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Morphometric Dimensions of Malleus in Male Cadavers

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ABSTRACT
The auditory ossicles; malleus, incus and stapes transfer sound vibrations in the tympanic membrane from the middle ear to the inner ear. These ossicles are located in the petrous part of the temporal bone and they form a chain across the tympanic cavity from tympanic membrane. This study is aimed at providing the anatomical details of the malleus in Nigerian male Population. The study was carried out on 94 Malleus (R= 44, L=50), 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. The result showed no statistical significant difference ($p > 0.05$) between morphometric measurements of the bone of right and left side. The mean weight of the malleus was 22.05mg, the mean total length was 8.05mm, mean length of the manubrium was 4.95mm and the mean of head and neck was 5.00mm. The precise measurements of the malleus among male Nigerian Population will be very helpful in designing the prosthesis in ossiculoplasty in Nigeria.

Keywords: Malleus, Otology, Measurements

INTRODUCTION
The tympanic cavity contains a chain of three movable auditory ossicles in humans – Malleus, Incus and Stapes[1, 2]. These ossicles form a chain across the tympanic cavity from tympanic membrane to fenestra vestibule[3, 4]. These bones are bound together by articulations and have ligamentous connections with the walls of middle ear cavity[5]. These ossicles transmit sound vibrations smoothly from the tympanic membrane and amplify them towards the surface of oval window[6, 7]. Many congenital malformations of the middle ear ossicles have been reported to cause hearing problems[8,9,10,11].

Globally, 5% of the world population (430 million) needs to address their disabling hearing loss (432 million adults and 34 million children). W.H.O assessed that by 2050, 2.5 billion people worldwide or one in four people will be living with some degree of hearing loss[12]. Nearly 80% of people with disabling hearing loss live in low and middle-income countries. Nigeria falls into the category of low and middle-income countries[12]. Therefore, Nigeria needs more than 32 million hearing aids per year[12].

The ossicular chain reconstruction by the otolaryngologists can bring a significant improvement in conductive hearing loses due to ossicular erosion[13,14]. The materials used in reconstruction of ossicular chain are autografts, homografts and allografts[15, 16, 17]. To achieve good postoperative results in patients who require middle ear surgery, the otologic surgeons need to be fully conversant with the anatomical details of the ossicles of the middle ear[18]. The study is aimed at providing the dimensions of malleus in Nigeria Population for designing and constructing the implants by using their precise measurements.

MATERIALS AND METHODS
The study was carried out on 94 malleus (R= 44, L=50), from 57 unidentified adult male cadavers from the Department of Anatomy of various Universities in Nigeria.

The ossicles were obtained manually after dissection of the petrous part of temporal bone using Cobbler's Cut Method[19]. The head of the cadavers were cut off from their bodies using handsaw then the calvaria were removed and the brain taken out to expose the petrous part of the temporal bone. All the soft tissues attached to the temporal bone were cleansed including the mastoid processes. The chisel was then used to open the zygomatic-temporal suture so as to remove the intact temporal bone from the skull[20]. The chisel was placed through the parieto-temporal suture and approached laterally thereby, making the temporal bone released from the skull. The temporal bone were situated in an upright position with squamous part as its bottom and the petrous part as its peak. The chisel was placed between the squamous part and the petrous part of the bone and smashed gently with a hammer till the time there appears a crack (cobbler's cut) in between the two parts of the temporal bone.

The two portions were easily separated into two unequal halves of the middle ear with precise and gentle manual force; the lateral and medial parts. The lateral part bears the tympanic membrane and two ossicles (malleus and incus) while the medial part bears the third middle ear bone (stapes). The malleus were easily harvested from the exposed parts with fine forceps. The bones were cleansed, dried and preserved in a 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 Malleus

Measurements of Malleus

- Total length (TL): maximum distance between top of the head and the end of the manubrium (mm)
- Length of manubrium (LM): distance from the end of the lateral process to the end of manubrium (mm)
- Length of head and neck (LHN): maximal distance between the top of the head and the end of the lateral process (mm)
- Index (I): length of manubrium x 100/ total length (%)
- Weight of Malleus (W mg)

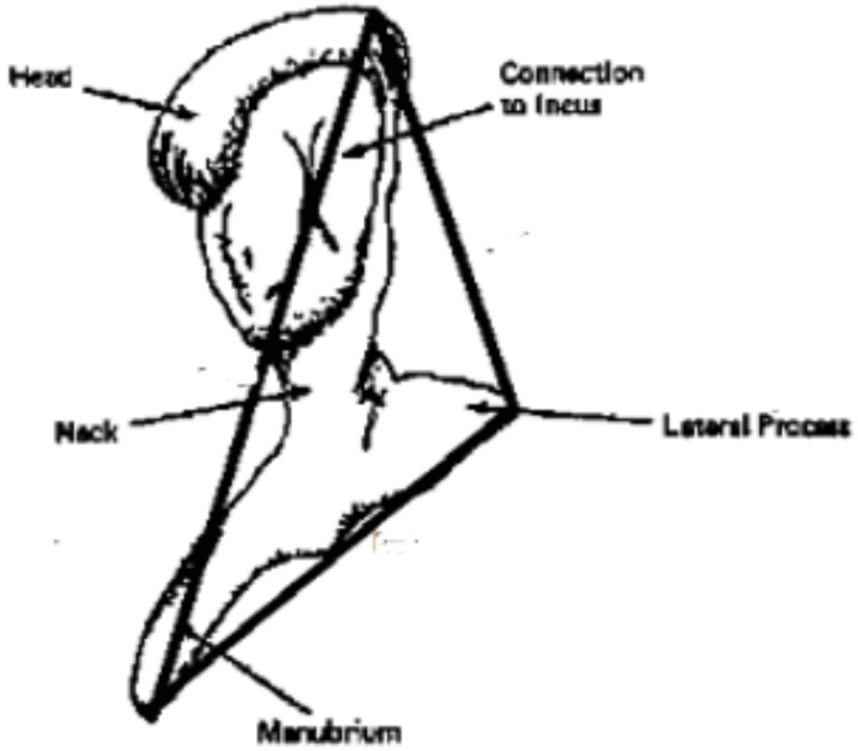

Figure 2: Diagram showing various measurements of Malleus (Sodhi et al. 2017)

The data was statistically analyzed using SPSS software version 20

RESULTS

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

Table 1: Descriptive analysis of Malleus (n= R (44), L (50)

	MEAN ± SD (RIGHT)	MEAN ± SD (LEFT)
Total Length (mm)	8.20 ± 0.32	7.90 ± 0.17
Length of Manubrium (mm)	5.00 ± 0.14	4.90 ± 0.11
Length of Head &Neck (mm)	5.10 ± 0.29	4.90 ± 0.17
Weight (mg)	21.7 ± 0.20	22.4 ± 0.05
Index (%)	60.90 ± 2.45	61.90 ± 2.45

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: Comparison between morphometric data of Malleus with previous studies

Author	Population	Sample size	Mean of Total Length	Mean of Length of Manubruim	Mean of Head & Neck	Weight	Index
Harneja (1973)[21]	Jaipur	50	7.15	4.22	--	23.65	--
Arrensburg	Israel	31	7.8	4.4	--	--	56.6
(1981)[22]	South	90	7.84	4.39	--	22	--
Oschman (1991)[23]	Africa	60	8.36	4.65	--	25.99	--
Bhatnagar	Punjab	40	7.69	4.70	4.85	--	60.97
(2001)[24]	Turkey	--	--	--	--	--	56.05
Unur (2002)[25]	Goa	50	7.65	3.52	2.37	20.90	--
Natekar (2010)[26]	Mysore	120	7.94	4.76	5.23	22.92	56.05
Jyoti (2015)[27]	Rohtak	30	8.00	4.58	--	--	--
Singh (2012)[28]	Aligarh UP	23	8.53	4.91	--	--	--
Gulrez (2013)[29]	Colombia	50	7.45	--	--	18.26	--
Ramirez (2013)[30]	Mangalore	100	5.54	3.03	2.79	--	54.73
Vinayachandra	AP	66	8.53	5.20	4.72	--	61.01
(2014)[31]	Rajasthan	60	7.81	4.59	5.00	--	--
Padmani (2014)[32]	Jamnagar	100	7.83	4.44	4.68	21.97	56.77
Mogra (2014)[33]	North	94	8.05	4.95	5.00	22.05	61.40
Rathava (2015)[34]	India						
Sodhi (2017) [35]	Nigeria						
Present Study							

DISCUSSION

The ear ossicles were first reported in 16th century. Hast and Garrisson[36] reported that Vesalius first described malleus and incus in 1543 in his monumental work "De Humani Corporis Fabrica" (the fabric of the human body), while Ingrassia and Eustachius were first to describe Stapes in 1546 [37,38]. According to Lempert and Wolff[39], the ear ossicles possess unique features in the form of: miniature size, these bones attain full adult size during fetal life[40]. However, it is possible that the development of bone mass of these ossicles may not have been completed during fetal life[41].

Over time, very few studies are reported regarding the precise measurements of these miniature bone (malleus). There is paucity of literatures regarding the morphometry dimensions of malleus among Nigerian population.

The mean weight of the malleus obtained from this present study was in agreement with the work of Sodhi[34] and Jyoti & Shama[26], whose values were 21.97mg and 20.90mg respectively. Harneja and Chaturvedi[21]; Bhatnagar[23] and Singh[27] tends to have a higher values of 23.65mg; 25.99mg and 22.92mg respectively with non-important significance.

The mean total length of malleus from this study was in agreement with the report from Oschman & Meiring[22], the value they obtained among South African population was 7.84mm. It was also similar to some of the Indian populations which were reported by Gulrez[28]; Ramirez & Ballesteres[29]; Sodhi[34]; Singh[27] and Bhatnagar[23], their values were: 8.00mm, 8.53mm, 7.83mm, 7.94mm and 8.36mm respectively.

The morphometric dimensions of the malleus have been compared with those prescribed by other authors over the period of past 50 years as reported from the different regions of the world (Table2).

When compared with the previous studies, the dimensions of malleus were almost similar to South Africa, Colombia, Rajasthan, Jaipur, and Turkey subjects, but were on higher side to that of Punjab subjects and lower side to that of Israel and North India subjects.

There was no statistical difference ($p > 0.05$) observed when all the morphometric data of malleus were compared in terms of sides. This was in agreement with the work of Sodhi[34] which revealed no significant difference between morphometric measurements of the bones of right and left side while it was in contrast with the report from Vinayachandra[30], they concluded that the left sided malleus dominated the right sided ones in both length and weight.

CONCLUSION

The auditory ossicles attain full adult size during fetal life but continues to undergo changes throughout life, so the variations in the size and morphology of these bones are expected. The malleus has shown great variety and complexity in measurements taken from all researchers and this results in variations seen in the dimensions of the malleus when compared with previous studies. The morphometric variations may be due to racial differences or regional population difference. The malleus is morphometrically identical in both ears (right and left). The precise measurements of the malleus have been reported in this study for Nigerian population (males). These values will be very

helpful in designing the prosthesis in ossicular chain pathology in Nigeria. This variability should be a strong reminder, that constructing an ossicle for ossiculoplasty or reconstruction, must be customized to a particular ear.

Even the implantable hearing aids may yield better performance if they are customized to variations in ossicle masses and dimensions.

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