Wildervanck's syndrome

Hereditary malformations of the ear in three generations

By P. M. Shenoi (London)

Congenital malformation of the external ear follows from a developmental failure of the mesenchyme of the first and second visceral arches. The resulting deformity of the external ear may be associated with malformation of the face and middle-ear structures. The common congenital malformations of the first arch due to a dominant gene have been classified by McKenzie (1966) into the following clinical entities: (*a*) Treacher-Collins Syndrome; (*b*) Pierre-Robin Syndrome; (*c*) Mandibulofacial dysostosis; (*d*) Deformities of the external and middle ears; (*e*) Congenital deafness; (*f*) Hypertelorism; (*g*) Cleft lip and cleft palate.

Wildervanck (1962) described a family of three generations with hereditary malformations of the external ear, some of whom also had a conductive deafness. The outstanding clinical features occurring in different combinations amongst the members of this family were-

(*a*) Pre-auricular sinus (marginal pits).
(*b*) Pre-auricular appendages.
(*c*) Malformations of the auricle.
(*d*) Conductive hearing loss.

Extensive review of the literature has failed to uncover reports of any other families conforming exactly to the original descriptions of Wildervanck. There are, however, several reports of families manifesting Wildervanck's original description of the hereditary malformations of the external ear together with developmental aberrations of the other visceral arches (Precechtel, 1927; Fourman and Fourman, 1955; Hall and Zimmer, 1958; McLaurin *et al.*, 1966).

The following report describes a British family of three generations in whom the hereditary malformations of the external ear closely resemble Wildervanck's original description. The investigation of the hereditary trait began with Case No. 10, a boy of 16 years. The state of the ossicular chain not previously described in this syndrome was revealed by tympanotomy.

Figure 1 illustrates the family tree.

Case histories

Case No. 10 (T.M.)

Healthy male, aged 16 years, was first seen as an out-patient in April 1969, with a five-year history of gradually increasing right-sided deafness. He com-

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plained of intermittent tinnitus in both ears. Although he had had several bouts of earache in childhood there was no history of otorrhoea or deafness following measles and mumps. There was no history of therapy with ototoxic drugs, Rubella deafness or Rh incompatibility. His mother and one of his brothers were deaf. In December 1968, he had been seen elsewhere and the right-sided deafness was presumed to be the result of previous otitis media. Because of the relatively normal hearing on the left side, he had not been investigated further.

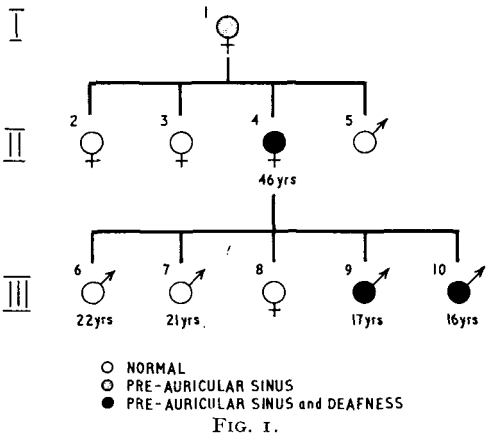


FIG. 1.

Family tree showing the affected siblings.

Both external ears were abnormally curved (flapped) and were placed rather lower than normal (Figs. 2 and 3). There was slight microtia on both sides with bilateral ear pits (Fistulae Auris Congenita), the openings of which were placed just anterior to the crus of the helix. Each ear pit ended in a cul-de-sac in the soft tissues around the anterior part of the external auditory meatus. Both external meatuses curved upwards, forwards and medially, making otoscopic examination rather difficult. The right external auditory meatus showed signs of residual external otitis due to abnormal accumulation of epithelial debris. The tympanic membrane on the right side was completely calcified and immobile. Rinne's test was negative. The left tympanic membrane was scarred and Rinne's test was positive. Weber's test was lateralized to the right ear. There were no other congenital abnormalities.

Pure tone audiogram (Fig. 4)

On the right side there was a combined loss with a well-marked air-bone gap. The average bone and air conduction for speech frequencies were 20 dB. and 73 dB. respectively; air-bone gap was 53 dB.

The left ear showed a slight combined loss in the upper frequencies with an average bone and air conduction loss for speech frequencies of 8 dB. and 25 dB. respectively. Both sides showed a high tone loss.

Speech audiogram (Fig. 5)

Showed a normal shaped curve but with a marked shift to the right for the right ear and slight shift to the right for the left ear.

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Impedance audiometry

Showed absent stapedius reflex on the right side with all stimulus of up to and including intensities of 110 dB. (90 dB. above threshold).

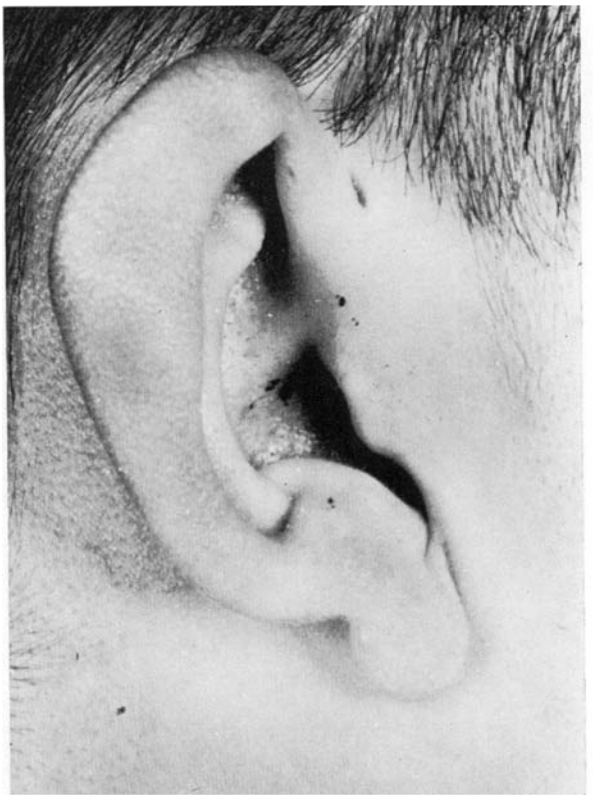


FIG. 2.

Enlarged lateral view of the right ear, showing the ear pit. There was a similar ear pit on the left side. Case No. 10 (T.M.).

Radiography of temporal bones (Fig. 6)

Showed sclerosis of right mastoid air cell system. The right petrous temporal bone appeared to be maldeveloped and placed at a slightly lower level when compared with the normal left side.

Tomography of temporal bones

Figure 7 (9·0 cm. cut) shows absence of development of outer and posterior third of petrous bone.

Figure 8 (10·5 cm. cut) demonstrates ossicles on the right side, which are smaller, especially the Malleus and Incus.

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Figure 9 (11·5 cm. cut) illustrates the deformed ossicles on the right side. ? fused Incus and Stapes.

The right external otitis was first treated and the right middle ear was then explored.

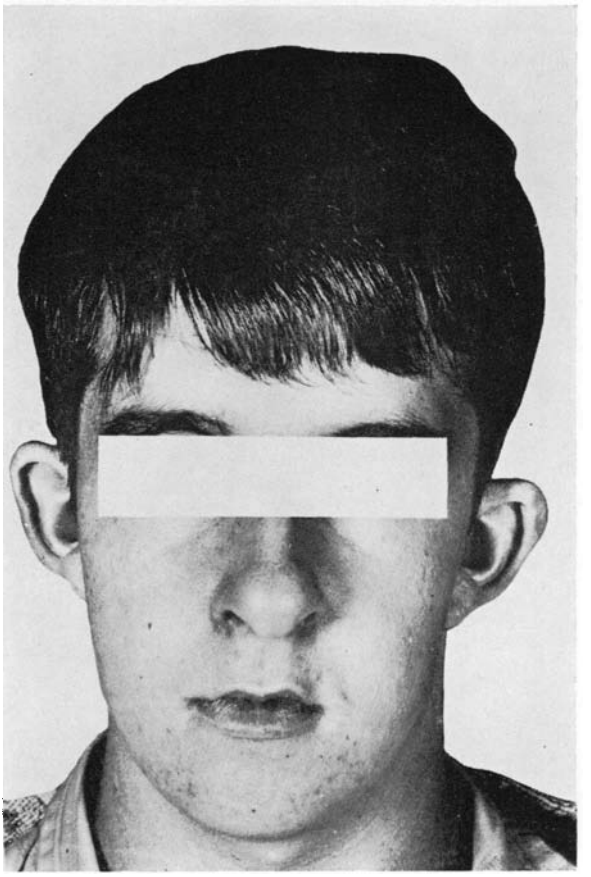


FIG. 3.

Frontal view showing small and abnormally curved ears. Note low attachment of the ears. Case No. 10 (T.M.).

Right tympanotomy (18 September 1970)

There was considerable difficulty in reflecting the tympano-meatal flap forwards due to extensive calcification of the fibrous middle layer of the membrane. The middle ear was finally entered through a small gap between the posterior edge of the calcified tympanic membrane and the tympanic annulus. Further exposure was made possible on partial removal of the posterior margin of the calcified plaque. Postero-superially there was a solid and fixed bony mass—Malleo-Incudo-Stapedial complex—in which individual ossicles

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could not be identified. The oval window could not be identified and the round window reflex was absent, although the round window niche itself appeared normal. The mesotympanum was lined with healthy mucosa. Attempted

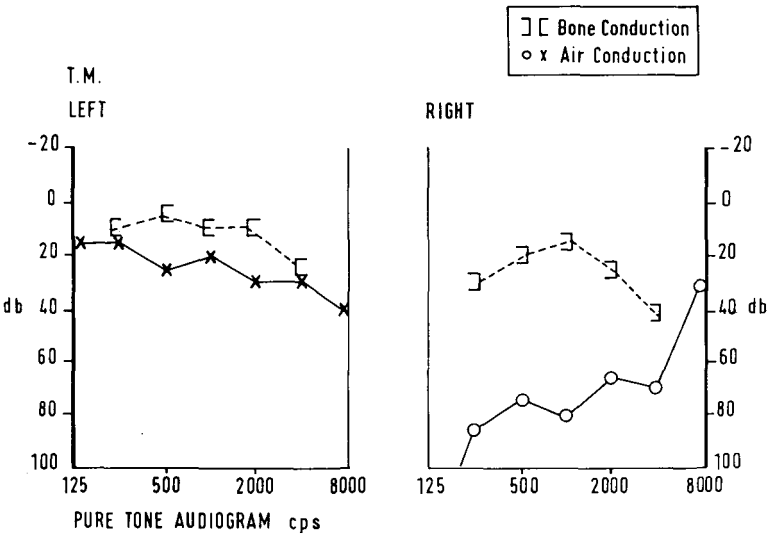


FIG. 4.

Pure-tone audiogram showing a combined hearing loss in both ears with a well-marked air-bone gap on the right side. Case No. 10 (T.M.).

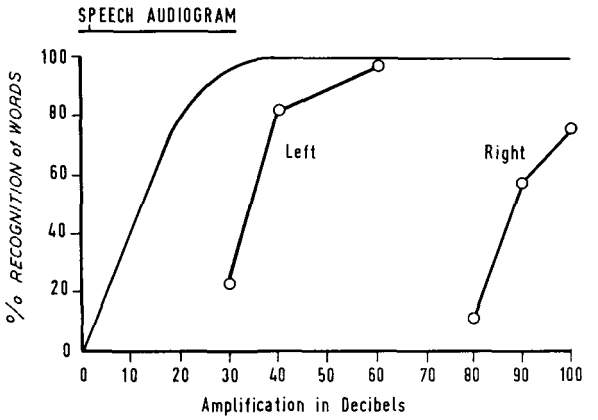


FIG. 5.

Speech audiogram showing a marked shift to the right for the right ear. Case No. 10 (T.M.).

mobilization of the bony mass was unsuccessful. There was a small perforation in the posterior part of the tympanic membrane at closure of the tympanotomy, which was sealed with gelfoam. The patient received a course of oral antibiotic therapy.

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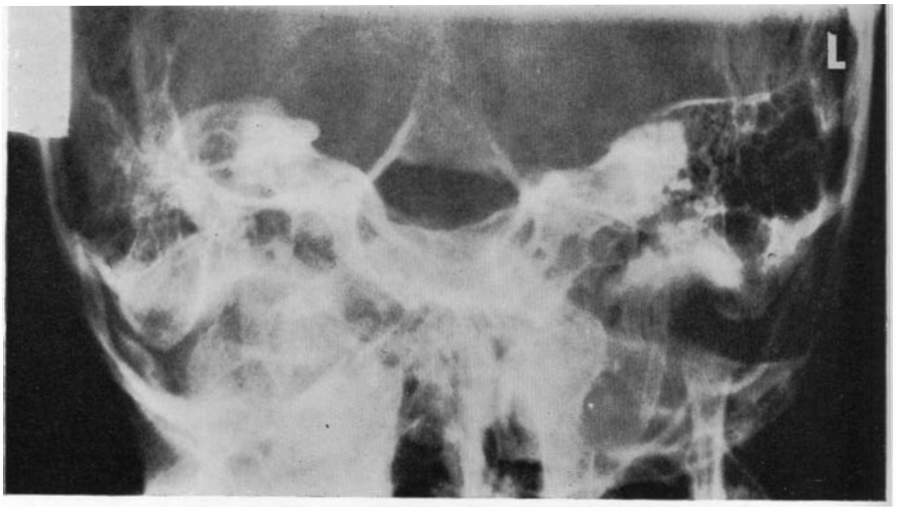


FIG. 6.
Townes' view showing a maldeveloped right petrous temporal bone. There is hypocellularity of right mastoid air cell system.
Case No. 10 (T.M.).

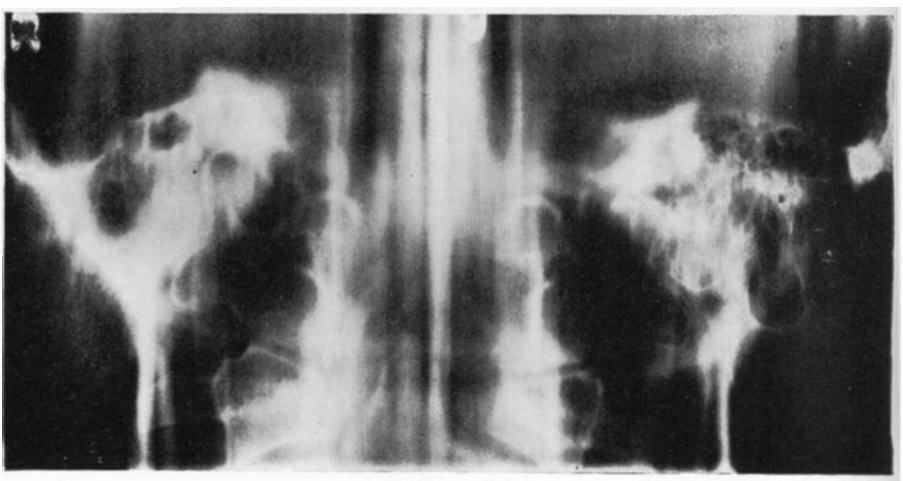


FIG. 7.
Linear tomogram (9·0 cms. cut), shows maldevelopment of the petrous temporal bone on the right side.
Case No. 10 (T.M.).

Post-operative recovery was marred by a recurrence of external otitis which required intensive aural toilet. Ear swab showed a growth of Pseudonomas Aeruginosa on culture, sensitive to Genticin.

The patient was re-admitted two days following his discharge from the hospital with a right-sided acute otitis media which proved resistant to treatment with broad spectrum antibiotics. The pars-tensa turned to a curious

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FIG. 8.

Linear tomogram (10·5 cms. cut). Note the smaller malleus and incus on the right side. Case No. 10 (T.M.).

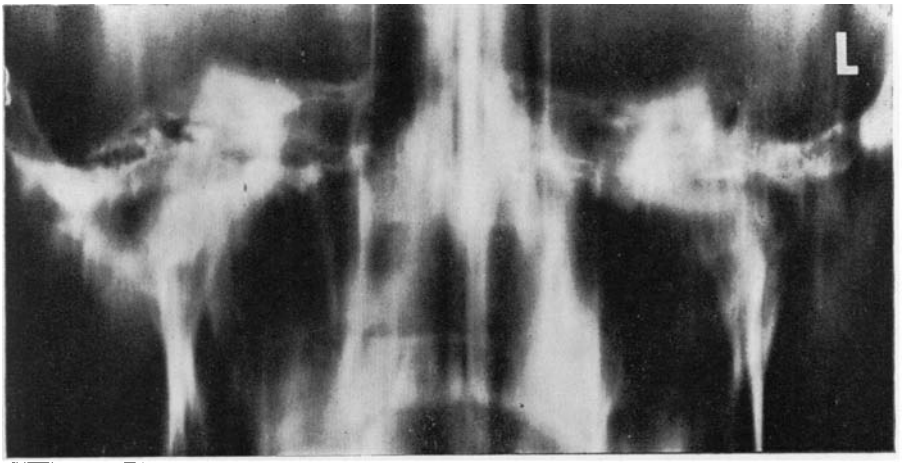


FIG. 9.

Linear tomogram (11·5 cms. cut).
? Fused malleus, incus and stapes on the right side.
Case No. 10 (T.M.).

'red glow' with dilated vessels on its surface and remained so for three weeks at the end of which a large calcified plaque was extruded into the external meatus from whence it was easily removed. Healing was then rapid and complete.

The developmental malformations in this boy, together with the history of deafness in the family, prompted audiological screening of both his brother and mother.

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Case No. 9 (N.M.)

The brother, a boy aged 14 years, had bilateral deafness first noticed three years previously. There was no history of otorrhoea or of trauma.

As in his elder brother, both the external ears were flapped, smaller and attached at a lower level. There were bilateral ear pits with openings situated just anterior to the crus of the helix (Fig. 10). Both external auditory meatuses showed an abnormal course, similar to that of his brother. Both tympanic membranes were normal and Rinne's test was positive on the left side, but negative on the right side. Weber's test was localized at the centre. There were no other developmental anomalies.

Pure tone audiogram (Fig. 11)

Both ears showed a combined hearing loss and were almost identical. On the right side the average bone and air conduction for speech frequencies were 20 dB. and 33 dB. respectively, with an air-bone gap of 13 dB. Both ears showed a high tone loss.

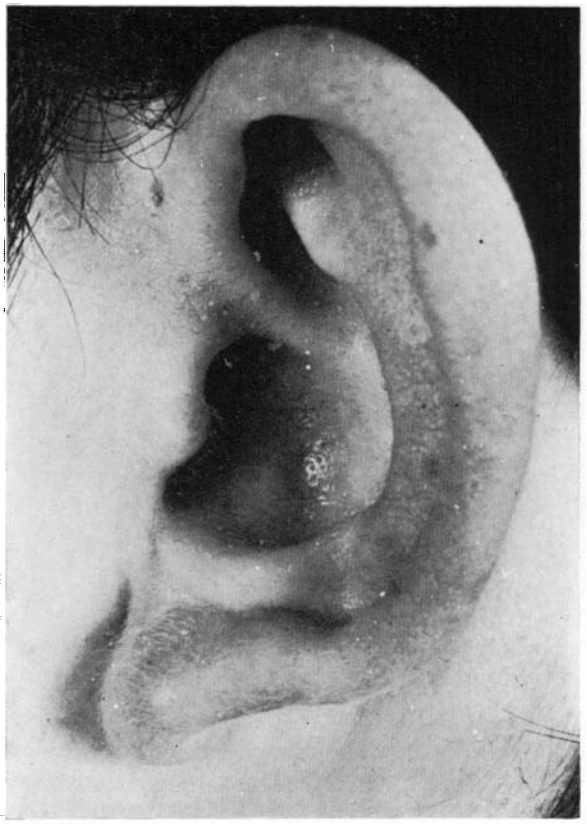


FIG. 10.

Enlarged lateral view of the left ear showing the opening of ear pit. There was a similar ear pit on the right side.
Case No. 9 (N.M.).

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Impedance audiometry

Both sides showed a faint stapedius reflex for 2,000 c.p.s. at a testing tone of 90 dB. above the threshold of hearing.

Left middle ear pressure was normal.

Right middle ear pressure could not be determined accurately.

Consent for tympanotomy was withdrawn by the parents after the discovery of the ossicular chain malformation in his younger brother. At present he is managing adequately with a hearing aid.

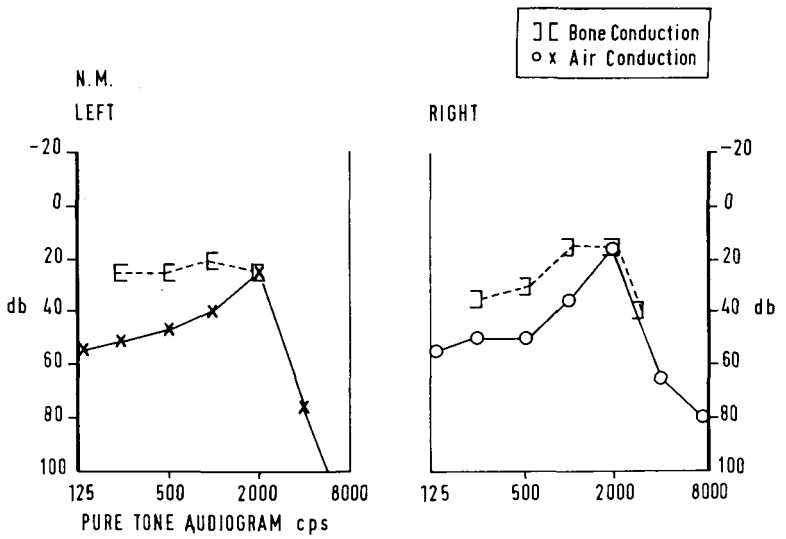


FIG. 11.

Pure-tone audiogram demonstrates bilateral combined hearing loss. Case No. 9 (N.M.).

Case No. 4 (B.M.)

The mother, a healthy woman of 46 years, had had a right-sided deafness since childhood. She complained of occasional tinnitus in the left ear, but no vertigo. Her hearing had been deteriorating rapidly on the left side and she had been wearing a hearing aid. There was a history of otorrhoea in childhood. Both external ears were small and lower in their attachment. There were bilateral ear pits with their openings situated just anterior to the crus of the helix. On the right side, in addition, there was a small pre-auricular appendage. Both external auditory meatuses were abnormal and similar in their course to that of her two sons (Fig. 12). Both tympanic membranes were scarred. Rinne's test was falsely negative on the right side and positive on the left side. Weber's test was lateralized to the left ear.

Table I gives details of the findings in the family.

Audiogram (Fig. 13)

Showed severe sensori-neural hearing loss on the right side and moderate sensori-neural hearing loss on the left side.

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Discussion

Developmental anomalies of structures derived from the first visceral arch have been well documented and indeed such characteristic anomalies have been grouped into well-defined syndromes. Congenital hereditary malformation of the external ear and its association with deafness have received very little attention until recently. The external ear develops

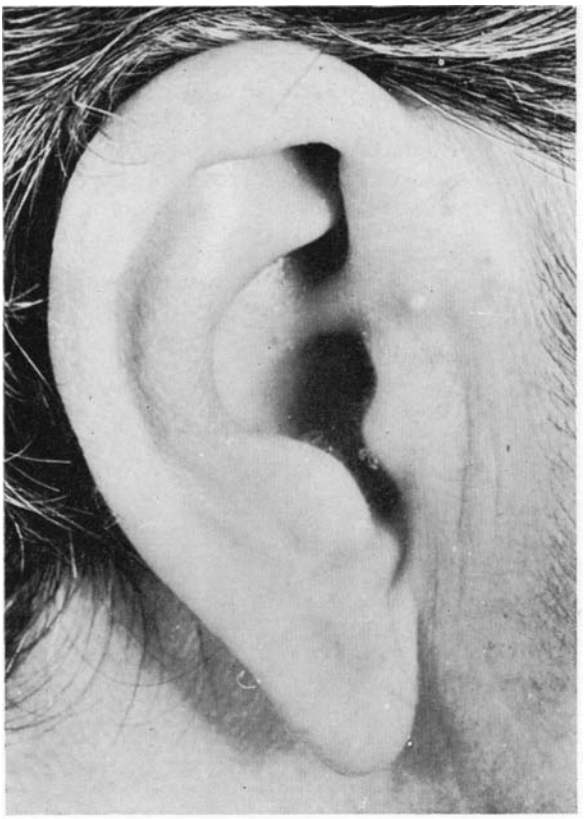


FIG. 12.

Enlarged lateral view of the right ear showing pre-auricular appendage and a smaller opening of the ear pit. On the left side the opening of the ear pit was comparatively larger. Case No. 4 (B.M.).

following the fusion of six mesenchymal hillocks which appear around the dorsal end of the first branchial cleft in the 12 mm. embryo (Hamilton, Boyd and Mossman, 1945). The greater part of the pinna owes its development to the mesenchyme of the hyoid arch whilst the tragus and an area immediately around it and in front of the external auditory meatus are derived from the mandibular arch. The final position of the external ear from its original antero-medial situation is due to the development of the face and the mandible during the second month of intra-uterine life.

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TABLE I.

Case No.	Age	Sex	Pedigree status	Pre-auricular pits	Pre-auricular appendages	Deformed auricle	Hearing loss
1	—	F	First generation	Bilateral	—	—	—
2	—	F	Second generation	—	—	—	—
3	—	F	Second generation	—	—	—	—
4	46	F	Second generation	Bilateral	Left side	Bilateral	Bilateral sensori-neural loss
5	—	M	Second generation	—	—	—	—
6	22	M	Third generation	—	—	—	—
7	21	M	Third generation	—	—	—	—
8	—	F	Third generation	—	—	—	—
9	17	M	Third generation	Bilateral	—	Bilateral	Bilateral combined loss
10	16	M	Third generation	Bilateral	—	Bilateral	Bilateral combined loss R>L

Cases No. 4, 9 and 10 were examined and their hearing was assessed.
Case No. 10 was responsible for initiating this enquiry.
Details of developmental anomaly of the external ear and hearing loss in members of the family.

Sir James Paget has been credited with the first English description of the ear pit or pre-auricular sinus in 1878, although Heusinger described it in German literature in 1864. There have been several reports since of its size, course and mode of origin (Stammers, 1927; Whitney, 1939; Miller and Moore, 1950; Aird, 1946; Congdon *et al.*, 1932). From a large series of 470 cases, Congdon (1932) divides these fistulae into truly helical and pre-auricular. Ninety per cent of these occur as truly anterior helical (marginal) type with a circular or lentiform opening situated just anterior to the crus of the helix. They vary in size and usually end in a cul-de-sac in the soft tissues around the anterior aspect of the external auditory meatus. The track is usually lined by squamous epithelium (Congdon, 1932), and the anomaly occurs under the influence of a dominant gene in several generations. There has been considerable speculation as to the mode of origin of ear pits and opinion may be summarized as follows:

(*a*) Branchial hypothesis of Virchow—that the fistula arises from

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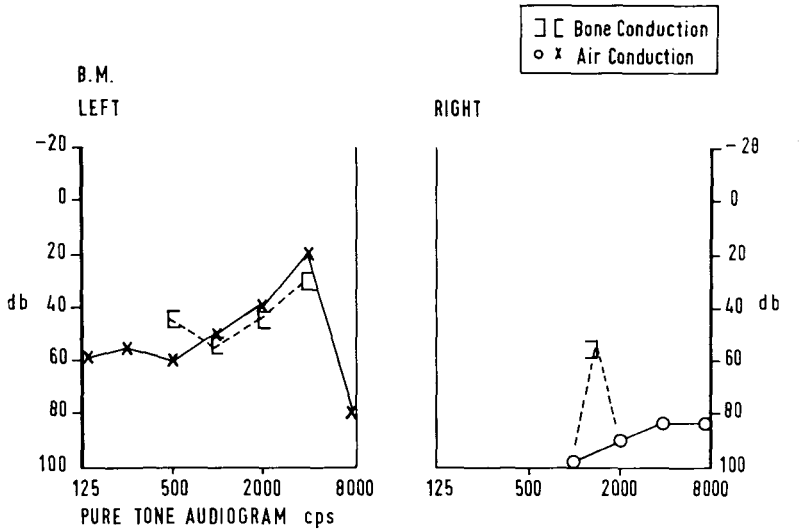


FIG. 13.

Pure-tone audiogram showing severe sensori-neural hearing loss on the right side and moderate sensori-neural hearing loss on the left side.
Case No. 4 (B.M.).

the first branchial cleft. This view has been discredited on grounds that Virchow's original description does not conform to the fistulae arising from the first branchial cleft (Aird, 1946). It is often claimed that the ear pit never communicates with the external auditory meatus or with the mesotympanum, an important clue in refuting the branchial hypothesis. However, recently Hall and Zimmer (1958) described a boy of 14 years, who, in addition to having all the features of Wildervanck's syndrome, also had a cervical fistula and in whom the anterior helicine fistula was shown both by fistulogram and at operation to communicate with the mesotympanum. The fistulous track was running parallel to the external auditory meatus in its anterior aspect in a separate bony furrow. The medial end of the track entered the mesotympanum just above the superior attachment of the tympanic membrane. This case substantiated Virchow's original hypothesis and its supporters (Stannus, 1914; Wood-Jones *et al.*, 1934).

(*b*) Inter-tubercular hypothesis of 'His' attributes the origin of the ear pits to failure of growth and fusion of the hillocks and this has remained by far the most widely accepted hypothesis (Stammers, 1927; Whitney, 1939; Miller and Moore, 1950; Aird, 1946; Wildervanck, 1962). However, Congdon (1932) believes that both the pre-auricular and helicine fistulae are derived from the groove between tubercles 2 and 3 of 'His'. Despite the wide acceptance of this hypothesis (Streeter, 1922) claims that the hillocks of 'His' are rather

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shallow and rudimentary and are replaced by a single component of tissue destined to be the future ear. In his challenge to the importance of the tubercles of 'His' Streeter claims that such tubercles are present in much the same form in mammals who have a completely different-shaped ear in the adult stage; furthermore, they are also present both in birds and reptiles which do not develop an external ear.

(*c*) The facial cleft hypothesis: due to the malunion of the maxillary and mandibular processes. Aird (1946) was able to find only one such case in the literature.

It would seem, therefore, that the most plausible theory to explain the development of ear pits would be the failure of fusion or tubercles of 'His'. It is certain, however, that ear pits are inherited as a Mendelian dominant in roughly half of the affected siblings. They may appear on one side only or on both sides in members of the same family. They may even skip a generation or two and may even be associated with atresia of the external auditory meatus, microtia or pre-auricular appendages, an expression of variable degree of penetrance by a dominant gene or groups of genes.

There are a few case reports of hereditary malformations of the external ears associated with cervical branchial fistulae. Some of the affected siblings also had a hearing loss (Table II).

TABLE II.

ANOMALIES OF FIRST AND SECOND VISCERAL ARCHES ASSOCIATED WITH HEARING LOSS, IN SIBLINGS OF FOUR FAMILIES DESCRIBED IN THE LITERATURE

Author	No. of siblings with pre-auricular sinus (ear-pits)	Associated cervical fistulae and branchial cyst	Type of hearing loss
Fourman and Fourman (1958)	Seventeen siblings with ear-pits.	Four also had cervical fistulae.	Hearing loss present in twelve of the seventeen siblings. Details of audiogram not available. Majority had sensori-neural deafness.
Hall and Zimmer (1958).	Seven siblings with ear-pits.	Two also had cervical fistulae	One had combined hearing loss on the left side and conductive deafness on the right side. Bilateral conductive deafness due to chronic suppurative otitis media was present in the other. No audiograms available in the rest.
McLaurin *et al.* (1966).	Seven siblings with ear-pits.	Six also had cervical fistulae.	Five showed conductive deafness. One showed sensori-neural deafness. Audiogram not available in one case.

In Wildervanck's original description (1962), the starting point of his investigation was a pupil at the school for hard-of-hearing children in Groningen. The boy had low implantation of bilateral flapped ears with

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a pre-auricular appendage anterior to the right tragus. Audiogram showed bilateral conductive deafness with an air-bone gap of 58 dB. and 52 dB. for the speech frequencies on the right and left side respectively. Wildervanck, in describing sixteen siblings in the family of three generations, assumes that the ossicular chain is probably ankylosed. Only one boy whose details are mentioned above showed this typical triad of malformation of the external ears (marginal pits, pre-auricular appendages and malformation of the auricle) and conductive hearing loss. Indeed, two siblings were normal, two had marginal pits but with normal hearing, three had flapped ears with normal hearing, three had pre-auricular appendages and normal hearing, in one the right auricle was slightly deformed but with normal hearing, one had a fold in front of the ear with normal hearing, and finally, in four there is no mention of hearing. Unfortunately, all except one had only free field voice tests to determine the hearing.

In the present paper, the patient who first stimulated interest (No. 10, third generation) and initiated an enquiry into the rest of the family, satisfies all but one of the criteria laid down by Wildervanck (pre-auricular appendages are absent). His brother (Case No. 9), however, has a bilateral combined loss in addition to both bilateral flapped ears and marginal pits. The mother of the above two patients (Case No. 4, second generation), has both bilateral microtia and marginal pits and pre-auricular appendages on the left side. She has, however, severe sensorineural loss on the right side and moderate sensori-neural loss on the left side. The grandmother (Case No. 1, first generation), has only bilateral marginal pits with normal hearing. Thus 40 per cent of the present family manifested developmental anomaly of the external ear which therefore, like other families in the literature, enlightens the dominant nature of the inheritance.

The aetiology of conductive deafness in this syndrome is a severe malformation of the ossicular chain—bony fusion of all three ossicles resulting in a solid and fixed bony complex which in developmental terms is an anomaly of not only the cartilage of the first visceral arch but also that of the second arch. Furthermore, in the same patient the footplate of the stapes was unidentifiable with an absent round window reflex showing further extension of developmental aberration medially to involve the otic capsular wall. Although the tomograms demonstrated a normal bony structure of the vestibular and cochlear apparatus, a definite high tone loss and slight degree of sensori-neural hearing loss substantiates the probability of hair-cell damage. The presense of severe sensori-neural loss in the mother (Case No. 4) and moderate sensori-neural hearing loss in the brother (Case No. 9) adds weight to such a hypothesis. It would seem, therefore, that the developmental anomaly in our patient with deafness ear-pit syndrome is due to a dominant gene or group of genes carrying a variable degree of 'Specificity and expressivity' (McKenzie, 1966). This

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would offer a rational basis for explaining different facets of developmental anomaly of the external ear associated with either cervical brachial fistulae, conductive deafness or sensori-neural deafness. It may well be that Wildervanck's original description of the syndrome is but one aspect of this fascinating maze of developmental defects.

Acknowledgements

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REFERENCES

AIRD, I. (1946) *Edinburgh Medical Journal*, **53**, 498.
CONGDON, E. D., ROWHANAVONGSE, S., and VARAMISARA, P. (1932) *American Journal of Anatomy*, **51**, 439.
FOURMAN, P., and FOURMAN, J. (1955) *British Medical Journal*, **2**, 1354.
HALL, J. G., and ZIMMER, J. (1958) *Acta oto-laryngologica*, **49**, 213.
HAMILTON, W. J., BOYD, J. D., and MOSSMAN, H. W. (1945) *Human Embryology*. Heffer, Cambridge.
HEUSINGER, —. (1864) *Virchows Archiv für pathologische Anatomie und Physiologie und für klinische Medizin*, **29**, 358.
MCKENZIE, J. (1966) *Developmental Medicine and Child Neurology*, **8**, 55.
MCLAURIN, J. W., KLOEPFER, H. W., LAGUAITE, J. K., and STALLCUP, T. A. (1966) *Laryngoscope*, **76**, 1277.
MILLER, J. B., and MOORE, P. M. (1950) *Archives of Otolaryngology*, **51**, 245.
PAGET, J. (1878) *Medico-Chirurgical Transactions*, **61**, 41.
PRECECHTEL, A. (1927) *Acta oto-laryngologica*, **11**, 23.
STAMMERS, F. A. R. (1926–27) *British Journal of Surgery*, **14**, 359.
STANNUS, H. S. (1914) *Biometrika*, **10**, 1.
STREETER, G. L. (1922) *Contributions to Embryology*, No. 69.
WHITNEY, D. D. (1939) *Journal of Hereditary*, **30**, 323.
WILDERVANCK, L. S. (1962) *Acta oto-laryngologica*, **54**, 553.
WOOD-JONES, F., and I-CHUAN, W. (1934) *Journal of Anatomy*, **68**, 525.

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