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## RESEARCH ARTICLE

### A STUDY OF MORPHOLOGICAL AND MORPHOMETRICAL ANALYSIS OF HUMAN INCUS

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#### ABSTRACT

**Background:** The three minute bones in the middle ear, the malleus, incus and stapes form articulated chain across the tympanic cavity. Sclerosis, ankylosis or any disease of these ossicles cause immobilization and dissociation of the chain leading to impaired hearing. Increasingly otologic surgeons are performing surgeries for deafness like ossicular replacements and ossiculoplasty. A resultant achievement of good hearing following surgery is one of the greatest challenges to the otologists. Successful ossicular repair depends on precise dimensions of implants.

**Objectives:** To study the morphometric measurements and morphological features of Incus and compare the results with other studies.

**Material and Methods:** 50 formalin fixed human temporal bones were dissected to remove incus by dissection method. The bones were photographed and measured using software and weight of individual ossicles were taken and recorded.

**Results:** Incus showed few morphological variations.

**Conclusion:** The knowledge of variations of the ossicles and its morphometric data will help the otologist during reconstructive surgery and provide necessary information for the prosthesis designer

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#### INTRODUCTION

The knowledge of sound transmission started in the sixth century B.C, when Greek mathematician Pythagoras introduced the concept of sound as a vibration in the air. Seven centuries later, in 175 A.d., the Greek physician Galen recognized that the sensation of sound was transmitted to the brain via nerves. The gap in knowledge between Pythagoras's sound as air vibration and Galen's nerves transmitting sound to the brain was filled in 1543 by Andreas Vesalius a Belgian anatomist, who discovered the malleus and incus. Seven years later, in 1546, Ingrassias discovered the third ossicle, the stapes (Afifi 2005). The malleus, incus and stapes are the three little bones, which forms an articulated chain across the tympanic cavity. This chain of ossicles forms a series of levers by means of which the movements of tympanic membrane are transmitted through the footplate of stapes to the labyrinth any disease of these ossicles cause immobilization of the chain leading to hearing loss (Mcvay 1984). There are about 250 million people suffering from hearing loss globally according to WHO survey. In India, 5.9% of the population has disabling hearing impairment and large segments of these deaf in

developing countries requires hearing aids per year (Wadhwa, 2005). Conductive hearing loss may result from either discontinuity or fixation of the ossicular chain. In order of frequency discontinuity occurs because of an eroded incudostapedial joint, an absent incus, or an absent incus and stapes superstructure. To restore appropriate sound transmission, ossicular chain reconstruction as to be perform (Cruz, 1994). As technology and instrumentation have advanced otologic surgeons are performing surgeries like ossicular replacements, ossiculoplasty and cochlear implant surgeries (Wadhwa, 2005).

The ossicular chain reconstruction using ossicular grafts has improved hearing significantly. The various materials used for ossiculoplasty includes biologic and alloplastic and the ideal material for prosthesis should be easily available, inexpensive, non toxic, stable and easily insertable, is not extruded or absorbed and does not induce any foreign body reaction and obtain permanent and maximal possible restoration of hearing (Jha S and Kandakure). The present study was undertaken to observe the morphological and morphometrical details of the incus of Indian population and compare the results of Indian population with that of western population. These details might help the otologist performing surgeries and for the prosthesis designer for designing prosthesis more appropriately suited for Indian population.

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## MATERIALS AND METHODS

Fifty incus that is twenty five each from right and left side were extracted from formalin fixed temporal bones. Twenty three pairs were removed from adult cadaveric temporal bones of unknown sex. One pair was obtained from 6 month old female foetus and one pair from new born male cadaver. The collected ear ossicles were placed individually on a graph paper which was a guide for the measurement. A good quality digital photograph was taken; all the photographs were taken from the same height with ossicle placed in the similar attitude. The image was transferred to computer, magnified and measured using measuring tool in the soft ware- COREL-DRAW. Various parameters of the ossicles were measured and recorded

The following parameters were measured (Fig. 1)

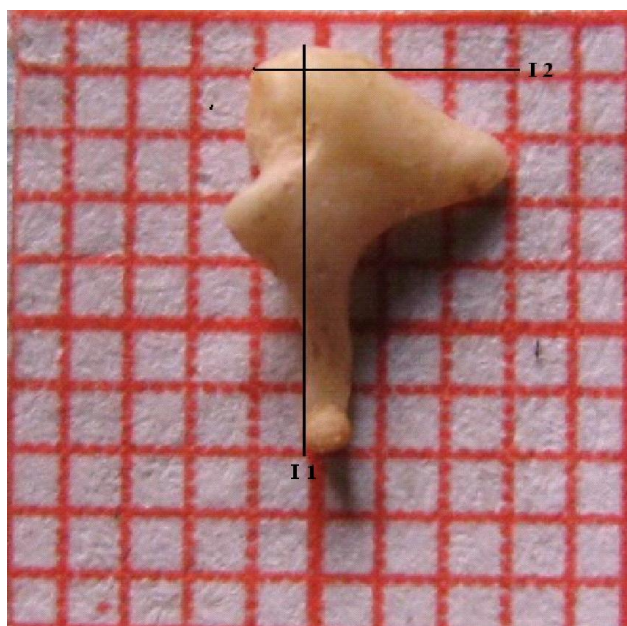


Fig. 1. Parameters measured on Incus

- I 1-Total length –distance between upper edge of the body and the end of the long process  
I 2-Width of the body- distance between the anterior end of the body and the end of short process

## OBSERVATIONS AND RESULTS

### Morphometrical observations

- The total length of the incus ranged from 5.46mm – 6.96mm with an average of 6.32mm on right side and 6.31mm on left side.
- The total width of the body ranged from 3.31mm – 4.96mm, with an average of 4.38mm on right side and 4.43mm on left side.
- The weight of the incus ranged from 11.10mg – 33.70 mg, with an average of 23.25mg on right side and 24.39mg on left side.
- There was no significant difference between right and left side on comparing the parameters.

Table 1. Statistical analysis of Incus (total- both sides)

Total ( Incus)	Total Length	Total width of the body	Weight
N	50	50	50
Mean	6.3208	4.4132	23.8220
Standard Deviation	.33887	.35502	4.70108
Range	1.50	1.65	22.60
Minimum	5.46	3.31	11.10
Maximum	6.96	4.96	33.70

### Morphological observations

- The two incus was showing thin and straight long process (Fig. 2).

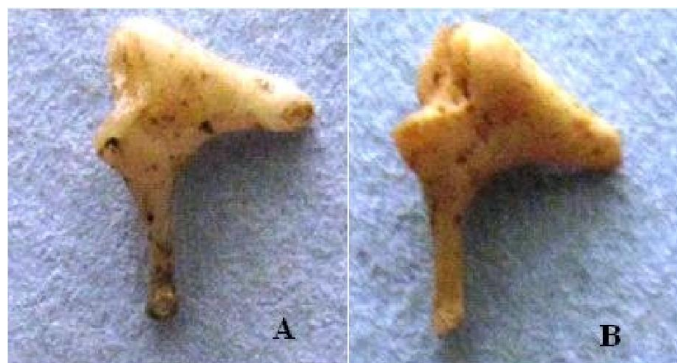


Fig. 2. Thin and straight long process of Incus

## DISCUSSION

Remarkable changes in the development of auditory system have occurred in number of vertebrates during the process of evolution. In Lower vertebrates there is presence of only one auditory ossicle called columella, but in mammal's three ossicles appear which provide them a special mechanical system capable of transmitting sound pressure from air to cochlear liquid which is the most effective gear in mammals (Solntseva 2013). Lempert, Wolff and Wolff, Belluci in their two different studies have reported a series of cases of otosclerosis and thought that a focus of otosclerosis occurred constantly on the inferior surface of the short process of incus and observed the notch being lined by cartilage and the posterior incudal ligament attached to its depth (Lempert & Wolff). Uner, Ulger and Ekinci in their morphometric analysis on 40 sets of ear ossicles from new born cadavers have observed the similar values as compared to adults. These values suggest that the ossicles complete morphometric development in foetal life. Morphologically incus was most stable among all the ossicles. These ossicles can be stored in ossicular bank and can be used as homografts to replace eroded middle ear ossicles in adults (Uner, 2002).

The morphometric study done on seventeen normal incus specimens using scanning electron microscope demonstrated the progressive and symmetric resorption of the long process and lenticular process with advancing age and this is attributed to its irregular and tenuous blood supply and biomechanical factors and concluded that human incus changes throughout life in a predictable, symmetrical and sex related ways (Lanningan 1995). Wehrs reported bilateral congenital absence of the incus in three successive generations of one family. They were operated for hearing impairment since birth

with no history of ear infections, with normal appearing tympanic membrane. The operative findings were identical that there was congenital absence of long process of incus and capitulum of the stapes. All three had improvement in hearing with ossicular reconstruction. The defect was found to be an inherited trait either due to autosomal dominant mutation or X-linked dominant inheritance (Wehrs 1999).

**Table 2. Comparison of morphometry of Incus with other studies**

Authors	Total length	Total width
Unur, Ulger & Ekinci	6.5 mm	4.9 mm
Latha p <i>et al</i>	5.7 mm	4.0 mm
Padmini <i>et al</i> ,	5.1 mm	3.4 mm
Present Study	6.3 mm	4.4 mm

In an another case of congenital absence of incus was reported in a 3 year old boy who was referred to otolaryngologic clinic for diminished hearing and significant speech and language delay, on middle ear exploration there was complete ossicular chain discontinuity with malleus and stapes were found to be intact with absent incus bilaterally (Rahbar 2002). The usage of incus homograft is satisfactory in various types of reconstructive surgeries. The transplantation of ossicle homografts are accepted by both middle and inner ear of human with no evidence of extrusion or adverse reactions with improvement in hearing Ossicular bone banks to supply ossicular homografts for reconstruction are feasible and may be established in various centers throughout the country (Hildyard VH 1967). A precise measurement of ossicle is essential for designing middle ear implants. The morphological and morphometrical data will help otologic surgeons in reconstructive procedures and also provide necessary informations for prosthesis designer to design accurate prosthesis suitable fit Indian population. Comparison of morphometric data among the authors is done. Due to lack of requisite data few parameters could not be compared.

Disparities in morphometric values and morphological observations of ear ossicles in different studies can be explained either by difference in the number of specimens studied by the definition adopted for anatomical variants or by the methodology of analysis.

### Conclusion

The study was undertaken on 25 pairs of incus which were extracted from formalin fixed temporal bones. The anatomical details of the ossicles and its relationship with other structures need to be known thoroughly during reconstructive surgeries. This will help the surgeons to perform microsurgical maneuvers and manipulations in a limited working space available in the ear. Its architecture & morphometry have surgical implications on the techniques designed to mobilize it. The data on dimensions of incus may have a bearing in designing prosthesis more appropriately suited for Indian population. Successful ossicular repair remains a challenge and this success depends on the precise dimensions of implants.

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