A Study to Predict Age from Ear Morphometry

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Abstract
Background: *The ear's shape and size completes the facial appearance, its morphometry helps to identify the age and gender of a person. It is known that gender dimorphism, difference in right and left ear exists in different ethnic groups. It is also known that the ear morphometry increases proportionally with age.*
Aim: *To measure the ear dimensions in men and women and correlate them with age. To predict age from ear dimensions.*
Material and Method: *Ear dimensions were measured in 100 people (50 men and 50 women) aged 18 to 57 years in a section of North India. Ear dimensions (EL, EW, LL and LW) were measured and statistically analysed with SPSS version 16.*
Results: *The ear morphometry were higher in the men than the women. The right ear dimensions were higher than the left in both the genders. Correlation of age with ear dimensions was done using correlation and regression analysis. Age was predicted from the ear dimension using the generated regression formula.*
Conclusion: *Ear dimensions were higher in men than in women. All the ear dimensions were higher in right ear in both genders, except for the left LL in men. Ear dimensions can serve as an additional tool to estimate age for forensic investigations and for surgical corrections of ear.*
Keywords: *Ear Morphometry, Age, Gender dimorphism, Correlation Regression analysis.*

Introduction

Human ear is an important feature of the face giving an aesthetic look. The features of the external ear helps identify the age and gender of a person[1]. Among the body structures, ear continues to grow the entire lifetime, even beyond the organogenesis, skeletal maturity[2].
Pinna is formed by a resilient yellow elastic cartilage thrown into folds which gives its characteristic shape. Lobule is formed by a tag of skin containing soft fibro fatty tissue. Though one's appearance may not depend on the ear's beauty but an abnormally shaped ear or mal-positioned ear does attract unwanted attention[3].
Size, shape and orientation of the external ear are unique like that of the finger print. The dimensions of the pinna have been found to vary across different ethnic groups. Studies have shown that males have larger ears than the females[4]. Sharma et al (2008) in his study showed that Indian population

had lower ear dimensions as compared to Caucasian and Japanese populations [5].

The external ear may get malformed due to trauma, hereditary diseases, radiation or infection[6]. Certain developmental defects and ear abnormalities due to chromosomal alterations like Down's syndrome, Apert Syndrome, Crouzon syndrome, Noonan's syndrome, Turner syndrome become evident postnatally and prenatal detection of these ear abnormalities would help in early diagnosis of the said chromosomal abnormalities[2].

The knowledge of ear dimensions according to gender, age and ethnicity helps an Otoplastic surgeon reconstruct the abnormal ear and build an appropriate aesthetic ear[6]. Sforza et al. mentions that the ear dimensions measures helps designing ear aids customized for that particular population or ethnic group. Knowledge of ear dimensions is also helpful in forensic medicine for personal identification and facial reconstruction[2].

There are not many studies which help in predict the age with the help of ear dimensions. This study is an attempt to measure the ear dimensions and find out the gender and age differences in the measures, if any. Also make an attempt to predict the age of the person using the ear dimensions.

Aims & Objectives

   i. To measure the Ear length and width and Lobular length and width in men and women.
   ii. To compare the measures of male and female ears.
   iii. To compare the measures of right and left pinna.
   iv. To statistically analyze and determine the age of the subject with the ear dimensions.

Material and Method

Ear dimensions were measured from 50 Men and 50 women aged 18 years to 57 years in a section of North Indians. Subjects with previous history of craniofacial trauma, ear diseases, congenital anomalies or surgery were excluded from the study. All subjects were informed about nature and

purpose of the study and were included in the study after their consent. A digital vernier calliper was used to measure the ear dimensions with an accuracy of 0.001 and recorded in millimeters (mm). Each subject was made to sit in a chair with backrest so that the head is positioned straight looking forward with the lower border of t he eye sockets in same horizontal plane as the external auditory meatus. Age was measured in years as told by the patient.

Ear measurements were taken as in Figure 1. Ear length (EL) measured was from the most superior point of the helix (A) to the most inferior point of the ear lobule (B). Ear width (EW) was transversely from the margin of the helical rim at the point where it meets the s kin of the temporal part of the head (C) to a point on the posterior part of the helix (D).

Lobular length (LL) was from the base of the intertragic notch (E) to the most inferior point of the lobule (B). Lobular width (LW) was the horizontal distance of the lobule at the midpoint of the lobular length.
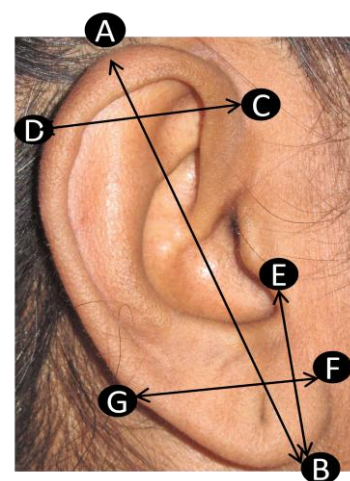

Figure 1.

Results and Analysis

The study group had 50 women & 50 men, the mean of all the variables are seen in Table 1. The mean age was 31.98 ± 10.01 years. The mean Ear Length (EL) was 61.13 ± 3.85 mm. The mean Ear Width (EW) was 24.28 ± 2.29 mm. The mean Lobular Length (LL) was 18.88 ± 2.47mm.The mean Lobular Width (LW) was 19.04 ± 2.07mm. It can be seen that the right ear has values than the left ear.

Table1: Mean values of the Study Population.

Heads	Minimum	Maximum	Mean ± SD	Variance
Age (years)	18	57	31.98 ±10.01	100.26
REL (mm)	52.26	68.82	61.15± 3.94	15.49
LEL(mm)	52.26	68.82	61.11 ±3.83	14.68
Mean EL (mm)	52.26	68.82	61.13±3.85	14.82
REW (mm)	15.73	29.26	24.30± 2.37	5.62
LEW(mm)	15.73	29.26	24.26±2.30	5.31
Mean EW (mm)	15.73	29.26	24.28±2.29	5.22
RLL(mm)	13.53	25.34	18.91±2.54	6.47
LLL(mm)	14.41	25.34	18.84±2.46	6.07
Mean LL(mm)	14.19	25.34	18.88±2.47	6.09
RLW(mm)	14.18	24.60	19.12±2.08	4.32
LLW(mm)	14.18	24.60	18.96±2.10	4.41
Mean LW(mm)	14.18	24.60	19.04±2.07	4.28
EL- Ear Length, EW- Ear Width, LL- Lobular Length, LW- Lobular Width, R- Right, L-Left				

The entire cohort was divided into 3 age groups; Up to 24 years, 25 to 35 years and 36 to 60 years as seen in Table 2. There were total 31 subjects in the up to 24 years; 18 women and 13 men. In 25 to 35 years there were total 19 subjects each in women and men. In 36 to 60 years, there were total 31 subjects of whom 13 were women and 18 were men.

a. Gender dimorphism in ear dimensions

All the ear dimensions were higher in men than women, except the EW which was higher in women as seen in Table 3 & Figure 2.

The mean EL in men was 62.85 ± 3.35 mm, compared to 59.42 ± 3.56 mm in women. The mean EW was higher in women, 24.38 ± 2.27 mm than in men, 24.18 ± 2.32 mm. The LL & LW were both higher in men (18.99 ± 2.47 mm & 19.54 ± 2.24 mm respectively) than in women (18.76 ± 2.48 mm & 18.54 ± 1.77 mm respectively).
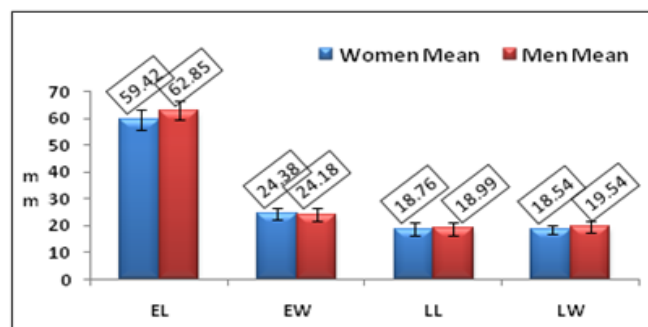

Figure 2: Mean Ear Dimensions in Men & Women
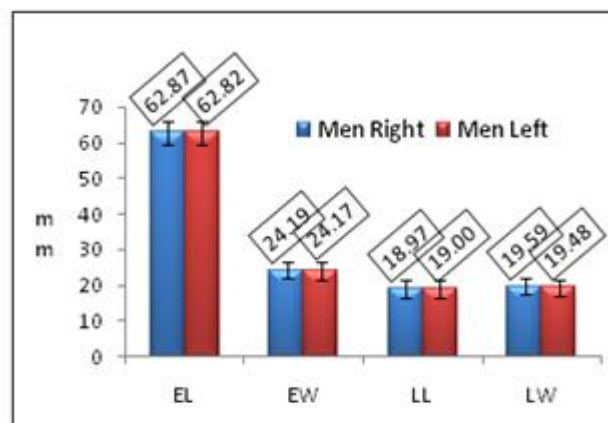
Figure 3: Ear Measures in Men (Right & Left)
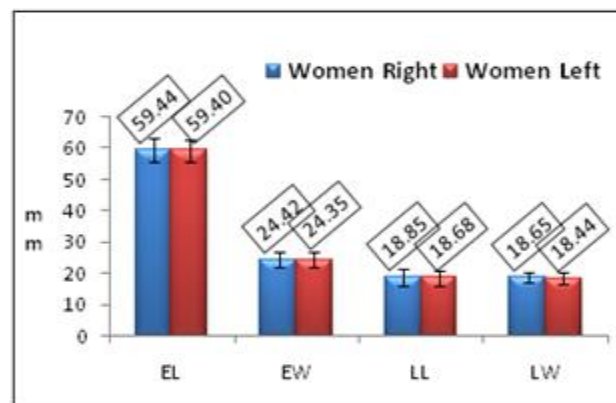
Figure 4: Ear Measures in Women (Right & Left)

Table 2: Gender distribution of the study population

Age (years)	Women		Men		TOTAL	
	No.	% age	No.	% age	No.	% age
Upto 24 yrs	18	36%	13	26%	31	31%
25 to 35 yrs	19	38%	19	38%	38	38%
36 to 60 yrs	13	26%	18	36%	31	31%
Total	50	100%	50	100%	100	100%

Table 3: Mean Ear Dimensions in Men & Women.

Ear Dimensions	Women Mean ± SD	Men Mean ± SD
EL	59.42 ± 3.56 mm	62.85 ± 3.35 mm
EW	24.38 ± 2.27 mm	24.18 ± 2.32 mm
LL	18.76 ± 2.48 mm	18.99 ± 2.47 mm
LW	18.54 ± 1.77 mm	19.54 ± 2.24 mm

Table 4: Mean Ear Dimensions in Right & Left side of Men & Women

Ear Dimensions	Women		Men	
	Right	Left	Right	Left
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Mean EL	59.44 ± 3.70 mm	59.40 ± 3.51 mm	62.87 ± 3.41 mm	62.82 ± 3.37 mm
Mean EW	24.42 ± 2.45 mm	24.35 ± 2.29 mm	24.19 ± 2.31 mm	24.17 ± 2.34 mm
Mean LL	18.85 ± 2.59 mm	18.68 ± 2.44 mm	18.97 ± 2.52 mm	19.00 ± 2.50 mm
Mean LW	18.65 ± 1.78 mm	18.44 ± 1.82 mm	19.59 ± 2.26 mm	19.48 ± 2.25 mm

Table 5: Ear Dimensions distribution in Different Age Groups.

Ear Dimensions	Age Group	No.	Mean ± SD(mm)	Std. Error	P value
Mean EL (mm)	Up to 24 yrs	31	59.46 ± 3.47	0.62	
	25-35 yrs	38	60.62 ± 3.85	0.62	
	>36 yrs	31	63.44 ± 3.15	0.57	0.000
	Total	100	61.13 ± 3.85	0.38	
Mean EW (mm)	Up to 24 yrs	31	24.43 ± 2.72	0.49	
	25-35 yrs	38	24.39 ± 2.21	0.36	
	36 to 60 yrs	31	24.00 ± 1.93	0.35	0.708
	Total	100	24.28 ± 2.29	0.23	
Mean LL (mm)	Up to 24 yrs	31	17.84 ± 2.31	0.41	
	25-35 yrs	38	18.63 ± 2.57	0.42	
	36 to 60 yrs	31	20.21 ± 1.89	0.34	0.000
	Total	100	18.88 ± 2.47	0.25	
Mean LW (mm)	Up to 24 yrs	31	18.75 ± 2.16	0.39	
	25-35 yrs	38	19.00 ± 2.22	0.36	
	36 to 60 yrs	31	19.38 ± 1.78	0.32	0.477
	Total	100	19.04 ± 2.07	0.21	

In both genders, the right ear had higher values except the left LL in men which was longer than the right, Table 4, Figure 3 &4. The women, higher right ear values, the EL, EW, LL & LW (59.44 ± 3.70 mm, 24.42 ± 2.45 mm, 18.85 ± 2.59 mm & 18.65 ± 1.78 mm respectively) than the left ear (59.40 ± 3.51 mm, 24.35 ± 2.29 mm, 18.68 ± 2.44mm & 18.44 ± 1.82 mm respectively). In men also the right ear had higher values for EL, EL and LW (62.87 ± 3.41 mm, 24.19 ± 2.31 mm & 19.59 ± 2.26 mm) than the left ear (62.82 ± 3.37 mm, 24.17 ± 2.34 mm & 19.48 ± 2.25 mm). However, the left LL(19.00 ± 2.50 mm) was longer than the right LL (18.97 ± 2.52 mm)in men

b. Ear Dimensions Change with Age
The study estimated that as age increase, the ear dimensions increased in EL,LL and LW except the

EW, Table 5. The increase was statistically significant as the p value is < 0.05 for EL and LL but not for EW and LW. The mean EL increased from 59.46 ± 3.47 mm to 63.44 ± 3.15 mm from up to 24 years to those in 36 to 60 years. The mean LL increased from 17.84 ± 2.31 mm to 20.21 ± 1.89 mm from up to 24 years to those in 36 to 60 years.

c. Correlation and Linear Regression:
The correlation of the ear dimensions with age was analysed, Table 6. The mean EL (r= 0.461) and LL (r = 0.035) was significantly correlated with p < 0.01. The mean EW (r =0.035) and the mean LW (r = 0.149) were not statistically significant as the p value > 0.05.

Using the regression model, the goodness of fit was checked by the coefficient (R^2), Table 7. For the mean EL which is statistically significant the R^2=

0.212 i.e , only about 20% of the variation in age can be accounted by variation in EL. For mean LL, only 12% (R^2= 0.123) of the variation in age can be accounted by variation in LL.

Table 6: Pearson's Correlation of Age with Ear Dimensions.

	Mean EL	Mean EW	Mean LL	Mean LW
Age	0.461**	0.035	0.350**	0.149
P Value	0.000	0.728	0.000	0.140
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 7: Regression Model of Ear Dimensions

Ear Dimensions	R	R^2	Adjusted R^2	SE	P value
Mean EL	0.461	0.212	0.205	8.929	0.000
Mean EW	0.035	0.001	-0.009	10.058	0.728
Mean LL	0.350	0.123	0.114	9.427	0.000
Mean LW	0.149	0.022	0.012	9.952	0.140

A regression equation was generated as seen in Figures 5 to 8, to predict the age (y) from the ear dimensions (x).For every increase by 1 mm in EL, age reduced by 41.39 years (Figure 5). For every 1 mm increase in EW, age increased by 28.23 years (Figure 6).
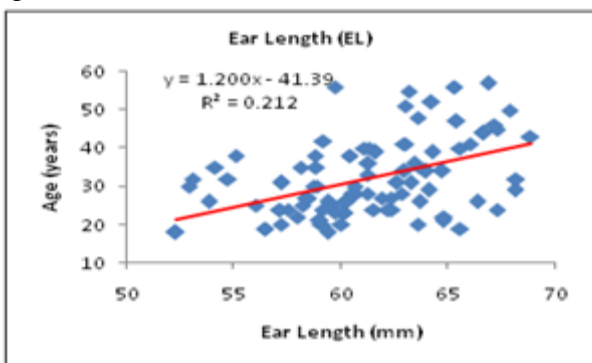

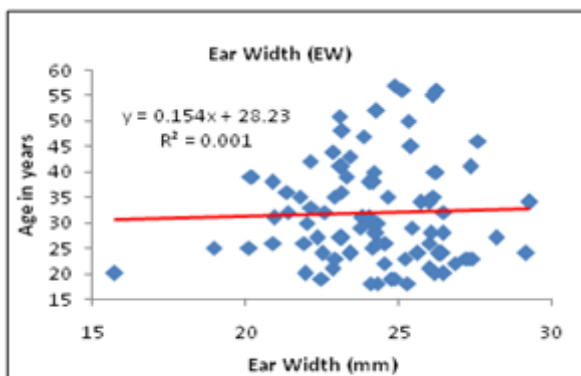Figure 5: Correlation & Regression of EL & Age

Figure 6: Correlation & Regression of EW & Age

For every 1 mm increase in LL, age increased by 5.16 years (Figure 7). For every 1 mm increase in

LW, age increased by 18.29 years (Figure 8). Thus the age could be predicted from the ear dimensions. The mean ear dimensions of the study group were checked to predict the age by using the formula y= b*x+ a and it related well with real values. As per the regression equation the predicted age (y) was approximately the same for each one of the ear dimensions (Table 8).
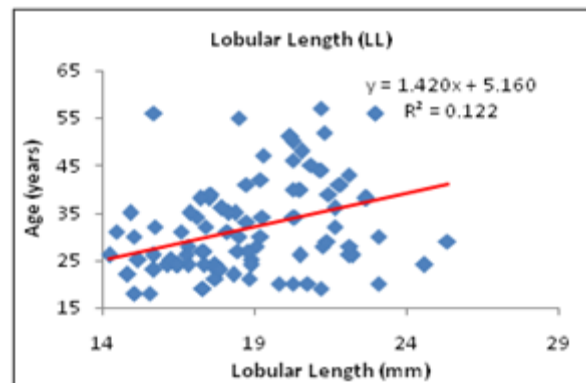

Figure 7: Correlation & Regression of LL & Age

Table 8: Prediction of Age from Regression Equation.

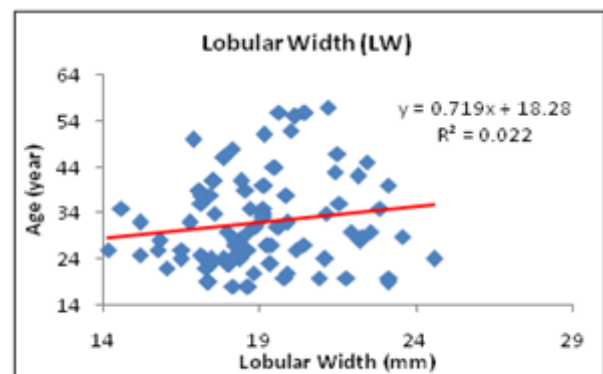| Ear Dimensions	x (value)	b (slope)	b*x	a (constant)	y (Age)
Mean EL	61	1.200	73.2	-41.39	31.81
Mean EW	25	0.154	3.850	28.23	32.08
Mean LL	19	1.421	26.999	5.161	32.16
Mean LW	19	0.719	13.661	18.288	31.95
y (Age)= b*x+ a					

Figure 8: Correlation & Regression of LW & Age

Discussion

The external ear consists of auricle or pinna and external acoustic meatus. The auricle is made up of elastic cartilage lined by skin on both sides. The lower part of the auricle made of connective tissue is covered by skin and is called as lobule. Formation of the auricle begins in the foetus (4th to 6th gestational week) and reaches a mature height at

around 13 years in males and around 12 years in females[7].

The ear's shape and size completes the facial appearance, however its importance has been under-recognized so far. The ear conveys a lot of information about the age and gender of an individual. The auricular expansion starts earlier in men than women and continues till older age and these are also influenced by genetic factors [7].

The present study showed higher values except mean EW (Table 1) than the Urhobo people of Southern Nigeria in Ebon's study[4]. Sharma et al. in his study estimated that Indian's had lower ear dimensions than the Caucasian and the Japanese [5]. Senthil et al studied the ear dimensions in Indians and Malaysians and found the Malaysian men and women have higher values than the Indian men and women [7].

Like in other studies, gender dimorphism of ear dimension (EL, EW, LL & LW) was evident in this study too with men having higher measures than the women except for a wider EW in women (Table 3). In the present study (Table 4) all the ear measures in women were higher in the right side. The men also had higher right ear values except for the Left LL was longer than the right LL. Senthil et al also estimated that the right ear dimensions in Indian Men and Women were higher except for the left EW in men[7]. In the Thakur community, Priyanka et al. found higher right ear measures in men for LL, LW and women for EW and LW. But in the same group the EL, EW of men and EL, LL of women were more in the left side[8].

In Ebon's study, the women showed statistically significant higher mean LL than men. The differences between genders in other parameters were not significant. In the same study women had higher values for LL and LW than men. The mean values in other parameters between men and women were nearly identical[3].

In a similar study of Indian Americans (18 to 30 years), men had higher ear values than women and the left measures were higher than the right measures both in men and women[6]. Taura et al also showed that the EL& EW was higher in the men

both in the left and right side than the women [4]. In Medical Students from Goa (18 to 25 years) men had higher EL & EW and women had higher LL & LW. Both women and men had left longer EL and wider right EW. The men had longer right LL and wider left LL, but the women's left LL and the right LW had higher values[9]. Thus it is seen that there is ethnic variations in the ear dimensions for gender and right and left ear.

In the present study there was a significant increase in EL, LL and LW with increasing age except in EW which decreased with age (Table 5). In Ebon's study too there was a gradual increase in EL & EW from 6 to 60 years[3]. In a study of 415 adult Indian men from Central India, all the linear measurements increased steadily in size with age [10].This indicates that morphometry of the ear increases proportionally with age.

Significant correlation of age was with EL and LL in the present study (Table 6). A similar correlation was found in another study of Magaji et al where all ear measures were significantly correlated with age[11]. The present study also revealed that from the linear regression, the age of the person could be predicted from the ear dimensions. This will help in forensic investigation where personal details are unknown.

Conclusion

From the present study on 100 persons from North India, it was evident, that gender dimorphism existed; men had higher ear dimensions than the women like in previous studies. The right ear had higher values than the left ear similar to other studies. The age related changes were very much in line with other studies where the ear morphometry increases proportionately with age. Age of a person could successfully be predicted from the ear dimensions in the present study. In conclusion, knowledge of ear dimensional changes according to ethnicity, gender, right or left ear is very helpful for forensic investigations and for surgical correction of ears. Limitation of the study was that age could not be confirmed and was recorded as told by the person. More studies are required to generate a

formula to identify the gender from the ear dimensions. Studies also are required to note ear morphometry changes beyond 60 years of age and to identify causes for ear dimensional difference due to gender, right ear and left ear. Is the difference in men and women and right and left ear due to cultural practice of ear piercing, wearing ear rings, ear pulling punishment in childhood needs to be explored.

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