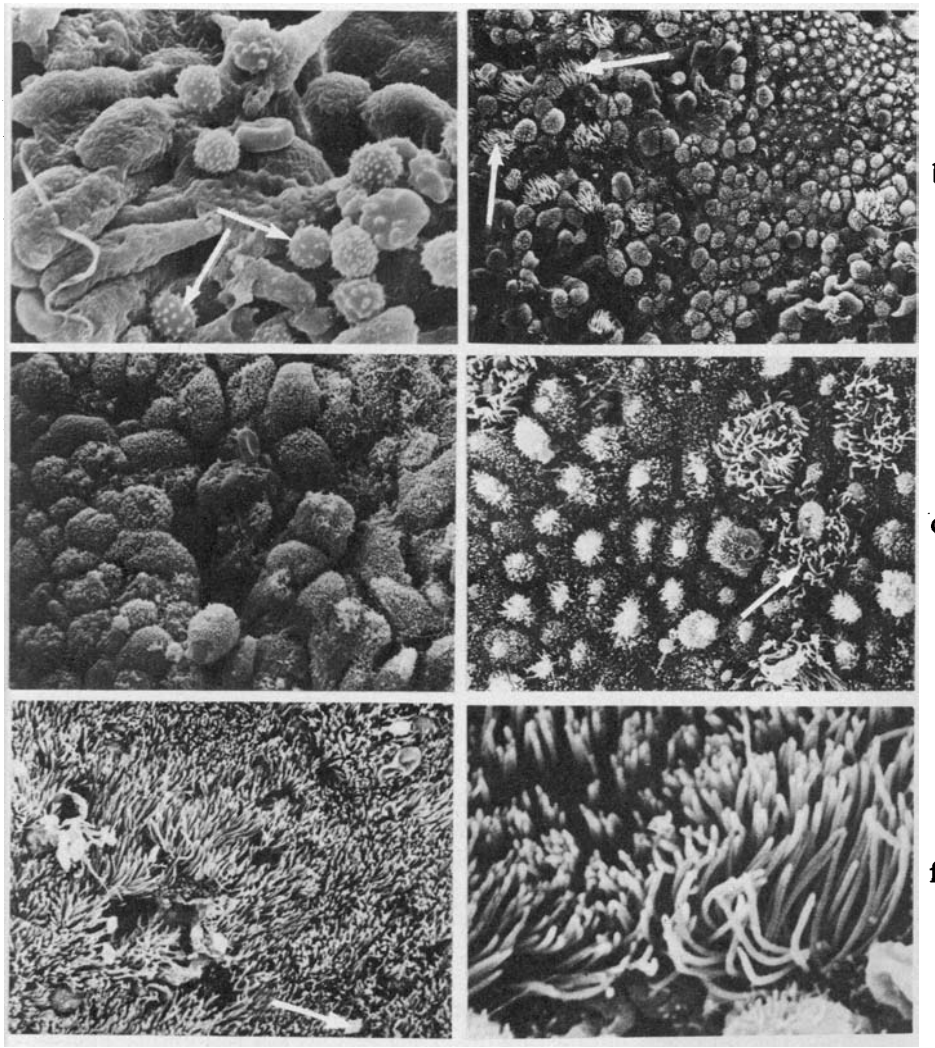



PLATE 3

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and (e) showing columnar cells devoid of cilia loosening away from the close packing needed to form a continent coherent surface. These are shed dying from the organized surface cell array and become associated with free pus cells, illustrating well the development of a crust.

*Comparison between primary familial and idiopathic atrophic rhinitis*

No difference was obvious in the specimens examined except that stunted cilia and microvillae are more obvious and plentiful in the familial condition (Plate 2(b) and (d)).

*Effects of nasal closure*

The cilia improve in length and appearance but not in numbers, being patchily distributed and probably insufficient to propel a mucus blanket (Plate 2(f) and Plate 3(b) and (d)).

Compare these with normal nasal mucosa with its dense cilia (Plate 3(e) and (f)) and confluent mucus coat (not shown).

The improvement in the appearance of the ciliated cells after closure agrees with the clinical findings which are detailed in the three case histories below.

1. S.W., woman aged 57.

The symptoms of atrophic rhinitis began in 1973 when she noticed nasal crusting and a tight feeling in her nose. Her nose was closed surgically in October, 1976 on the right side. This reopened spontaneously and was reclosed with the left side one week later. Specimens at this time proved unsatisfactory for scanning electron microscopy.

Two months' later the left side was opened at the patient's insistence that a large crust lay behind. This was not so and the nose was closed again.

Four months' later the nose had opened spontaneously, the left side widely so and the right to a 'slit'. Crusting was minimal and the patient was pleased with the result and has remained so to date.

Scanning electron microscope appearances are shown in Plate 2(f).

2. B.P., woman aged 60.

Her symptoms began in 1967 with a mucopurulent nasal discharge, crusting, anosmia and an apparent obstruction. The nose was closed in March, 1977 and the scanning electron microscope appearances are shown in Plate 3(a).

Fourteen months later the nose was reopened and symptoms were much improved with no crusting and only occasional mucopurulent discharge. This was still true in September, 1978 and March, 1979 and the patient has good airways and remains happy. The scanning electron microscope appearance is shown in Plate 3(b).

3. N.A., woman aged 44.

Her symptoms began in 1975 at the age of 20 with a yellow discharge and anosmia. The nose was closed in June, 1976 so that the respiratory apertures were narrowed to one third of their normal size on both sides. Plate 3(c) shows the appearance on scanning electron microscopy.

The nasal apertures were restored to normal in August, 1978 after twenty-six

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months of partial obstruction. She then had no symptoms but her husband stated that the characteristic smell had returned. In April, 1979, she was still symptom-free and pleased with the result. On that occasion her husband's opinion was not recorded! Plate 3(d) shows the mucosa after reopening the nose.

## Discussion

A metaplastic change to squamous epithelium with no cilia has been the principal finding from light microscopic studies. This investigation has produced abundant evidence that wherever one takes biopsy material in the anterior half of the atrophic nose, dying columnar cells devoid of cilia are becoming detached from the surface.

The photographic evidence presented here suggests that a crust forms in the following fashion. Sparsely ciliated or bare epithelial cells are unable to maintain their integrity due to surface damage; they die and become detached. The surface of the cells is directly exposed to relatively cold inhaled air, drying, bacterial and viral attack and the fermentation products of pre-existing crusts. In these circumstances the cell dies and is shed into the surface where free white cells and micro-organisms complete the formation of a new crust.

Cilia, although reported to be absent by light microscopy, are present in most patients but are sparse. The normal cell carries 36 to 125 cilia of approximately equal length (8–12 $\mu$) and thickness (0·2–0·38 $\mu$) with occasional extra long cilia. Those few cells which are ciliated in atrophic rhinitis carry irregular cilia of varying length and thickness (Plate 1(e)) or may carry a fairly uniform crop of dwarf cilia as appear in Plate 3(d). In many biopsies cilia were present on only five to ten per cent of suitable looking cells and, in one patient, absent from all areas scanned.

The mucus droplets seen well in Plate 1(a) and (b) and Plate 2(f) seem to repel each other and remain discrete. It is difficult to imagine the formation of a continuous mucus blanket from these non-coherent globules.

Most features of atrophic rhinitis are seen in specimens from both teh autosomal dominant patients and those without family history and attempts to differentiate between them with the scanning electron microscope would seem profitless.

It was most encouraging to see the improvement in the micro-anatomy following closure of the nostrils as this correlates well with the clinical findings. The three obvious features are: first, improvement in the number and morphology of the cilia; second, almost no cell shedding from the close phalanx of columnar units; and, third, an absence of the free white blood cells so markedly associated with shed cells in a forming crust. Plate 3(a) is a good example of this.

## Conclusions

The surface features of atrophic rhinitis are shown and it is suggested that these explain the majority of symptoms.

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It seems clear that any lesion preventing the formation or maturation of large numbers of motile cilia, or the production of mucus capable of forming confluent sheets suitable for continuous propulsion, may cause atrophic rhinitis. In both familial and idiopathic forms of the disease, both abnormalities are present. It would be most interesting to know the ultrastructure of the cilia in transverse section of this condition. Transverse electron microscopic studies in Retinitis Pigmentosa, Usher's syndrome and Kartagener's syndrome now becoming known as the low cilia motility diseases show clearly the primary lesions in the micro-tubules and dynein arms of the cilia. A similar transmission electron microscopic study in atrophic rhinitis may show the fundamental cilial lesions.

Surgical closure of the nasal passages has much to offer the patient with severe symptoms as the clinical features of the disease improve with the increasingly normal micro-anatomical features demonstrated in this paper as a result of closure. This improvement in structure is not in all cases sufficient to fulfil the above criteria so a complete cure is improbable in the majority of cases.

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