The Sheffield Nasal Pressure Probe: The development of a new device to measure intranasal pain thresholds*

J. W. Fairley¹, M. P. J. Yardley¹, L. H. Durham¹, J. Stevens²

 ¹ Department of Otolaryngology, Royal Hallamshire Hospital, Sheffield, United Kingdom
² Department of Medical Physics and Clinical Engineering, Royal Hallamshire Hospital, Sheffield, United Kingdom

SUMMARY

We present the development of a mechanical pressure probe which was constructed from items readily available to most university departments. The device is simple to operate and gives repeatable determinations. Its main use has been to measure the pressure thresholds for pain in the nasal mucosa.

Key words: nasal pressure, pain objectivation, intranasal pain, headache

INTRODUCTION

Sluder (1920) put forward the concept of mucosal contact pressure zones, particularly involving the middle turbinates and septum, as one cause of headache. Further experimental work by Wolff in the 1940s confirmed the somatotopic surface projections of pain resulting from pressure and electrical stimuli applied within the nasal fossa and sinuses (Stevenson, 1987). More recently, nasal endoscopists have re-affirmed the importance of nasal mucosal contact pressure zones as a cause of facial pain and headache (Stammberger and Wolf, 1988). We were interested in measuring the pressure required to produce pain at various specific anatomical sites in the nose. To achieve this we developed and built the Sheffield Nasal Pressure Probe.

MATERIAL AND METHODS

We needed to develop a probe that could be precisely placed within the narrow nasal cavities and apply increasing pressure to the nasal mucosa to allow us to accurately measure nasal pain thresholds.

At first we studied the use of a small angioplasty balloon catheter fixed to a mercury manometer. This proved unsuitable for several reasons; firstly, the balloon needed very high inflation pressures and it proved difficult to easily convert intraluminal pressures to the external pressures exerted on the nasal mucosa. Secondly, it was difficult to judge the exact contact area the balloon made with the nasal mucosa and as the balloon was inflated it impinged on several areas within the nasal cavity all of which could be responsible for producing the painful sensation. In view of these difficulties the balloon was abandoned and a spring-loaded applicator was designed and built (Figure 1), the overall dimensions being $19 \times 5.5 \times 1.2$ cm.

The probe handle is fashioned from perspex, one end of which is expanded with gradations marked linearly along an arch described by the stainless steel shaft, and thus acts as an accurate scale (Figure 1). The stainless steel shaft (12-gauge stainless steel hypodermic tubing; Coopers Needle Works, Birmingham, U.K.) pivots on a fulcrum incorporated into the opposite end of the handle to the scale, and protrudes for about 4 cm from the handle. This allows easy, accurate access to the nasal cavities. The movement of the stainless steel shaft is resisted by a spring also incorporated into the handle. Interchangeable plastic probe tips formed from Delrin (extruded acetal polyoxymethylene rod; Amari Plastics plc., Leeds, U.K.) are mounted onto the stainless steel shaft with the probe tip head being at 90° to the shaft. The surface area of the probe head varies from tip to tip. The dimensions and design of this probe allow accurate placement within the nasal cavity with easy operation and recording of the probe tip deflection.

Pressure is calculated by dividing the force necessary to produce a specific deflection of the lever by the surface area of the probe head. The device was calibrated by suspending a series of weights from the probe tip and noting the deflection of the meter (which could be read to within plus or minus half a division).

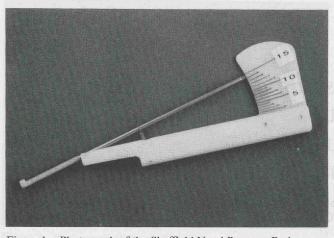


Figure 1. Photograph of the Sheffield Nasal Pressure Probe.

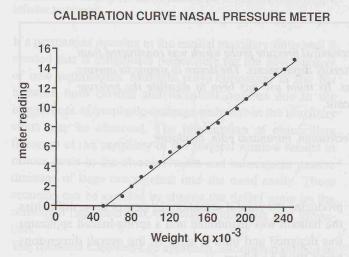


Figure 2. Calibration curve for the Sheffield Nasal Pressure Probe.

The matrice wells if your 15. The standard trail and a start (13-starts anotes their hypotenus minut; Choper begale Works firminitian; (1A.) profil and the matricentes and the opticale start of the builderto the set in and produces for their 4 or firm the builderto the set allows have accurate near to the mast ensure. The mose are at of the steplates start shall is misted by a spring the invert of the steplates start shall is misted by a spring the provident of the steplates start shall is misted by a spring the invert and the rest head shall is misted by a spring the invert and the mister is and shall is mistered by a spring the provident of the steplates start shall be mistered by a spring the start. The mister is the first of the provident of the minimer start is an inverse of the provident of the start provident of the mast of the provident of the bill of the theory of the matrix of the provident of the the start. The mister matrix and the provident of the bill of the theory of the matrix and the provident of the bill of the theory of the matrix and the provident of the bill of the theory of the matrix and the provident of the bill of the theory of the matrix and the provident of the bill of the theory of the matrix and the provident of the bill of the steplates in the matrix of the provident of the bill of the theory of the matrix and the provident of the bill of the steplates in the the matrix of the provident of the bill of the steplates in the matrix of the provident of the bill of the steplates in the the matrix of the provident of the bill of the steplates in the the steplates of the provident of the bill of the steplates in the matrix of the provident of the bill of the steplates in the the matrix of the provident of the bill of the steplates of the provident of the provident of the bill of the steplates in the bill of the steplates of the provident of the provident of the bill of the steplates of the steplates of the provident of the provident of the bill of the steplates of the provident of the pro

Preventer to called list by dividing the force processory to weakers a pecific deflection of the term by the surface area of the frohe heal. The deflect was calibrated by suspending a series of weights from the probe to and miting the detheories of the meter (which could be used to within plus or minic helf a division).

RESULTS

Figure 2 shows the relationship between applied weight and meter deflection. The calibration curve is linear with an initial offset. The relationship between the force applied and the resulting deflection is:

$$F = (A \cdot D + B) \cdot g$$

in which F represents force (in N); D is the meter deflection; A is a constant value (i.e., 13.75) obtained from the calibration graph; B is a constant value (i.e., 50), the initial offset of the calibration curve; g is the factor (i.e., 9.81) converting kilogrammes weight to Newtons. The maximum error is $\pm 5\%$ at any point on the scale. Knowing the force (F) required to produce a specific deflection for a constant probe-head area (a) which is also known, the pressure applied to the nasal mucosa can be calculated with the formula:

Initial studies on healthy volunteers showed the device was simple reliable and rapid in operation. Repeatable measures of pain thresholds could be obtained.

 $P = F \cdot a^{-1}$

REFERENCES

- 1. Sluder G (1918) Concerning some headaches and eye disorders of nasal origin. CV Mosby Company, St. Louis, pp. 1–272.
- 2. Stammberger H, Wolf G (1988) Headaches and sinus disease: The endoscopic approach. Ann Otol Rhinol Laryngol Suppl 134.
- Stevenson DD (1987) Allergy, atopy, nasal disease and headache. In: DJ Dalessio (Ed.) Wolff's Headache and Other Head Pain, 5th Edition. Oxford University Press, New York, pp. 215–254.

M.P.J. Yardley, FRCS Dept. of Otolaryngology Royal Hallamshire Hospital Glossop Road Sheffield S10 2JF United Kingdom

And J F 34 31 420 FER Property We needed to develop a pictur dust could be providely placed virtue file course meat sentities and apply indexents pressure to the need surveits to shift us in accurately indexage and pain thresh intode first we interies interies a static regionlasty ballond auticular for several materias in which us ballond are surfacter freed to a memory interies in the ballon medical virtue auticular for several materias in the ballon medical virtue auticular for several materias in the ballon medical virtue auticular for several materias for the esternal presents receiped with the meal materia balloch and so with the mean state of and as the ballons was utilisted a analoged on several area within the formal courty at of which could be recommended for

Tories and individual Servician (17, 1991, accepted December (1, 1991, -