# ELASTIC TISSUE IN THE MIDDLE-EAR CAVITY

By MICHAEL HARTY* (Cambridge)

THE study of elastic tissue has aroused considerable interest since it was first mentioned by von Haller in the middle of the eighteenth century. The hæmodynamic problems associated with vascular hypertension provided the greatest impetus to continue investigations in this field. Hass (1939) gave a detailed account of the distribution and changes of elastic tissue under physiological, pathological and senile conditions but made no comment of its presence in the middle-ear cavity. Davies (1948) summarized the previous descriptions of the elastic tissue components in the middle-ear joints and gave a very accurate account of its position in those articulations and in the tendons of the stapedius and tensor tympani muscles.

## Material and Methods

Twelve right temporal bones, removed from recent post-mortem bodies were segregated chronologically into three groups. In the first group the ages ranged from birth to twenty-eight years, in group two the age variation was from 47 to 56 years and the third group were aged between 78 and 84 years. All specimens were fixed in 10 per cent. formal saline and decalcified in 1½ per cent. nitric acid over a period of fourteen months. The lateral wall of the otic capsule was preserved as a scaffolding to support the middle-ear joints during celloidin embedding and section cutting. Orcein, which has a specific affinity for elastic fibres, was used to demonstrate the elastic tissue.

## Joints

The capsule of the synovial incudo-malleolar and incudo-stapedial joints is composed entirely of elastic tissue. At the joint margins the individual elastic fibres diverge to gain a very firm attachment to perichondrium and underlying cartilage (Figs. 1 and 2). In some areas the elastic fibres of the capsule blend with the adjacent periosteum and even reinforce this attachment by entering the penetrating periosteal canals.

The margin of the foramen ovale is attached to the footplate of the stapes by fibro-cartilage containing radially arranged elastic fibres which are condensed on the lateral aspect as the ligamentum orbiculare

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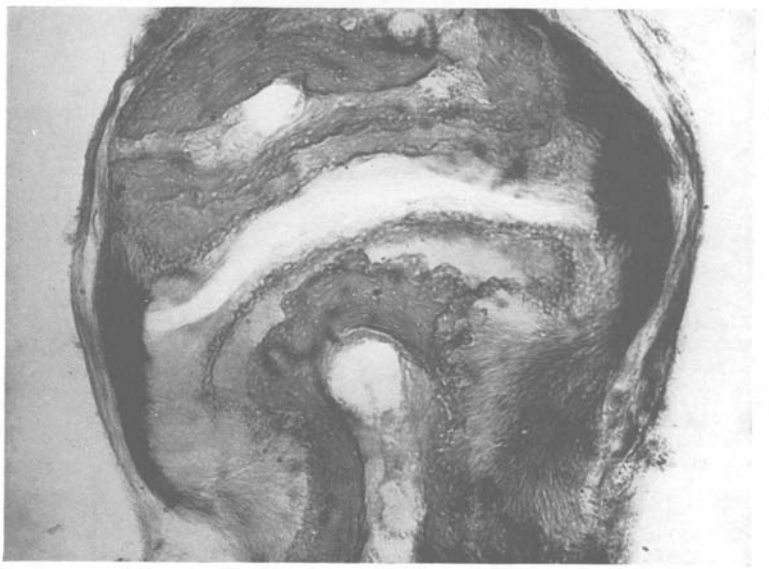


FIG. 1.

Male 28 years. Section of the incudo-stapedial joint. Elastic fibres appear black in the photographs. ×60.



FIG. 2.

Female 55 years. Coronal section of incudo-malleolar joint. Elastic fibres shown in capsule and accessory ligament. ×25.



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baseos stapedis tympanicum, and on the medial margin as the ligamentum orbiculare baseos stapedis vestibulare as described by Rudinger (Figs. 3 and 4).

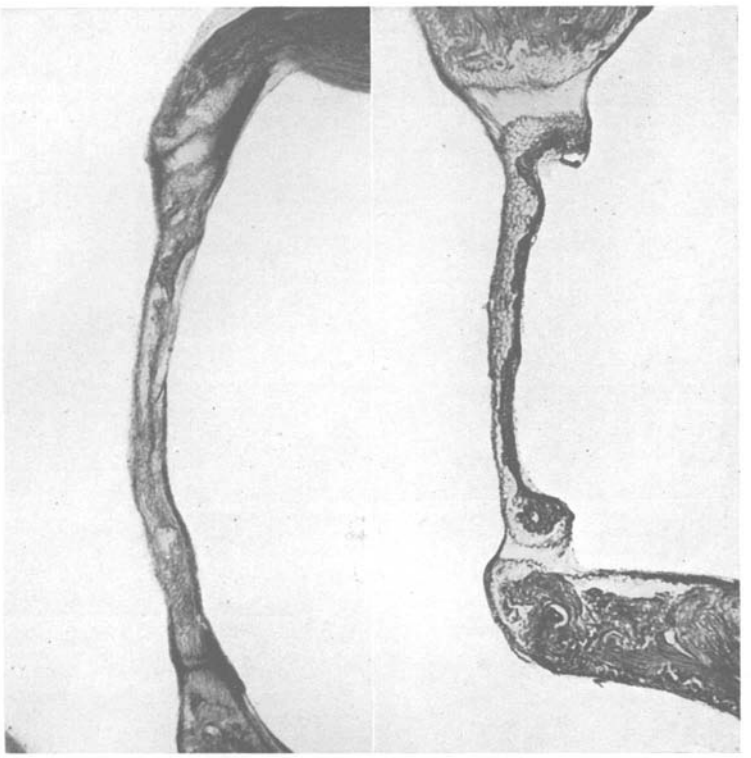


FIG. 3. FIG. 4.

FIG. 3.
Male 26 years. Section through footplate of stapes and adjacent foramen ovale. × 50.

FIG. 4.
Male 78 years. Similar section to Fig. 3, showing reduction in the quantity of elastic tissue. × 50.

The bony surfaces forming the joint between the short process of the incus and the fossa incudus, at the aditus ad antrum, have a covering of hyaline cartilage only where the bones are in actual contact. The surrounding capsule is again composed predominantly of elastic tissue covered by mucous membrane (Fig. 5).

### Tendons and Ligaments

Davies (1948) pointed out that the tendons of the stapedius and tensor tympani muscles are rich in elastic tissue. This is situated on the periphery of the tendons surrounding a central core of white fibrous tissue (Fig. 6).



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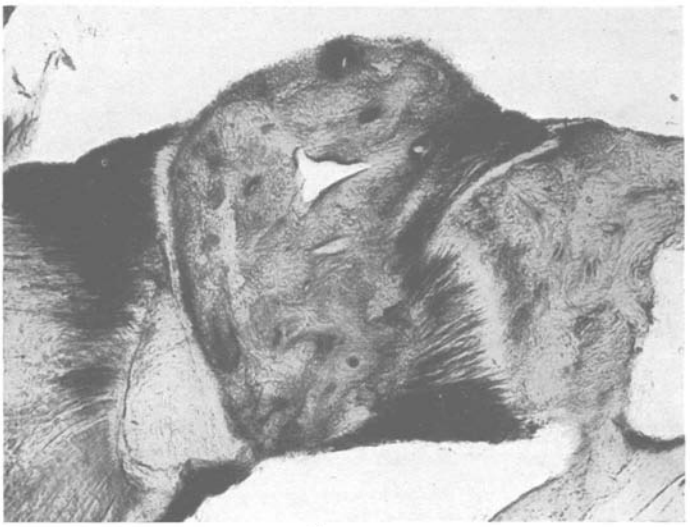


FIG. 5.
Male 25 years. Coronal section of posterior joint of incus in fossa incudus. × 50.

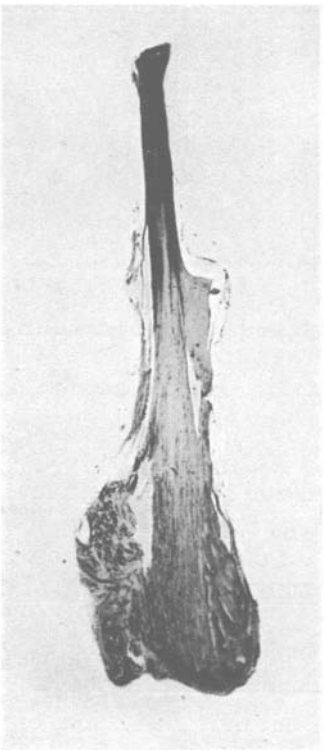


FIG. 6.
Male 51 years. Longitudinal section of stapedius muscle and tendon. × 25.



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Those elastic fibres have a diverse origin, some arise from muscle fibres, while others take origin from the adjacent periosteum, lining the pyramid or semi-canal for the tensor tympani.

The accessory ligaments of the auditory ossicles, which are really folds of mucous membrane, have a connective tissue core. This is composed of collagenous fibres containing scattered elastic bundles and small blood vessels (Fig. 2).

In the tympanic membrane the radially placed elastic fibres blend with the deeper connective tissue layer, but the elastin is concentrated peripherally by the annulus tympanicus and centrally around the handle of the malleus.

The secondary tympanic membrane, which closes the foramen rotundum is composed of three layers, an outer stratum of mucous membrane, an inner covering continuous with the cochlear lining, and an intermediate layer of connective tissue. The central portion of this intermediate layer is composed exclusively of elastic fibres while the peripheral margin consists of white fibrous tissue.

The elastic fibres in all those structures run a direct course as condensed skeins from their points of attachment. No evidence of cross fibres or fenestration, which is such a characteristic feature of the arterial wall, is noticed.

## Age Changes

Elastic tissue shows mesodermal differentiation at the fourth month of intra-uterine life. The reduced affinity for orcein stain is mentioned as evidence of age changes in elastic tissue, this is a difficult factor to interpret, although the elastic component in Figs. 3 and 4 shows a reduction in the older specimen. Fragmentation and splitting of the elastic fibres in the tendon of the stapedius muscle occurs as an age change (Fig. 8).

A marked feature of the infant tendon is the evidence of elastic recoil as shown by the wavy outline of both the elastic and white fibres (Fig. 7). Alteration in histological features does not always signify important changes in the functional capacity or structural integrity (Bramwell *et al.*, 1923) but from the evidence of senile changes in the vascular system we may assume that a similar process occurs in the elastic tissue of the middle-ear cavity.

## Discussion

Elastic tissue, and its intimate relation to smooth muscle, has been ascribed divers functions in physiology. The following are some of the suggestions which have been put forward:

(1) The dissemination of strains directed at an isolated point.
(2) The conservation of energy through partial maintenance of tone during relaxation of the muscular component.



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(3) The reduction of injury liability to the delicate middle-ear joints and membranes.
(4) The mechanical co-ordination of movements of individual units, and, in engineering parlance, the elimination of back-lash and chatter.

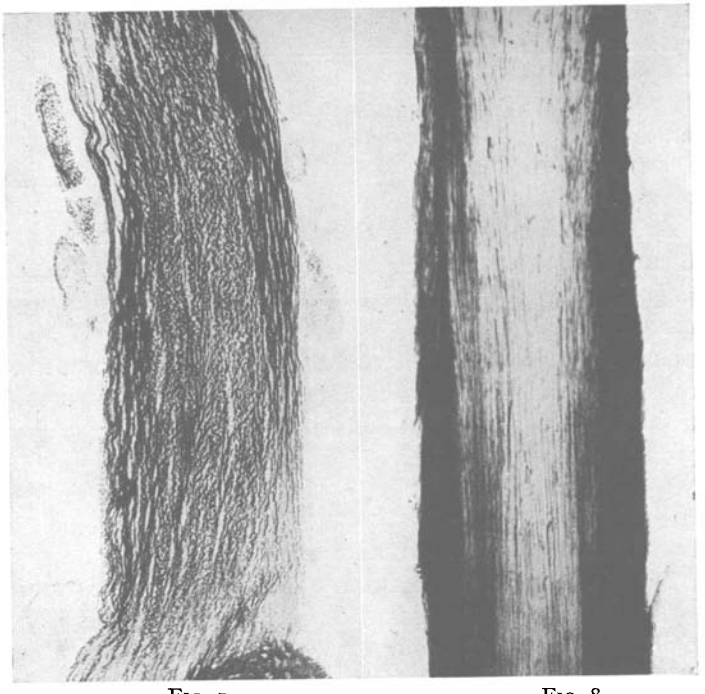


FIG. 7. FIG. 8.

FIG. 7.
Nine months fœtus. Tendon of stapedius in longitudinal section, showing wavy outline of fibres. × 300.

FIG. 8.
Female 51 years. Stapedius tendon with fragmented elastic fibres. × 300.

The elastic tissue in the muscle tendon converts sudden muscular contractions into a smooth even displacement at the interosseous joints. Unlike somatic muscles the stapedius possesses no antagonistic muscle group and any displacement must be corrected by elastic recoil.

In the ordinary synovial joints intra-articular contact is preserved by local muscle tone, this factor is absent in the middle-ear joint, but the joint tension is maintained efficiently by the elastic capsule.

The single auditory ossicle or columella of the lower reptile does not provide sufficient reinforcement of air conducted vibration for accurate hearing in the mammalian kingdom.



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# Elastic Tissue in the Middle-Ear Cavity

At mammalian levels the articulated auditory ossicles are a constant feature, and Nature's efforts to provide a single physiological unit is attained by the elastic capsule in the intervening joints.

The variations in the elastic tissue of the middle ear show the same evidence of age changes as are found in the other systems of the body.

Although senile deafness is predominantly of the perception variety, some conduction deafness is often found on closer examination. The pathology of the latter component may be explained by the changes in the elastic tissue of the joints and tendons.

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