INFERIOR MEATAL ANTROSTOMY

Fundamental Considerations of Design and Function

by

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Abstract

The operation of inferior meatal antrostomy has emerged as the most popular surgical technique in the management of maxillary sinusitis though the surgical anatomy and natural history of the procedure are poorly understood. The anatomy of the inferior meatus determines surgical limitations and a retrospective study of 108 patients who have undergone antrostomy provides a basis for a prospective study in which the size of the antrostomy has been assessed in 65 patients pre- and post-operatively using direct measurement and serial photography. After initial circumferential healing within the first few weeks, the majority remain unchanged unless infection supervenes when complete closure may result. The closure is a combination of fibrous tissue and bone in the majority of cases. A critical size is apparent below which complete closure can be anticipated whereas if too large an antrostomy is fashioned, related anatomy is jeopardised and therefore the dimensions must be carefully judged if long-term patency is desired.

The effect of patency on the mucus-secreting elements of sinus mucosa is examined in a second prospective group of 19 patients. Assessment of subjective clinical success determines overall benefit from the operation in most patients though mucous discharge is least improved and this is directly related to the level of increase in goblet cells.

The role of the inferior meatal antrostomy is dependent upon an understanding of the pathophysiology of sinusitis and thereby determining those patients who have potentially reversible mucosal damage and are therefore most likely to benefit from the procedure.

Introduction

A century ago, Mikulicz described the operation of inferior meatal antrostomy. Much speculation but little scientific research has been performed during that one hundred years with regard to the natural history and efficacy of an operation which after antral lavage, is the commonest procedure performed on the maxillary sinus in Great Britain.

It would seem appropriate at this juncture to evaluate the procedure and to examine the rationale for the performance of the antrostomy in modern rhinology. A number of aspects of the operation require investigation. Paramount in this is an appraisal of the anatomy of the inferior meatus in children and adults to reveal anatomical limitations on the dimensions of the antrostomy which have implications both at the time of surgery and post-operatively.

In the literature, causes of failure have principally been attributed to premature closure of the antrostomy. Several factors have been suggested as responsible for this, in particular the initial size of the hole, but also irregular margins and inadequate lowering of the inferior margin to the level of the floor of the nose (Myles, 1907; Hempstead, 1939; Moore, 1939; Hilding, 1950; Capps, 1952; Lavelle and Spencer Harrison, 1969, Mann and Beck, 1978). Mucosal swelling or overhanging inferior turbinates which occlude the antrostomy have also been suggested as important factors (Buckley, 1934; Mann and Beck, 1978).

In the presence of this controversy, the aim of this work is to answer a number of questions with regard to the natural history of the operation. Firstly, it is necessary to establish whether antrostomies close or not, and if so, to establish the manner of closure. Investigation is required to establish measurable factors associated with closure, such as operative technique, and age of the patient and also to establish whether long-term patency is important to clinical success. Information obtained from these sources would confirm a number of assumptions made about the present role of the operation. A retrospective examination of patients who have already undergone intranasal antrostomies would in part answer some of the questions posed but a prospective study is needed to accurately determine changes in the antrostomy itself and possible causes. The speed, pattern and manner of closure can thus be determined. No study of this sort is apparent in the literature, and the results, therefore, have important implications on the statements and suggestions of previous writers on this topic and on our present understanding of the operation.

Having established the natural history of the antrostomy itself, it is next appropriate to consider the effect of the patent antrostomy on the mucous membrane of the maxillary sinus, in particular on the mucus-secreting elements. Thus, some understanding of the pathophysiological function of the antrostomy might emerge and indicate those patients likely to derive benefit from the operation.

Historical aspects

The first description of an intranasal antrostomy was probably by Gooch in the 1770's (Cordes, 1905) but routine puncture of the inferior meatus was not common

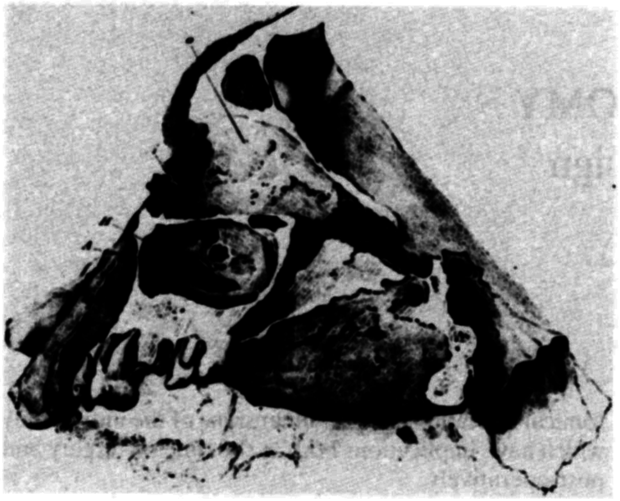

FIG. 1
Anatomical drawing by Mikulicz showing inferior meatal antrostomy

until advocated by Lichtwitz (1886), Krause (1887) and Mikulicz (1887). They used a needle, trocar and stylette respectively to puncture the inferior meatal wall. Thus began the first attempts at diagnosis by proof puncture followed by treatment by irrigation.

In an excellent and definitive paper on intranasal antrostomy, Mikulicz (1887) described the history of the treatment of sinusitis and the advantages and disadvantages of each approach. He realised that any perforation tended to close and felt that the cavity must be kept open if purulent secretions were to drain. An intranasal approach had seemed physiologically superior to Jourdain (1767), Hunter (1835) and Zuckerkandl (1893) but they had recommended using the middle meatus, the disadvantages of which were enumerated by Mikulicz.

First, he pointed out that the middle meatal approach was not always anatomically possible. He appreciated the presence of a large blood vessel lying behind the inferior turbinate, the proximity of the orbit and the thinness of the intervening bone, rendering the blind use of a perforating instrument dangerous.

The inferior meatal approach, on the other hand, was easy to perform, reasonably safe and the hole could be enlarged to allow pus to flow out. His understanding of the detailed anatomy of the area was excellent. He appreciated that inferiorly and anteriorly the bone was hard and it was necessary to enter above and behind where the bone thinned out. He designed his own instrument, a short strong double cutting stilette with an upward curve and a collar which prevented too deep a penetration. He perforated the thin bone, enlarged the hole to 5-10 mm in height and 20 mm in length and this was made as flush with the floor of the nose as possible despite the difficulty posed by the thicker bone (Fig.1). The antrostomy was packed with iodoform gauze and subsequently washed out using a balloon syringe.

This clear description has remained unaltered for one hundred years and has been supported by enthusiasts such as Lothrop (1897), Canfield (1908) and Claoué (1912). However, shortly after the introduction of the inferior meatal antrostomy, it was largely superseded by a more radical procedure described in 1893 by the American, Caldwell, in 1894 by Spicer from England and, in 1897, by Luc from France.

Desault published several papers between 1798 and 1801 on the canine fossa approach and this was also referred to by Watson, the English laryngologist (1875), by Küster in his paper 'Basic Principles of the Treatment of Suppuration in Rigid Walled Cavities' and by Heath, both writing in 1889. Jansen (1893) employed this method but packed the sinus to encourage granulation tissue. However, none of these earlier methods were satisfactory until Caldwell, Spicer and Luc suggested a counter-opening into the nose. Enthusiasm for the Caldwell-Luc procedure as the primary treatment of choice lasted throughout the early part of this century but in the 1920's a more conservative approach prevailed which meant that antral washout was succeeded by intranasal antrostomy via the inferior meatus and a Caldwell-Luc only performed if that failed.

There have been many celebrated supporters of the intranasal approach including Parker (1906), Colledge (Parker and Colledge, 1921) and McKenzie (1927) who declared that 'The intranasal operation suffices for all cases of antrum suppuration'. St. Clair Thomson stated in 1926 'The intranasal method is now the usual operation in all chronic cases', and this was endorsed by Capps (1952) and Negus (1954). This conservative approach has persisted in many quarters to the present day. (Dixon, 1958; Link, 1968; Reynolds and Brandow, 1975; Wigand and Steiner, 1977) despite the work and writing of Hilding (1950) and Macbeth (1968).

A number of authors have supported the intranasal antrostomy approach after trying a Caldwell-Luc and finding the results disappointing (Goodyear 1934, 1949). Many large series have been published demonstrating the success of intranasal antrostomies (Barlow 1921, Hempstead 1927, Tucker 1928, Stevenson 1931) and purporting to show that the lining returns to normal. Hempstead (1927) like many others, modified the Mikulicz technique and claimed a 97% success rate. Rethi (1910) and Sluder (1919) described a technique of intranasal fenestration in which the entire medial wall of the antrum in both inferior and middle meatus was removed but leaving the inferior turbinate. A similar technique was also described by Freer (1905), Canfield (1908) and Sturmann (1908). McKenzie (1927) advocated enlarging the inferior meatus superiorly into the middle meatus but the technical difficulties meant that these modifications never became popular.

When the operation was first devised the mucous membrane was usually left undisturbed and allowed to recover naturally, but a number of surgeons have recommended both conservative (Myles, 1907; Unterberger, 1932 and Eckert-Mobius, 1933) and radical removal of the sinus lining (Vacher, 1910; Halle, 1923).

Subsequently, interest in this subject waned. Apart from a few large series (Boies, 1954; Schicketanz, 1959; Tarkkanen *et al.*, 1969) the whole subject of maxillary sinusitis was supplanted by other topics as a matter for further investigation. However, more recently in conjunction with the development and availability of fibreoptic instruments, interest has been reawakened in the middle meatal antrostomy, championed by Stammberger (1986), from Messerklinger's department, and

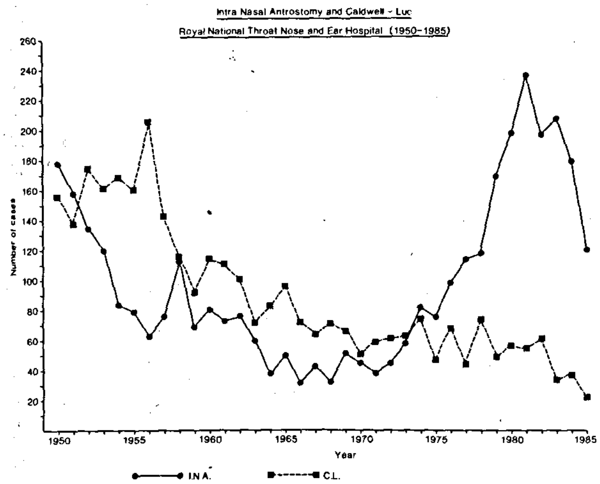

FIG. 2.

Graph showing numbers of intranasal antrostomies and Caldwell-Luc procedures performed annually at the Royal National, Throat, Nose and Ear Hospital 1950-1985

this has led to further controversy in both Europe and America.

An analysis of intranasal antrostomies and Caldwell-Luc procedures performed at the Royal National Throat, Nose and Ear Hospital between 1950-1985 shows that the number of intranasal antrostomies performed each year increased up to the early 1980s whilst Caldwell-Luc operations gradually decreased in popularity. Thereafter a marked decline in intranasal antrostomies as well as 'Caldwell-Lucs' is noted suggesting a cyclical pattern for the antrostomies (Fig. 2). These changes are genuine and are not due to differences in overall operating nor do they appear dependant on local factors as they can be demonstrated in figures from district general hospitals during the same period.

Anatomical limitations on the inferior meatal antrostomy

The inferior meatus lies under the inferior concha and extends downwards to the floor of the nasal cavity. It is the largest of the three meatus and extends almost the entire length of the lateral wall of the nose. It is deepest at the junction of its anterior and middle thirds, and at this level is found the lower orifice of the nasolacrimal canal (Gray's Anatomy 1973).

Dimensions of the inferior meatus

Macroscopic appearances

The inferior meatus is narrow at birth and remains so until after the deciduous teeth have erupted with the concha almost touching the floor of the nose and the latter being on average 4 mm lower than that of the maxillary sinus. Enlargement of the maxillary sinus and inferior meatus occurs throughout childhood so that by eight to nine years the sinus and nasal floors are in the same plane and expansion continues until the adult stage is reached when the sinus floor is usually lower than the nasal cavity (0.5-10 mm).

Coronal computerised tomograms from 64 patients were assessed from which it was possible to obtain the

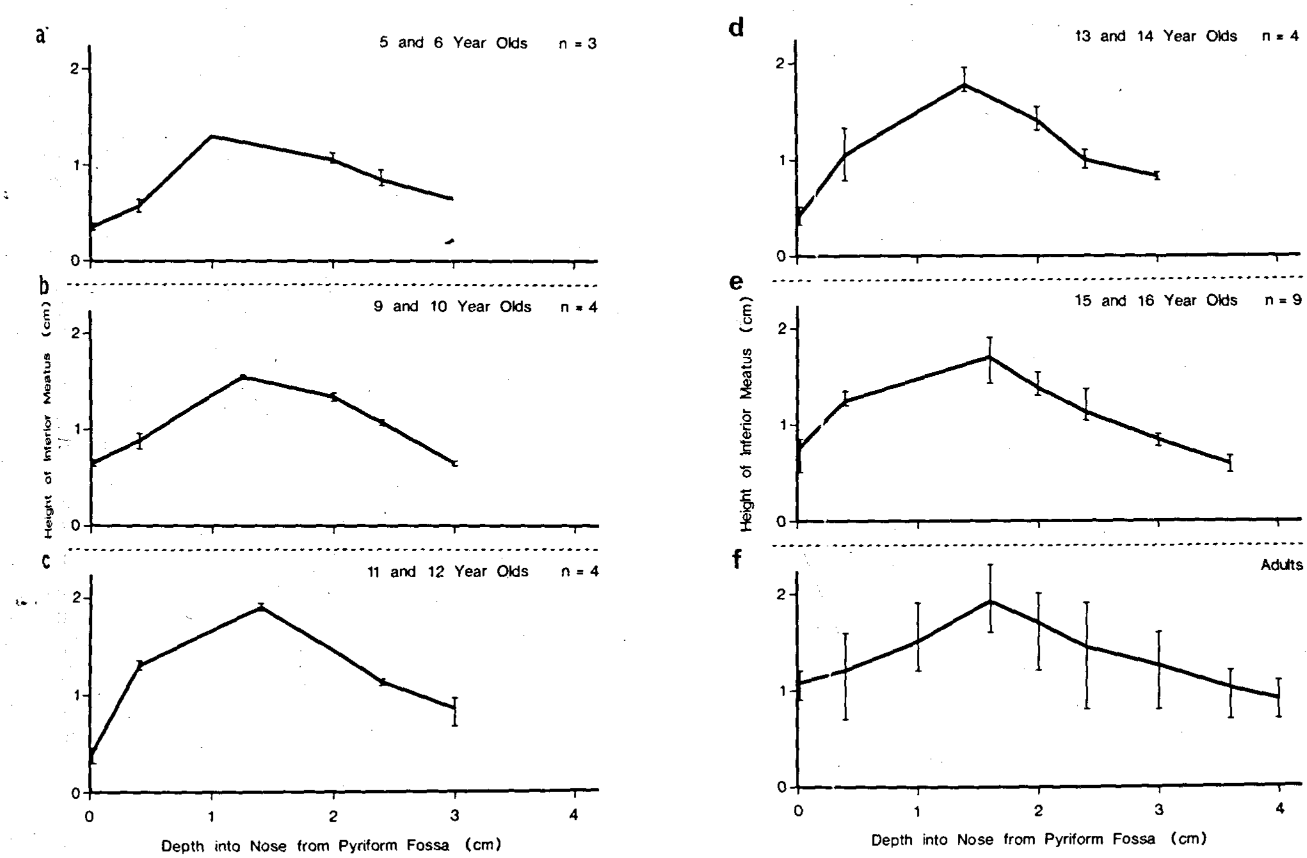

FIG. 3

Figures (a-f) showing height of inferior meatus and attachment of inferior turbinate in children and in adults.

height of the inferior meatus moving from the most anterior to most posterior attachment of the inferior turbinate and results corrected for magnification. Forty-five males and nineteen females were examined, their ages ranging from 5-69 years. The dimensions were examined in the patients grouped by age. There were 40 adults (17-69 years), and 24 children (5-16 years). The children were further subdivided into three 5-6 year olds, four 9-10 year olds, four 11-12 year olds, four 13-14 year olds and nine 15-16 year olds.

Figure 3f shows the attachment of the inferior turbinate in adults with a maximum height range of 1.6-2.3 cms (mean 1.92 cm) at 1.6 cm along the bony lateral wall, consistent with the appearances seen in sagittally sectioned skulls. In the children, the numbers in each group are, of necessity, small. Although the dimensions are correspondingly less, with the maximum height occurring at shorter distances into the meatus, the configuration of the anatomy is similar in all groups (Figs.3a-e). Whilst it would be possible to attain an antrostomy height of 1 cm in all ages examined, the potential length is limited by the attachment of the turbinate as shown.

Microscopic appearances

Serial coronal sections (5μ thick) taken from two mid-facial adult blocks demonstrate how the thickness and quality of the bone changes within the meatus, with a gradual change from compact to lamellar, superior to inferiorly, and anterior to posteriorly so that the thinnest bone lies in the superior central portion of the meatus (Fig. 4). The height of the meatus ranges from 6-18 mm with the highest point occurring at the genu of the inferior turbinate confirming data obtained from the coronal CT scans. The maximum distance between the floor of the sinus and floor of nose was 16 mm in one specimen and 5 mm in the second. There is evidently a wide range of measurements but this does serve to demonstrate that there is always a potential 'sump' in the fully developed adult maxillary sinus.

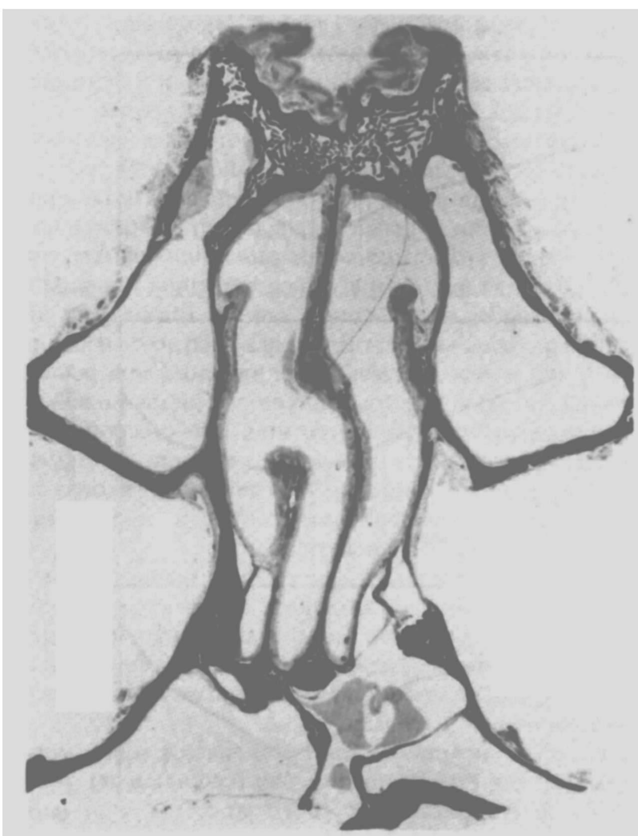

Fig. 4

Coronal section (5μ) through adult mid-facial block (Haematoxylin and Eosin)

The orifice of the nasolacrimal duct

The nasolacrimal duct opens into the anterior portion of the inferior meatus, 15-20 mm dorsal to the limen nasi and 30-40 mm from the anterior nares (Schaeffer, 1920; Gray's Anatomy 1973). It is described as opening at the most cephalic part of the meatus, under the genu of the inferior turbinate which was confirmed when 21 dacrocystograms were examined and anatomical dissection in 16 cadavers performed. In all cases, the orifice was found at the most cephalic portion of the inferior meatus, under the genu of the inferior turbinate, which explains why nasolacrimal dysfunction rarely results from surgery in the inferior meatus.

The arterial supply of the inferior meatus

The blood supply of the inferior meatus derives primarily from the sphenopalatine artery, which may be regarded as the terminal part of the maxillary artery. It passes through the sphenopalatine foramen into the cavity of the nose at the posterior part of the superior meatus. Here it gives off its posterior lateral nasal branches which ramify over the conchae and meatus, anastamosing with the ethmoidal arteries and the nasal branches of the greater palatine (Gray's Anatomy 1973). This vessel (also described by Djindjian and Merland (1978) and Lasjaunias (1981) using super-selective arteriography), the lateral sphenopalatine artery, is said to divide into two branches, one supplying the middle and inferior conchae which subdivides to supply the meatus, and one which supplies the ethmoid cells.

The existence of a major vessel in the posterior part of the inferior meatus has been known to surgeons since Mikulicz described it in 1887 and the risk of severe bleeding if it is injured when creating an antrostomy is well-recognised by ENT surgeons. To demonstrate the exact route of this vessel ten super-selective arteriograms were examined and on each a constant vessel was demonstrated arising from the lateral sphenopalatine artery and entering the inferior meatus, running superiorly to inferiorly at between 4-5 cms. along the bony lateral wall (Fig. 5). It then descends below the level of the palate, rising again very anteriorly on the lateral wall. This may be distinguished from the leash of vessels supplying the inferior turbinate, the descending palatine running more posteriorly and inferiorly and the septal artery running down and forwards on the vomer.

Distribution of anterior superior alveolar nerve

The anterior superior alveolar nerve derives from the infra-orbital nerve and contributes to the superior dental plexus. Wood Jones (1939) states that whilst the lateral

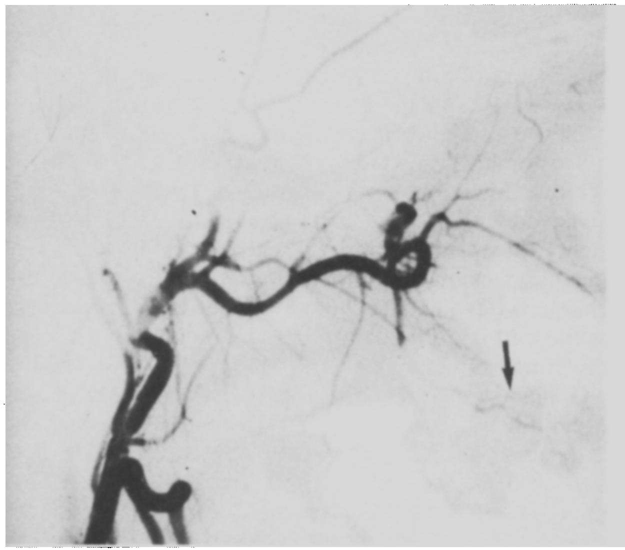

FIG. 5

Super-selective arteriogram: lateral aspect showing subtraction view of nasal region with vessel to inferior meatus (arrowed).

three-quarters lies in the anterior wall of the antrum, the medial quarter lies in the lateral wall of the nasal chamber. The nerve is brought very constantly to the level of the anterior attachment of the inferior turbinate and lower end of the naso-lacrimal duct. At this point, branches pass inwards to the nasal chamber to the inferior turbinate, meatus and naso-lacrimal duct. The presence of this nasal branch which passes through a minute canal in the lateral wall of the inferior meatus and supplies the mucous membrane of the anterior part of the lateral wall as high as the ostium of the maxillary sinus and the floor of the nasal cavity, communicating with nasal branches of the pterygopalatine ganglion is also described in Gray's Anatomy (1973).

When maxillary blocks, in which an inferior meatal antrostomy has been fashioned, are stained with osmic acid, the relationship of the nerve anterior and inferior to the antrostomy can be readily demonstrated. The frequency with which patients complain of disturbances in dental sensation following antrostomy procedures may thus be explained.

Retrospective analysis of intranasal antrostomies

All patients who had had intranasal antrostomies performed at the Royal National Throat, Nose and Ear Hospital between 1979 and 1982 were requested to attend so that an assessment could be made of the patency and size of the antrostomy. This was done using an 0° Hopkins rod, Olympus camera with in-built graticule and a Xenon light source as described. The present medical status of the patient was discussed and nasal symptoms noted. The patency of the antrostomy was considered in terms of length of time since the operation, the age of the patient, the experience of the operator and past and present nasal symptoms.

Results

One hundred and eight patients were assessed. There were 58 men and 50 women, their ages ranging from 7 to 73 (average age 41 years, with the majority (40%) between 41-60). On initial attendance, an average of 27 months had elapsed since the operation (range 1-63 months).

Thirty seven patients were followed up for an average of five months. Two hundred and sixteen antrostomies had been performed of which 45% were closed and 50% patent (and no assessment could be made in 5%) at initial assessment. The average age of those patients in whom the antrostomies had closed completely was 35 years compared with 44 years in the group which had remained patent, ($p = 0.05$). The 'closed' group included 13 of the 15 patients, 16 years old or under at the time of the operation (with an average post-operative follow-up of 28 months). The degree of patency varied considerably from pinholes 1-2 mm in diameter to holes 2.5 × 0.8 cm.

Patency was considered in relation to time elapsed since operation and shows that the ratio of patency to closure remains virtually the same during the first 3 years though at 4 and 5 years the percentages do alter (38:62% [open:closed] at 4 years and 64:36% at 5 years). Only three antrostomies closed during follow-up (1.3% at 3, 6 and 7 months respectively. Patency was also considered in relation to operator status and suggests that the experience of the operator does not improve the length of patency, with consultants having the highest percentage closure of 54% compared to senior registrars with a 48% closure, registrars with a 42% closure and senior house officers with 43% closure, though these differences are not statistically significant.

The percentage of patients complaining of obstruction, post-nasal drip, rhinorrhoea, headache and facial pain is shown in the patent and closed antrostomy groups in Fig. 6, demonstrating an increase in post-nasal drip, rhinorrhoea and headaches in the patent group. Facial pain and nasal obstruction are equally common in the two groups.

The results from this study provide important information about the natural history of intranasal antrostomies but it is particularly relevant to the pro-

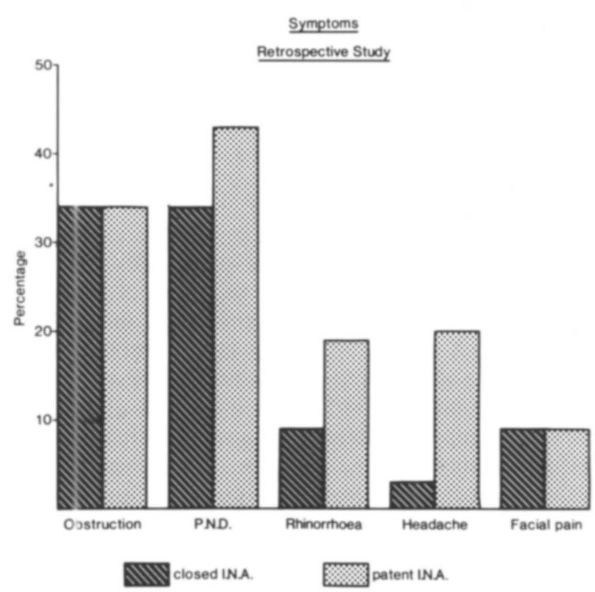

FIG. 6

Histogram showing symptoms of patients in retrospective study.

spective clinical studies providing a population comparable in age and sex distribution. It indicates the effect of the age of the patient at the time of operation on subsequent closure, demonstrating a significant difference between the average age of those in whom the antrostomy had closed and those in whom it was patent. The majority of children under 16 had antrostomies which had closed and it is noteworthy that the two with open antrostomies were 14 and 15 respectively.

The degree of patency raises a number of questions. Due to anatomical constraints it was not always possible to make an accurate assessment of antrostomy size and no information is available on the initial size made at operation. In 12 patients only a tiny pinhole was visible which is presumably smaller than that originally made.

Amongst the rest which were measured, the dimensions ranged from 0.5-2.5 cm in length, and 0.5-1.0 cm in height but again it is difficult to comment on this in the absence of pre-operative measurements.

It might have been expected that the less experienced operator would have a higher incidence of closure compared with those of greater experience. Interestingly the results demonstrated a trend towards consultants having the greatest closure rate but the difference in percentage patency between the groups was not significant.

Most relevant to the prospective study, retrospective analysis demonstrates that change in patency occurs early on in follow-up, usually during the first year. Thus long-term follow-up of antrostomy patency is likely to be unrewarding. As no quantative assessment of symptoms is available, only a crude correlation with patency has been possible, emphasising the need for more accurate clinical assessment in prospective studies. Nevertheless, as might be expected if mucosal damage persists, patency was associated with a higher incidence of drainage as manifested by the rhinorrhoea and post-nasal drip but the increased incidence of headache is more difficult to explain.

Prospective clinical study: I

A prospective clinical study was performed to examine the natural history of the inferior meatal antrostomy and to establish factors relevant to changes in size and closure. It aimed to examine antrostomies of different dimensions to establish a critical size which would remain patent in the long-term.

Method

Sixty-five patients were admitted to the study. Pre-operative assessment included an assessment of symptoms and their duration, full ENT examination and standard plain sinus X-rays. Previous surgical treatment was noted. The patients underwent inferior meatal antrostomy either bilateral (65%) or unilateral (35%). The technique employed in each case was identical and was performed by the same surgeon. A Hill elevator was used to perforate the inferior meatus at the highest point under the genu of the turbinate. Enlargement was performed posteriorly with a Grunwald nasal turbinate forceps, anteriorly with a Seymour Jones antrum forceps and superiorly and inferiorly with a Hayek antrum punch forceps, either up- or down-cutting. Using a specially designed measuring instrument and Hegar's dilators, a direct assessment of the antero-posterior and supero-inferior dimensions was obtained and the antrostomy was enlarged until the predetermined size was achieved. Eighteen patients had had previous antrostomies performed and when enlarged, the tissue removed was sent for histology. Haemostasis was achieved with a 1 inch vaseline gauze pack in the nasal cavity for 24 hours. Post-operatively, gentle suction of the nasal cavities was performed, patients were discharged after 48 hours and were reviewed at three weeks in the Out-patient department. Using photographs and direct measurements, an assessment of antrostomy size was made on each visit. Accurate measurement was often difficult on the first visit due to clot, crusting and discomfort in the nasal cavity. An accurate assessment was usually obtained on the second attendance. The patients were followed-up at regular and frequent intervals so that a serial record of antrostomy change was obtained. The use of Hegar dilators was unsuitable for many patients under local anaesthestia and post-operatively direct measurement was mainly confined to antero-posterior length. On each visit, symptoms were noted and at the end of the study a questionnaire completed to assess post-operative complications and overall clinical success. The results were assessed and the changes in antrostomies of differing sizes compared using an unpaired 't' test. The serial photographic records were measured using an Apple II graphics board and percentage change in area compared with percentage change in antero-posterior length. The term 'closure' is used throughout the text to refer to a diminution in length rather than as an absolute term.

Results (Figs. 7-10)

Sixty-five patients have been operated on between June 1983 and March 1985. There were 24 women and 41 men, their ages ranging from 11 to 73, with an average of 44 years and including four patients under 15 at the time of operation. The follow-up ranges from 25-104 weeks with an average of 58 weeks and 65% of patients were studied for one year or longer. Symptoms of obstruction, anosmia, sneezing, rhinorrhoea, post-nasal drip, epistaxis, facial pain and headache were discussed and the main complaint sought (Fig. 11). Obstruction, post-nasal drip and facial pain were the commonest symptoms and also the commonest main complaints. The length of history varied from four months to over 30 years with a mean of nine years. The patients were divided into acute recurrent sinusitis (37%), chronic with persistent symptoms (32%), and acute on chronic sinusitis (31%) with exacerbations in addition to persistent symptoms. Generalised loss of translucency and thickening of the antral mucous membrane was demonstrated in all cases radiologically. In the 18 who had had surgery 18 months to 20 years previously, the tissue from the edge of the antrostomy was sent for histology and was found to be primarily composed of fibrous tissue in nine and in nine a variable amount of bone was present. In ten cases the exact dimensions were known and antrostomies were refashioned to the same size in three, five were made larger and two were enlarged but were smaller than at the first operation. When the antrostomy

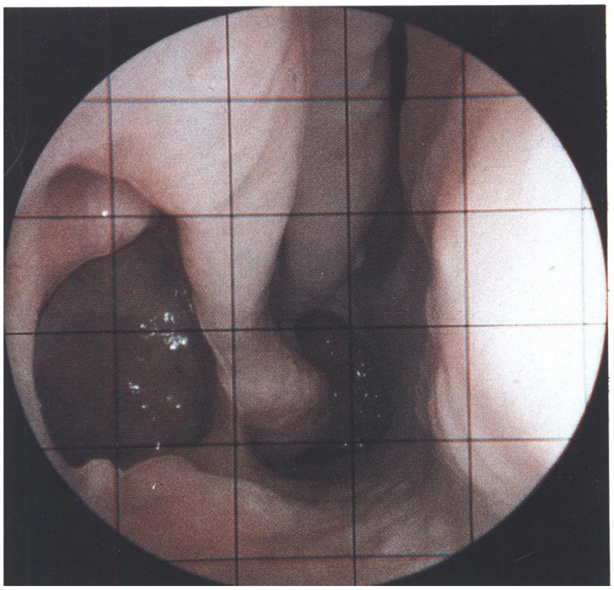

FIG. 7a

Photograph of R antrostomy in Patient A (initial size 2.0 × 1.0cms) showing appearances after initial % closure of 20% in 8 weeks.

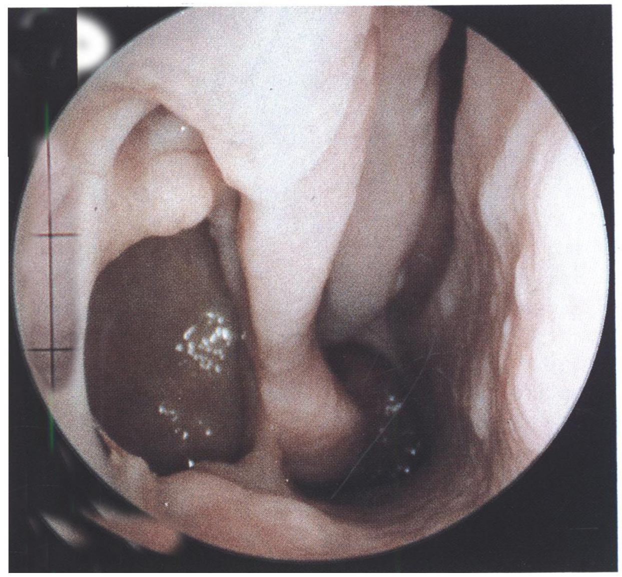

FIG. 7b

Photograph showing appearances after final % closure of 20% in 76 weeks.

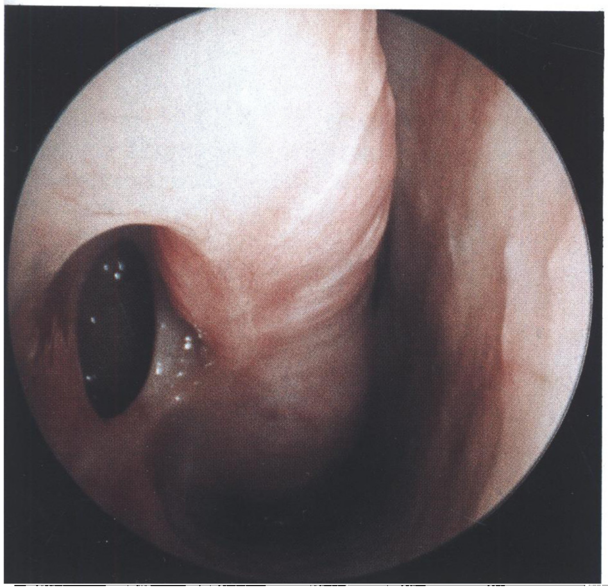

FIG. 8a

Photograph of R antrostomy in Patient B (initial size 2.0 × 1.0cms and initial % closure of 12.5% in 5 weeks) showing appearances after 37.5% closure at 21 weeks.

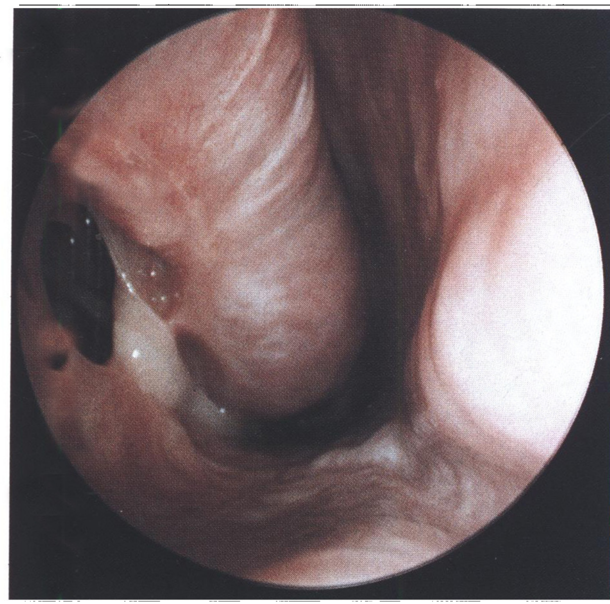

FIG. 8b

Photograph showing appearances after final % closure of 37.5% at 61 weeks with mucopurulent discharge pouring from antrostomy.

is made of the same dimensions, all parts of the edge showed fibrous tissue with areas of new bone formation (Fig. 12). The edges of the five enlarged antrostomies also showed a margin of fibrous tissue with small scattered areas of bone and normal meatal bone at the periphery and the two which were partially enlarged showed only fibrous tissue.

One hundred and one antrostomies of various sizes were fashioned; eleven at 2.75 cm, twenty-one at 2.5 cm, thirty-two at 2.0 cm, ten at 1.5 cm, twenty-two at 1.0 cm and five at 0.5 cm. The supero-inferior height was 1.0 cm in all cases except for the 0.5 cm group, which were also 0.5 cm in height. When the results are considered overall, it becomes apparent that an initial diminution in size occurs due to healing though an average of five weeks elapsed before an accurate measurement was possible (Table 1). The range of initial closure was 8-100% with an average of 27% and when converted demonstrates initial closure of a similar amount, in all groups (range 3.4–4.8 mm, average 4 mm). Examination of the serial photographs to determine direction of closure shows it to be circumferential. After initial healing 73% remained completely unchanged, including seven which had undergone 100% closure by the first out-patient attendance. Further gradual closure occurred in 16 antrostomies, rapid closure was observed in eleven. Rapid closure was associated with an obvious clinical infection (severe exacerbation of muco-purulent discharge) in 11 antrostomies and resulted in complete closure in six. Percentage closure for each group of different length was considered overall irrespective of follow-up and, if available, at one year follow-up (Table

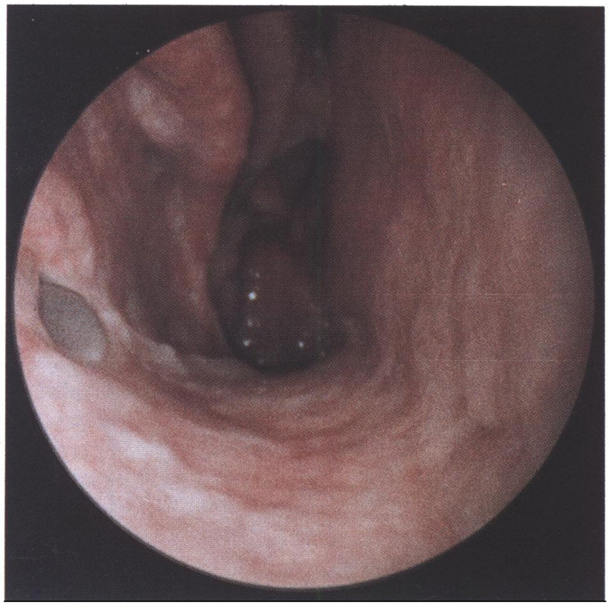

FIG. 9a

Photograph of L antrostomy in Patient C (initial size 1.0 × 1.0cms) showing appearances after initial % closure of 50% in 8 weeks.

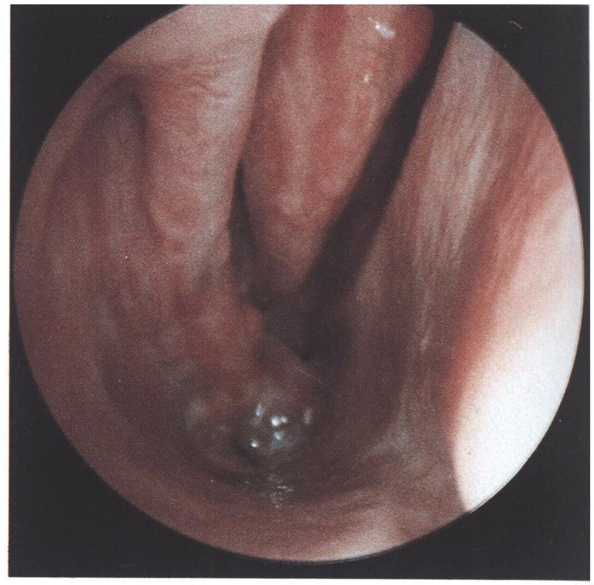

FIG. 9b

Photograph showing appearances after final % closure of 100% in 25 weeks.

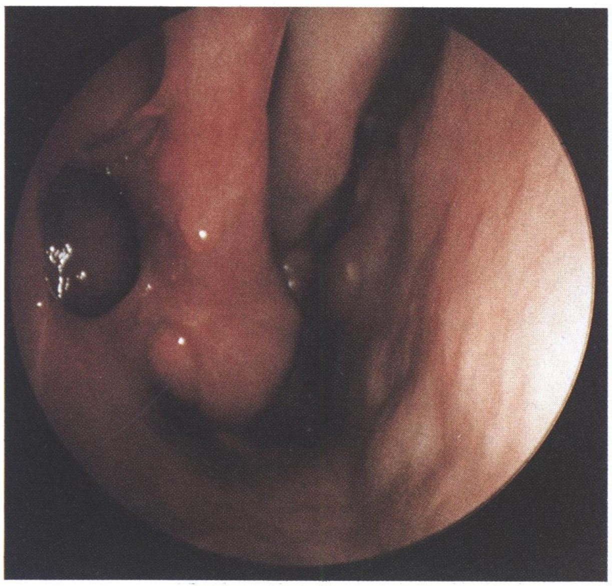

FIG. 10a

Photograph of R antrostomy in Patient D (initial size 2.0 × 1.0cms) showing appearances after initial % closure of 25% in 13 weeks.

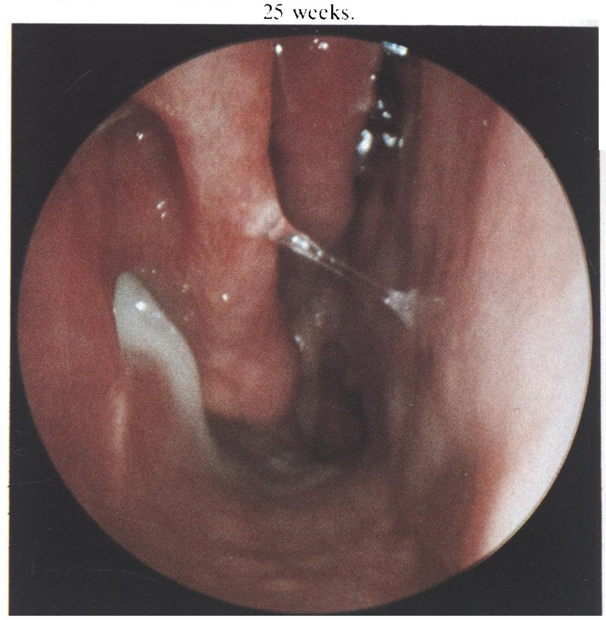

FIG. 10b

Photograph showing appearances after 62% closure at 37 weeks associated with infection.

I). The results for each group were compared and demonstrate a significant difference between the 1 cm group and the 2.0, 2.5 and 2.75 cm groups irrespective of time after operation (Table II). In those nine patients (13 antrostomies) with 90-100% closure during follow-up, there was one at 2.0 × 1.0 cm, one at 1.5 × 1.0 cm, six at 1.0 × 1.0 cm and five at 0.5 × 0.5 cm which represents 27% of 1.0 × 1.0 cm group and 100% of 0.5 × 0.5 cm. Three of the 1.0 × 1.0 cm patients were under 16 at the time of operation. With regard to clinical success, the majority of patients experienced an improvement in nasal obstruction, post-nasal drip, rhinorrhea, facial pain and headache (Fig.13). The improvement in post-nasal drip was less dramatic than for other symptoms with 25% claiming improvement, 23% no change and 19% a worsening of symptoms. In those nine patients whose antrostomies underwent rapid closure associated with infection, an exacerbation of symptoms was experienced at the time of infection. Otherwise, change in size of the antrostomy, particularly gradual closure, was not indicated clinically in the majority of patients.

Discussion

It has been possible in the prospective study to eliminate a number of variable factors which are intrinsic to a retrospective study. All the antrostomies have been performed by the same surgeon, employing an identical operative technique, post-operative management and serial assessment. All patients had experienced long-standing problems which may be loosely classified as 'sinusitis', either acute recurrent episodes or chronic persistent symptoms with or without more severe exac-

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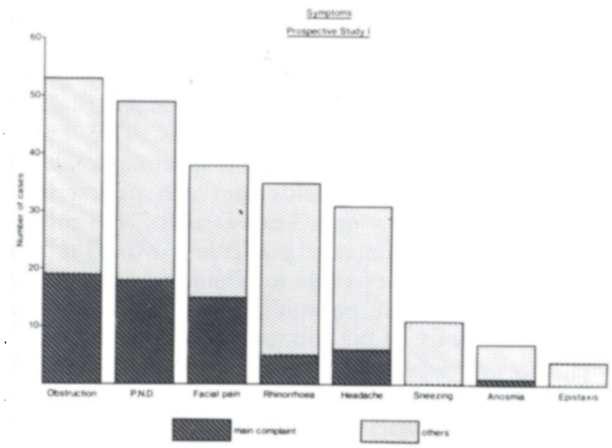

FIG. 11

Histogram showing symptoms of patients in prospective study I.

erbations. All patients had failed conservative management and in some cases repeated antral wash-out and previous antrostomies. Problems of examination prevented the first accurate assessment at the same time in all cases, but clearly an initial healing occurs within the first few weeks which is of the same order (0.4 cm) in all cases and is circumferential. The majority then remain unchanged unless infection supervenes when rapid closure may be observed. It is difficult to define the degree of infection which precipitates this change as many patients undergo cyclical symptomatic deterioration and improvement without any alteration in antrostomy appearance apart from the presence of muco-purulent discharge draining from the sinus. A number of antrostomies close more gradually, again usually associated with an increase in muco-purulent discharge but the change is always within the first year and none appeared to change within the subsequent follow-up period. The results demonstrate a significant difference between the 1.0 cm group and the greater lengths with the complete closures predominantly in the 1.0 cm and 0.5 cm groups. This suggests that if the long-term patency is desired, an antrostomy greater than 1.0 cm should be fashioned. It is not possible to draw conclusions about the effect of patient age on antrostomy closure as there were only four patients under 16 at the time of surgery on whom six antrostomies were performed, all 1.0 × 1.0 cm. All six underwent rapid closure but whilst closure might be a consequence of continued bony growth as suggested by the retrospective results, it might merely be a reflection of the initial size irrespective of age. Histological examination demonstrates the composition of the healing edge to be fibrous tissue with a variable amount of new bone formation. In the ten revision procedures where the original dimensions were known, new bone is seen in all cases revised to the same or larger size and these histological appearances do not seem to be related to time. Overall patients derived clinical benefit from the procedure though post-nasal discharge was least improved, reflecting the drainage of maxillary sinus secretions via the antrostomy and about which patients may complain bitterly.

Prospective clinical study: II

Goblet cells of the maxillary sinus mucosa in health and disease

Having established the degree and nature of closure of the inferior meatal antrostomy, it is appropriate to consider next the effect of the patent antrostomy upon the mucosa of the sinus. When the subjective clinical success

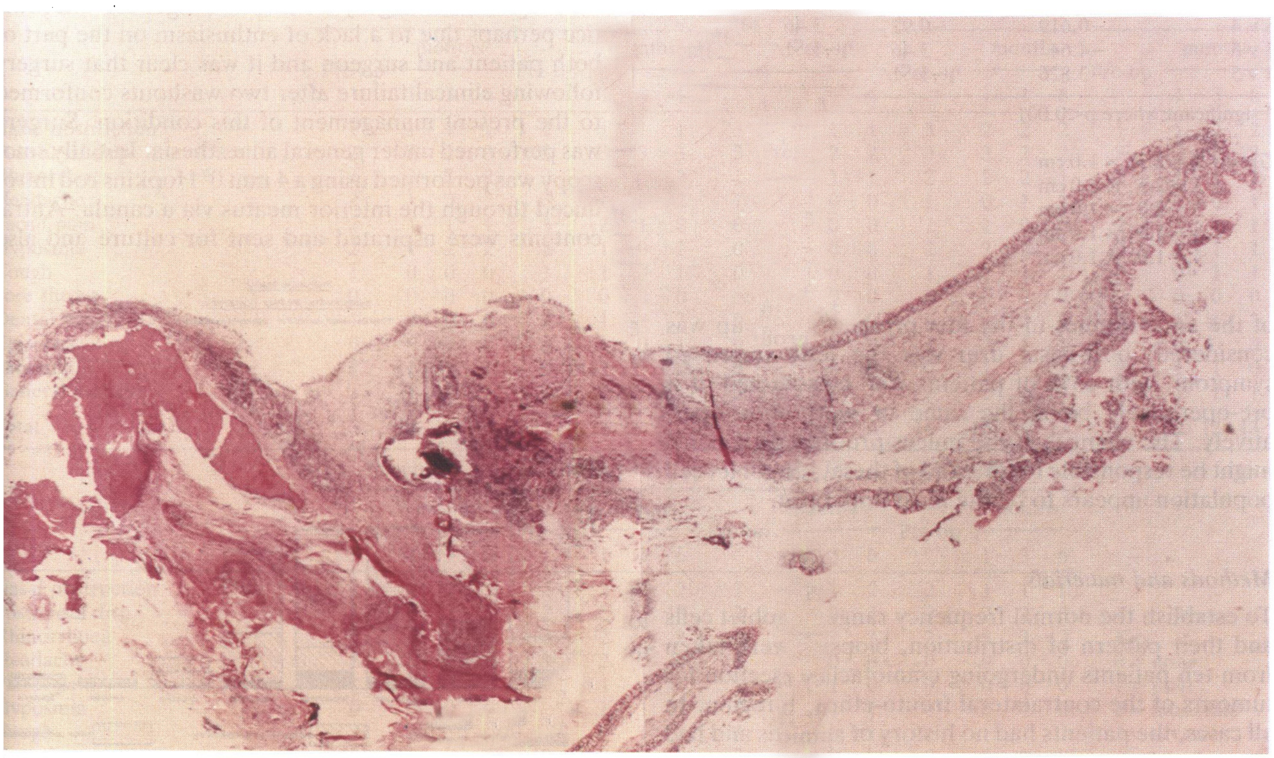

FIG. 12

Photomicrograph showing edge of antrostomy revised at 7 months. Fibrous tissue with bone at periphery at a distance of 0.45cms. (Haematoxylin and Eosin).

TABLE I

INITIAL % CLOSURE, FINAL % CLOSURE AND % CLOSURE AT ONE YEAR FOR GROUPS 1–6

Size	No	Mean	Standard deviation	Groups	% converted to mm
Initial % closure					
2.75 × 1.0	11	12.8	5.76	1	3.5
2.5 × 1.0	21	19.3	6.76	2	4.8
2.0 × 1.0	32	19.9	9.31	3	4.0
1.5 × 1.0	10	22.5	7.29	4	3.4
1.0 × 1.0	22	39.1	17.23	5	3.9
0.5 × 0.5	5	90		6	4.5
Final % closure					
2.75 × 1.0	11	24.9	20.9		
2.5 × 1.0	21	29.9	15.9		
2.0 × 1.0	32	28.0	17.98		
1.5 × 1.0	10	36.1	25.8		
1.0 × 1.0	22	51.4	27.9		
0.5 × 0.5	—	—	—		
% Closure at one year					
2.75 × 1.0	10	19.9	13.4		
2.5 × 1.0	19	28.9	15.8		
2.0 × 1.0	26	25.8	10.5		
1.5 × 1.0	7	32.9	13.0		
1.0 × 1.0	11	70.0	27.6		
0.5 × 0.5	—	—	—		

TABLE II

COMPARISON OF GROUPS 1–6 USING UNPAIRED t TEST

Group v Group	t Initial % closure	Sig	t Final % closure	Sig	t 1 Year % closure	Sig
1 v 2	−2.88	*	−0.69		−1.62	
1 v 3	−2.98	*	−0.44		−1.24	
1 v 4	−3.37	*	−1.08		−1.99	*
1 v 5	−6.48	*	−3.05	*	−5.37	*
2 v 3	−0.73		0.39		0.76	
2 v 4	−1.16		0.70		0.64	
2 v 5	−4.99	*	3.12	*	4.52	*
3 v 4	−0.619		−0.92		−1.33	
3 v 5	−4.64	*	3.46	*	5.17	*
4 v 5	−3.826	*	−1.51		−3.84	*

* significant where $p<0.001$

Group 1 = 2.75 × 1.0 cm
2 = 2.5 × 1.0 cm
3 = 2.0 × 1.0 cm
4 = 1.5 × 1.0 cm
5 = 1.0 × 1.0 cm

of the antrostomies in the first prospective group was considered, post-nasal drip was the least improved symptom, with 63% of patients who complained of it pre-operatively being the same or worse post-operatively. The changes in the mucus-producing elements might be responsible for this and of these, the goblet cell population appears to be the most important.

Methods and materials

To establish the normal frequency range of goblet cells and their pattern of distribution, biopsies were taken from ten patients undergoing craniofacial resection for tumours of the contralateral fronto-ethmoid region. In all cases, the patients had no history of sinusitis and had normal radiological appearances (sinus X-rays and CT scan) of the maxillary sinus. As part of the surgical procedure the lateral wall of the nose was removed exposing macroscopically normal mucosa which was biopsied with a Barts cupped forceps from four areas: floor, anterior, posterior and lateral walls.

The tissue was fixed and stained by a standard combined Alcian Blue- PAS technique (Cook 1974). Three sections were examined from each specimen and the goblet cells counted in five fields from each specimen at a magnification of 400× on a Leitz Dialux 22EB microscope. Using a superimposed graticule showing 1 mm in 100 divisions, it was possible to obtain a figure for the number of goblet cells per millimetre of epithelium by taking the average of the counts for each specimen.

Having established the range of normality, 19 patients were examined using a similar technique. Their inclusion criteria was strict. Only patients with a history of maxillary sinusitis who had failed two courses of conservative medication and two antral washouts were included in the study. The length of history exceeded three months, ranging from 4-20 months, and abnormal radiological appearances of the maxillary sinus were present in all cases. None had undergone previous surgery other than the washouts, all were negative to routine skin testing and all had normal naso-mucociliary clearance (NMCC) as judged by saccharine testings (Mackay, *et al.* 1983). A careful assessment of symptomatology was made with regard to nasal obstruction, post-nasal drip, rhinorrhoea, headache, facial pain, hyposmia, cough, sore throat and dental pain, epistaxis, sneezing and general malaise. Each symptom was scored on a 0-3 point scale (none, mild, moderate, severe) and particular attention was paid to post-nasal drip and rhinorrhea. A symptom score was derived for each patient at operation and for each subsequent visit (Table III).

In the past multiple antral washouts would have been performed to eradicate purulent secretions before considering further surgery. This is no longer current practice perhaps due to a lack of enthusiasm on the part of both patient and surgeon and it was clear that surgery following clinical failure after two washouts conformed to the present management of this condition. Surgery was performed under general anaesthesia. Initially sinoscopy was performed using a 4 mm 0° Hopkins rod introduced through the inferior meatus via a canula. Antral contents were aspirated and sent for culture and also

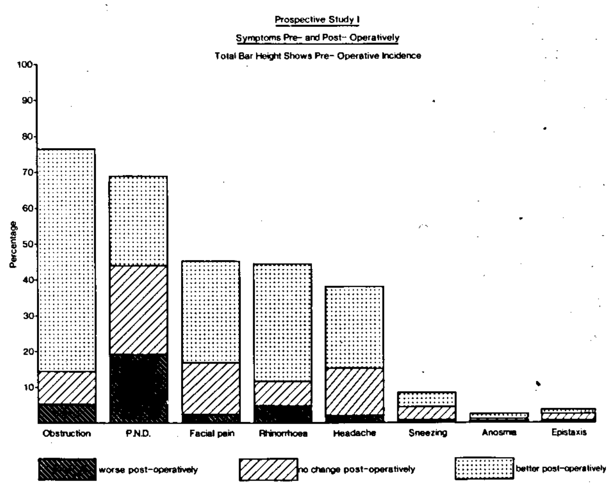

FIG. 13

Histogram showing symptoms pre- and post-operatively in prospective study I.

TABLE III

SYMPTOM SCORES FOR EACH PATIENT IN PROSPECTIVE CLINICAL STUDY: II

Symptom Scores

	Patient 1				Patient 2				Patient 3				Patient 4				Patient 5			
	Pre-op	months			Pre-op	months			Pre-op	months			Pre-op	months			Pre-op	months		
		1	3	6		1	3	6		1	3	6		1	3	6		1	3	6
Nasal obstruction	2	2	2	2	2	2	1	1	1	1	0	0	1	0	0	0	2	1	1	0
Post-nasal drip	2	2	1	1	2	1	1	1	2	2	1	1	2	2	1	0	1	1	1	0
Rhinorrhoea	2	1	0	0	1	1	0	0	1	2	1	1	0	0	1	0	2	1	1	0
Headache	1	0	0	0	1	1	0	1	2	2	1	0	1	0	0	0	1	1	0	0
Facial pain	2	1	1	1	1	1	0	0	2	2	0	0	0	0	0	0	1	0	0	0
Hyposmia	0	0	0	0	1	0	0	0	0	1	0	0	1	1	1	1	1	0	1	0
Cough	1	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0
Sore throat	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Dental pain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epistaxis	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0
Sneezing	1	1	1	1	0	0	0	0	1	1	1	1	1	1	0	1	1	0	0	0
General malaise	1	1	0	0	2	1	0	0	1	1	0	0	1	0	0	0	2	1	0	0
Total	12	8	5	5	12	8	2	3	12	14	4	4	9	4	3	2	11	5	4	0

	Patient 6				Patient 7				Patient 8				Patient 9				Patient 10			
	Pre-op	months			Pre-op	months			Pre-op	months			Pre-op	months			Pre-op	months		
		1	3	6		1	3	6		1	3	6		1	3	6		1	3	6
Nasal obstruction	2	1	0	1	2	1	1	1	2	1	1	0	2	1	1	1	2	0	0	1
Post-nasal drip	2	1	2	2	3	2	2	2	3	2	2	3	2	1	1	1	2	2	1	1
Rhinorrhoea	2	1	2	2	2	1	2	1	1	1	1	1	0	2	0	1	2	2	1	1
Headache	2	2	2	2	2	1	1	1	2	1	0	1	2	1	1	0	1	1	0	0
Facial pain	1	1	1	1	2	1	0	0	1	0	0	0	2	1	0	0	2	0	0	0
Hyposmia	0	0	0	0	2	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Cough	1	1	1	1	1	0	0	0	1	0	1	1	1	1	0	0	1	0	0	0
Sore throat	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dental pain	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epistaxis	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
Sneezing	0	0	0	0	2	1	2	1	1	0	0	0	1	0	0	0	0	1	1	0
General malaise	2	2	1	2	2	2	1	1	1	1	1	1	1	1	0	0	1	1	0	0
Total	14	11	12	12	19	10	10	8	13	7	7	7	11	9	3	3	11	8	3	3

	Patient 11				Patient 12				Patient 13				Patient 14				Patient 15			
	Pre-op	months			Pre-op	months			Pre-op	months			Pre-op	months			Pre-op	months		
		1	3	6		1	3	6		1	3	6		1	3	6		1	3	6
Nasal obstruction	1	1	1	1	2	1	1	1	3	2	1	1	3	2	2	2	1	1	2	2
Post-nasal drip	2	2	2	3	3	3	3	3	3	3	2	2	3	3	3	2	3	2	3	3
Rhinorrhoea	3	2	2	2	3	3	2	2	1	0	1	1	2	2	2	1	2	1	1	1
Headache	2	1	2	2	3	2	2	2	1	1	0	0	1	0	1	1	1	1	0	1
Facial pain	2	1	1	1	3	2	1	2	0	0	0	0	1	1	0	0	2	3	1	1
Hyposmia	2	1	2	2	2	1	0	2	0	0	0	0	2	2	2	2	2	1	1	1
Cough	1	0	0	0	1	1	0	1	0	0	0	0	1	1	1	1	0	0	1	1
Sore throat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dental pain	1	0	0	0	2	1	2	2	0	0	0	0	0	0	0	0	2	1	1	2
Epistaxis	0	0	0	0	0	1	0	1	0	1	0	0	1	2	1	1	0	0	0	0
Sneezing	1	1	1	1	0	1	0	0	0	0	0	0	0	1	1	1	0	1	1	0
General malaise	2	1	1	1	2	1	2	1	3	2	2	2	2	2	1	2	1	1	1	1
Total	17	10	12	13	21	17	13	17	11	9	6	6	16	16	14	13	14	12	12	13

	Patient 16				Patient 17				Patient 18				Patient 19			
	Pre-op	months			Pre-op	months			Pre-op	months			Pre-op	months		
		1	3	6		1	3	6		1	3	6		1	3	6
Nasal obstruction	2	0	1	1	2	2	2	2	2	2	1	2	2	1	1	1
Post-nasal drip	3	3	3	3	2	2	3	3	2	2	2	2	3	2	2	3
Rhinorrhoea	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3
Headache	2	2	1	0	1	2	0	0	0	0	0	0	0	0	0	0
Facial pain	1	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0
Hyposmia	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
Cough	2	2	2	2	1	0	1	1	1	0	0	1	1	1	1	1
Sore throat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dental pain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epistaxis	0	0	0	0	0	1	0	0	0	0	1	0	1	1	1	1
Sneezing	0	1	0	0	1	0	1	0	1	2	1	2	2	2	2	2
General malaise	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1
Total	13	11	10	9	12	12	10	10	11	10	10	11	12	10	10	12

Key:
0 = none
1 = mild
2 = moderate
3 = severe

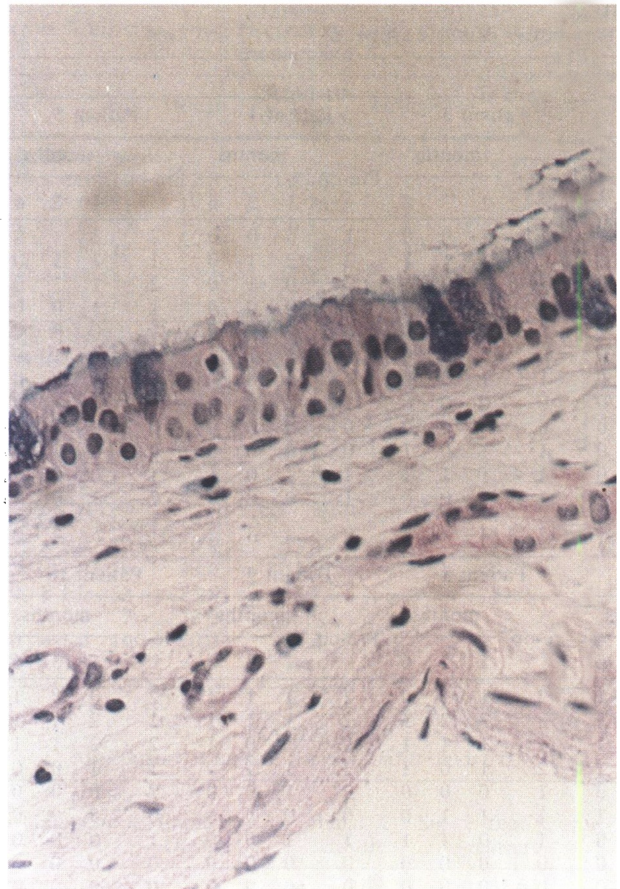

Fig. 14
Photomicrograph showing maxillary sinus mucosa with normal number of goblet cells (PAS/Alcian Blue).

smeared on a glass slide to be stained for the presence of mucus. Biopsies were taken with rigid and flexible optical biopsy forceps and 2.7 mm 0° Hopkins rod from the mid-region of the posterior antral wall, floor, lateral and anterior walls and subsequently processed by the standard Alcian Blue-PAS technique. An inferior meatal antrostomy was made using the same surgical technique described in the first prospective study, and based on this study each one was made 2 cm × 1 cm, which would probably remain patent during follow-up. The inferior turbinate was displaced during the procedure and repositioned at the end.

The patients were seen at regular intervals on an Out-patient basis and biopsies taken from the antrum at one, three and six months post-operatively. The biopsies were taken using the 2.7 mm 0° Hopkins rod and rigid optical biopsy forceps through the inferior meatal antrostomy from the posterior antral wall under local anaesthetic.

Each biopsy, weighing approximately 1mg, was examined for goblet cells, taking an average of five fields from three sections of each specimen. Morphological changes in the cells were noted. At each examination, a careful clinical history was obtained using the same assessment of symptoms as pre-operatively. The number of goblet cells/mm were divided into three groups: (Figs.14-16)

normal	:	<75/mm
moderately increased	:	75-125/mm
severely increased	:	>125/mm

The patients were grouped according to initial goblet cell count and subsequent outcome and the average overall symptom score for the patients in each of these groups was examined during follow-up. The summated

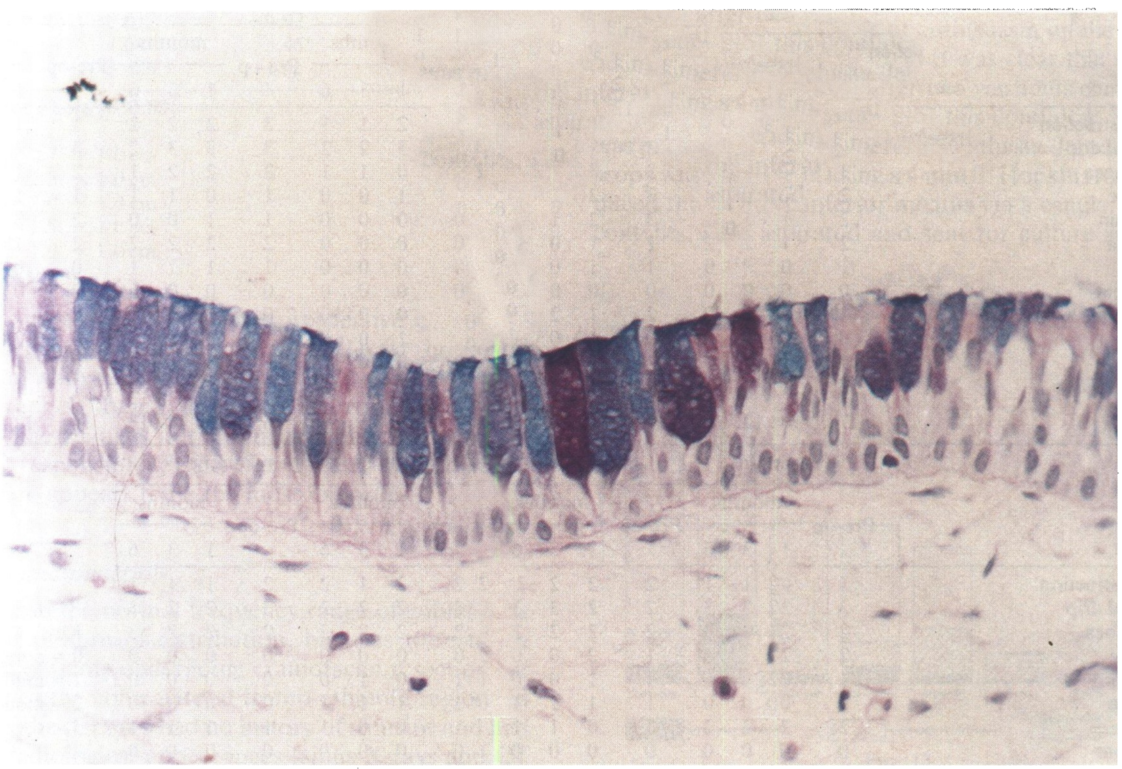

Fig. 15
Photomicrograph showing maxillary sinus mucosa with moderate increase in goblet cells (PAS/Alcian Blue).

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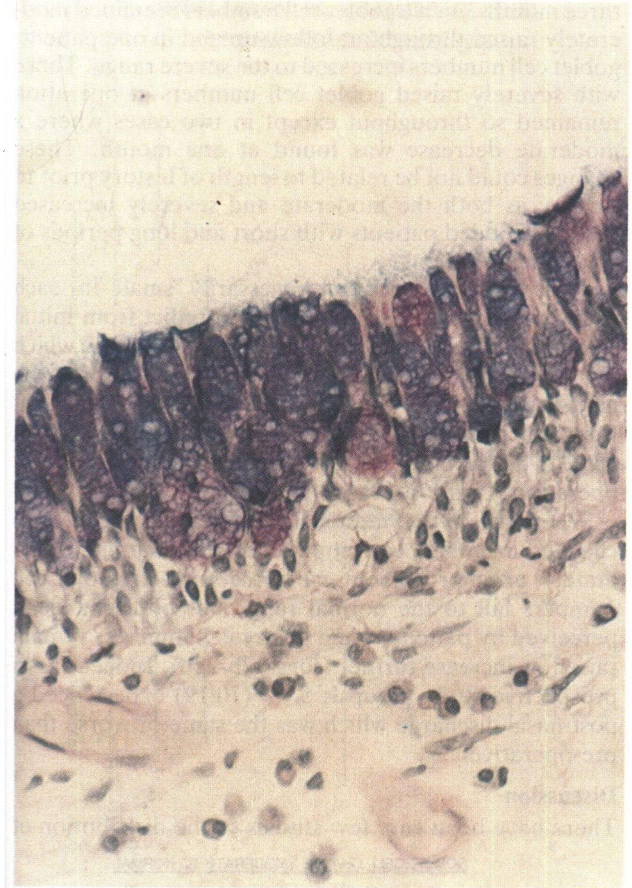

FIG. 16

Photomicrograph showing maxillary sinus mucosa with severe increase in goblet cells (PAS/Alcian Blue).

TABLE IV

MICROBIOLOGICAL CULTURE FROM ANTRA IN PROSPECTIVE CLINICAL STUDY: II

Micro-organisms	No of pts
Haemophilus influenzae	4
Staphylococcus aureus	3
Klebsiella pneumoniae	2
Escherichia coli	2
Gram +ve cocci	2
Steptoccoccus pyogenes	1
Streptococcus pneumoniae	1
Few pus cells—no growth	4
	19

TABLE V

AVERAGE GOBLET CELL COUNTS/MM FOR PATIENTS IN PROSPECTIVE CLINICAL STUDY: II

	Sex	Age	Length of history	Pre-operative		Follow-up					
						1 month		3 months		6 months	
1	f	41	18 months	95	M	90	M	60	N	55	N
2	f	48	4 months	80	M	72	M	72	M	55	N
3*	m	54	20 months	125	M	90	M	65	N	50	N
4	f	45	20 months	98	M	85	M	55	N	53	N
5	m	27	13 months	116	M	119	M	60	N	55	N
6	f	30	6 months	99	M	110	M	100	M	105	M
7*	m	66	20 months	110	M	80	M	85	M	98	M
8	m	36	9 months	85	M	90	M	82	M	110	M
9	f	48	20 months	90	M	105	M	72	M	100	M
10	m	26	6 months	98	M	115	M	100	M	90	M
11	m	54	18 months	72	M	105	M	95	M	>125	S
12	m	66	18 months	>125	S	>125	S	>125	S	>125	S
13	m	19	12 months	130	S	132	S	>125	S	>125	S
14	f	52	6 months	>125	S	>125	S	135	S	132	S
15	m	40	10 months	>125	S	>125	S	>125	S	>125	S
16*	m	67	18 months	>125	S	>125	S	145	S	135	S
17	m	35	6 months	>125	S	>125	S	>125	S	>125	S
18*	f	38	6 months	>125	S	125	M	125	M	82	M
19	m	26	8 months	135	S	125	M	113	M	108	M

* Illustrated

Key: N = normal; M = moderate; S = severe

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average scores for post-nasal drip and rhinorrhoea were examined in a similar way.

Results

The examination of the biopsy material from the 'normal' subjects demonstrated a range of goblet cell numbers of 35-70/mm. Although there was some small individual variation between the different walls of the maxillary sinus, these were not significant.

In the clinical study, there were twelve men and seven women, their ages ranging from 19-66 years (average 43 years). Results of culture of antral contents is shown in Table IV. Mucus was present in all cases, even when only a few pus cells were found without an identifiable organism.

When the goblet cell population is considered, 11 patients had a moderate increase in goblet cell density at the time of operation and eight had severely increased numbers of goblet cells (Table V). Comparisons of results from the four sites within the sinus showed the same degree of change in all areas. This, together with the results from 'normal' subjects supported the decision based on practical considerations that biopsies could be taken from one wall over a period of time and would be representative of general changes occurring in the goblet cell population of the maxillary sinus mucosa.

During subsequent follow-up, five cases changed from moderate to within the normal range at between one and three months, in five goblet cell numbers remained moderately raised throughout follow-up and in one patient, goblet cell numbers increased to the severe range. Those with severely raised goblet cell numbers at operation remained so throughout except in two cases where a moderate decrease was found at one month. These changes could not be related to length of history prior to surgery as both the moderate and severely increased groups included patients with short and long periods of preceding problems.

Although numbers are necessarily small in each group, it does not seem possible to predict from initial symptomatology the degree of goblet cell increase which has occurred (Tables III and V). Furthermore, the majority of patients (16/19:84%) derived overall benefit from the procedure, though this was least marked in those with severely increased goblet cell numbers at operation (Figs.17a-22a).

When the two symptoms most directly related to changes in goblet cell population are examined separately, an improvement can be seen when goblet cell numbers fall to the normal range but little change is perceived by patients when goblet cell numbers remain raised or increase further (Figs.17b-22b). Indeed, as in prospective study group I, 53% (10/19) experienced a post-nasal discharge which was the same or worse than pre-operatively.

Discussion

There have been very few studies of the distribution of

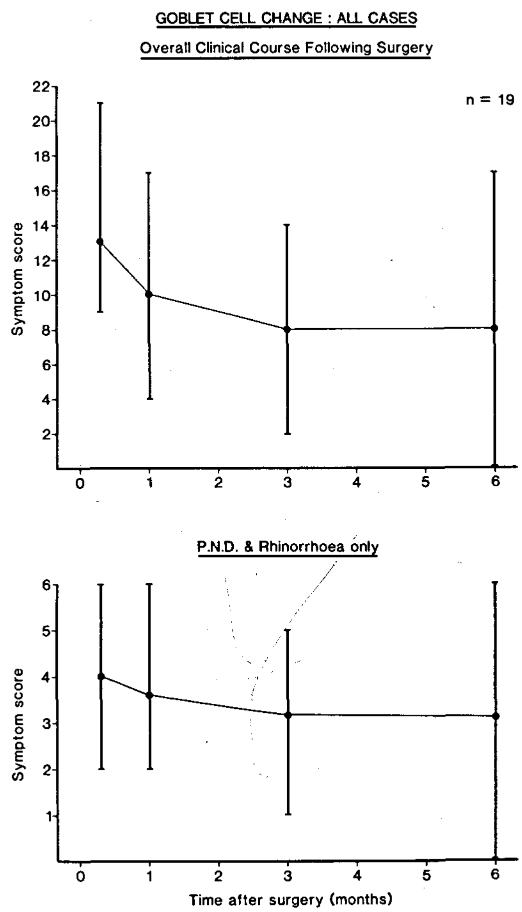

FIG. 17

Goblet cell count in all patients: graph showing change in overall symptom score (a) and mucus discharge symptom score (b).

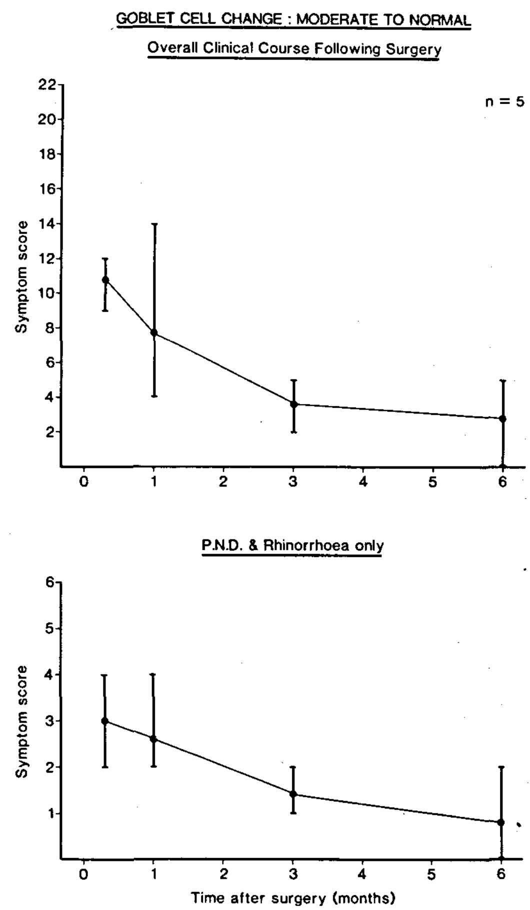

FIG. 18

Goblet cell count falls from moderate to normal range: graph shows change in overall symptom score (a) and mucus discharge symptom score (b).

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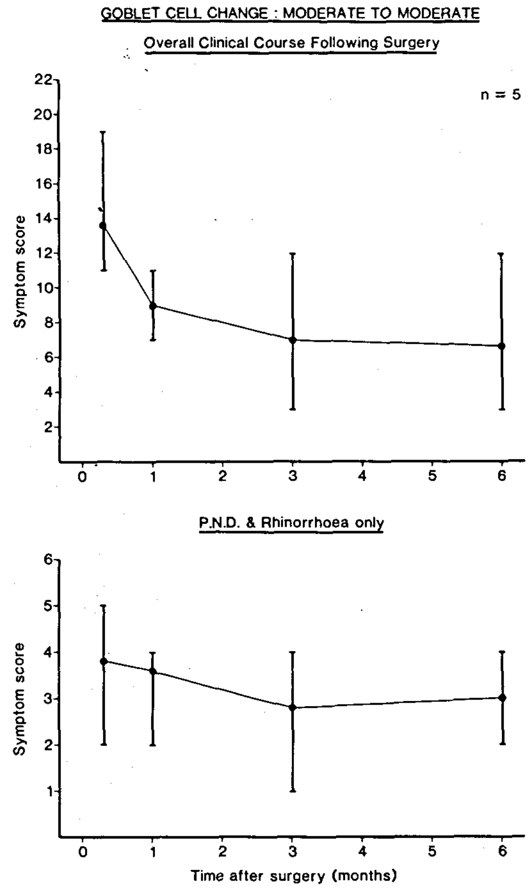

FIG. 19

Goblet cell count remains moderately increased: graph shows change in overall symptom score (a) and mucus discharge symptom score (b).

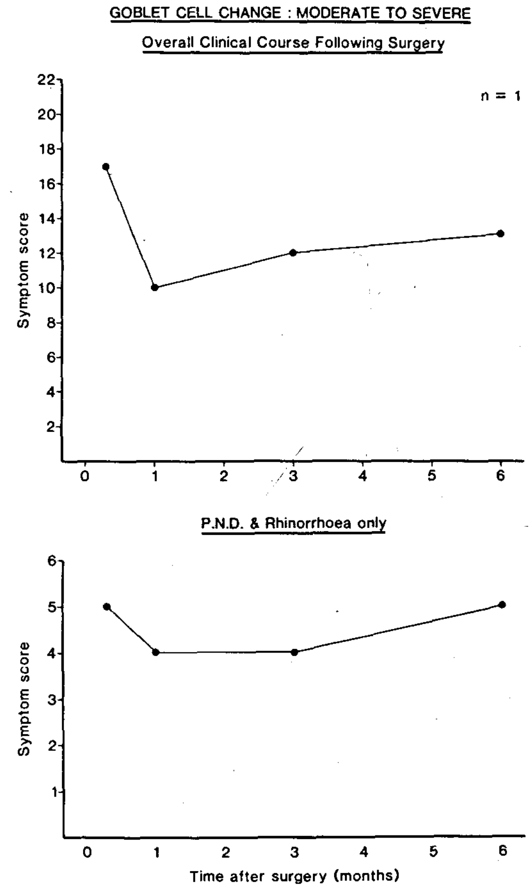

FIG. 20

Goblet cell count increased from moderate to severe range: graph shows change in overall symptom score (a) and mucus discharge symptom score (b).

goblet cells within the nose and paranasal sinuses. Work by Poulsen and Tos (1980) suggests that the appearance of the goblet cell is the final link in the process of differentiation of the respiratory epithelium in the embryo occurring after the tenth week of fetal life. Using a whole-mount method of dissection and Alcian Blue-PAS staining from cadavers, Tos and Mogensen (1979) have examined the mucus-secreting elements in the nose and sinuses in adults in some detail. None of the sinuses showed significant differences in inter individual median density between various walls or parts though the individual median density, based upon all counts from a patient exhibited a relatively wide range. The goblet cell density was highest in the maxillary sinus, their results being expressed as cells/mm^2 (median value 9700/mm^2). These compare with the results obtained in my series of normals when extrapolating from the 5μ thick sections.

There was no glandular layer in the greater part of the sinus mucosa, the few tubulo-alveolar sero-mucinous glands being scattered singly in the mucosa which had large areas entirely devoid of glands. Tos and Mogensen concluded that mucus production by the glands is negligible in relation to that by goblet cells. The paucity of glandular elements was confirmed by my own investigations.

It has been suggested that the density of goblet cells is highest in areas with little or no air currents (Hilding 1932) which is supported to a large extent by the Danish studies. In comparison with the nasal mucosa, the sinuses contain fewer mucous glands and somewhat more goblet cells. The greater density of mucous elements in the nose, however, is substantially greater than in the sinuses which is connected with greater mucin production as physiologically requisite.

As there is little or no air current in the nasal sinuses, there is little need for protection of the mucous membrane by such large amounts of mucus. This protection is adequately provided by the goblet cell secretion which is involved in mucociliary clearance. To avoid any possible effects of altered airflow in the sinuses resulting from trimming the inferior turbinates, in this study the turbinate was displaced during the procedure and repositioned at the end.

Acute inflammation and infection has been shown both experimentally and clinically to produce goblet cell hypertrophy and hyperplasia in the respiratory tract (Van Alyea, 1951; Messerklinger, 1958; Terrahe, 1970; Ellefsen and Tos, 1973; Jones *et al.*, 1975; Nielsen and Bak Pedersen, 1984). In all patients examined there was a moderate to severe increase in goblet cell numbers at initial biopsy consistent with inflammation and infection. Ventilation and drainage are considered the important functions of the antrostomy. If Hilding and later workers are correct, the introduction of air currents into the sinus alone would account for a decrease in goblet cell density. In the initial post-operative period, gravitational drainage also occurs irrespective of whether normal mucociliary pathways still operate.

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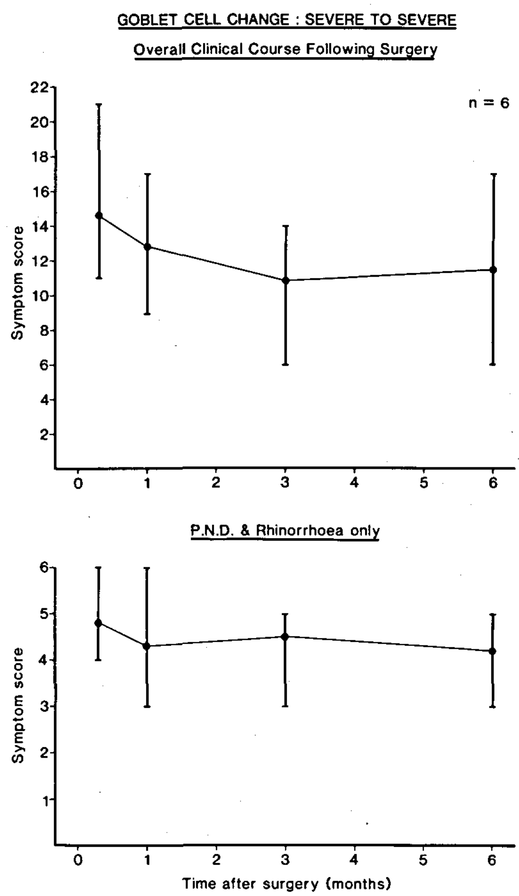

FIG. 21

Goblet cell count remains severely increased: graph shows change in overall symptom score (a) and mucus discharge symptom score (b).

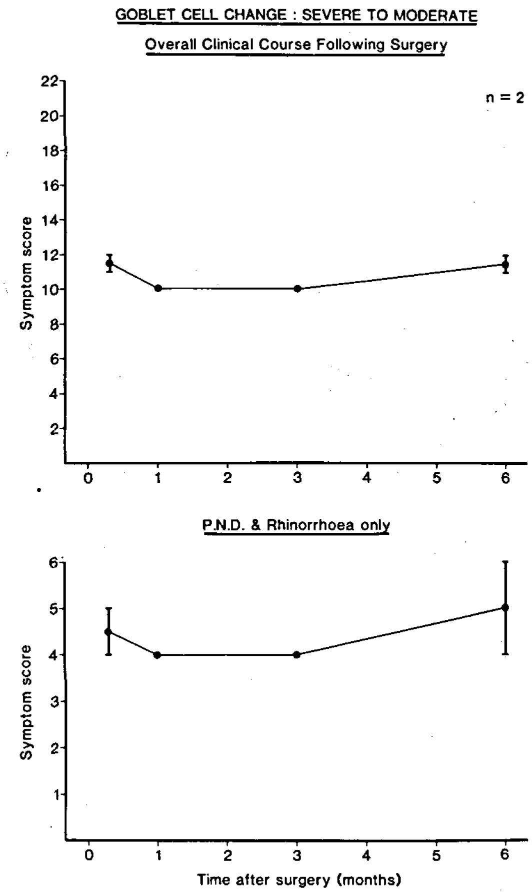

FIG. 22

Goblet cell count decreases from severe to moderate range: graph shows change in overall symptom score (a) and mucus discharge symptom score (b).

Because of the possibility of variation in goblet cell numbers, results are expressed as trends of change between normal, moderate and severe which can be more readily compared with changes in symptomatology rather than reliance on absolute figures. It would seem that the pre-operative finding of severely increased numbers of goblet cells suggests generally irreversible disease associated with persistent or increased secretion usually experienced as post-nasal discharge and even a decrease to moderate numbers is rarely perceived clinically.

In those patients with moderate increase in goblet cell population, there is the possibility of a return to normal with a concomitant improvement in symptoms though this improvement cannot be guaranteed and there may even be a further increase in goblet cells potentially associated with an exacerbation of symptoms.

Differences in size of goblet cells may reflect the different phases in the cycle of mucin synthesis and release but in the severe cases, the epithelium appeared to be primarily composed of large deeply-staining goblet cells showing both hypertrophy and hyperplasia. These results suggest that in patients whose mucosa shows this sort of change, the inferior meatal antrostomy would be of questionable value. It is much more likely to be successful in cases showing moderate changes, and this information could be obtained by biopsy performed during Out-patient sinoscopy.

Conclusions

The dimensions of the inferior meatus in children and adults, determine the limitations on the size of the antrostomy. Whilst it would be possible to achieve a height of 1 cm within the meatus of most children, the maximum length is limited by the turbinate attachment, particularly in younger children. In addition to the attachment of the inferior turbinate superiorly, changes in bone thickness inferiorly, anteriorly and posteriorly and the position of the inferior meatal artery impose definite technical restrictions. Development of the sinus, ultimately resulting in discrepancy between the floor of nose and the floor of the maxillary sinus inevitably compromises any attempt to achieve an inferior margin flush with the floor of the nose.

In answer to the question of whether antrostomies close or not and how this relates to operative size, after initial circumferential healing within the first few weeks, the majority of antrostomies remain unchanged unless infection supervenes when complete closure may result. It is apparent that there is a critical size (1 cm × 1 cm) below which complete spontaneous closure can be anticipated. If too large an antrostomy is fashioned, related anatomy is jeopardised and in practice, size will be related to exposure and individual local factors. The surgeon must judge the dimensions carefully if long-term patency is desired, making the hole neither too small nor too large.

With regard to the effect of the age of the patient, whilst speed and degree of closure probably differ in adults and children as suggested by the retrospective study and to a lesser extent by the prospective work, it is not possible to determine whether this is due to continued maxillary growth or simply a consequence of the initial size which was 1 cm × 1 cm or less in children.

In answer to the question how do antrostomies close, direct and photographic observation demonstrates this to be circumferential and shows that new bone formation probably occurs in the majority of patients within the fibrous tissue both contiguous with the bony margin and scattered amongst the fibrous tissue. It has not been possible, however, to determine at what point this occurs post-operatively.

To examine the effects of the patent inferior meatal antrostomy on the mucus-secreting elements which in the sinuses is principally the goblet cells, a series of normals was needed for both numbers and distribution of goblet cells within the maxillary sinus. The strict inclusion criteria and the desire for at least 6 months follow-up limited the number of patients but nevertheless, definite trends emerged demonstrating the importance of determining the degree of change in the goblet cell population in relation to clinical success. It is apparent that length of preceding history and degree of symptomatology cannot be used to predict the degree of goblet cell increase. However, whilst the majority of patients derived overall benefit from the procedure, this was least marked in those with severely increased goblet cell numbers and in particular symptoms of mucus discharge persisted or increased in this group.

Is long-term patency important to clinical success? Information from both prospective groups suggests that overall, patients derived benefit from the procedure irrespective of degree of closure. However troublesome secretion was the commonest symptom to persist or increase and drainage through the patent antrostomy can be readily demonstrated and explained by changes in the mucus-secreting elements in the sinus mucosa. It is therefore not so much the long-term patency of the antrostomy which is important but the degree of damage which has occurred within the sinus.

The purpose of the inferior meatal antrostomy is presumed to be a combination of aeration and gravitational drainage which facilitates a return to normal of damaged mucous membrane. To determine the precise role of the operation in maxillary sinusitis, it will be necessary to determine the degree of that damage. The change in goblet cell population can be readily established by preoperative sinoscopy and biopsy, performed under local anaesthesia in the Out-patient department.

Normal mucociliary patterns are disturbed by changes in secretion viscosity and evidence is emerging that certain organisms such as Haemophilus influenzae are capable of producing toxins which specifically immobilise cilia (Wilson *et al.*, 1986). Certainly many antrostomies can be shown draining mucopus, presumably by gravity, where these paths are grossly disturbed. The whole area of mucociliary transport within the sinus requires further investigation and this is particularly important at a time when enthusiasm in Europe and America is increasing for middle meatal surgery under fibre-optic control. Thus, the appropriate moment for surgical intervention and the nature and degree of that surgery might be determined based on a better understanding of the pathophysiology of the condition and the surgical options available.

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