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CIRCULAR TOMOGRAPHY IN MALDEVELOPMENT AND DISLOCATION OF THE OSSICULAR CHAIN

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The role of conventional radiography in disorders of the middle ear, while being accepted by most members of the ear, nose and throat specialty, has also had many critics.

This criticism is unquestionably based on fact, arising, in a large proportion of cases, from poor and restricted radiography and equally defective interpretation. Where these factors do not apply, the limitation of radiographic resolving factors, with particular reference to radiographic micro-anatomy, comes into play. Apart from this, the superimposition of overlying structures adds to the difficulty of the interpretation, and it is generally accepted that cholesteatomas are often not diagnosed when present, and, less frequently, diagnosed when not present.

Body section radiography, or tomography, is some 40 years old, and its value in elucidating difficult radiological problems is unquestioned. This technique has been pioneered by Portes and Chausse,[1] Bacage,[2] Pohl,[3] Vallebona,[4] Ziedeses des Plantes[5] and Kieffer.[6] In this country Weinbren,[7] to a large extent, popularized the technique and indeed published a manual on the subject.

Linear tomography, the initial and most generally used method of tomography, produces disturbing vertical parasite shadows, which without doubt, detract from the diagnostic value of the radiograph. The literature, therefore, has been studded with descriptions of attempts to devise a pluridirectional type of movement capable of eliminating these parasite shadows.

The most successful and one of the more recent developments is the Massiot Philips Polytome presented by Raymon Sans and Jean Porcher of Paris in July 1951.

This equipment which is incredibly expensive in its tilting form, is capable of circular, hypercycoidal, elliptical and linear movement, producing at its best sections of no more than 1 mm. in thickness.

The clinical uses of the new method have made rapid advances, and outstanding results have followed its application to investigation of the middle ear and the mastoid process.

Mundnich and Frey,[8] Petersen and Stoksted,[9] Tarp[10] and more recently Ross[11] and Valvassori and Dabben[12] have reported striking results in this field. The work of Mundnich and Frey and Valvassori, in particular, can be regarded as of inestimable value in enlightening the student in the interpretation of the radiographic micro-anatomy of the middle ear.

More recently the Zuder Company of Genoa has marketed the Pluristrator, a machine capable of circular, transverse and linear movement. The unit is approximately half of the cost of the Polytome in its tilting form, and it is claimed by the makers that only the circular movement is provided since it is believed that this is the active principal of the figure-of-eight or hypercycoidal movement. It must be stressed, however, that the minimal thickness of section on the Pluristrator is 2·3 mm. as opposed to the 1 mm. section of the Polytome.

In June of 1962 our practice installed the Zuder Pluristrator and one year later papers on the experimental basis of the study[13] and its application to the middle ear[14] were presented at the 44th South African Medical Congress.

It is believed that since this technique is of such great value in general tomography, and in particular in the diseases of the middle ear—and because I am unaware of any publication in the English-speaking world on the Zuder Pluristrator—that a report of our further experience in the middle ear field would be of some value, if only comparative.

It is proposed, therefore, in this paper, to describe its use in the diagnosis of maldevelopment of the middle ear, and in the diagnosis of ossicular dislocation.

The problem encountered by most authors, as clearly shown in Ross' article,[11] is the inadequate reproduction of the radiographs in published papers. Exceptions are the clearly defined reproductions of Frey and Mundnich[8] and Valvassori,[12] which are further clarified by accompanying diagrams. For this paper logotronic contact reproductions of the radiographs have been used, and it is our opinion that this is probably the best method of producing prints comparable to the original radiographs.

MALDEVELOPMENT OF THE MIDDLE EAR

In approximately 48% of cases of the Treacher-Collins syndrome, deafness is present and is related to all types of congenital variations in the middle ear of the development. Livingstone,[15] pointed out that developmental variations of the middle ear are more marked when facial anomalies are present than when these are not associated with atresia of the middle ear.

Where the anomalies are not marked and aeration of the tympanic cavity is established, surgical reconstruction may be of considerable value to the patient. It is accordingly of paramount importance to be able (pre-operatively) to establish:

(*i*) The degree of development and disposition of elements of the ossicular chain.
(*ii*) The integrity of the labyrinth.
(*iii*) The nature and extent of the deformity of the bony external canal.

It would appear that not only is the first branchial arch concerned in the congenital variations of the ossicular chain,[16,17] but that the second branchial arch is also of significance.[18,19] The degree and nature of the deformities are dependent on the complex interrelation between the derivatives of the second and first branchial arches at their cranial ends.

It is possible to demonstrate the partially superimposed malleus and incus in their normal position in the antero-

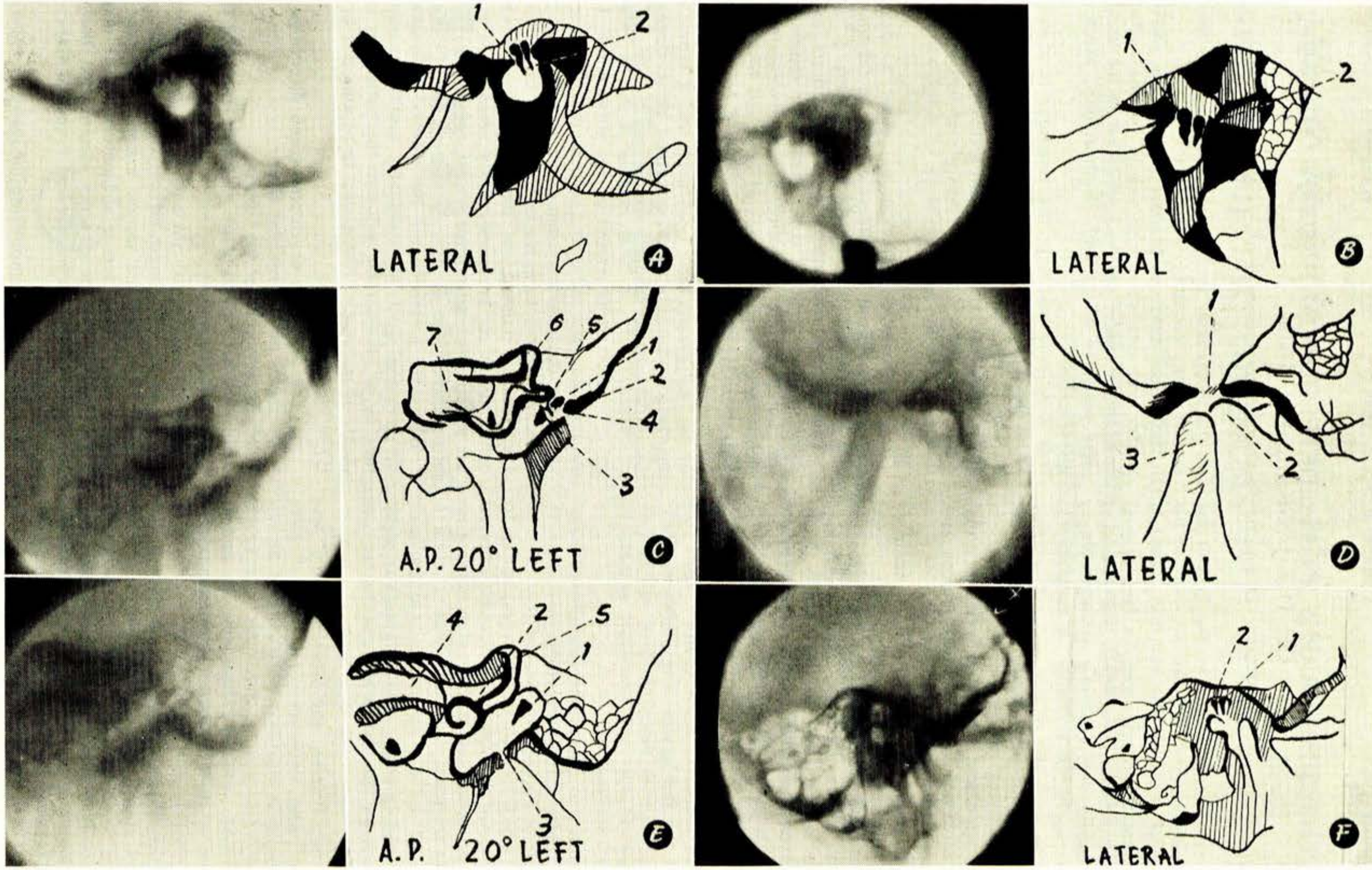

Fig. A. Normal position of (1) malleus and (2) incus. *Fig. B*. Normal position of (1) malleus and (2) incus. *Fig*. C. 1 = malleus, 2 = stapes, 3 = incus, 4 = rudimentary EAC, 5 = lateral SCC, 6 = superior SCC, 7 = internal AM. *Fig. D*. 1 = defect condylar fossa, 2 = defect anterior wall EAC, 3 = condylar process. *Fig. E*. 1 = ossicles, 2 = cochlea, 3 = rudimentary EAC, 4 = internal AC, 5 = superior SCC. *Fig. F*. 1 = malleus, 2 = incus.

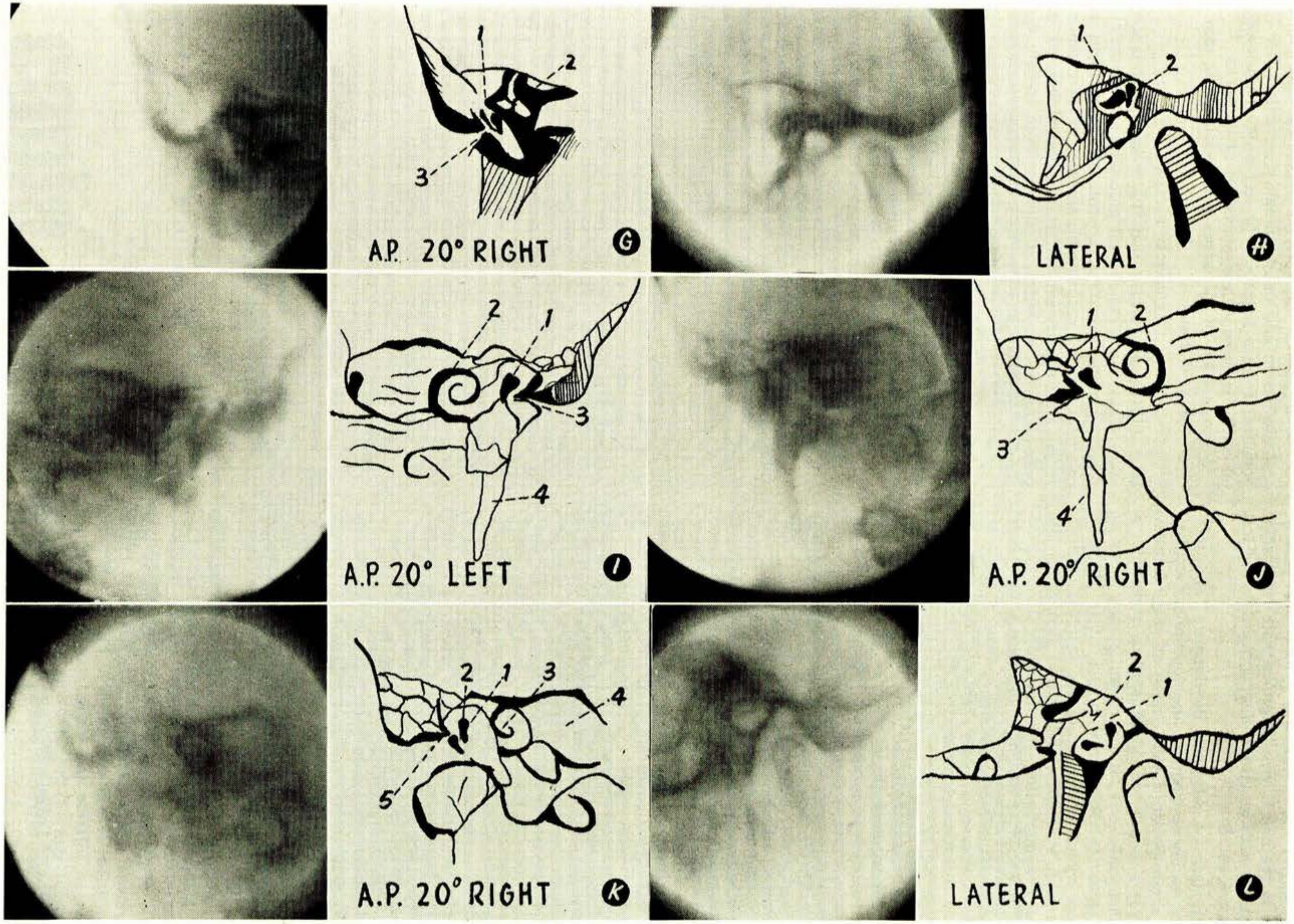

Fig. G. 1 and 2 = malposition malleus and incus, 3 = conical atresia EAM. *Fig. H.* 1 and 2 = malposition malleus and incus. *Fig. I.* 1 = ossicles, 2 = cochlea, 3 = atretic EAC, 4 = styloid process. *Fig. J.* 1 = ossicles, 2 = cochlea, 3 = atretic EAC, 4 = styloid process. *Fig. K.* 1 = malleus, 2 = incus, 3 = cochlea, 4 = internal AC, 5 = external AC. *Fig. L.* 1 = malleus, 2 = dislocated incus.

posterior 15-degree tilt position (Fig. E). The parallel relationship in the lateral view, together with the incudo-malleal joint, are likewise visible in sections between 3 and 3·6 cm. (Figs. A and B).

Deformity, lack of adequate development, and malposition, are readily apparent on the appropriate sections. Fig. C, an antero-posterior view, shows all these features, demonstrating a poorly developed malleus superiorly, a deformed incus inferiorly, and a central stapes. None of the bones appear to articulate with each other. An associated almost complete absence of the external auditory canal is present. A conical dish-shaped depression and central small communication with the tympanic cavity represents the rudimentary structure. The lateral view of the same case, Fig. D, demonstrates the absence of the anterior wall of the external auditory canal and the consequent deformity of the condyloid fossa. This deformity was unilateral and on the affected side an almost complete microtia was present. No facial deformities were noted.

Fig. E is the antero-posterior study of an adult female with unilateral conductive deafness; it demonstrates complete absence of a recognizable external auditory canal. The lateral boundary of the aerated tympanic cavity merely shows as a flat bone containing a small communicating defect. The ossicular chain, however, in contradistinction to the preceding case, is seen to be well formed and intact, auguring well for reconstructive surgery. The lateral view, Fig. F, of the same case, shows the normal relationship of the ossicular chain in this plane.

The third case was that of a child without facial deformity and exhibiting unilateral deafness. Fig. G, an antero-posterior study, shows a conical atresia of the external auditory canal and disruption of the normal ossicular pattern. The configuration suggests separation of the malleus and incus; the appearance resembles a child's catapult. The lateral view of the same case, Fig. H, shows slight inferior displacement of the incus and an oblique disposition of this ossicle, with widening of the incudo-malleal joint.

A similar type of conical atresia is shown in the next case. The lesion is bilateral, but the ossicular chain itself is normal in appearance, indicating the possibility of a favourable response to surgical intervention.

Labyrinthine deformities do not appear to be common and I have not observed significant reduction of the tympanic cavity or diminution of aeration of this cavity.

The normal appearance of the external auditory canal is shown in Fig. K, and it is of a case of ossicular dislocation.

OSSICULAR DISLOCATION

The normal position of the ossicles in the antero-posterior and lateral planes is illustrated in Figs. I and J and Figs. A and B respectively.

Separation of the superimposed malleus and incus, with possible downward displacement of one ossicle, is indicative of dislocation. This is well shown in Fig. K, where the incus lies in an inferior and medial position contiguous with the lateral spur of the aditus. In the lateral plane, Fig. L, the incudo-malleal joint is disrupted. The incus is in a horizontal plane and a complete right-angle is formed by the two bones. This dislocation followed exposure to a blast injury. Direct injury to the middle ear may produce a similar lesion and in one instance a vertical fall onto both feet from a height of 10 feet produced immediate unilateral deafness with displacement of the incus.

Demonstration of the stapes is unusual, but is seen on occasions, as in Fig. C.

TECHNICAL FACTORS

It should be emphasized that this examination is not a radiographic but a radiological procedure and should at all times be under the direct control of a radiologist well cognizant with the radiographic anatomy of the middle ear. In our own department the senior radiographer has been controlling this examination, and has been training other suitable operators during the past two years.

THE APPARATUS

Unit—American General Electric. K × 8 4-valve unit.

Tube—American General Electric. Heavy Duty 1 and 2 mm. foci.

Focus used—1 mm.

Factors—KV 70 - 80. M.A. 50. Time: 3·8 - 4 seconds.

Grid—Schonander. 1 to 14 ratio.

Diameter circle—C6 - 60 cm.

Distance—40.

Zuder Serial Cassette Changer—Allowing for 4 exposures on the Italian film. $9\frac{1}{2} \times 11\frac{3}{4}$.

Screens—High definition.

Films—Ferrania.

Views—AP 15° tilted (routine). Lateral when necessary.

There is no doubt that a 3-phase unit would produce better quality radiographs and it is also possible that the hard base Du Pont Cronex II film would further improve the results since the fog level of this film under conditions of automatic processing appears to be low.

Thanks are due to my colleagues, who have been kind enough to refer a great number of cases for investigation, and to Miss J. Robb, Chief Radiographer to this practice, whose dedication to this study was to a great extent responsible for the results achieved; also to Dr. J. N. Jacobson for his advice and constructive criticism.

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