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A STUDY OF MORPHOMETRICAL ANALYSIS OF HUMAN INCUS USING CADAVERS

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ABSTRACT

The three auditory ossicles in the middle ear; the malleus, incus and stapes forms an articulated chain across the tympanic cavity. Congenital malformations, Sclerosis, ankylosis or any disease of these ossicles causes immobilization and dissociation of the chain leading to hearing loss. Surgeons are performing surgeries for deafness like ossicular replacements and ossiculoplasty. This study is aimed at determining the morphometric dimensions of Incus in cadaveric specimen. The study was carried out on 70 incus (R= 34, L=36), which were collected from 57 adult male cadavers. The various measurements parameters were taken with the help of digital Vernier caliper and weighed with mettler Toledo weighing balance. Results revealed no statistical significant difference ($p > 0.05$) between morphometric measurements of the bone of right and left side. The knowledge of the morphometric data will help the otologic surgeon during reconstructive surgery and provide necessary information for the prosthesis design.

KEYWORDS: Incus, Ossiculoplasty, Middle Ear.

INTRODUCTION

The malleus, incus and stapes are the three miniature bones, which forms an articulated chain across the tympanic cavity. This chain of ossicles forms a series of levers of which the movements of tympanic membrane are transmitted through the footplate of stapes to the labyrinth, any disease of these ossicles can cause immobilization of the chain leading to hearing loss.[1] There are over 5% of the world population (430 million) who require rehabilitation to address their disabling hearing loss (432 million adults and 34 million children). W.H.O estimated that by 2050, 2.5 billion people worldwide or one in four people will be living with some degree of hearing loss [2]. Nearly 80% of people with disabling hearing loss live in low and middle-income countries. Nigeria with the largest population in Africa falls into the category of low and middle-income countries.[2] Therefore, Nigeria needs more than 32 million hearing aids per year.[2]

Conductive hearing loss may result from either discontinuity or fixation of the ossicular chain. Frequent discontinuity occurs because of an eroded incudostapedial joint, an absent incus, and stapes superstructure. To restore appropriate sound transmission, ossicular chain reconstruction has to be performed.[3] As technology and instrumentation have advanced, otologic surgeons are performing surgeries like ossicular replacements, ossiculoplasty and cochlear implant surgeries.[4]

The ossicular chain reconstruction using ossicular grafts has improved hearing significantly. The various materials used for ossiculoplasty includes homograft and alloplastic materials.[5] The present study is aimed at observing the morphometrical details of the incus of Nigerian population and compare the results with that of other population. These details might help the otologist performing surgeries and for the prosthesis designer for designing prosthesis more appropriately suited for Nigerian population.

MATERIALS AND METHOD

The study was carried out on 70 incus (R= 34, L=36), from 57 unidentified adult male cadavers from the Department of Anatomy of various Universities in Nigeria.

The ossicles were procured manually after dissection of the petrous part of temporal bone using Cobbler's Cut Method.[6,7] The head of the cadavers were first detached from their bodies using handsaw for easy maneuvering then the calvaria was removed and the brain taken out to expose the petrous part of the temporal bone. The temporal bone were cleared off of all the soft tissues attached to it including the mastoid processes. Removal of the intact temporal bone from the skull was done by

opening the zygomatic-temporal suture using a chisel.[6] The chisel was placed through the parieto-temporal suture and pushed on the lateral side making the temporal bone relieved from the skull. The temporal bone were placed in an upright position with the squamous part as its base and the petrous part as apex. The chisel was placed between the squamous part and the petrous part of the bone and tapped gently with a hammer till the time there appears a crack (cobbler's cut) in between the two parts of the temporal bone.

Then with precise and gentle manual force these two portions were easily separated in two unequal halves of the middle ear; the lateral and medial parts. The lateral part bears the tympanic membrane and two ossicles (malleus and incus) while the medial part with an oblique wall bearing the third middle ear bone (stapes). The incus were easily picked up from the exposed parts with fine forceps. The bones were cleansed and dried. They were stored into plastic bags with labels indicating the sides. Measurements were taken with the help of digital Vernier caliper with the least count of 0.01 mm. Each bone was weighed on the mettler Toledo weighing balance.

Figure 1: Diagram showing harvested Incus.

Measurements of Incus

- Total length (TL): maximal distance between the superior edge of the body and the end of the long process (mm)
- Total width (TW): maximal distance between the superior edge of the body and the end of the short process (mm)
- Maximal distance (MD) between the tips of the processes (mm)
- Total height (TH): maximum height of incus (mm)
- Index (I): Total width X 100/ total length of incus (%)
- Weight of Incus (W mg)

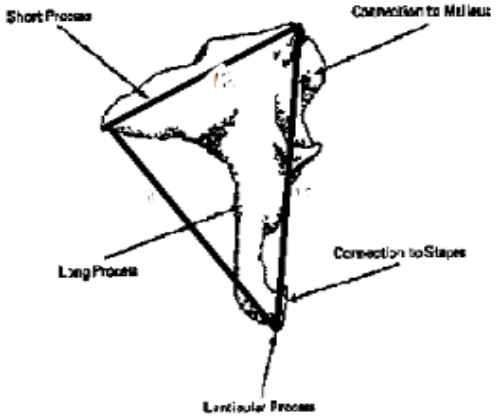

Fig 2: Diagram showing various measurements of Incus (Sodhi et al. 2017).

The data was statistically analyzed using SPSS software version 20.

RESULTS

The results of this study are presented in the tables below.

Table 1: Table showing the Descriptive analysis of Incus (n= R (34), L (36).

	MEAN ± SD (RIGHT)	MEAN ± SD (LEFT)
Total Length (mm)	6.75 ± 0.17	6.72 ± 0.14
Total Width (mm)	4.10 ± 0.23	4.18 ± 0.17
Two processes Distance (mm)	6.10 ± 0.20	6.00 ± 0.18
Total Height (mm)	2.24 ± 0.11	2.26 ± 0.11
Weight (mg)	27.00 ± 0.27	27.10 ± 0.26
Index (%)	61.00 ± 3.75	62.40 ± 3.65

There was no statistical difference ($p > 0.05$) observed when all the morphometric data of malleus were compared in terms of sides (right and left).

Table 2: Table showing the Comparison between morphometric data of Incus with previous studies.

Author	Population	Sample size	Mean of Total Length	Mean of Total Width	Mean of Distance between two processes	Weight	Index
Harneja (1973)[8]	Jaipur	50	3.14	1.82	--	25.06	--
Arrensburg (1981)[9]	Israel	22	6.4	5.1	--	--	80.1
Unur (2002)[10]	Turkey	40	6.47	4.88	6.12	--	79.84
Natekar (2006)[11]	Goa	--	6.52	5.06	5.86	20.74	--
Jyoti (2015)[12]	Mysore	50	6.32	4.41	--	23.82	--
Gulrez (2013)[13]	Aligarh	30	6.38	4.60	--	--	--
Padmani (2014)[14]	AP	100	5.13	3.47	4.5	--	67.75
Mogra (2015)[15]	Rajasthan	66	7.26	5.95	6.80	--	82.41
Singh (2016)[16]	Rohtak	120	6.67	5.04	6.01	26.30	75.71
Sodhi (2017)[17]	North India	100	6.47	4.88	5.31	23.88	75.45
Present Study	Nigeria	70	6.73	4.14	6.05	27.05	61.7

DISCUSSION

The ear ossicles were first described in 16th century. The report of Hast and Garrisson[18] stated that Vesalius described incus and malleus in 1543 in his monumental work "De Humani Corporis Fabrica" (the fabric of the human body), whereas Ingrassia and Eustachius[19] were the first to describe Stapes in 1546.[19,20] Eustachi Bartolomeo granted to be the founder of Descriptive Anatomy. The Greek Alcmaion (5th century BC), anatomist, philosopher and apprentice of Pythagoras have written the acclaimed first Medical book "Concerning Nature" in which fragments have been saved and have described the eustachian tube and perhaps the "traversing by a chain of small bones" of the middle ear whilst others consider that he believed that the external sound is picked up by empty space in the inner ear.[21]

These bones attain full adult size during fetal life but continues to undergo changes throughout life, so the variations of the size and morphology of these bones are expected.[22]

However, there are few studies in the literature on individual differences in these ossicles that are reported from the different regions of the world and these studies were on either adult or different species. There is paucity of data regarding the morphometry of incus among Nigerian population.

The mean weight of incus obtained from this study was higher with the reports from Harneja & Chaturvedi[8]; Natekar & Souza[11]; Jyoti & Shama[12]; Singh[16], and Sodhi.[17] The values they obtained were 25.06mg; 20.74mg; 23.82mg; 26.30mg and 23.88mg respectively.

The mean total length of incus from this present study was similar with the report from Natekar & Souza[11], it was shown to be 6.52mm. It was also in agreement with the works from Unur[10]; Mogra[15]; Singh[16] and Sodhi[17]; their values were shown to be 6.47mm, 7.26mm, 6.67mm and 6.47mm respectively.

Furthermore, the mean total width of the incus from this present study was in agreement with the work of Jyoti & Shama[12], whose value was 4.41mm. It was also similar with the report from Gulrez[13], his value obtained was 4.60mm while it was in contrast with the reports from Unur[10]; Natekar & Souza[11]; Mogra[15]; Singh[16] and Sodhi[17], they showed their values to be 4.88mm, 5.06mm, 5.95mm, 5.04mm and 4.88mm respectively.

When compared previous studies with different regions (Table 2), the dimensions of the values obtained in incus were almost identical to Rohtak and Aligarrh populations (both in the city of India). The dimensions were again at higher side to that of Rajasthan, Goa, Turkey and Israel Subjects and at lower level to North India and Andhra Pradesh populations.

The morphometric values of right and left incus was compared, the differences ($p > 0.05$) was not statistically significant. The incus attain their maximal size in fetal life, however, their development continue after birth and their weight and size increase. This results in variations seen in their measurements when compared with previous studies. The study also confirms that the adult bones show marked morphometric variations which may be due to racial differences.

CONCLUSION

The incus is morphometrically similar in both ears. There was no significant difference in left and right side. The anatomical details of the incus 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 Nigerian population. Successful ossicular repair remains a challenge and the success depends on the precise dimensions of implants. The incus showed great variety and complexity in measurements as well as in morphology taken from all researchers. The harvested incus should be preserved in ossicular banks following proper sterilization method for future use as homografts in ossiculoplasty, they may also be used to replace

eroded incus as an alternative to manufactured prosthesis.

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