The nose after laryngectomy[1]

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Summary: Previous studies of nasal function after laryngectomy have suggested that patients must accept complete and irreversible anosmia as an inevitable consequence of the operation, and that this is due to interruption of a poorly defined neuronal interaction between larynx and nose. In this study nasal function was investigated in 23 laryngectomees and 10 patients about to undergo laryngectomy. Scanning electron microscopy showed a more densely ciliated nasal epithelium in the laryngectomees compared with the preoperative controls, and nasal mucociliary transport, measured by saccharine clearance, was significantly faster ($P<0.01$) in laryngectomees. Olfactory acuity, as determined by the threshold for detection of insufflated pyridine vapour, was normal in laryngectomees. Some laryngectomees did have a relatively normal sense of smell; these were shown to be those who had discovered a technique of sniffing using buccopharyngeal rather than respiratory musculature.

These findings have obvious implications for the rehabilitation of laryngectomees, many of whom may otherwise have to contend with distressing anosmia as well as the other physical and psychological consequences of the operation.

Introduction

After laryngectomy loss of normal speech is inevitable, and it is hardly surprising that this obvious disability is the focus of most of the rehabilitation of such patients. Nasal function is largely ignored, although research in the United States some years ago suggested that total and irreversible anosmia was the inevitable result of laryngectomy (Henkin *et al.* 1968, Hoye *et al.* 1970, Henkin & Larson 1972), and that patients should be warned of this preoperatively.

Many laryngectomees find their anosmia – and the consequent diminution in their sense of taste – both distressing and potentially dangerous. Some patients, though, report that their ability to smell is preserved to a greater or lesser degree. The present study of post-laryngectomy nasal function was undertaken to investigate this apparent discrepancy and the extent of loss of olfactory function.

Methods

The subjects investigated fell into two groups: Group A comprised 10 patients about to undergo laryngectomy (ages 35–75 years, mean 57 years); and Group B comprised 23 patients who had undergone laryngectomy between 1 and 15 years previously (ages 35–78 years, mean 59 years). The studies were carried out with the approval of the hospital ethical committee and with the informed consent of each patient.

Nasal mucosal surface structure

Using aural granulation forceps, biopsies were taken 1 cm behind the anterior tip of the inferior turbinate. In Group A, this was performed under general anaesthesia at the time of laryngectomy. In Group B, local anaesthesia was achieved using a submucosal injection of 2% lignocaine/1:200 000 adrenaline delivered via a dental syringe. Specimens were prepared for

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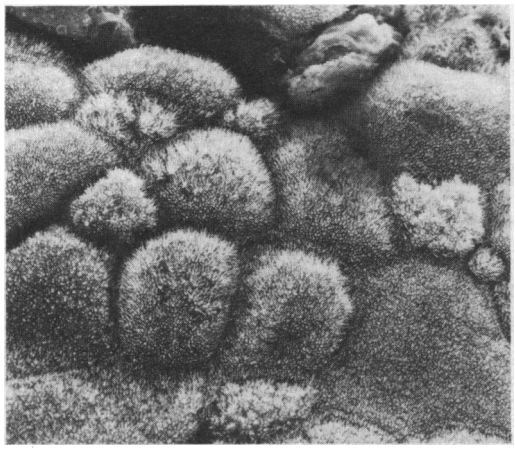

Figure 1. Scanning electron micrograph of nasal mucosa from a preoperative control patient showing transitional-type epithelium with microvillous cells. No cilia are present. (× 2300, picture width 65 μ)

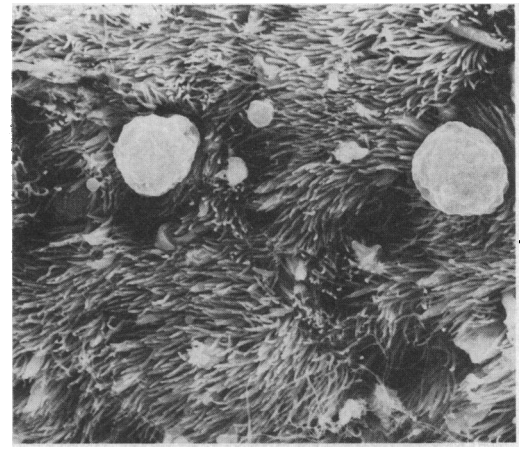

Figure 2. Scanning electron micrograph of nasal mucosa from laryngectomized patient showing densely ciliated epithelium and secretion of mucus globules. (× 2700, picture width 55 μ)

scanning electron microscopy using the osmium thiocarbohydrazide method (Malick & Wilson 1975).

Nasal mucociliary transport

A small particle of saccharine was placed on the inferior turbinate. The time elapsing before a sweet taste is detected reflects nasal mucociliary transport, which is directed posteriorly from anterior nares to nasopharynx. The technique, described by Andersen *et al.* (1974), gives reliable and reproducible results when it is carried out under conditions of identical particle placement, temperature and humidity.

Sense of smell

(1) Objective measurements of the olfactory threshold were made by the pyridine vapour method (Amoore & Ollman 1983). Squeeze bottles containing serial dilutions of pyridine in mineral oil were used to insufflate accurately odorized puffs of air into the nose. In this study, binary dilution steps 6–21 were used, producing progressively lower concentrations of pyridine vapour (2700 to 0.165 parts per million).

(2) Four conventional smell test bottles, with odours of lemon, coal tar, cloves and ammonia, were presented to the subjects who stated whether they could detect and identify them. Unlike the bottles used in (1) above, the smells were not puffed directly into the nose.

(3) In patients with a tracheostome, respiratory effort produces no nasal airflow. Measurements were made of the nasal airflow which could be generated by 17 of the laryngectomized subjects by manipulation of their buccopharyngeal musculature. A close-fitting mask covering nose and mouth was attached to the flow transducer of a rhinomanometer (Mercury Instruments NR 1) and the output displayed on a previously calibrated oscilloscope. The maximum flow of air that each patient could generate by 'buccopharyngeal sniffing' was termed the maximal inspiratory sniff rate (MISR).

Results

Nasal mucosal surface structure

Figure 1 is a scanning electron micrograph demonstrating the epithelium found in the control, pre-laryngectomy biopsies. All the biopsies showed a 'transitional' epithelium in which the cells are mainly nonciliated stratified microvillous cells with a cuboidal outline. Figure 2

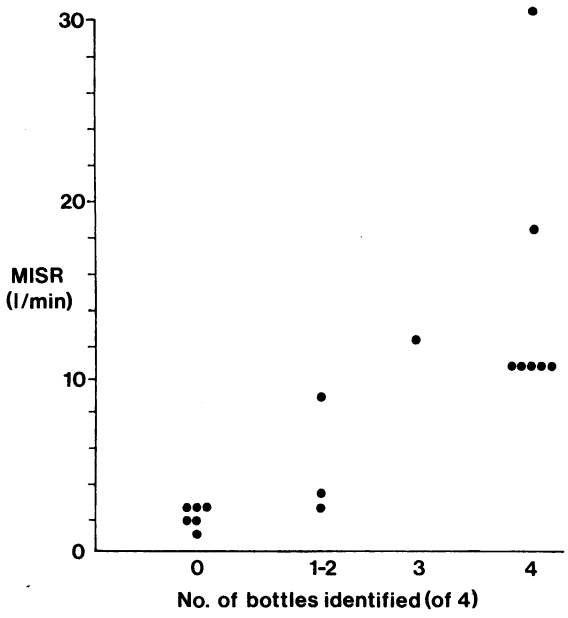

Figure 3. Relationship between ability of laryngectomees to identify conventional smell bottles and maximum sniff rate generated

demonstrates the type of epithelium found in all the post-laryngectomy biopsies. Two features were consistently seen: a densely ciliated mucosa, and an abundance of mucus.

Nasal mucociliary transport
The saccharine clearance time for the preoperative control group was 18 ± 1.47 min (mean $\pm$ standard error of mean) and for the laryngectomees 13.4 ± 1.25 min. This shorter time represents significantly faster clearance ($P < 0.01$).

Sense of smell
Olfactory threshold: When tested by insufflation of pyridine vapour into the nose, all but one of the preoperative control group and all the laryngectomees had olfactory acuities within the normal range (binary dilution steps 14–21, 10–0.8 ppm). There was no significant difference between the mean detection thresholds in the two groups.

Conventional smell bottles: The one control patient with abnormally low olfactory acuity could not identify any of the conventional smell bottles; the other controls could identify all four bottles. Of the 23 laryngectomees tested, 11 could correctly identify all four odours and one could identify three of the four. Three laryngectomized subjects were able to identify one or two of the test bottles, and 8 were unable to identify any of them.

Maximal inspiratory sniff rate: The relationship between the ability of laryngectomees to identify the conventional smell bottles and the MISR they could generate is shown in Figure 3. There was a highly significant association between the ability to identify three or more bottles and the ability to achieve an MISR $\geqslant 10$ l/min ($P > 0.005$).

Discussion

At laryngectomy, the lungs and lower trachea are completely disconnected from the nose, mouth and pharynx and respiratory airflow takes place directly through an end tracheostome

above the suprasternal notch. This contrasts with an ordinary tracheostomy where continuity still exists between lungs and upper airways.

In normal individuals, inspired air causes drying of the sol part of the mucus layer and consequently some destruction of cilia in the anterior part of the nose. Following laryngectomy, airflow through the nose ceases. Light microscopy studies (Dixon *et al.* 1949) have suggested a change towards a more densely ciliated nasal epithelium in laryngectomized subjects and this is strikingly demonstrated in the scanning electron micrographs.

The saccharine clearance time (SCT) is a measure of nasal mucociliary function and the significant shortening of SCT in the postoperative group implies that mucociliary transport is faster in laryngectomees. This functional improvement seems to correlate well with the structural change towards a more densely ciliated mucosa with an increase in mucus secretion.

Although Ritter (1964) had suggested that there may be some residual sense of smell after laryngectomy, current generally accepted views are based on the work of Henkin and colleagues (Henkin *et al.* 1968, Hoye *et al.* 1970, Henkin & Larson 1972). They suggested that smell via the olfactory epithelium and first cranial nerve was completely abolished by laryngectomy, and any residual sensitivity to a vapour stimulus was mediated by what they termed 'accessory areas of olfaction' present in the lateral wall of the nose, the oropharynx and larynx, and supplied by the V, IX and X cranial nerves. They postulated that surgical interference with sensory nerves in the larynx at the time of laryngectomy altered olfactory acuity by some complex feedback mechanism, and surmised that there might be anatomical connections between the laryngeal nerves and olfactory cortex. They concluded that anosmia was an inevitable consequence of laryngectomy.

The present study was originally undertaken to further investigate this phenomenon, but it soon became clear that the initial results were considerably at variance with earlier reports. All the laryngectomized patients had detection thresholds for pyridine which were within the normal range when the vapour was insufflated into the nose with squeeze bottles. The dilutions detected by all these patients were too weak to stimulate the V, IX and X nerves (Sherman & Amoore 1979) and must represent detection via the olfactory nerve. It seems likely that the disparity between the present study and previous reports may at least in part be due to the manner in which the stimulus was delivered. Henkin and colleagues used 'gentle nasal nebulisation' so as to avoid stimulating the proposed accessory areas of olfaction, whereas the (much weaker) stimulus detected by our patients was delivered by insufflation of a puff of odorized air into the nostril.

The suggestion that the means of presentation of an olfactory stimulus is of great importance in laryngectomees is supported by the disparity which existed between the normal olfactory threshold measurements of our patients when the vapour was squeezed into the nose and their ability to smell and identify the conventional smell test bottles with which no active insufflation is possible. It would seem that although all laryngectomized patients retain the capacity for normal olfaction, many are unable to detect smells in everyday life. It was noted that in their attempts to smell the conventional bottles, many of the laryngectomees made orofacial and maxillary movements. It was realized that they were in fact generating a 'sniff'. In such patients, conventional sniffing by sudden diaphragmatic contraction will only result in sudden intake of air through the tracheostome. Manipulation of cheeks and jaw with the mouth closed causes rapid volume changes in the buccopharynx such that increases in volume cause inflow of air through the nose and decreases of volume result in the reverse. This 'artificial sniff', although less powerful than a conventional sniff, presents the vapour stimulus to the olfactory mucosa. The association demonstrated in this study between ability to identify the smell bottles and ability to generate such an artificial sniff is striking.

It should not be assumed by clinicians that the potential for relatively normal olfaction is irreversibly lost after laryngectomy; contrary to the findings of previous workers, the olfactory threshold is unchanged. The anosmia reported after laryngectomy is almost certainly due to failure of the olfactory stimulus to reach the olfactory mucosa, and some laryngectomees have spontaneously found a way of overcoming this problem. The findings of this study may have considerable implications for the rehabilitation of patients after laryngectomy.

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