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Original Research Article

MORPHOMETRIC STUDY OF EXTERNAL EAR OF MEDICAL STUDENTS IN COLLEGE OF MEDICAL SCIENCES AND TEACHING HOSPITAL, BHARATPUR, CHITWAN, NEPAL

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ABSTRACT

Background: The human ear is unique and auricular biometrics has been adopted as reliable aid in personal identification in forensic sciences. The ear morphometry plays a critical role in reconstructive auricular and peri-auricular surgery to reproduce an anatomically correct and esthetically pleasing ear.

Objectives: To determine mean values of linear ear measurements and their variation with age, sex and side.

Materials and Methods: The study was conducted in 192 students consisting of 98 females and 94 males, in College of Medical Science, Bharatpur, Chitwan, Nepal. Students were categorized in three age groups (17-18 years, 19-20 years and >=21 years). Both ears and their lobule length were measured with standard Vernier caliper. The data was analysed using SPSS version 16.0.

Results: The mean values of EW and LW were more on the right side than on the left in both males and females whereas mean LH was more on the right side in females only. There were significant differences in linear measurements of ear between males and females ($p<0.05$), the EL, EW, LL and LW being higher in males than females. Aging had a significant effect on EH in both males and females.

Conclusion: This study provides mean values of different morphometric measurements of right and left ears in both sexes, which may be used as reference data to guide plastic surgeons during auricular reconstruction and may assist the forensic pathologist in the identification of a living or deceased individual.

KEY WORDS: Ear measurement, ear height, ear width, lobule height, lobule width.

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INTRODUCTION

The external ear consists of the auricle (pinna) and the external acoustic meatus. The auricle projects from the side of face and displays non uniform concavity apart from numerous elevations and depressions on its lateral surface. The

osseo cartilaginous external acoustic meatus extends inwards from the auricle to the tympanic membrane. Yellow elastic cartilaginous folding gives the characteristic configuration to the pinna; whereas the lobule (an inferior part of pinna) contains only fibro-fatty tissue covered by cutaneous fold [1].

In human, external ear is an important aesthetic-defining attribute of the face [2]. Malformations of the external ear as a consequence of hereditary diseases or injuries (following trauma), infection or excision of tumor, etc [3], require surgical intervention or prosthetic replacement [4]. As such, plastic surgeons require detailed information about its complex morphology and normal dimensions to construct and to determine precisely the position and orientation of the auricular framework [5].

During legal investigations, especially in crimes (resulting in fatality) or discovery of unidentified human remains, the jurisprudence requires to gives an opinion regarding personal identification of the deceased [6]. As the morphological characteristics and measurements of external ear vary with ethnicity, age and sex [7], ear biometrics can be utilized as an aid for personal identification of the living or deceased [8] in absence of valid fingerprints.

Although many literatures have been cited on morphometry of external ear, no such study was found for Nepalese population. We carried out this study to generate the baseline data to guide reconstructive surgeons involved in reconstruction and peri-auricular surgery reproduce an anatomically correct ear.

MATERIALS AND METHODS

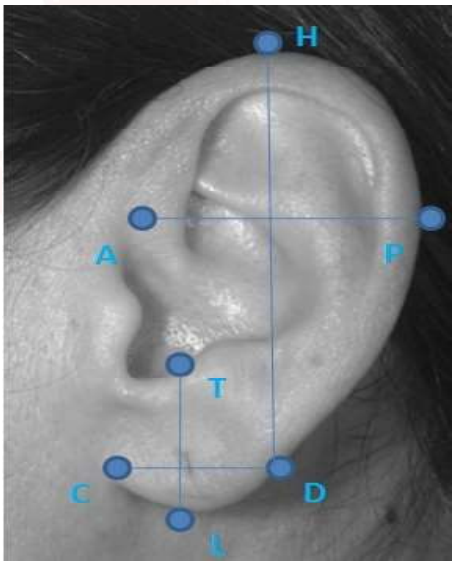
We conducted a cross sectional study in the Department of Anatomy, College of Medical Sciences and Teaching Hospital, Bharatpur, Chitwan, Nepal. It is a medical school affiliated under Kathmandu University (KU) and runs undergraduate courses in various disciplines (MBBS, BDS and BSc Nursing) apart from many post-graduate courses. After obtaining clearance from Institutional Ethical Committee, we collected data from 192 students of first and second year MBBS from March to May 2017. Students with an evidence of congenital malformations of ear or previous ear surgery were excluded from the study. All the students were briefed about the purpose of study and informed and written consent was obtained. The students were further divided into different subgroups of age (group 1: 17-18 years, group 2: 19-20 years and group 3: >=21 years) and gender (males and females).

Objective measurements were made in the sitting position with the head in Frankfort horizontal plane. The following anthropometric landmarks were identified on the subjects with careful inspection and then marked on the ear with black marker:

Table 1: Ear anthropometric landmarks.

A	Preaurale	Most anterior point of the ear
P	Postaurale	Most posterior point of the ear
H	Supraurale	Most superior projection of the helix
L	Subaurale	Most inferior projection of ear lobule
T	Tragion	Point on the base of intertragic notch

Fig. 1: Photograph shows the ear anthropometric landmarks and linear measurements (A, preaurale; P, postaurale; H, superaurale; L, subaurale; T, tragion) and Ear linear measurements: ear width (A-P); ear height (H-L); lobule height (L-T) and lobule width (C-D).



The parameters measured were:

Ear height (EH) - Distance from supraurale (H) to subaurale (L)

Ear width (EW) - Distance between preaurale (A) to postaurale (P)

Lobular height (LH) - Distance from subaurale (L) to tragion (T)

Lobular width (LW) - Maximum transverse width of lobule (C to D)

All the measurements were taken by principal

author in order to minimize bias and error of identification of the landmarks involved in measurement. Standard Vernier caliper capable of measuring to the nearest 0.1 mm was used. For each subject, the measurements were carried out twice to ensure accuracy.

Data obtained were first entered in epidata 20.1 and was analysed using Stastical Package for Social Science version (SPSS) 16.0. Normality of distribution of ear measurements (EH, EW, LH and LW) were tested using Shapiro Wilk test which showed normal distribution for EH, EW and LH but significantly skewed for LW. As such, a parametric approach was used to analyze normally distributed data. For skewed data, non parametric tests were employed. A p-value <0.05 was considered significant.

RESULTS

Of the total 192 students from first and second years of MBBS, 98 were females (51.04%) and 94 were males (48.96%). Majority of participants (113; 58.85%) (53 males and 60 females) were either 19 or 20 years old. The mean age of overall students was 19.55±1.19 years while that of females and males were 19.24±1.17 years and 19.87±1.23 years respectively.

Table 2: Distribution of students according to sex and age-group.

Gender	Age groups (years)			
	Group 1 17-18	Group 2 19-20	Group 3 >=21	Total
Male	12	53	29	94
Female	24	60	14	98
Total	36	113	43	192

A one way ANOVA (Analysis of Variance) test was performed to compare the impact of age on measurements (EH, EW and LH) of right and left ears. The test revealed that the effect of age on EH was statistically significant on both right and left sides and that on LH only on left side among all three age groups (p<0.05). Post-hoc analysis using Hochberg test indicated that the mean height of both right and left ears and that of left lobule for group 1 was statistically greater than group 3, whereas, Group 2 did not differ significantly from either group 1 or 3 (p<0.05). Kruskal Wallis test was conducted to determine the influence of age on LW. The width of lobule among the different age-groups on the right and left ears was not significantly different (p>0.05).

Table 3: Relationship between ears measurements (EH, EW and LH) and age-groups on right and left ears.

Side	Measurements	Age-group in years (n)			F	P value
		17-18 (36)	19-20 (113)	>=21(43)		
		Mean ±SD	Mean ±SD	Mean ±SD		
Right	EH	5.79±0.39	5.97±0.44	6.09±0.44	4.75	o.o10
	EW	3.1±0.25	3.32±o.31	3.2±0.35	0.313	0.732
	LH	1.71±0.19	1.75±0.23	1.75±0.21	1.43	0.241
Left	EH	5.77±0.41	5.95±0.45	6.09±0.43	5.23	0.006
	EW	3.01±0.31	3.13±0.29	3.13±0.34	2.16	0.119
	LH	1.64±0.32	1.73±0.23	1.79±0.18	4.09	0.018

Table 4: Relationship between LW and age-groups on right and left ears.

Side	Age-group in years (n)			Median (Q1-Q2)	Chi square	P value
	17-18 (36)	19-20 (113)	>=21 (43)			
	Mean rank	Mean rank	Mean rank			
Right	84.38	100.44	96.29	1.92(1.68-2.14)	2.28	0.319
Left	87.08	99.74	95.86	1.85(1.65-2.04)	1.42	0.491

A result of One way ANOVA showed that the influence of age on mean ear measurements (EH, EW and LH) was statistically non significant in both sexes among all three age groups (p>0.05). However, it has been detected that mean EH increased with advancing age in overall participants, the mean height of ear for group 3 (6.09 cm) being statistically greater than group 1 (5.78 cm), whereas, Group 2 did not differ significantly from either group 1 or 3. Likewise, no significant difference was noted in mean LW in both males and females (p>0.05).

Table 5: Relationship between mean ear measurements (EH, EW and LH) and age-groups in males and females.

Gender	Measurements	Age-group in years (n)			F	P value
		17-18 (36)	19-20 (113)	>=20 (43)		
		Mean ±SD	Mean ±SD	Mean ±SD		
Female	EH	5.63±0.34	5.77±0.33	5.73±0.33	1.66	0.195
	EW	3.00±0.24	3.04±0.22	2.90±0.31	1.78	0.174
	LH	1.67±0.20	1.72±0.22	1.76±0.14	1.01	0.37
Male	EH	6.08±0.30	6.17±0.44	6.26±0.36	0.94	0.395
	EW	3.25±0.22	3.30±0.29	3.20±0.23	0.24	0.791
	LH	1.70±0.23	1.77±0.23	1.80±0.20	0.98	0.379
Overall	EH	5.78±0.39	5.96±0.44	6.09±0.43	5.18	0.006
	EW	3.09±0.26	3.16±0.28	3.17±0.32	1.15	0.318
	LH	1.68±0.20	1.74±0.22	1.79±0.18	2.78	0.65

A Paired t-Test was performed to compare mean ear measurements (EL, EW and LL) between right and left sides in three groups: overall, males and

females. The result showed that the mean width of right ear was statistically greater than that of left ear in all three groups; but lobule of right ear was longer than that of left only in females and overall participants. Beside, the mean EH in all three groups and mean LH in males revealed no differences between right and left ears (p>0.05). Wilcoxon signed rank test revealed that the difference of LW between right and left ears was significant in males and overall participants, the width of left lobule being greater than that of right (p<0.05).

Table 6: Relationship between mean LW and age-groups in males and females.

Gender	Age-group in years (n)			Median (Q1-Q2)	Chi square (df)	P value
	17-18 (36)	19-20 (113)	>=21 (43)			
	Mean rank	Mean rank	Mean rank			
Female	50.79	47.56	55.61	1.77(1.65-1.95)	0.975(2)	0.614
Male	39.58	52.66	41.34	2.00(1.79-2.15)	4.38(2)	0.112
Overall	86.46	99.88	96.02	1.87(1.67-2.09)	1.597(2)	0.45

Table 7: Relationship between right and left ears measurements (EH, EW and LH) in males and females.

Measurements	Side	Female (98)			Male (94)			Overall (192)		
		Mean±SD	t	P value	Mean±SD	t	P Value	Mean±SD	t	P value
EH	R	5.74±0.34	0.9	0.37	6.20±0.41	0.85	0.39	5.96±0.44	1.24	1.24
	L	5.72±0.35			6.18±0.42			5.95±0.45		
EW	R	3.06±0.26	3.44	0.001	3.44±0.28	4.99	<0.05	3.20±0.31	5.73	0.05
	L	2.97±0.28			3.25±0.28			3.10±0.31		
LH	R	1.74±0.21	4.18	<0.05	1.76±0.23	-0.17	0.86	1.75±0.22	2.8	0.06
	L	1.68±0.21			1.77±0.22			1.73±0.22		
R- Right; L- Left										

Table 8: Relationship between right and left LW in males and females.

Gender	Side	Median(D1-D2)	Mean rank	Z	P value
overall	Right	1.92(1.68-2.14)	85.81	-3.13	0.002
	Left	1.84(1.65-2.04)	102.25		
Female	Right	1.80(1.63-1.99)	44.8	-1.78	0.75
	Left	1.78(1.58-1.94)	52.21		
Male	Right	2.05(1.80-2.22)	41.69	-2.62	0.009
	Left	1.94(1.76-2.14)	50.35		

An Independent t-Test was performed to examine gender difference in various measurements of ear (EH, EW and LH) on right and left side. There was a significant difference in length of ear between males and females on both sides, the ear being longer in males than females (p<0.05). Likewise, EW was statistically greater in males compared to females on both right and left sides (p<0.05). Result also indicated that there was no significant difference in LL of right ear, however, the mean length of lobule was higher in males than in females on left side (p= 0.007). Mann-Whitney U test revealed lobule was significantly wider in males than in females on both right and left ear (p<0.05).

Table 9: Relationship of ear measurements (EH, EW and LH) between males and females on right and left ears.

Side	Gender (n)	EH			EW			LH		
		Mean±SD	t	P Value	Mean±SD	t	P value	Mean±SD	t	P value
R	Female 98	5.74±0.34	-8.45	<0.01	3.06±0.26	-7.35	<0.05	1.74±0.21	-0.98	0.32
	Male 94	6.20±0.41			3.34±0.28			1.77±0.23		
L	Female	5.72±0.35	-8.25	<0.01	2.97±0.28	-6.96	<0.05	1.68±0.21	-2.72	<0.05
	Male	6.18±0.42			3.24±0.28			1.77±0.22		
R- Right; L- Left										

Table 10: Relationship of LW between males and females on right and left ears.

Side	Gender (n)	Mean rank	Median (Q1-Q2)	Mann Whitney U	P value
Right	Female (98)	80.34	1.92(1.6-2.14)	3022.5	<0.05
	Male (94)	113.35			
Left	Female (98)	79.97	1.85(1.65-2.04)	2986.5	<0.05
	Male (94)	113.73			

DISCUSSION

Anomalous external ears have been reported in 1:6000 [9] to 1:6830 [10] newborns, and may involve the glitches in position, orientation, size and relief patterns of pinna [3]. Moreover, malformation of an external ear may be an outcome of genetic disease or injuries due to environmental factors such as trauma, infection, radiation, etc [3]. The auricular deformity is esthetically unpleasing and imposes social rejection and solitude, adversely affecting the physical and mental growth of a person. Otoplastic surgery can correct a congenital auricular infirmity or can treat deformed ear (caused by injury) [4]. Hence, a detailed knowledge of morphometric parameters of various auricular landmarks in different gender and age groups has become paramount for precise plastic reconstruction [5].

Sharma et al found that the linear ear dimensions increased with advancing age [11]. To add to it, the auricular growth ceases at 13 years for males and at 12 years for females [12]. McKinney et al conducted study on 100 volunteers and discovered no significant correlation between LH and aging [13]. In a study by Deopa et al, the mean EH, EW, LH and LW were shown to increase with age on both sexes [14]. Brucker et al analysed the age related changes in ear morphometry in three age groups (18-30 years,

31-45 years and 46-65 years) and noted significant differences in EH and LH, which increased from age group of 18-30 years to 46-65 years in both sexes while the LW significantly decreased with age for females only [2]. In contrary, in the present study, the impact of age on the mean values of EH, EW, LH and LW was not significant in either males or females among all three age groups (17-18 years, 19-20 years and >=21 years). However, the mean EH increased with advancing age in overall participants, the difference being more pronounced between age group of 17-18 years and 21-22 years.

In a similar study, Sharma et al analyzed the LL in 260 males between 1 and 80 years of age in North East region of India and found that maximum length of lobule increased appreciably between 6-15 years and 41-80 years of age group. On the other hand, the LW showed major growth up to the age of 15 years and was almost static between the ages of 16 and 40 years and then again progressed from 41 years onwards [11]. Their findings with regard to variations of LH and LW in right and left sides do not fully conform to our study in which LH increased from age group of 17-18 years to >=21 years only on the left side and no significant differences in right LH and left LW were observed among all three age groups.

Sadacharan in 2016 surveyed 100 students emphasizing the clinical implications of ear morphometry in personal identification in forensic and repair of traumatic ear in cosmetic surgery and discovered mean EH of 60.27 mm and 60.29 mm on right and left ear respectively in males and 54.52 mm and 54.54 mm on right and left ear respectively in females [15]. In our study, the mean values of EH for females were 5.74 cm and 5.72 cm on right and left side respectively and that for males were 6.20 and 6.18 cm on right and left side respectively. These values, however, didn't differ significantly in both sexes. This finding is similar to the result of Deopa et al who observed the mean EH of 6.04 cm for right ear and 6.03 cm for left ear in males and 5.74 cm for right ear and 5.77 cm for left ear in females [14].

Abnormally wider or narrower ears are the orofacial manifestations of some genetic diseases. Fragile X syndrome is characterized by disproportionately enlarged and wider ear; whereas low set narrow ear is often seen in Treacher Collin's and Jocobsen syndrome [3]. Likewise, variations do occur in normal populations as well. Deopa et al found no significant difference in mean EW of right and left sides in both males and females [14]; whereas, mean EW was more on left ear (32.25 mm) than on the right (32.04 mm) in male subjects in a separate study carried out by Sadhacharan [15]. In the current study, mean scores of EW for females were 3.06 cm and 2.97 cm on right and left sides respectively and those for males were 3.44 cm and 3.25 cm on right and left sides respectively, the difference being statistically significant in both sexes.

Aging in human is characterized by elongation or ptosis of ear lobules which is a result of gravity and depletion of elastic fibres [16] and is worsen by an extra weight of earrings in females [17]. The mean LH was more on left ear (1.69 cm) than right (1.67 cm) in both males and females and showed no significant difference [15]. On the contrary, in the current study, lobule length was greater in right ear (2.97 cm) than left (1.74 cm) in females; no significant difference was observed in males ($p>0.05$). Furthermore, the difference of LW between right and left ears was significant in males and overall participants, the width of left lobule being greater than that of right. This findings do not match the findings of Doepa et al [14].

The findings of many studies are supportive of the fact that ear measurements exhibit sexual dimorphism and the differences between the sexes are statistically significant with a higher value in males [2,18]. The differences in linear ear measurements between males and females may be due to auricular expansion which occurs earlier in males compared to females and continues till it reaches maturity [2]. In regard to gender difference in various measurements of ear (EH, EW and LH) on right and left sides, the present study showed significant difference in EH between males and females on both sides, the length of ear being greater in males than females. Conversely, no sexual dimorphism was observed in EH in a survey conducted by Sharma in both right ($p=0.13$) and left ears ($p=0.37$) [19]. In the study, Sharma also revealed that the EW

was more in males (2.89 cm) compared to females (2.81cm) on right ear and the difference was insignificant on left ear [19]. Whereas, in the present study, the ear was wider in males than in females on both sides. Additionally, Sharma found that both LH and LW of right and left ears were higher in females than males [19] which does not relate to the result of our study in which LW of both ears and LH of left ear showed sexual differences, the measurements being higher for males than females.

There was a difference in the values of ear measurements between our study and other authors and this breach could be a result of factors like heredity, race, age and human errors in collecting data. The present study was undertaken in students of MBBS first and second years with no significant age variation. Hence, age related changes in ear measurements were not appreciable**.** As the sample size was small comprising of 192 students with no consideration of race and ethnicity, the result of the study may not be generalized to overall Nepalese population.

CONCLUSION

This study provides mean values of different morphometric measurements of right and left ears in medical students of 17 to 22 years old in both sexes. This may act as a baseline data to guide reconstructive surgeons reproduce an anatomically correct ear. It will also be useful for ergonomic design of hearing aids and auricular prosthesis and will assist the forensic pathologist in the identification of a living or deceased individual.

Conflicts of Interests: None

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