Malleus Fixation

By D. Garfield Davies (London)*

Restriction and later fixation of the movements of the head of the malleus as a direct or indirect result of inflammatory processes has been well documented. It is the purpose of this paper to briefly review the non-osseous types of fixation and then to examine more fully bony fixation of the malleus.

In 1860 Toynbee stated that "The mucous membrane of the tympanum may be subject to chronic inflammation complicated or not with rheumatism at any period of life, and if neglected, this is liable to terminate in a rigid state of the membrane so that the ossicles become bound together more firmly than is natural. In advanced years, this rigid condition seems to take place without any symptom of inflammation." Toynbee also found that the fibrous laminae of the membrana tympani frequently underwent calcareous degeneration. "In some cases this calcareous condition of the membrane is symptomatic of calcareous deposits in the tympanic cavity; in others it follows, and appears to be produced by chronic inflammation." During the course of dissecting 1,013 diseased ears he found two cases of "osseous anchylosis of the malleus" to the upper wall of the tympanum, three cases of ankylosis of this bone to the incus and also three ears in which the malleus was fixed by ligamentous ankylosis to the upper wall of the tympanum.

Tympano-sclerosis

Zöllner (1956) attributed the first description of this condition to von Tröltsch (1873), but it is evident that calcareous degeneration had been recognized earlier. The term "chalk plaque" has fallen into disrepute as tympanosclerotic patches normally contain very little calcium. The condition is essentially the result of hyalin degeneration of collagenous connective tissue in the submucosa of the middle ear and is usually a sequel of healed chronic otitis media. Some anchoring plaques can be easily removed and, as the underlying bone can appear normal, recovery of function may be anticipated. However, in advanced cases the ossicles are completely covered by thick sclerotic masses and the attic may be completely filled by a massive block of this material. Fig. 1 illustrates fixation of the malleus and incus by tympano-sclerosis and fibrous

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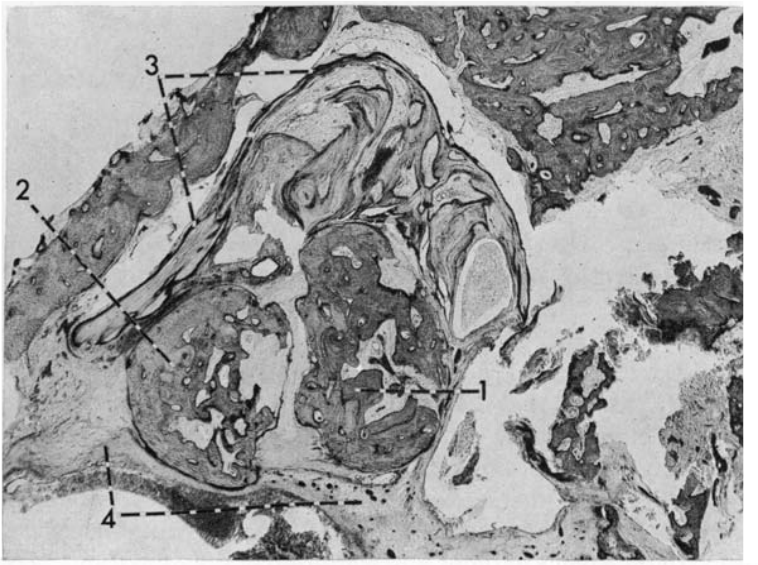


FIG. 1.
Tympano-sclerosis and fibrous tissue fixing a partially devitalized malleus and incus.
(1) Malleus. (2) Incus. (3) Tympano-sclerosis. (4) Fibrous tissue.

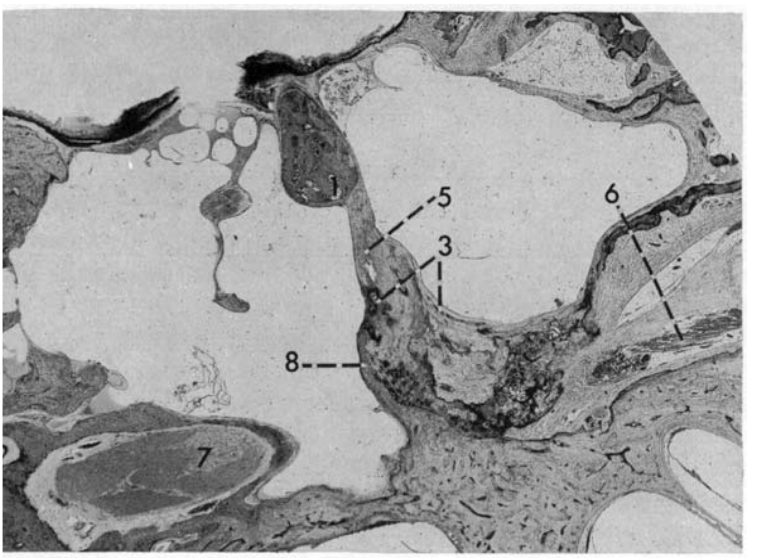


FIG. 2.
Tympano-sclerotic plaques embedded in the tensor tympani tendon.
(1) Malleus. (3) Tympano-sclerosis. (5) Tensor tympani tendon. (6) Tensor tympani muscle.
(7) Facial nerve. (8) Processus cochleariformis.

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tissue fixation. The blood supply to the ossicles is slowly strangulated and the bone eventually becomes devitalized. Any tympanoplastic procedures utilizing the structures depicted in Fig. 1 are obviously doomed to failure as only bony shells remain. Limitation of movement of the malleus may be caused indirectly by infiltration of the tensor tympani tendon by tympano-sclerosis (Fig. 2). Section of tendon should be carried out if malleus movement is still limited after the clearance of obvious tympano-sclerotic plaques.

Adhesive Otitis or Middle-Ear Fibrosis

Chronicity in middle-ear inflammation is recognized by a decrease in the number of polymorphonuclear leucocytes and a relative increase in lymphocytes, plasma cells, histiocytes and fibroblasts. Fibrous tissue bands ensue and gradually blood vessels are occluded until the mucosa lining the ossicles and tympanic cavity walls is replaced by dense avascular fibrous tissue.

Procter (1964) has stressed that the epitympanum is almost completely separated from the mesotympanum by the ossicles and their folds except for two small but constant openings, which he termed the isthmus tympani anticus and the isthmus posticus. Whenever exudates or transudates are trapped in the attic by swelling of the opening of these isthmuses and the condition is not relieved, then organization of the fluid and resulting

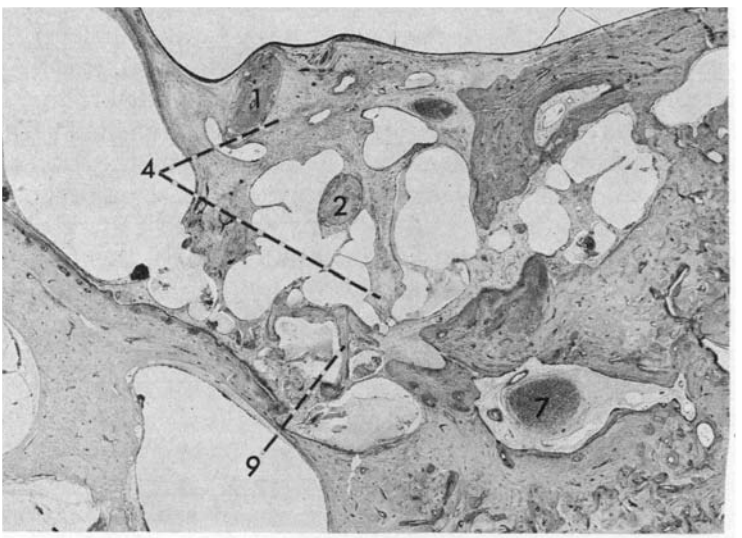


FIG. 3.
Bands of fibrous tissue partially fixing the malleus, incus and stapes.
(1) Malleus. (2) Incus. (4) Fibrous tissue. (7) Facial nerve. (9) Stapes.

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fibrosis occurs. Adhesions in Prussak's space cause deep retraction of Shrapnell's membrane and in Ojala's (1953) material adhesions starting from the incus were rare but fibrous bands from the malleus to the lateral wall and to the roof of the tympanic cavity were common. Fig. 3 illustrates webs and bands of fibrous tissue restricting and partially fixing the ossicles.

Bony or Osseous Fixation

Developmental Anatomy

The external ear canal is formed from an extension of thickened ectoderm (meatal plug) at the upper end of the first branchial groove and the middle-ear cavity is developed from the pharyngotympanic tube—a prolongation at the upper end of the first pharyngeal groove. The ossicles, muscles and other structures of the middle ear develop from the mesenchymal substance around these indentations which are called the first and second pharyngeal arches. Neither Reichert's or Meckel's cartilages, *per se*, contributes to ossicular origin (Strickland *et al.*, 1962). These cartilagenous bars which later form such structures as the mandible and the hyoid develop from the mesenchyme of the arch as does the ossicular cartilage. Ancestor cells are present for each structure, such as the malleus, incus, hyoid and mandible and these cells are pre-destined to differentiate especially into one particular structure. However, cells which are the precursor of the malleus and incus are not entirely confined to the first pharyngeal arch as they also extend into the second arch. The manubrium of the malleus and the long process of the incus are derived more from the mesenchyme of the second arch and the tissue of the bridge between the two arches than from the first arch alone. The head of the malleus and body of the incus are formed from the first arch (Hough, 1963). It is thus apparent that the upper ossicular chain is more closely related to the first arch whereas the lower ossicular chain is related to the second arch. The proximal end of Meckel's cartilage which is continuous with the anterior aspect of the head of the malleus, undergoes gradual disorganization in late foetal life and is converted into the anterior ligament of this bone. The slit-like distal expanded part of the auditory tube, mentioned above, which represents the primitive tympanic cavity after the twenty-second week, begins to enlarge rapidly within the tympanum proper. This expanding tympanic cavity encroaches on the ossicles and its epithelium is wrapped round these bones in a manner analogous to the mesothelium covering the intestines (Bast and Anson, 1949). Pneumatization of the epitympanum lags behind that of the tympanum and although during the last month of foetal life full pneumatization of both the tympanum and epitympanum is virtually attained, the actual tympanic space continues to enlarge after birth due to condensation and thinning of the remaining connective tissue. Bony spicules are resorbed as the epithelium lining the pneumatic spaces insinuates into the soft tissue. Variations of this

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pneumatization process can occur if the resorption of the primitive mesenchymal elements and bony spicules is not complete. Another variable entity is the size of the malleus. Bast and Anson (1949) have found the maximum diameter of the head of this ossicle ranged from 2·13 mm. to 2·84 mm. and the minimum diameter of the head varied from 1·67 mm. to 2·07 mm. In the neo-natal period the malleus undergoes a series of changes in structure which are similar to those taking place in the incus. Areas of bone are locally eroded and after resorption of the primary osseous layers, new lamellae of bone are deposited. This irregular form of secondary lamellae alters the primary pattern of ossification and this involves the perichondral as well as the endochondral layers (Hanson and Anson, 1962). The process of malleolar re-modelling may begin during the second decade of life or it may be observed in elderly patients. The central marrow cavity is, however, obliterated and the basic pattern of perichondral and endochondral bone occurs throughout the ossicles except at the site of attachment of the ligaments and at the tip of the manubrium. The extent of the re-modelling varies and is manifest by the presence of tertiary lamellae and accompanying disruption of the primary pattern. Occasionally the malleus may show little evidence of re-modelling and can be mistaken for that of a young patient even though the patient may be in the seventh or eighth decade. The presence of cartilage in the zone beneath the periosteal layers may be taken to represent the foetal characteristic of the malleus. It is important to recognize these variations for lack of familiarity with the different types of bone which may normally be present in the ossicles may lead investigators to label these findings pathological and occasionally link these observations with otosclerosis.

Congenital Abnormalities

Livingstone (1965) on reviewing congenital abnormalities of the middle-ear cleft stated that the incus and malleus are usually found to be malformed in these conditions. These ossicles are frequently found to be fused together and may be attached to the bony wall of the cavity either individually or together. This author stated that the malleus is the most frequently malformed of the ossicles. Fig. 4 is a photomicrograph of a section taken from a temporal bone of a patient with congenital atresia and middle-ear anomalies. Examination of this temporal bone indicated that the area normally occupied by the external auditory canal was replaced by solid periosteal bone possessing normal lamellar structure. The head of the malleus was seen to be in contact with the anterior and lateral attic walls of the epitympanum, the epitympanic space being reduced in size. In other sections ankylosis of the head of the malleus to the body of the incus by a bridge of bone which replaced the normal articular surfaces was noted. A dehiscence of a large part of the bony wall of the Fallopian canal was also apparent.

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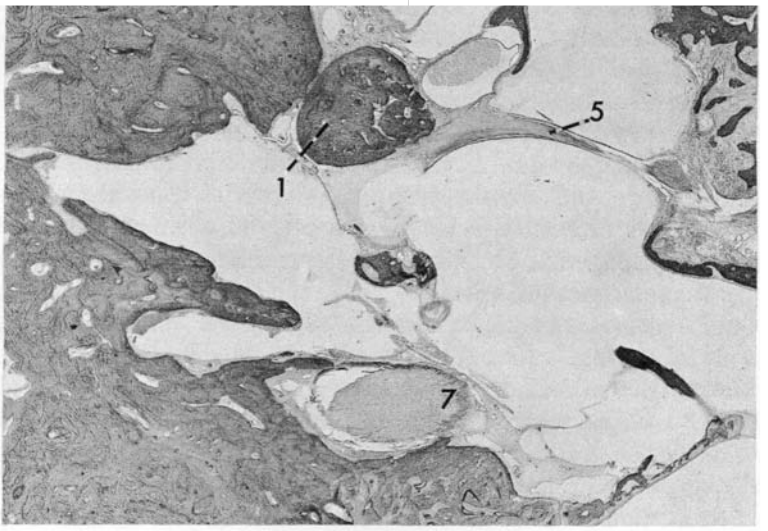


FIG. 4.
Head of malleus in contact with epitympanic wall.
(1) Malleus. (5) Tensor tympani tendon. (7) Dehiscence in bony wall of facial canal.

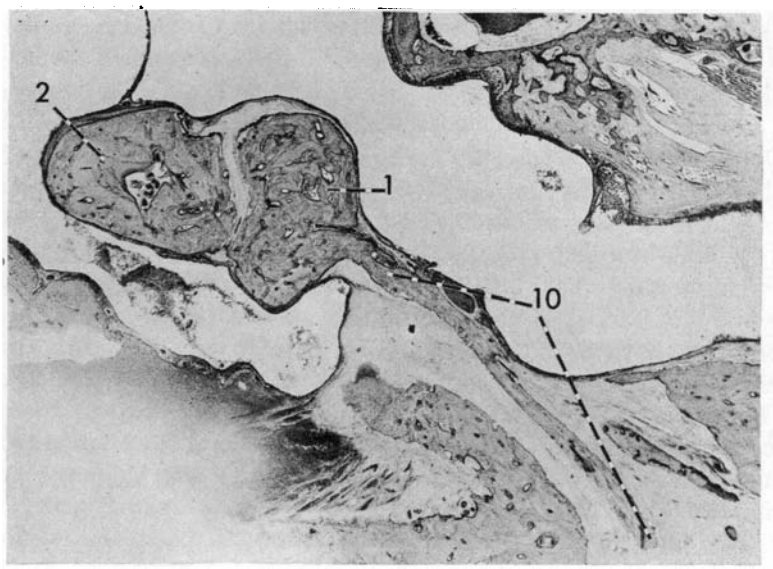


FIG. 5.
Elongated anterior process extending well into the Glaserian fissure.
(1) Malleus. (2) Incus. (10) Anterior process.

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Malleus Fixation

The only portion of the ossicles that does not exist as a cartilagenous model prior to ossification is the anterior process of the malleus. It appears as a spicule of membrane bone adjacent to the malleus and Meckel's cartilage. This processus longus or folianus in the human ear may reach a length of 3·5 mm. by the fifth month and ultimately reaches 6 mm. The anterior process later fuses with the malleus proper and is present in the Glaserian or anterior tympanic fissure. The process, always present at birth, becomes surrounded by the anterior ligament of the malleus and is greatly resorbed in later life. If it is assumed that the malleus and incus vibrate as a combined unit, rocking on a linear axis which runs from the anterior ligament of the malleus to the attachment of the short process of the incus in the fossa incudis, then it is likely that an extremely long anterior process extending well into the Glaserian fissure may well have some limiting effect on the free movement of the malleus. Fig. 5 illustrates a very long process surrounded by the ligament and extending well into the petrotympanic fissure.

Yates (1936) found in anatomical dissections of the ear that the superior ligament of the malleus varied in width in different specimens, being in some cases a thin narrow band while in others it was represented by two thin strands and yet in other temporal bones by a thread of mucosa which extended obliquely across the head of the malleus. The length of the fold varied. In some cases the heads of the mallei and incudes were almost in contact with the attic roof while in others a considerable gap was noted. The combination of a high malleus head and lack of full development of the epitympanum is likely to make this ossicle "at risk" to fixation as an aftermath of infection. Otto Mayer (1917) first noted hammer head ankylosis and suggested that in later life persistent mechanical irritation could cause a bony junction between the head of the malleus and the tegmen tympani and result in fixation.

Most temporal bone laboratories employ the horizontal cutting plane for the study of temporal bones and although it has many advantages, it is impossible to clearly assess the vertical relationship of the head of the malleus to the tegmen tympani. Nevertheless a good impression of the superior relations of the head of the malleus to the surrounding epitympanum can be obtained by examining the horizontal sections. Although many fine bony spurs protrude in a haphazard manner from the epitympanic walls towards the superior aspect of the malleus, a fairly constant projection was noted to extend from the lateral part of the anterior upper attic wall. The process was occasionally no more than a fine bony lamella just stopping short of the muco-periosteum of the ossicle and joined to it by the anterior mucosal fold. In other bones examined in the temporal bone collection at the Massachusetts Eye and Ear Infirmary the projection was much thicker and projected in an analogous manner to the antero-lateral aspect of the malleus head. Fig. 6 is a view of the

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FIG. 6.
Normal right temporal bone (J.M.) showing epitympanic projection.
(1) Malleus. (2) Incus. (11) Epitympanic projection.

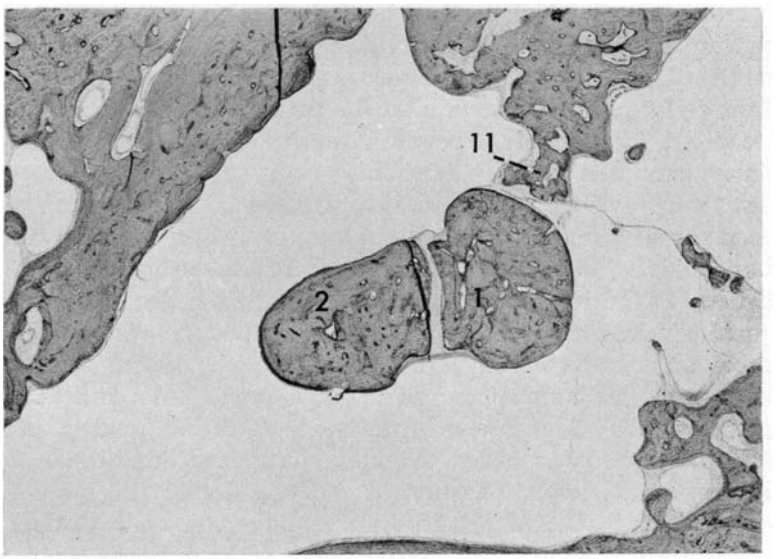


FIG. 7.
Normal left temporal bone (R.H.). A similar projection is seen to extend towards the malleus head.
(1) Malleus. (2) Incus. (11) Epitympanic projection.

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epitympanum from a normal right temporal bone (J.M.) while Fig. 7 indicates a similar bony projection from the attic region of a second temporal bone (R.H.). Both these spurs almost made contact with the malleus head and in the second temporal bone (R.H.) a fairly well developed anterior process (Fig. 8) was evident 2·4 mm. below the level of Fig. 7. Temporal bones removed from a patient (A.K.) with moderately severe Paget's disease were examined and it was interesting to find bilateral bony spurs, having the characteristic features of osteitis deformans, projecting from the anterior attic wall to lie in close proximity to the anterior aspect of the mallei heads. A photomicrograph (Fig. 9) from the left temporal bone illustrates this observation.

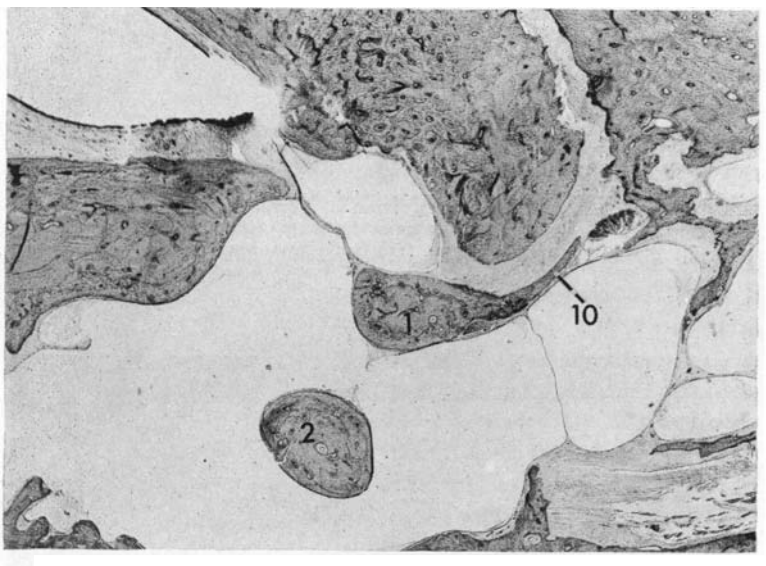


FIG. 8.

Another photomicrograph from the left temporal bone (R.H.). The plane of this section is 2·4 mm. below Fig. 7.
(1) Malleus. (2) Incus. (10) Anterior process.

Chronic Infection

The structure of the osseous part of the middle ear suffers considerable change in infection of this area (Friedmann, 1957). Whereas in the early stages of acute otitis media destructive processes are striving for supremacy, the regenerative efforts of bone soon begin to assert themselves. During the process of healing of diseased bone, new bone may be laid down by osteoblasts or by the accretion of calcium lining the edge of viable bone. As a result a rather amorphous structure known as osteoid may be produced and this may then be gradually modified with the result that

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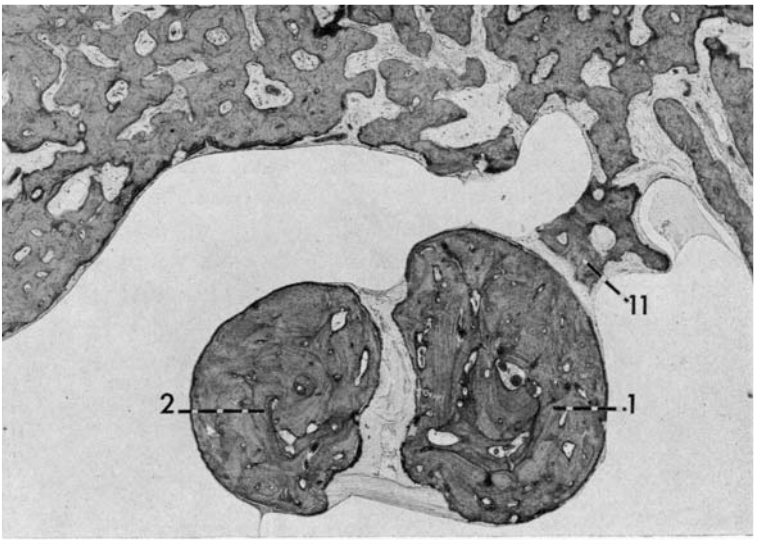


FIG. 9.

Left temporal bone (A.K.). Pagetic infiltration of bony bar extending from the lateral aspect of the anterior epitympanic wall.
(1) Malleus. (2) Incus. (11) Epitympanic projection.

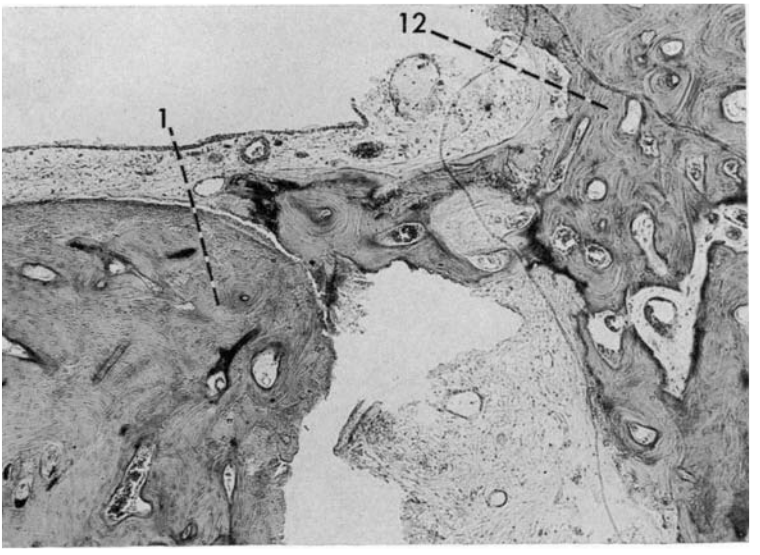


FIG. 10.

A newly formed bony projection, resulting from lamellar osteogenesis, is seen to stretch from the anterior aspect of the malleus head to the epitympanic wall.
(1) Malleus. (12) Epitympanic wall.

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the original configuration may be superseded by a more extensive deposition than normal. Osteophytic projections and an overall increase in size of the ossicles may result from lamellar osteogenesis as a result of periosteal osteoblast activity. In addition osteoblasts lining bone spaces cause obliteration of the spaces and osteosclerosis. Intra-membranous bone formation is less common than lamellar osteogenesis and arises from connective tissue replacing destroyed bone.

Fig. 10 illustrates an example of lamellar osteogenesis resulting in the formation of a bony projection stretching from the anterior aspect of the head of the malleus to the epitympanic wall. This newly-formed bone was more eosinophilic and formed lines of apposition, indicating previous bone absorption and bone reconstruction. There was some separation artifact of the new bone from the ossicular head due to the microtome cut. The architecturally irregular margin of new bone was surrounded with fibrous tissue and cells of chronic inflammation. This left temporal bone was taken from an 83-year-old woman (P.A.) with a known hearing loss for 23 years. The general findings in the rest of the temporal bone were characteristic of old healed otitis media and the mastoid was found to be densely sclerotic. Hilding (1965) reported a case of post-inflammatory fixation of the malleus head and Grippaudo (1958) has demonstrated concentric rings of new bone formation in the head of the malleus as a result of otitis media.

Case History

A female patient (M.C.) was first seen at the age of 62 years when she was found to have bilateral eczematous otitis externa. One year later she developed slowness of speech, dysphagia, dyslexia and visual field defects consistent with a lesion in the left temporal lobe. The diagnosis was thought to be Jacob-Creuzfeltd's disease. At this time she developed acute otitis media and a myringotomy was performed. The condition quickly resolved and at the age of 64 years, 2 months before her death, otological examination revealed a normal right tympanic membrane and a slightly retracted left drum with a posterior inferior scar. It is significant to note that the Rinne test was positive and the Weber test did not lateralize. The patient died of bronchial pneumonia and both temporal bones were removed for histological study. General examination of the horizontal serial sections revealed a fairly well pneumatized temporal bone. Post-mortem autolysis was of a moderate degree and some preparation artifact was found to invade the bony and membranous structures.

In the right ear most of the attic and antrum contained some loose fibrous tissue with some small and large round cells and a small number of blood vessels. Loose fibrous tissue partially enveloped the ossicles. A partly bony, partly fibrous band was seen to extend from the lateral aspect of the anterior epitympanic wall to the head of the malleus (Fig. 11).

In the left ear a bony bridge (Fig. 12) was seen to span from the head of the malleus so as to fix it to the lateral aspect of the anterior attic wall. The bodies of both incudes were in close apposition to the epitympanic wall and

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FIG. 11.

Section from a right temporal bone (N.C.). A partly bony, partly fibrous band extends from the lateral aspect of the anterior attic wall to the head of the malleus.

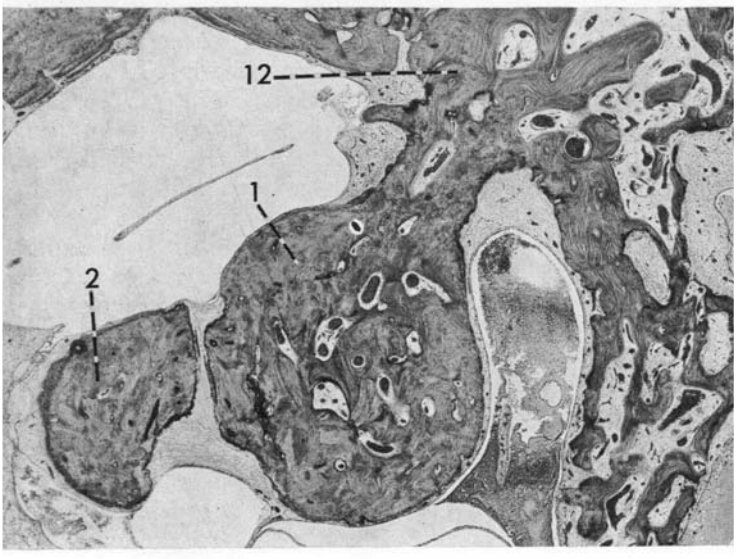


FIG. 12.

A section from the left temporal bone (N.C.). A bony bridge has fixed the malleus to the anterior epitympanic wall.
(1) Malleus. (2) Incus. (12) Epitympanic wall.

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supported by a thin layer of fibrous tissue. The findings in these temporal bones were of special interest as bilateral congenital anomalies were superimposed on pathological changes of old infection in the left ear, but with little impairment of sound transmission.

Bony Fixation of the Malleus with Associated Stapedial Otosclerosis

Guilford (1961), first noted bony fixation of the malleus head occurring with stapedial otosclerosis. In 1963 this author reported further cases and postulated that otosclerosis in one area could excite bone growth in another. However, no histo-pathological evidence was volunteered. Covell (1940), examined 46 temporal bones removed from patients suffering from otosclerosis and found, in one malleus head, areas of bone which were suggestive of otosclerosis. No evidence of malleus fixation was observed. In 1960 Dietzel claimed to have found an abnormally high position of the malleus "hammer head" in 10 out of 55 temporal bones with stapedial ankylosis. Altmann (1965) commented on Dietzel's observations and thought that, in the majority of cases, the high position of the malleus and incus was not caused by a congenital anomaly of its position but by stapedial ankylosis and a subsequent dislocation of the incus and malleus. Unilateral pressure exerted by the otosclerotic focus on the footplate resulted in it being subluxated into the vestibule or middle ear with a slight change in position of the capitulum and crura. Altmann mentioned that this ensuing malposition of the stapes produces a twisting of the malleus and incus with subsequent arthritic changes of varying degree in the joints. On examining 45 serially sectioned temporal bones from patients suffering from labyrinthine otosclerosis this author found arthritic alterations in the incudo-malleolar joint with lipping of the cartilage and some calcification within the intra-articular disc in one patient.

In an attempt to glean information on the malleus and incus in otosclerosis, 27 temporal bones from 18 patients in the histo-pathology laboratory at the Massachusetts' Eye and Ear Infirmary were examined. Special attention was paid to: (*a*) displacement of the footplate, (*b*) the incudomalleolar joints and (*c*) the relations of the ossicles to the surrounding epitympanic walls. Eight of the temporal bones examined revealed obvious displacement of the footplate out of the oval window as a result of "leverage" by the otosclerotic foci. Two footplates had their anterior edge tilted down into the vestibule while in the remainder the anterior margin was subluxated outwards into the middle ear by the pressure of the advancing otosclerotic lesion. In only one temporal bone was there any evidence of disorganization of the incudomalleolar joint, and only to the extent of deposition of two small calcified plaques in the joint interspace. One patient (G.L.) was of particular interest in that although the left footplate was slightly displaced out of the oval window, the malleus and incus was found to be normal as was the incudomalleolar joint.

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Even though the right footplate was hemmed in by otosclerosis, there was virtually no displacement from the oval window niche but, nevertheless, calcification of the hyaline cartilagenous interjoint disc was noted in the incudomalleolar joint (Fig. 13). No obvious stretching or distortion of the medial and lateral joint ligaments were noted. More superior sections revealed a bony bar extending from the anterior aspect of the head of the malleus to the lateral part of the anterior attic wall (Figs. 14 and 15). Layers of lamellar bone surrounded the large central marrow space and the bony bridge consisted of architecturally mature bone, although slightly more eosinophillic in colour. No increase in osteocytes was noted in this area and no definite junctional zone was seen. Once more it is worthy of note that the site of the bony fixation was in an analogous position in this specimen to the previously described examples of impinging projections and ankylosing spurs. One other temporal bone

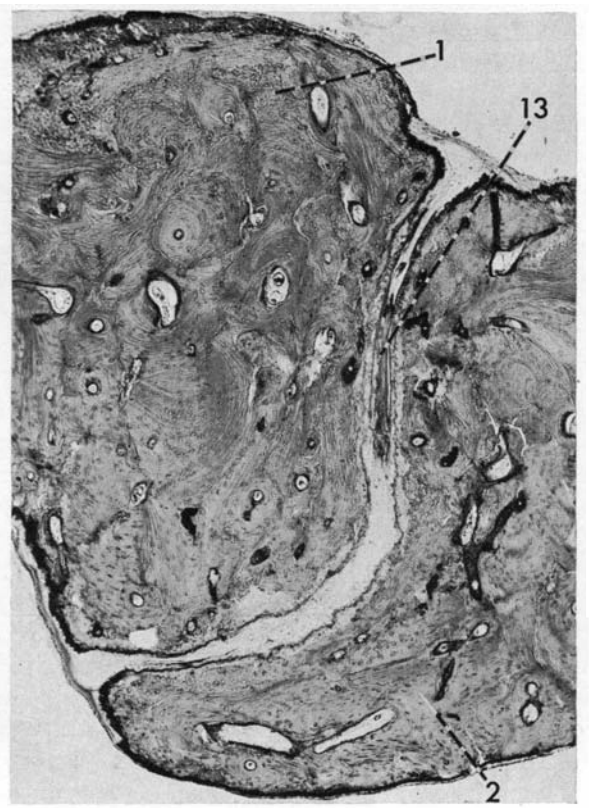


FIG. 13.
Calcification of the interjoint disc. Left temporal bone (G.L.).
(1) Malleus. (2) Incus. (13) Calcified disc.

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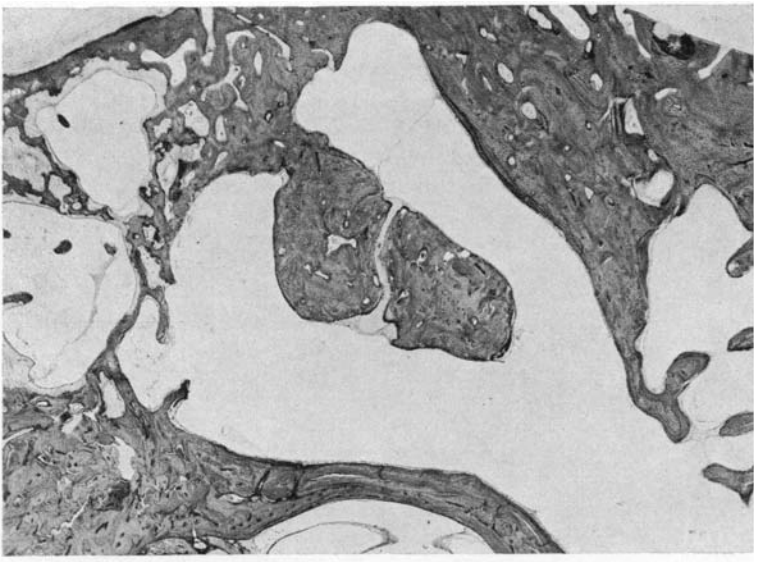


FIG. 14.

Right temporal bone (G.L.). Bony bar fixing the malleus to the lateral aspect of the anterior attic wall.

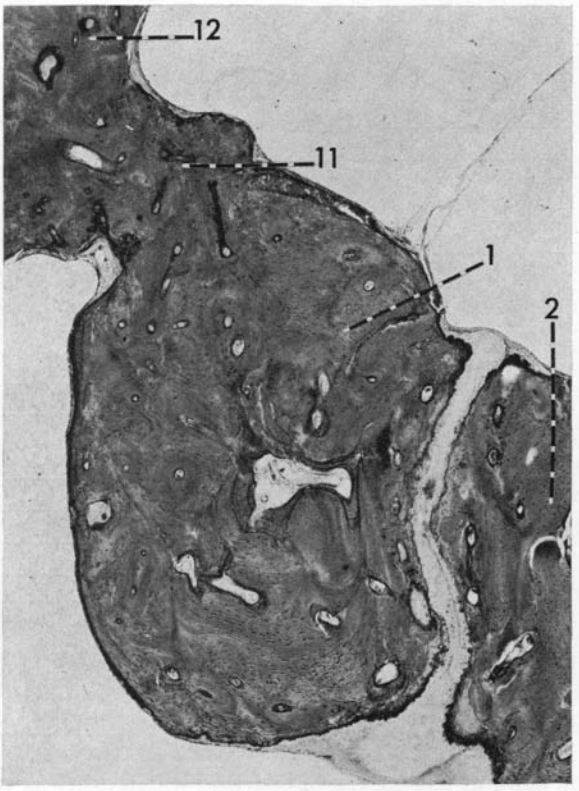


FIG. 15.

High-power view of Fig. 14.
(1) Malleus. (2) Incus. (11) Epitympanic projection. (12) Epitympanic wall.

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in this series from an otosclerotic patient was found to have a marked antero-lateral epitympanic finger-like bony process almost touching the malleus, but no evidence of true otosclerosis was noted in this or any other malleus under review.

Bony Fixation of the Malleus without Stapedial Otosclerosis

Case History

A 53-year-old man (C.M.) was admitted to a general medical ward at the Massachusetts General Hospital. An otological opinion was sought as the patient had noted very mild progressive deafness. On examination it was found that the tympanic membranes were intact and the Rinne tests were positive. Full audiometric assessment was not carried out. The patient later died of lung carcinoma and the left temporal bone was obtained for histological study. Examination of this revealed a well marked bar of bone extending from the anterior epitympanic wall and anchoring the superior aspect of the head of the malleus (Figs. 16 and 17). A definite junctional area was seen where the epitympanic outgrowth made contact with the ossicle head. The cyto-architecture of the rigid fixing bar appeared typical of normal periosteal bone.

Surgical Management

An impression of stiffness of the malleus handle can sometimes be obtained by using a well fitting pneumatic otoscope and assessing the excursion of the lateral process and handle of this ossicle. Although suspicion of malleus fixation should be aroused if a scar or a chalk plaque is evident in the tympanic membrane, palpation of the handle of the malleus should be as consistent a discipline as the routine inspection of the facial canal and round and oval window areas during exploratory tympanotomy.

If the malleus head is found to be fixed, the tympanomeatal flap can be enlarged by extending the superior incision anteriorly to just beyond the neck of the malleus. The incudostapedial joint should be dislocated and a needle introduced into the incudo-malleolar joint so as to disrupt and separate this joint. The incus can then be rotated out of the epitympanum by means of a right-angled hook. A good view of the head of the malleus should be obtained so that any bony bar extending from its anterior surface to the anterior epitympanic wall can be clearly assessed. Removal of bone, however, from the area of the tympanic notch should be limited so as to obviate the likelihood of retraction pockets developing later.

If the stapes is found to be mobile, the incus can usually be repositioned between the head of the stapes and handle of the malleus (Goodhill, 1966) after the neck of this latter ossicle and its ankylosing bar have been

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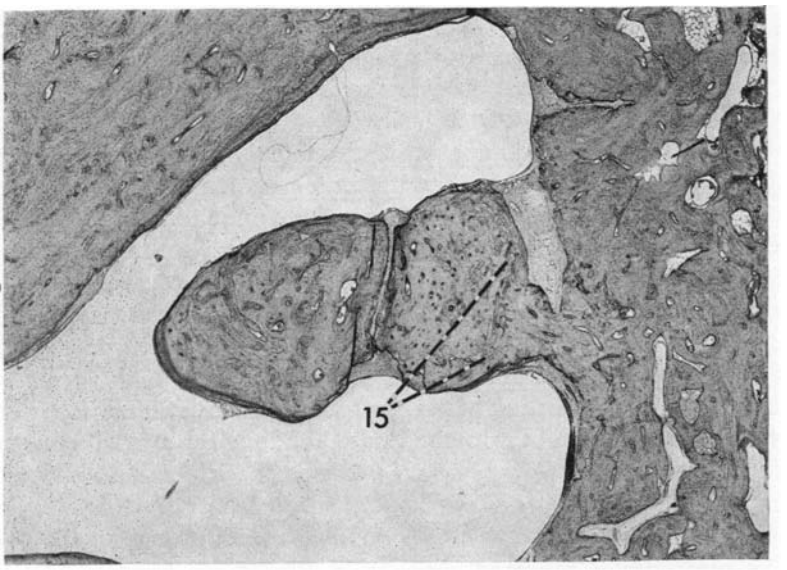


FIG. 16.
Left temporal bone (C.M.). A projection from the anterior wall of the epitympanum has extended into the malleus head.
(15) Junctional zone.

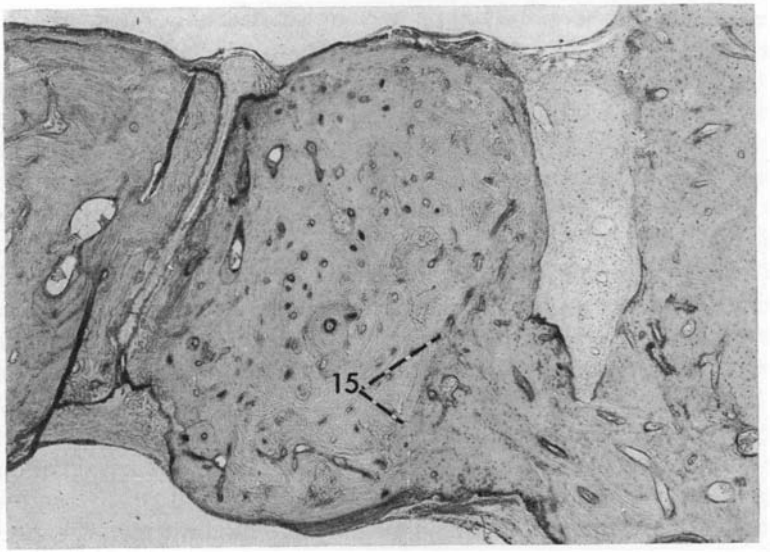


FIG. 17.
High power view of Fig. 16.
(15) Junctional zone.

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severed by means of a drill or malleus clippers, and then removed. If a fluctuating hearing loss, due to poor ossicular contact, should develop later a stapedectomy and malleus oval window prosthesis would be indicated.

Should stapedial fixation accompany malleus fixation, many methods of management are available. A wire prosthesis of the Sheehy or Schuknecht type can be inserted into a preformed tunnel on the handle of the malleus. The oval window can then be closed with gel-foam, fat or vein graft. Decapitating the malleus and severing its epitympanic bony attachment results in greatly increased mobility of the handle of this ossicle and so it is advantageous to attach the prosthesis to the manubrium before the head is removed.

No one method of dealing with the problem of malleus fixation is entirely satisfactory, and the best method based on long term results has yet to be determined.

Discussion

The majority of reported cases of malleus head fixation have been found in conjunction with stapedial fixation due to otosclerosis (Powers *et al.*, 1967; Sleeckx *et al.*, 1967; and Guilford and Anson, 1967). These investigators reported on ossicles or parts of ossicles removed at operation and so no histological examination could be made of the epitympanic attachment. Malleus head fixation can exist alone and in this form appears to produce only a mild conductive hearing loss. Two patients reported above illustrated this point.

It seems likely that an anterior epitympanic bony spur, not infrequently found to be a greater or lesser degree in normal temporal bones, sometimes just stops short and in other cases makes loose contact or lies in very close apposition to the malleus head. Partial failure of normal epitympanic expansion during development and poor absorption of bony spicules by the tympanic epithelium, as mentioned above, results in minute clearance between the ossicles and the surrounding attic wall. Thus the ossicles may be considered to be anatomically "at risk" to fixation. Developmental bony fixation of the malleus *per se* only accounts for a small number of cases and therefore extraneous factors must be involved. Infection, as we have seen, can undoubtedly convert a thin bony lamella, by the apposition of osteoid, into an anchoring bar. It is, however, interesting to note that osseous fixation of the malleus is regarded by Guilford and Anson (1967) to be a rare complication of chronic ear suppuration for they stated that they have only come across one instance of bony fixation of this ossicle due to inflammatory change.

The onset of a mild conduction deafness from 4 months to 4 years after successful stapedectomy has been reported (Sleeckx *et al.*, 1967) to be due to epitympanic fixation. It is conceivable that a thin bony anky-

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losing projection from the anterior epitympanic wall to the malleus may have been fractured by manipulation during the primary operation and a more massive re-fixation later ensued. Powers *et al.* (1967) stated that their earlier method of correction of bony fixation of the malleus consisted of malleolysis. The area of bony fixation was removed but long-term results indicated that re-fixation of the malleus head occurred if it was left *in situ*. It is also possible that bone dust or bone scrapings, from the use of curettes or drills could be deposited in the anterior epitympanum and serve to act as a focus for refixation. In view of this it would seem prudent to irrigate the middle ear with Ringer's solution to obviate the deposition of bone dust on the mucous membrane. The fixed malleus syndrome probably occurs more frequently than is realized but as the conduction hearing loss is mild, usually less than 24 db. in uncomplicated cases, some patients do not seek advice until a more profound hearing deficit—associated with otosclerosis—appears. Any cause of persistent mechanical irritation at the junction between a bony spur and the head of the malleus may result in new bone formation and cause a progressive hearing loss.

Although reports that otosclerosis can exist in the malleus are very sparse and inconclusive, biochemical differences have been noted between normal ossicles and the ossicles removed from patients with otosclerosis. Maurer (1961) found that ossicles from otosclerotics had a higher nitrogen and lower mineral and alkaline phosphatase content than those from normal ears. Soifer *et al.* (1967) observed that the protein extracted from the heads of mallei from individuals with clinical otosclerosis was 50 per cent. higher than the protein extracted from supposedly normal heads of mallei removed from cadavers.

Pathological changes in areas other than the otic capsule have been said to co-exist with labyrinthine otosclerosis. In 1964, Compere concluded, from radiological observations, that patients with diffuse otosclerotic lesions have a greater tendency to hyperostosis frontalis interna, calcification of the falx, calcification of the petroclinoid and interclinoid ligaments, calcification of the pineal body and choroid plexus and also the formation of exostosis. Nevertheless, it is hard to agree with these views as calcification in these areas is a fairly common occurrence. To obtain some idea of the frequency of calcification in the above named structures, an examination of 50 unselected consecutive skull X-rays were carried out by Du Boulay (1967) in the Radiology Department of St. Bartholomew's Hospital. It was found that calcification was present of the pineal body in 52 per cent. of skulls and the petroclinoid and/or interclinoid ligaments were calcified in 24 per cent. of patients in this series. Calcification in the habenula (18 per cent.), choroid plexus (16 per cent.) and falx (8 per cent.) was also noted. Parnitzke (1961) has stated that 40–50 per cent. of people over 20 years of age have pineal

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calcification. Stauffer *et al.* (1953) examined 285 "normal" skull X-rays and observed that 187 of these had calcification in the pineal body and in 40 skulls calcification was also present in the habenula.

Summary

The histopathology of congenital and acquired types of malleus fixation have been discussed. In normal temporal bones a fine bony spur was frequently found to extend from the lateral aspect of the anterior epitympanic wall towards the head of the malleus. If well developed this projection resulted in this ossicle being "at risk" to fixation.

When stapedial otosclerosis was found to accompany osseous fixation of the malleus no evidence of any otosclerotic changes were observed in the epitympanic ankylosing bony bar or in the head of the malleus.

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