

Original Research Article

A study on development of ear ossicles from prenatal to postnatal life of humans

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ABSTRACT

Background: Malleus, incus and stapes are the three ear ossicles present in middle ear. The auditory ossicles of the middle ear have a fundamental role in transmission of sound. The aim of this study was to determine development of ear ossicles from prenatal to postnatal life which will be of great help for an ENT surgeon who should be well conversant with the anatomical details of middle ear prior to undertake reconstruction procedures for the improvement of sound conduction in conductive deafness.

Methods: The study was conducted in 25 fetuses and 25 adult ossicles after removal from temporal bones of embalmed cadavers. Vernier caliper was used to measure different morphometric parameters to study growth and development of ossicles.

Results: Malleus: The average length of Malleus varies from 4 to 7.24mm in fetuses and adults respectively. The length of the anterior process was variable and some of the processes were quite long. Incus: The incus had minimum morphological variations in the ossicles. Its length ranges from 4.97-6.94mm. Stapes: The stapes had maximum morphological variations in the ossicles. The variations of stapes were in the neck, the crurae and the foot plate. The variations seen in stapes were no neck, a short or a long neck. The crurae of the stapes had symmetry or asymmetry. Length varies from 2.45-3.8mm.

Conclusions: Ossicles at 20 weeks of prenatal life were cartilaginous, and at 24 weeks they were ossified and surrounded by mesenchyme. Postnatal changes were minimal. These parameters of Ossicles will help in designing of implants and treating hearing loss.

Keywords: Adult, Development, Fetuses, Incus, Malleus, Stapes

INTRODUCTION

The middle ear ossicles or auditory ossicles are seen in tympanic cavity in humans. These are three very small bones named Malleus, Incus and Stapes. These ossicles form a chain across the tympanic cavity from the tympanic membrane to the fenestra vestibuli respectively.¹ Our knowledge about these ossicles helps us in surgeries to recover the ossicular chain pattern and advanced procedures like treatment of conductive deafness. Developmentally middle ear ossicles are of neural crest origin; i.e. crest cells are migrated from rhombomeres 1-4 in to the mesenchyme of 1st and 2nd

arch. Malleus develops from dorsal end of Meckel's cartilage. Incus develops from dorsal cartilage of 1st arch. The origin of stapes in human remains controversial. It is thought to be derived mainly from an analage situated in cranial end of cartilage of 2nd arch, initially as a ring.²

The ossicles of the middle ear are completely formed around the fifth month of foetal life.⁵ Since a long time extensive studies have been carried out on their morphology and anomalies.^{3,4} Postnatal development of middle ear ossicles contributes to the functional maturation of middle ear.² The middle ear cavity is seen in the petrous part of the temporal bone and is lined with

mucous membrane. Their function is to transmit the vibrations of the tympanic membrane (eardrum) to the perilymph of the internal ear. The malleus is the largest of the ossicles, and is shaped somewhat like a mallet. It has a head, neck, handle and anterior and lateral processes. Incus is shaped like an anvil from which it is named. It has a body and two processes. Stapes is also known as stirrup. It has a head, neck, two limbs and a base.² Most of the studies were done on adult ossicles. In this study we were studying growth in terms of length of ear ossicles from prenatal to postnatal life of humans.

METHODS

Material for the study comprised 25 fetal and 25 adult cadavers. This study was done in the Department of Anatomy, Andhra Medical College, Visakhapatnam, Andhra Pradesh, India. The fetuses were obtained from Obstetrics and Gynaecology Departments, KGH and VGH, Visakhapatnam. The adult cadavers were routine dissection cadavers of our Department. Mallet, chisel and forceps were used to remove the tegmen typani of petrous portion of temporal bone, bony fragment was removed to reveal middle ear cavity.

The ossicles were obtained from tympanic cavity. The measurements were made by vernier calipers. Photographs were taken and observations made.

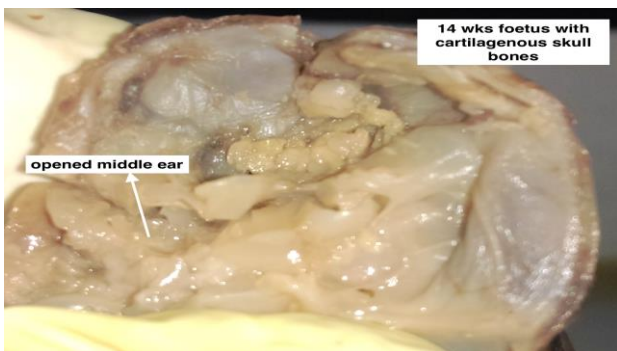


Figure 1: 14 weeks fetus.

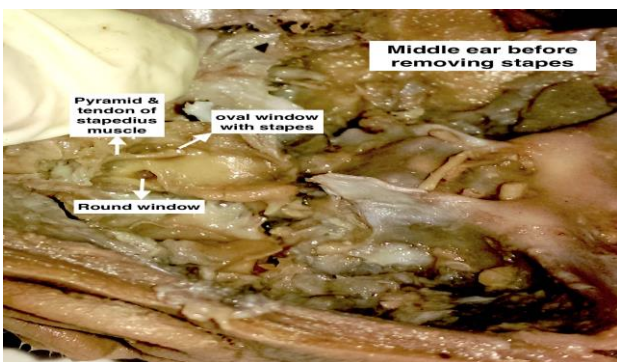


Figure 2: Middle ear cavity.

Gestational age of fetuses was determined by crown-rump length using following the formula which states:

For the first 5 months, age of fetus in lunar months = length of fetus in cm. For the last 5 months, age of fetus in lunar months = length of fetus/5.

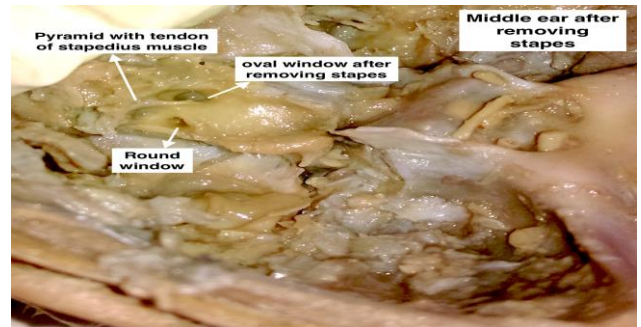


Figure 3: Pyramid in middle ear.

RESULTS

Malleus

The average length of Malleus varies from 4mm to 7.24mm in fetuses and adults respectively. The length of the anterior process was variable and some of the anterior processes were quite long. The length of manubrium ranges from 3.4mm to maximum of 7mm (Figure 4).

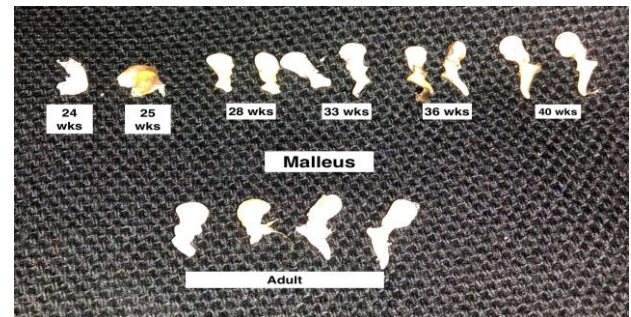


Figure 4: Malleus in fetuses and adults.

Incus

The incus had minimum morphological variations in the ossicles. Its length ranges from 4.97mm-6.94mm. It is the most stable bone which shows all adult features in foetal life (Figure 5).

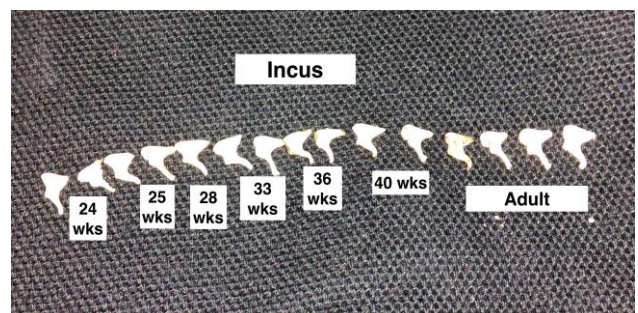


Figure 5: Incus in fetuses and adults.

Stapes

Stapes had maximum morphological variations in the middle ear ossicles. The variations of stapes were in the neck, the cruses and the foot plate. The variations seen in stapes neck were no neck, a short or a long neck. The cruses of the stapes had symmetry or asymmetry. Length varies from 2.45mm-3.8mm (Figure 6).

The Table shows that the values of malleus for length of ossicle and length of manubrium similarly for incus the values for length of ossicle and total width of ossicle are on the lower end in the present study (Table 1).

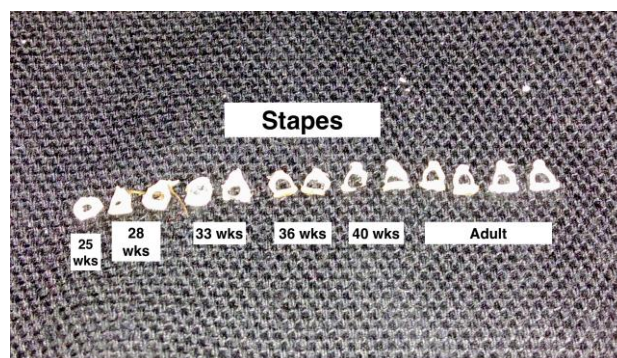


Figure 6: Stapes in fetuses and adults.

Table 1: Morphological variations in ear ossicles during different ages (mm).

Age in weeks	Length of malleus (mm)	Length of manubrium (mm)	Length of incus (mm)	Width of incus (mm)	Length of stapes (mm)	Width of foot plate of stapes (mm)
24	4.12	3.4	5.8	3.8	Not obtained	Not obtained
25	4	3.8	4.9	3.5	2.45	1.9
28	5.7	4.7	6.94	5.1	2.9	1.8
33	6.4	5.6	6.2	5.5	2.78	2.1
36	7.11	7	7	6.2	2.56	2.1
40	7.19	6.8	6.45	5.4	2.9	2
Adult	7.11-7.24	6.9-7	5.9-6.8	4.8-6.1	2.9-3.8	1.9-2.4

DISCUSSION

Anomalies and morphometric studies of ear ossicles were done in adults extensively than foetal ossicles. In present study at 14 weeks we found the skull bones were cartilaginous and could not find ear ossicles (Figure 1). And at 20 weeks the ear ossicles were seen but unable to pick as they were cartilaginous and embedded in mesenchyme. And at 24 weeks all the ossicles except stapes were obtained. And we observed gradual increase in length of the ossicles (Table 1) (Figure 4-6).

Literature in Dodds GS et al says ear ossicles begins to ossify during fifth month and by the time of birth have attained their adult size.⁶ As per Mossman, Boyd, Hamilton ossification of ossicles occurs in the cartilaginous malleus, incus and stapes in the fourth month of intrauterine life. These are the first bones to be fully ossified and to reach adult size.⁸

Thomas JB mentioned in his book, Introduction to human embryology, that in the fifth lunar month of pregnancy primary ossification continues to appear and fusion of the basocranium continues. Also ossification of the auditory ossicles occurs and ossification centers appear in otic capsule.⁹ These were in support of present study. But according to Minn RMHM et al developmentally all ossicles are of hyaline cartilage type, they all commence to ossify at the 12th week and at this stage the ossicles are

already almost in full adult size.⁷ This was contradictory to our study.

We observed ear ossicles embedded in mesenchyme in fetuses during all weeks. According to Saddler TW et al, although the ossicles appear during the first half of foetal life, they remain embedded in mesenchyme until eighth month.¹⁰ Migration of neural crest cells into mesenchyme produces maxillary and mandibular processes.¹¹ All the three ossicles are developed from the cartilaginous viscerocranium and appears from 7th week.¹² Few studies in the literature on individual differences in these ossicles and these studies were on either adult or embryo.^{13,14}

We studied both foetal and adult ossicular morphometry to know the dimensional differences and variation in the development of ear ossicles from fetus to adult. And this study showed that increase in size of fetal ossicles occurred evenly, with certain periods of most intensive growth. It has been reported that the anterior process was the longest process of malleus in foetal life and, this process shortened after birth.

In present study malleus length varies from 4mm to 7.24mm and manubrium length varies from 3.4mm to 7mm in fetuses and adults respectively. A long anterior process was seen to exist in newborns. Forward handle curve was also found in others study.¹⁵ In the present study, total length of malleus was found to be 7.24mm

which was in support to the study of Unur E et al.¹³ It was reported in the literature that the free ends of manibrium mallei curve slightly forward at a rate of 53-70%. We found it 26% in newborns and 50% in adults. Incus is the most stable bone during development in different weeks. It is the stable ossicle in variation.⁷

Developmental studies have shown that ear ossicles morphology and morphometry differ from person to person. Our study suggests that morphological variations in malleus could be having the different handle curves which were also suggested in the study of Unur E et al on fetal ear ossicles.

The incus had minimum morphological variations in the ossicles. Stapes shows higher variations out of all ossicles. Most of the variations were seen in neck, cruses and handle. Present study also showed the ossicles at birth is almost equal to adult's size and there are minimal modifications seen after birth which corresponds to the work of others study.¹⁶ However some studies discussed ossicular development continues after birth in their morphometry.¹⁷

CONCLUSION

In the present study, at 14 weeks of prenatal life skull bones were cartilaginous and ear ossicles were not seen. And at 20 weeks of intrauterine life the ear ossicles were seen. But could not be retrieved as they were cartilaginous and completely embedded in mesenchyme. At 24 weeks ossicles were available and they were embedded in mesenchyme.

In adults, morphometric changes were minimal. Out of the three ear ossicles, stapes showed maximum morphometric variations both in prenatal and postnatal life. Developmental study of ossicles is useful for advanced surgical procedures for treating conductive deafness and bone ossicular replacements or alignment.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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