

Morphometry of human ear ossicles in female cadavers of North India

S. Sodhi¹, Z. Singh² and J.L. Davessar³

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¹Shubhpreet Sodhi, Senior Resident, Department of Anatomy, Dr. YSP Govt. Medical College, Nahan, Himachal Pradesh. E mail: sodhishubhpreet@gmail.com

²Zora Singh, Professor and Head, Department of Anatomy, Dasmesh Institute of Research & Dental Sciences, Faridkot 151203 (Pb) India. E mail: drzsingh04@yahoo.com

³Jai Lal Davessar, Professor and Head, Department of ENT, Guru Gobind Singh Medical College & Hospital, Faridkot 151203 (Pb) India. E mail: drjailaldavessar@gmail.com

Corresponding author: Shubhpreet Sodhi, Senior Resident, Department of Anatomy, Dr. YSP Govt. Medical College, Nahan, Himachal Pradesh. E mail: sodhishubhpreet@gmail.com

ABSTRACT:

Introduction: The ear ossicles contained in tympanic cavity are responsible for the conduction of sound waves from external to inner ear. A very few studies have been reported regarding the morphometric details of these ear ossicles in females. The mean values of the various parameters of the three bones, malleus, incus and stapes, have been reported in the present study in female population of North India.

Materials and methods: 100 sets of middle ear ossicles (50 right and 50 left), consisting of malleus, incus and stapes were collected from 50 female cadavers available from the various medical colleges of North India.

Results: Our study provides the mean values of the various dimensions of the three bones in female population of North India. There is no statistical differences between any of the morphometric measurements of the bones of right and left sides in females. However, a statistically significant difference is noted in the measurements of stapes between male and female population.

Conclusion: The results of the present study are not only of academic interest but would be very helpful in designing the prosthesis in ossicular chain pathology.

Key words: Ossicles, measurements, females, north India population, prosthesis

INTRODUCTION:

The knowledge about the three ossicles residing in the middle ear is known to us from 15th century (Arensburg et al.,1981). Since that time, extensive studies have been carried out on morphometry, embryology, function and structure of middle ear ossicles. But most of the

studies were performed on adult male ossicles (Harneja and Chaturvedi,1973, Awenger,1995, Farahani and Nooranipur, 2008, Natekar and De Souza, 2006, Olszewski, 1990) and a very few studies have been reported on adult female ossicular morphometry (Singh et al.,2012, Singh et al., 2016) due to insufficient availability of female cadavers. This research paper is in continuation with an earlier research publication on the dimensions of ear ossicles of males (Sodhi et al., 2017). The results of this paper are a part of the research project investigated for PhD (Medical Anatomy) degree from Faculty of Medical Sciences, Baba Farid University of Health Sciences, Faridkot.

The present study provides the data of the three ossicles of females in North Indian Population.

MATERIALS AND METHODS:

This study was performed on 100 sets of middle ear ossicles (50 right and 50 left) consisting of malleus, incus and stapes. These bones were collected from 50 female cadavers available among the various medical colleges of North India.

The three ossicles were obtained after removing the calvaria with the help of electric bone cutter. The brains were severed at the level of medulla oblongata and the duramater was stripped off, thus removing the brain from cranium. With the help of hammer and chisel, a small aperture was made by removing tegmen tympani to expose the roof of the middle ear. The rounded head of the malleus articulating with the incus in epitympanum were identified and were taken out with forceps after fine manipulations. Later to expose the stapes, a diagonal section of the temporal bone was taken through arcuate eminence. Then the stapes was removed with the help of fine forceps. The bones thus obtained were cleaned and put into plastic satchel bags with zip locking mechanism. These pouches were assigned the serial number, side and gender.

Institutional ethical clearance was obtained for this work.

The following measurements were taken with the help of digital vernier caliper with the least count of 0.01 mm. Each bone was weighed on Metledo weighing machine with least count of 0.01mg.

1) Measurements of **Malleus** (Figure 1)

- a) Total length (M1): maximum distance between top of the head and the end of the manubrium (mm)
- b) Length of manubrium (M2): distance from the end of the lateral process to the end of manubrium (mm)

- c) Length of head and neck (M3): maximal distance between the top of the head and the end of the lateral process (mm)
- d) Index: length of manubrium x 100/total length
- e) Weight of Malleus (mg)

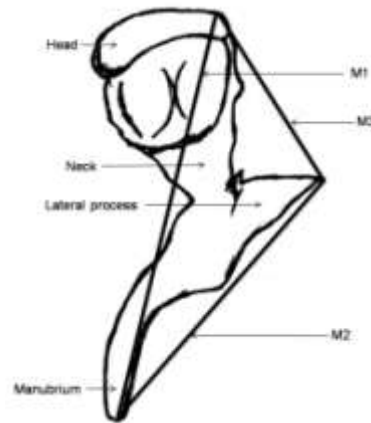


Fig 1: Shows various measurements of Malleus

2) Measurements of **Incus** (Figure 2)

- a) Total length (I1): maximal distance between the superior edge of the body and the end of the long process (mm)
- b) Total width (I2): maximal distance between the superior edge of the body and the end of the short process (mm)
- c) Maximal distance between the tips of the processes (I3 in mm)
- d) Index: Total width X 100/total length of incus
- e) Weight of Incus (mg)

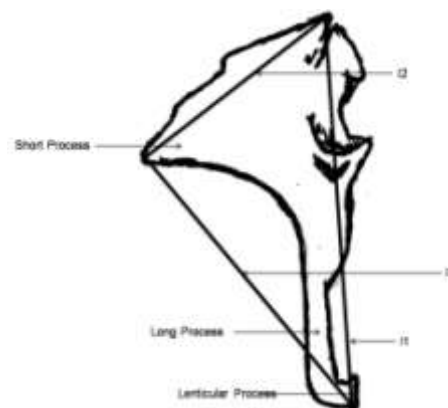


Fig 2: Shows various measurements of Incus

3) Measurements of **Stapes** (Figure 3)

- a) Total height (S1): maximal distance between the top of the head and the foot plate (mm)
- b) Length of foot plate (S2): maximal length of the long axis of foot plate (mm)
- c) Width of foot plate (S3): maximal width of the foot plate (mm)
- d) Index: Length of foot plate X 100/total height of stapes
- e) Weight of Stapes (mg)

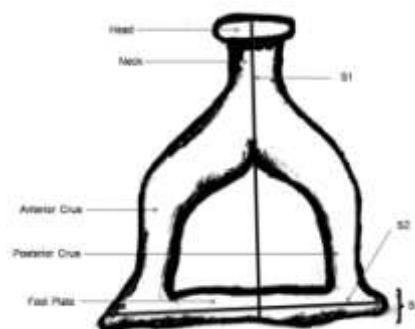


Fig 3: Shows various measurements of Stapes

The data has been statistically analyzed using SPSS software version 20.0

RESULTS:

The following parameters were recorded:

Table 1: Descriptive analysis of malleus in females (n=50)

Malleus	Range		Minimum		Maximum		Mean		Std. Deviation	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
-Total length(mm)	2.63	2.31	5.89	6.35	8.52	8.66	7.680	7.79	0.519	0.478
-Length of Manubrium (mm)	2.00	2.64	3.40	2.91	5.40	5.55	4.353	4.42	0.424	0.513
-Length of Head and Neck(mm)	2.27	2.40	3.15	3.14	5.42	5.54	4.578	4.67	0.385	0.417
-Weight (mg)	22.68	25.10	6.10	7.60	28.78	32.70	21.174	22.03	4.610	4.794

Index was calculated to be 56.69% on right side and 56.67% on left side

Table 2: Descriptive analysis of incus in females (n=50)

Incus	Range		Minimum		Maximum		Mean		Std. Deviation	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
-Total length(mm)	2.17	1.81	5.49	5.26	7.66	7.07	6.44	6.417	0.398	0.356
-Total Width (mm)	1.48	1.81	4.02	3.97	5.50	5.78	4.85	4.889	0.334	0.353
-Distance between two processes (mm)	1.77	1.73	4.42	4.26	6.19	5.99	5.30	5.291	0.472	0.378
-Weight (mg)	26.70	26.70	6.80	7.30	33.50	34.00	23.51	24.789	5.769	4.954

Index was calculated to be 75.46% on right side and 76.27% on left side

Table 3: Descriptive analysis of stapes in females (n=50)

Stapes	Range		Minimum		Maximum		Mean		Std. Deviation	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
-Total Height (mm)	1.11	0.96	2.73	2.87	3.84	3.83	3.304	3.311	0.226	0.212
-Length of footplate (mm)	0.94	0.88	2.50	2.40	3.44	3.28	2.734	2.753	0.171	0.200
-Width of footplate (mm)	0.53	0.53	1.15	1.17	1.68	1.70	1.360	1.389	0.109	0.102
-Weight (mg)	3.14	2.90	1.09	1.00	4.23	3.90	2.550	2.742	0.630	0.656

Index was calculated to be 83.03% on right side and 83.27% on left side.

All the parameters of the three bones of both sides (right and left) (Tables 1-3), were analyzed statistically by applying Independent Sample T test / Mann Whitney Test (after the data analysis for assumption tests). All the statistical calculations were performed using the software SPSS version 20.0. On comparison of each parameter of right side with its counterpart of left side, no statistically significant difference was observed in morphometry of the three bones (Table 4,5,6).

Table 4: Side comparison of Malleus in Females

Parameters	N	Mean Values	p value
Total Length (mm) Right Left	50	7.68	0.238
	50	7.79	
Length of manubrium (mm) Right Left	50	4.35	0.473
	50	4.42	
Length of Head & neck (mm) Right Left	50	4.57	0.179
	50	4.67	
Weight (mg) Right Left	50	21.17	0.331
	50	22.03	

Table 5: Side comparison of Incus in Females

Parameters	N	Mean Values	p value
Total Length (mm) Right Left	50	6.44	0.710
	50	6.41	
Total width (mm) Right Left	50	4.88	0.662
	50	4.89	
Distance b/w two processes (mm) Right Left	50	5.37	0.849
	50	5.29	
Weight (mg) Right Left	50	23.51	0.352
	50	24.78	

Table 6: Side comparison of Stapes in Females

Parameters	N	Mean Values	p value
Total Length (mm) Right Left	50	3.30	0.881
	50	3.31	
Length of footplate (mm) Right Left	50	2.73	0.647
	50	2.75	
Width of footplate (mm) Right Left	50	1.36	0.094
	50	1.38	
Weight (mg) Right Left	50	2.55	0.140
	50	2.72	

Furthermore, the correlation between various morphometric measurements of the three bones were also studied using Pearson correlation test. A statistically significant positive correlation was found between total length of malleus and total length of incus on both the sides (right side $p \leq 0.0005$, $r = 0.551$; left side $p \leq 0.0005$, $r = 0.539$) whereas total height of stapes was found to be correlated significantly and positively correlated with total length of malleus ($p = 0.007$, $r = 0.037$) and total length of incus ($p = 0.010$, $r = 0.361$) only on left side. Pearson's correlation test was also applied on the weight of three bones and a positive correlation was seen among the weights of all the three bone with each other on both the sides.

The data of the three bones in females were also compared with the data generated for males in the previous paper (Sodhi et al., 2017) by applying Independent T test/Mann Whitney U test (Table 7,8,9).

Table 7: Comparison of Malleus between Males and Females

	n	Mean Values	p value
Total Length (mm) Male Female	100	7.83	0.314
	100	7.73	
Length of manubrium (mm) Male Female	100	4.44	0.349
	100	4.38	
Length of Head & neck (mm) Male Female	100	4.65	0.248
	100	4.62	
Weight (mg) Male Female	100	21.97	0.759
	100	21.60	

Table 8: Comparison of Incus between Males and Females

	n	Mean Values	p value
Total Length (mm) Male Female	100	6.47	0.304
	100	6.43	
Total Width (mm) Male Female	100	4.88	0.536
	100	4.87	
Distance b/w two processes (mm) Male Female	100	5.31	0.840
	100	5.29	
Weight (mg) Male Female	100	23.88	0.955
	100	24.15	

Table 9: Comparison of Stapes between Males and Females

	n	Mean Values	p value
Total Height (mm) Male Female	100	3.38	0.012
	100	3.30	
Length of footplate (mm) Male Female	100	2.80	0.007
	100	2.74	
Width of footplate (mm) Male Female	100	1.36	0.325
	100	1.37	
Weight (mg) Male Female	100	2.55	0.315
	100	2.64	

No significant differences were found for malleus and incus between male and female population of North India. However, total height of stapes ($p=0.012$) and length of footplate ($p=0.007$) showed statistically significant difference between the two groups.

DISCUSSION:

Ossicles play very important role in hearing. Morphometric analysis of ear ossicles is the area of exploration since mid fifteenth century (Arensburg et al., 1981). Studies on embryogenesis of the ossicles concluded by saying “No two ears are same” (Hough, 1963).

The review of Indian and International literature reveals that most of the work has been done on the males and very few authors have studied and reported the morphometry of female ossicles separately. The malleus (Singh et al. 2012) and incus (Singh et al. 2016) were studied in female population of Haryana, from both left and right sides. Singh et al (2012) reported malleus mean length in females to be 7.81 mm, length of manubrium to be 4.62 mm, head and neck to be 5.28 mm and weight to be 22.44 mg. In the present study, malleus mean length is found to be 7.73 mm, length of manubrium to be 4.38mm, length of head & neck 4.62 mm and weight to be 21.60 mg. Thus findings in the North Indian females in the present study are on the lower side as compared to those of Haryana population.

In case of incus, Singh et al.,(2016) reported that total length is 6.65mm, total width is 5.01mm, distance between two processes is 5.99mm. In the present study, total length of incus is 6.43mm, total width is 4.87mm, distance between two processes is 5.29mm. The

findings on morphometric variables of incus in the present study are comparatively lower in values than those of the Haryana population.

Singh et al (2012) also reported significant difference between male and female mallei measurements but the contradictory results are observed in the present study. However, the results of the present study are in line with those reported by some other authors (Oschman and Meiring, 1991; Unur et al., 2002; Dass et al., 1969; Vinayachandra et al., 2014), where no significant difference was found between male and female population in case of malleus and incus bones. Total height of stapes and length of footplate were found to be significantly different between males and females with mean values being more in males than females. This may be due to the simple fact that male bones are in general larger than those of females.

CONCLUSION

The mean values of the ear ossicles in North Indian female Population have been reported in the present study which would be very helpful in designing the prosthesis in ossicular chain pathology. The variations seen in the dimensions of the ossicles as compared with other studies may be due to racial differences or regional population difference.

CONFLICT OF INTEREST

There are no conflicts of interests involved.

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