THE SURGICAL CORRELATION OF X-RAY FINDINGS BY POLYTOMOGRAPHY.*†

With Special Reference to Chronic Otitis.

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INTRODUCTION.

During the past 15 years great advances have been made in surgery of the chronically damaged ear. The radiology of the temporal bone, however, has remained static for decades. Fortunately, the need for better ear radiology has resulted in the recent development of highly precisioned tomographic units. Utilization of such units depends on how much knowledge concerning the ear can be obtained from such examinations. We feel that a great amount of information can be gained with this new equipment.

Fifty patients with chronic otitis media and mastoiditis had tomograms of the ear as part of their pre-operative evaluation. The correlation between the tomograms and the surgical findings is the subject of this report. Other pathological conditions of the temporal bone which have been investigated are atresias of the external canal, congenital and acquired stenosis of the external canal, congenital deformities of the middle ear, fractures of the temporal bone, otosclerosis, tumor formation of the middle ear, ossicular dislocation and fixation, facial paralysis, carotid-cavernous AV fistula, tym-

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panosclerosis, glomus tumor and internal auditory canal lesions, but these are not included in this presentation.

The utilization and acceptance of any diagnostic method depends upon three essentials: *1.* a high degree of accuracy; *2.* a high degree of reproducibility; and *3.* simplicity of examination for the technician. Any method having all of these attributes would be able to offer reliable information concerning the status of the middle ear and mastoid. We are impressed with the degree of clarity with which the anatomy and pathology is demonstrated. There are some areas where still further detail would be helpful, such as in erosion of the tip of the lenticular process of the incus and the arch of stapes, but we are confident that these few remaining problem areas will soon be erased.

CONVENTIONAL MASTOID RADIOGRAPHY.

Conventional mastoid films have been inadequate in patients with chronic middle ear disease. The many films of the mastoid area which are taken on standard X-ray equipment in an attempt to define more accuratey temporal bone pathology, are testimony to the fact that no really satisfactory method of X-ray examination of this intricate area has been discovered. As each contributor proposes his particular tilt, angle, inclination, variation of exposure time, KV or grid, rather than clarification, more confusion and doubt are created, to the point where X-rays of the temporal bone were taken with little expectation that the true nature and extent of the pathology would be revealed. Whereas otological surgery was "in orbit", temporal bone radiology had not got off the drawing board.

It has always been the otologists' hope that some day a technique of radiological examination would be devised which would show the ear free of overlying, underlying and superimposed tissues, so that more information could be obtained from the films than the mere finding of sclerosis and other remarks relating to the degree of aeration of the mastoid. It seems that a large step in this direction has been made by the development of the polytomographic X-ray technique.

Standard views and their modifications depend upon po-

sitioning of the head at a certain prescribed degree of angulation in reference to various body planes. The fault with these views is that the temporal bone does not have a consistent angulation in the skull. Racial, genetic and developmental factors determine the position of the temporal bone. One of us (LK) previously demonstrated this variation in children with congenital ear malformations.[2] This finding was confirmed by Peggs,[4] who found a significant variation in the position of the temporal bone in a measurement of over 1,000 skulls; therefore, routine mastoids, taken with prescribed angulation, usually fail to visualize the contents of the middle ear. Multiple views must then be taken to compensate for these variations, and even then are not often reliable, accurate, reproducible, or technically easy for a technician to perform.

AIR TOMOGRAPHY.

The above variations are of no significance with the tomographic method. Thin sections are taken of the middle ear. Superimposed structures such as the dense labyrinth and mastoid process are uniformly blurred when outside the plane of focus.

Tomography of the middle ear has been used only during the past few years, while the principle of tomography has been known for over 35 years. The early tomographic equipment was unable to make thin sections with sharp definition. The standard uni-directional tomograph fails to blur structures parallel to the direction of the X-ray movement. This results in the objectionable streaking seen on layer tomograms with loss of definition.

The recent use of highly precisioned multidirectional tomographs has enhanced the X-ray examination of the temporal bone. These units can take tomographic sections as thin as one millimeter. The multidirectional motion of the tube uniformly blurs all structures outside the plane of focus. The Polytome, having these characteristics, is the unit employed in this study.

In examining the film, an attempt is made to comment on several anatomical considerations, *i.e.*, the size, shape and configuration of the external canal; the appearance of the

scutum region, whether or not it is eroded and whether or not it bears a normal relationship to the head of the malleus; the aeration of the tympanum and epitympanum; the ossicles, their presence or absence, their relationship to one another and to surrounding landmarks, their size, shape and degree of erosion, if any; the facial nerve canal and the semicircular canals; the round and oval windows; the cochlea, vestibule and the internal auditory meatus. These structures are seen with great consistency in polytomographic studies. The carotid canal and jugular foramen are also seen.

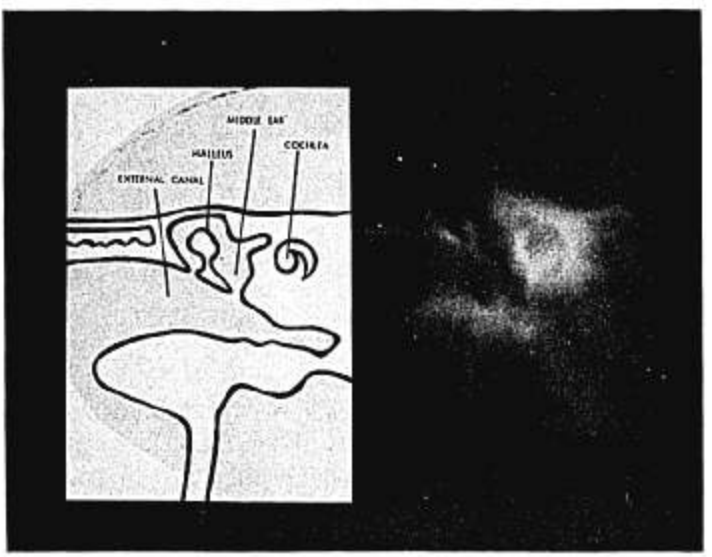

Fig. 1.

TECHNIQUE.

The technique for the examination can be quickly learned by the technician. The head is placed in a straight frontal and lateral position. The projections are easy to position and reproduce. The tomogram in the frontal plane demonstrates a single section through the normal ear at the level of the malleus, external auditory canal, attic and cochlea (Fig 1). Serial sections are taken through the middle ear to identify each anatomical structure. A single section through the lateral plane

identifies the ossicles within the tympanic cavity (Fig. 2). Routine mastoid films were taken in a majority of the patients to compare the diagnostic accuracy of each method. No reliable information concerning middle ear structures was obtained from the standard films. In all fairness it must be added that although not technically difficult, the examination is time consuming and expensive at this stage of development.

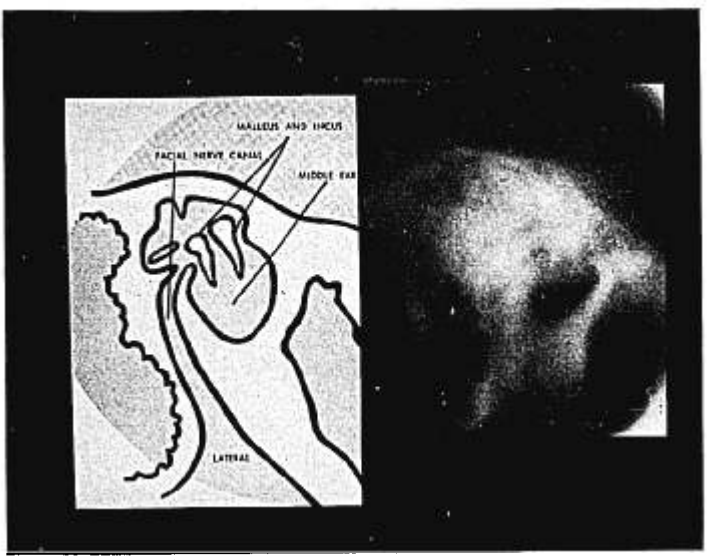

Fig. 2.

METHOD.

Fifty patients were studied by tomography prior to middle ear exploration. Five of these patients had additional surgery involving the opposite ear or re-exploration of the same ear; thus, 55 cases of ear tomograms confirmed by surgery are included in this study.

An interpretation was made prior to exploration; however, the surgeon was not given the results. An operative report was made immediately after surgery. The results of polytomography and surgery were then compared, and an analysis of the entire series was performed at the termination of the project.

The structures in the external, middle and inner ear in each case were placed in one of three categories: *1.* normal; *2.* abnormal; or *3.* not visualized. Six structures were most commonly affected with chronic middle ear disease. Seen in Table I these are the mastoid process, antrum, attic, scutum, tympanic cavity and ossicles. The antrum, attic, scutum and tympanic cavity seem to be the least affected whereas the ossicles and mastoid appear to be the most involved.

TABLE I.

Interpretation of Middle Ear Structures by Tomography.

	Mastoid Process	Antrum	Attic	Scutum	Tympanic Cavity	Ossicles Mall.	Incus
Normal	19	43	45	43	42	39	34
Abnormal	35	12	10	12	13	16	19
Not Visualized	1	0	0	0	0	0	2
Total	55	55	55	55	55	55	55

PATHOLOGICAL ANATOMY.

The X-ray changes seen in the middle ear are as follows:

1. Increased density in the tympanic cavity, attic, antrum and mastoid process.

2. Bony erosion of the scutum, ossicles, tegmen, sigmoid sinus plate and promontory.

3. Enlargement of the tympanic cavity, attic, and antrum due to erosion.

Interpretation of these X-ray changes usually includes the following diagnoses:

1. Chronic otitis media. The bone surrounding the antrum and tympanic cavity has a uniform increase in density. No localized areas of increased density are seen. The scutum and ossicles are well defined. The middle ear and antrum are of normal size.

2. Cholesteatoma. This condition cannot always be differentiated from granulation tissue or fluid. The tomographic diagnosis is based on the surrounding bony erosion. The scutum is one of the first structures affected. The normally sharp

border for attachment of the tympanic membrane is blunted (Fig. 3). The distance between the scutum and malleus is increased. The cholesteatoma may involve the ossicles primarily with gradual erosion of the incus and malleus. Although the perforation may be small, the cholesteatoma may be massive with involvement of the entire tympanic cavity and antrum. This was demonstrated in a 53-year-old female with a small perforation, cholesteatomatous debris in the ear canal and a

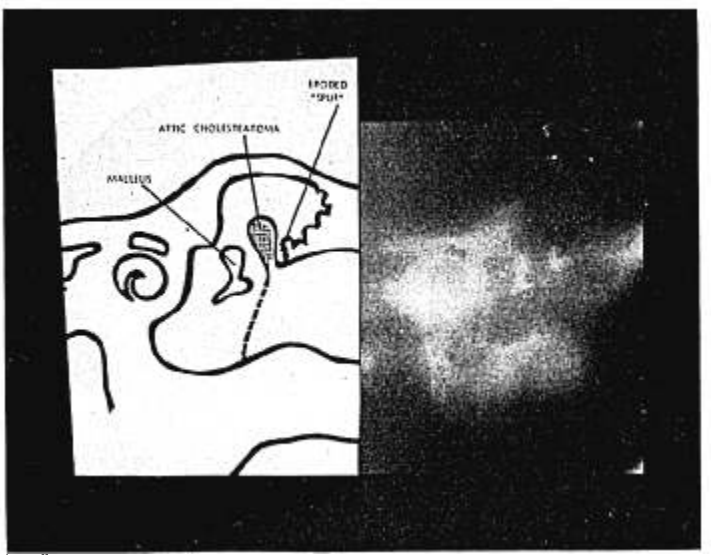

Fig. 3.

50 decibel loss (Fig. 4). A large cholesteatoma had destroyed the ossicles and eroded the scutum and tegmen. The tympanic cavity and antrum were enlarged, due to the erosion; thus, the tomograms not only indicated the presence of cholesteatoma but also its extent.

3. Osteitis. The changes seen with chronic osteitis were an increased density of the tympanic cavity and antrum. The long process of the incus was often affected with amputation of its tip. The scutum was usually intact, and the attic and antrum were of normal size.

4. Tympanosclerosis. Calcification was demonstrated in the tympanic membrane together with increased density of the intact bony structures. The number of cases, however, was insufficient to confirm this finding.

SURGICAL-TOMOGRAPHIC CORRELATION.

After comparison of the surgical and tomcgraphic aspects, there was agreement on 46 occasions and disagreement on nine occasions. The disagreements were as follows:

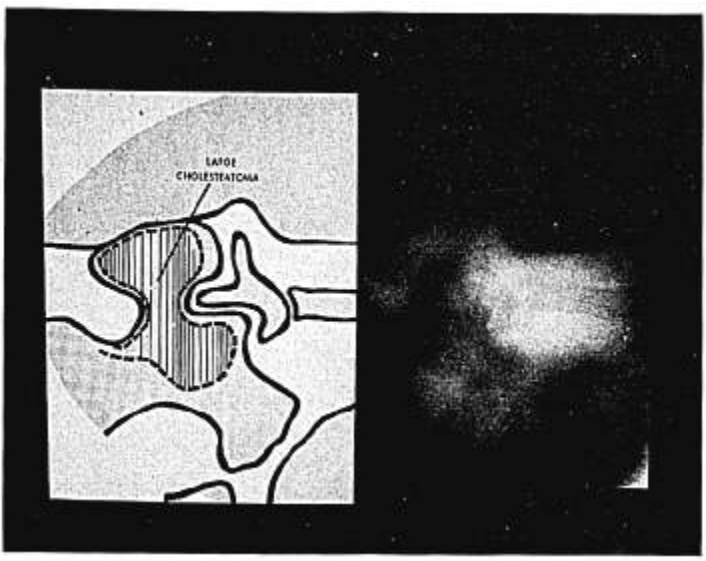

Fig. 4.

1. Failure to visualize otosclerotic foci. Two patients had coincident otosclerosis of the foot plate. The difficulty in identification was due to the increased density in the middle ear, which may have obscured the recognized findings as described by Valvassori.[6]

2. Failure to visualize erosions of the incus in three patients. The lenticular process is often involved in otitis media with osteitis and cholesteatoma. This process is difficult to identify in the tympanic cavity filled with fluid or granulation tissue.

Ideally, examinations should be performed after drainage has ceased with treatment.

3. Failure to visualize a cholesteatoma. Primary cholesteatomas may occasionally grow in a misleading pattern. Instead of producing an expanding destructive lesion, the cholesteatoma may be seen to infiltrate the tympanic cavity and antrum. The ossicles may be enveloped by the cholesteatoma but not eroded. Certain cells in the mastoid process are occupied by the cholesteatoma, but other cellular walls remain intact. Both the routine mastoid X-rays and the tomograms reveal an increased density. This is a nonspecific finding and can be due either to granulation tissue or cholesteatoma. Two children exhibited increased density in the middle ear without erosive changes. Large infiltrating cholesteatomas were found in both cases.

4. Failure to differentiate cholesteatoma from osteitis. Chronic otitis media with osteitis usually affects the ossicles. When the incus reveals erosion in its long process, the cause cannot be differentiated between osteitis and cholesteatoma. Enlargement of the attic and antrum was seen in one case, suggestive of cholesteatoma but was due to osteitis.

SURGICAL CORRELATION WITH ROUTINE MASTOID FILMS.

Comparison with conventional mastoid films revealed a poor correlation with the surgical findings. The most common radiological finding was sclerotic mastoids. Three patients were referred with the diagnosis of cholesteatoma on the conventional mastoid films. No cholesteatoma was seen on the tomograms or at surgery. The findings on the routine films were due to a sharply defined, aerated antrum in a small sclerotic mastoid process. The antrum thereby gave an illusion of being enlarged.

CLINICAL-SURGICAL CORRELATION.

The clinical diagnosis of cholesteatoma may be difficult in patients with chronic otitis media. In this series, three patient's revealed clinically unsuspected cholesteatomas by tomography. The first patient presented with a facial palsy and a normal intact drum. The tomograms revealed a large chole-

steatoma in the attic and antrum. The second patient had a persistent draining ear with pain. A large cholesteatoma was seen in the attic with partial destruction of the ossicles on polytomography. The third patient had a dry ear with a marginal perforation. A tympanoplasty was being considered when she suddenly developed pain and dizziness. Tomograms again revealed a large destructive cholesteatoma.

In another reported series of 98 cases of surgically verified cholesteatoma, the pre-operative clinical diagnosis was correct in 61 cases. The remaining 37 cases did not reveal cholesteatoma on clinical examination alone. Surgery for these cases was based on the radiological examination.

SUMMARY.

Fifty patients with chronic otitis media were examined with the Polytome prior to surgical exploration. Diagnosis of middle ear disease was 80 per cent correct with the use of tomography. Conventional mastoid views failed to show pathological changes except for sclerotic mastoids. The diagnosis of cholesteatoma can be made when bony erosion is present even when the clinical diagnosis is obscure. Failure to diagnose otosclerotic lesions of the foot plate, erosions of the lenticular process and stapes, and a noneroding cholesteatoma usually of the primary type are the principal drawbacks of this technique at this time. The evaluation of patients with chronic otitis media can be enhanced by tomography of the temporal bone.

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