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Study of Morphological Variations of The Human Ear for its Applications in Personal Identification

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ABSTRACT

The external human ear is considered to be a remarkably diverse structure, displaying a wide array of personal and morphological traits across different individuals and demographic groups. The study evaluates ear morphological features in a Swat district population; involving 54.2% males and 45.8% females aged 15-60. Vernier Caliper was used for measurement and Sony Cyber-shot DSC-H55 camera for morphological study. The study analyzed ear characteristics such as size, shape, anti-tragus shape, posterior helix rolling, Darwin tubercle, crus helix expression, and ear protrusion. It also examined ear length, breadth, concha length, and width. To find relation between the gender and different ear features statistical Pearson correlation test was used. The study revealed that both sexes had ear types like square, tongue, and triangular, with asymmetry in shape and tragus form. Individual differences were observed in earlobe structures, with half being unattached. The earlobe's size and shape vary by gender, with males having longer lift ear tragus and females having equal lift ear lengths above and below the tragus. Both sexes have distinct ear widths and sizes. The height of the lift ear and the concha length varied according to gender as well. There are reports of differences in both sexes' lift ear width and height. The right ear's total length varies across the sexes. The right ear's ear length is different above the tragus but similar below it. The length of the breadth varies across the sexes. The dimensions of the concha vary depending on the gender. In both sexes, the height of the lobes is comparable, but the width varies. Darwin's tubercle displayed a range of structures. Most of the both ear length of parameters is significantly associated with gender. The current study concludes that the unique traits of the ear can yield highly valuable data for forensic examinations, including personal identification. A range of features and personalities can be seen in the ear's form as well as in key components such as Darwin's tubercle, helix, tragus, and earlobe.

INTRODUCTION

People may be easily identified by their unique characteristics, such as their size, shape, skin tone, and genetic features. In addition to DNA profiling, physical traits and biometric measurements including fingerprints, facial features, footprints, and gait patterns are frequently used in forensic investigations (Alexander *et al*. 2011; Osunwoke *et al*. 2018). Human identification and discrimination depend on anatomical features such as hand geometry, external ear, dentition, and cranium. The forensic community is interested in using ear prints, which are similar to fingerprints, to distinguish between even identical twins (Gibelli *et al*. 2012, Kumar and Singla 2013; Krishan *et al*., 2019, Verma *et al*. 2016; Rubio *et al*. 2017). According to research, which dates back to Bertillon and Iannarelli in the 19th century, external ear identification may be accomplished for both living and deceased people (Swift and Rutty 2003; Abbas and Rutty 2005; Krishan *et al*. 2019; Purkait *et al*., 2016).

The human external ear's architecture has evolved into a very complicated structure throughout time (Luo and Manley, 2020; Le Maître *et al*., 2020). Anatomy is complex because of the development of both high and depressed tissues (Rani *et al*., 2020). The anatomical features of the external ear that have improved the sound gathering mechanism throughout time are these elevations and depressions (Qvist, 2009). Many scientific disciplines have looked at the relevance of the morphological features of the human external ear. The domains of otoplasty (Park and Jeong, 2012; Carrillo-Córdova *et al*., 2017), ergonomics (Lu, *et al*., 2021), forensic investigations (Rani *et al*., 2022), acupuncture (Gates *et al*., 2006), and other related subjects have proved the significance of the external ear. Morphometric aspects (Rani *et al*., 2021), morphological traits (Rani *et al*., 2020; Rani *et al*., 2021; Krishan *et al*., 2019) and ear-print characteristics (Rani *et al*., 2022) have all been studied in relation to the human external ear. In the domain of Age, sex (Sforza *et al*., 2009) ethnicity (Verma *et al*., 2016) and bilaterality (Krishan *et al*., 2019) are other factors that affect them. The way that genes interact with the environment determines how any trait manifests. As such, the external ear's differences are influenced by both genetic and regional variables (Rani *et al*., 2022).

There are three parts to the human ear: the internal, middle, and external. In forensics causes, the external ear is used. A typical characteristic of the human face that acts as an identification marker is the pinna, an external component of the ear (Krishan *et al*. 2019; Murgod *et al*. 2013; Ahmed and Omer 2015; Alexander *et al*., 2011; Murgod *et al*. 2013).When protective gloves prevent fingerprints from being obtained, forensic investigations frequently turn to ear morphology and biometrics instead of fingerprints since they can yield important evidence by matching fingerprint-like ear prints discovered on doors and windows (Alexander *et al*. 2011; Meijerman, 2006).The stability and uniqueness of the human ear, which is unaffected by age or facial expression and can be captured from a distance, make it an excellent biometric option for face recognition and other applications. Additionally, it is a highly effective forensic tool for personal identification (Amirthalingam and Radhamani 2013; Muntasa *et al*. 2011; Victor *et al*. 2002; Hurley *et al*. 2005). Researchers found that up to 69.3% of men and 72% of women may be correctly identified by ear morphometrics. (Ekanem *et al*., 2010; Taura *et al*., 2013; Ahmed and Omer, 2015; Eboh, 2013) have all employed anthropometric ear measurements in people from Sudan and Nigeria to investigate variations in external ear anthropometry and pinna morphological alterations.

Furthermore, morphological characteristics are implied to be interdependent in some way since their manifestation is contingent upon the expression of the other qualities. For instance, the ear prominence has been associated in literature with the antihelix, concha, helix, and angle of protrusion (park *et al*., 2010). The ear has become more prominent due to the loss of separation between the anterior portion of the helical rim and the temporal portion of the head, as reported by (Karmody and Annino, 1995). These factors include the underdevelopment of the antihelix, the enlargement of the conchal bowl, the unrolled margin of the helix, and the increased angle of lobular protrusion. Additionally, total ear protrusion is linked to the degree of concavity shown in the prominence of the lower region of the anti-helix (Rubio *et al*., 2019). Like the lop ear, the helix folds downward and the antihelix under develops from the scapha, whereas the concha's extreme concavity causes the helix and antihelix to twist forward and downward in cupped ears (Karmody and Annino, 1995). Furthermore, established is the link between Down syndrome and the prenatal ear length measurement. Awwad et al. have suggested that the measurement of the prenatal ear length may serve as a tool for sonographic screening in the second trimester of pregnancy to diagnose Down syndrome. Thus, a particular correlation between the various morphological traits of the ear is proposed by the literature. Its existence has been extensively studied for the purpose of otoplasty, even if the genetic basis for this link and correlation has not been fully explored (Awwad *et al*., 1994). (Rubio *et al*., 2019) stressed the significance of the correlation among the ear morphological features for the first time in forensics. This is the first research that will be conducted on variations in morphology in residents of district swat, Kp Pakistan. Therefore, the goals of the study were to determine the sexual dimorphism and uniqueness of the external ear in the community will be studied, as well as to provide critical ear landmark accuracy for forensic gender population identification.

MATERIALS AND METHODS

Subjects / Participants

The research conducted at the University of Swat comprised a sample of 120 individuals with varying ethnic backgrounds. This sample consisted of individuals from the Main/Sayed, Pakhtun, Zargar, and Sahibzada clans. The age range of the research subjects was 15 to 60. All of the participants were first given an explanation of the nature and goals of the study. Those who were willing to participate were informed that all information gathered would be kept private, and then their signed agreement was obtained. The University of Swat Institutional Ethical Committee granted ethical approval for the current study.

Photographs of the Study

To create guidelines for the distinct ear morphology in the population, morphological features of the research were assessed. Photographs of the individuals' ears were taken, and the population under study had a few oddities identified. The Sony Cyber-shot DSC-H55 camera was used to snap pictures of the ears at the same distance from each individual.

Morphological Characteristics of the Ear

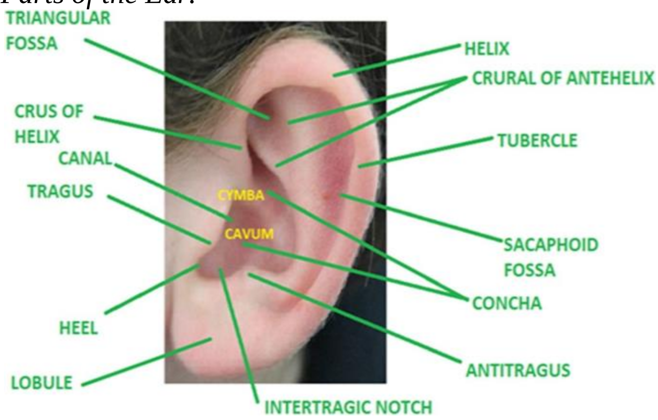
In the prior investigation, the ear trait phenotypes were evaluated with minor adjustments (Rubio, 2019). A lobe's size (small, medium, big); form (triangular, tongue, square); form of the lobe (free, partially attached); anti-tragus shape (absence, average, and prominent); and posterior helix rolling (under folded, partial folded, and over folded), average, and prominent tragus size; under-, partial-, and over-folded superior helix rolling; under-, partial-, and over-folded antihelix folding; antihelix superior crus (flat, average, and extended); Darwin tubercle (absent, degree, and prominent); small, average, and extended crus helix expression; and small, medium, and large ear protrusion, few categories assigned to the ear characteristic as detailed by (Singh and Purkait., 2009) Using a Vernier Calliper, the sizes were measured.

Statistical Analysis

IBM SPSS26 was used to investigate the study's finding. Pearson correlation was use to find out correlation between gender and different parameter of both ear

Figure 1

Photograph Showing the Morphology and Different Parts of the Ear.



RESULTS

Length of the Left Ear in the Study Population

The length was measured in MM. Mean ear length was 62.98 and the STD. deviation was 3.88 and range was 22.00. Ear Length above *Tragus*, mean was 29.2642, Std. Deviation was 4.6723 and range was 36.30. Ear Length below Tragus, mean was 17.2042, Std. Deviation was 2.85 and range was 15.00, Tragus Length, mean was 18.0583, and Std. Deviation was 3.75129 and range was 24.00. Ear Breadth mean was 31.1333, Std. Deviation was 4.69925 and range was 26.00. Concha Length mean was 26.6433, Std. Deviation was 4.63615 and range was 35.80. Concha Breadth mean was 19.1083, Std. Deviation was 3.50461 and range was 16.00. Lobule Height, mean was 15.7583, Std. Deviation was 4.16265 and range was 20.00. Lobule Width mean was 21.9083, Std. Deviation was 4.36948 and range was 21.00 as shown as in table 1.

Length of the Right Ear in the Study Population

The length was measured in MM. Mean length of the right ear was 62.93 and the Std. Deviation was 3.66 and range 18.00. Ear Length above *Tragus*, mean was 29.40, Std. Deviation was 3.88, and range was 18.00. Below Tragus, mean length was 17.36, Std. Deviation was 3.49052 and range was 23.00. Tragus mean length was 18.28, Std. Deviation was 4.15 and range was 31.00. Ear breadth, mean length was 30.9832, Std. Deviation was 4.53421 and range was 26.00. Concha mean length was 26.44; Std. Deviation was 4.09 and range was 23.00. Concha Breadth, mean length was 19.20, Std. Deviation was 3.50 and range was 18.00. Lobule height mean was 15.91; Std. Deviation was 4.25 and range was 23.00. Lobule Width means length was 21.87; Std. Deviation was 4.21594 and 22.00 as reported in Table1.

Table 1

Length (Mean ± SD) of the different parameters) of the Left and Right Ear in the Study Population. Range of (minimum and maximum, length) the Left and Right Ear.

Parameter (MM)	Left ear		Right ear	
	Mean ± SD	Range	Mean ± SD	Range
Ear length	62.98 ± 3.88	22.00	62.93 ± 3.66	18.00
Ear length above tragus	29.26 ± 4.67	36.30	29.40 ± 3.88	18.00
Ear length below tragus	17.36 ± 2.85	15.00	17.36 ± 3.49	23.00
Tragus length	18.05 ± 3.75	24.00	18.28 ± 4.15	31.00
Ear breadth	31.13 ± 4.69	26.00	30.98 ± 4.53	26.00
Concha length	26.64 ± 4.63	35.80	26.44 ± 4.09	23.00
Concha breadth	19.10 ± 3.50	16.00	19.20 ± 3.58	18.00
Lobule height	15.92 ± 3.74	20.00	15.91 ± 4.25	23.00
Lobule width	21.90 ±4.36	21.00	21.87 ± 4.21	22.00

Gender Based Ear Length of Both Ear

Both genders have varying lift ear lengths, with males having larger ear lengths above the tragus, and females having similar lengths below the tragus. The breadth of the ear varies in both sexes, with different concha length, height, and lobe height. The total ear length also varies, with similar results below the tragus. Breadth length and concha length vary across genders, while lobe height remains similar but breadth differs in both sexes as shown in table2.

Table2

Gender Based Ear Length (L in MM) of Both Ear of the Study Population. Mean, Stander Deviation (Std. D)

Parameter (MM)	Left ear of male	Right ear of male	Left ear of female	Right ear of female
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Ear length	63.98 ± 4.21	63.87 ± 3.94	61.80 ± 3.07	61.81 ± 2.98
Ear length above tragus	30.55 ± 4.20	30.52 ± 4.01	27.74 ± 4.77	28.07 ± 3.28
Ear length below Tragus	17.35 ± 2.61	17.03 ± 3.37	17.38 ± 3.14	17.76 ±3.61
Tragus length	19.16 ± 3.60	19.33 ± 4.26	16.74 ± 3.51	17.03 ± 3.69
Ear breadth	31.33 ± 5.52	31.38 ± 5.24	30.89 ± 3.52	30.50 ± 3.47
Concha length	27.75 ± 4.98	27.70 ± 3.74	25.32 ± 3.82	24.94 ± 4.02
Concha breadth	19.72 ± 3.23	19.53 ± 3.35	18.38 ± 3.69	18.80 ± 3.81
Lobule height	15.86 ± 3.43	15.90 ± 4.10	16.00 ± 4.11	15.92 ± 4.45
Lobule Width	22.47 ± 4.86	22.13 ± 4.89	21.23 ± 3.63	21.56 ± 3.25

Ear Lobe in the Study Population

There were three categories for lobe size: small, medium, and large. (83.4%) had medium-sized lobes; while (8.3%) each had large and small lobes. Different lobe sizes were noted in each gender. In the case of men, the proportion of large ear lobes was (7.7%) medium lobes were (83.1%) and small lobes were (9.2%). There were (9.1%) of large ear lobes in females, (83.6%) of medium ear lobes, and (7.3%) of small ear lobes. Three types of lobe shapes were identified. Three lobe shapes made up (73.3) percent of the population was tongue, followed by square (14.2%) and triangle (12.5%). The lobe morphologies of the male population were tongue (73.8%), square (13.8%), and triangle (12.3%). Within the female population, the lobe forms that made up (72.7%) were tongue, (14.5%) were square, and (12.7%) were triangular. Moreover, we identified three different forms of earlobes: partly, free, and attached. (65%) of the lobe was in its free form, (23.3%) was partially attached, and (11.7%) was attached. For males, the free form of the lobe was (83.1) percent, partially attached was (15.4) and attached was (1.5%). In females, free was (43.6%); in partially attached form, it was (32.7%) and in attached form, it was (23.6%) as shown in figure 2 and figure S1.

Figure 2

Percentages of Ear Lobe, Shape, Size, Form, Tragus Shape and Anti- Tragus in the Study Population

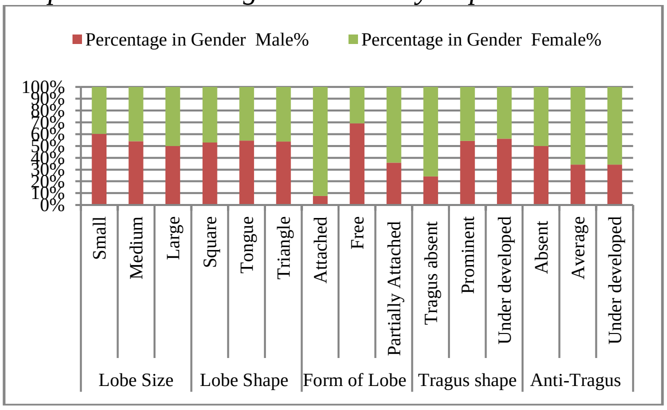
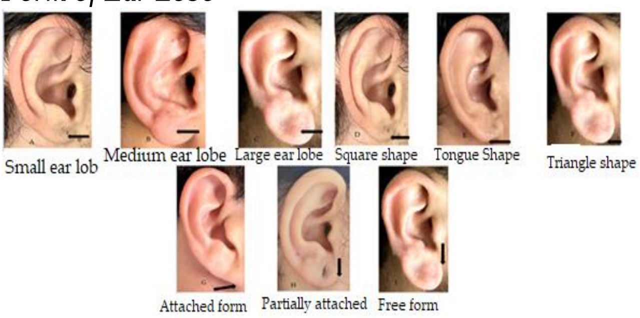


Fig S1

Ear Lobe Size, Shape and Form, (A) Small Ear Lobe, (B) Medium Ear Lobe, (C) Large Ear Lobe, (D) Square Shape, (E) Tongue Shape (F) Triangle Shape, (G) Attached Form, (H) Partially Attached Form, (I) Free Form of Ear Lobe



Tragus and Anti- Tragus

Three distinct tragus morphologies were identified: underdeveloped, prominent, and absent. 50.7% were underdeveloped, 40.7% were prominent, and 3.3% were absent. In the case of females, the percentages of prominent, underdeveloped, and absent were 56.9%, 38.2%, and 5.5%, respectively, but in the case of males, the percentages were 56.1%, 41.5%, and 1.5%, respectively. Anti-tragus was found in three different forms in the current study: absent, average, and prominent. In terms of anti-tragus, there were three categories: predominant (60.8%), average (34.2%), and absent (5.0%). Prominent anti-tragus was 45.5% in females, average anti-tragus was 49.1.2%, and absent anti-tragus was 5.5%; in contrast, prominent anti-tragus was 73.8% in males, average anti-tragus was 21.5%), and absence anti-tragus was 4.6% as shown figure 1 and figure S2.

Fig S2

Tragus and Anti-Tragus of the Ear, (A) Tragus is Absent, (B) Underdeveloped, (C) Prominent, (D) Anti Tragus is Absent, (E) Average Anti Tragus, (F) Prominent Anti Tragus

Helix Rolling, Crus Helix, Anti Helix Folding, Anti-Helix Superior Crus

Three forms of posterior helix rolling were identified in this study: under, partial, and over folded. Underfolded was (6.6%), while overfolded and partially folded were both (46.7%). Partial folded was (41.8%) and overfolded posterior helix rolling was (47.3%) and underfolded was 10.9% in females. In the population of males, the percentage of overfolded posterior helix rolls was (46.2%), partial folds accounted for (50.8%), and a while underfolded was (3%). Three forms of superior helix rolling were identified: underfolded, partial folded, and over folded. (51.7%) were folded partially, (45.8%) were overfolded, and (2.5%) percent were underfolded. The current investigation found three different forms of anti-helix folding. According to the current study, half of the study participants (50.8%) had partial anti-helix folds, (43.3%) had overfolds, and (5.8%) had underfolds. Three forms of Crus helix expression were observed: small, extended, and average. The population with the highest expression of the crus helix (80.8%), small expression (15.8%), and expression (3.3%) had the extended crus helix. The current investigation found three different forms of anti-helix folding. According to the results of the current study, (5.8%) of the study participants were underfolded, (43.4%) were overfolded, and (50.8%) were partly anti-helix folded. There were three varieties of anti-helix superior crus: flat, extended, and average. The average anti-helix superior crus were (44.2%), the extended was (54%), and the flat was (1.7%). Data as shown in table 3 and figure S3.

Table 3

Percentage of Posterior Helix Rolling, Superior Helix Rolling, Crus Helix Expression, Anti Helix Folding, Anti-Helix Superior Crus

Parameters of ear		Gender	
		Male	Female
Antihelix Superior Crus	Average	19.2%	25.0%
	Extended	34.2%	20.0%
	Flat	0.8%	0.8%
Crus Helix Expre ssion	Average	44.2%	36.7%
	Extended	0.0%	3.3%
	Flat	10.0%	5.8%
Antihelix Folding	Over Folded	30.0%	13.3%
	Partial Folded	22.5%	28.3%
	Under Folded	1.7%	4.2%
Superior Helix Rolling	Over Folded	21.7%	24.2%
	Partial Folded	32.5%	19.2%
	Under Folded	0.0%	2.5%
Posterior Helix Rolling	Over Folded	25.0%	21.7%
	Partial Folded	27.5%	19.2%
	Under Folded	1.7%	5.0%
Ear Protrusion	Large	3.3%	2.5%
	Medium	48.3%	42.5%
	Small	2.5%	0.8%
Darwin Tubercle	Absent	46.7%	23.3%
	Degree	5.0%	16.7%
	Prominent	2.5%	5.8%

Figure S3

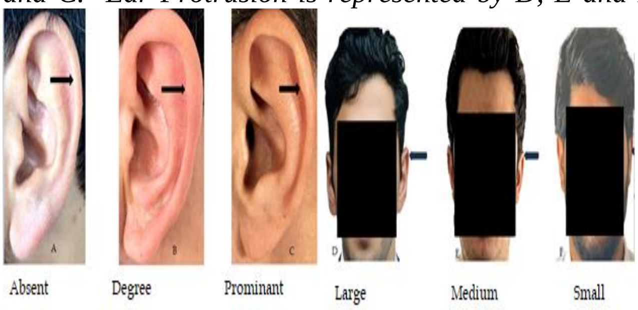
Posterior Helix Rolling was Underdeveloped, Overdeveloped and Partial Developed, represented by A, B and C; Superior Helix Rolling represented by D, E and F; crus helix expression were represented by H, H, I; Anti helix folding represented by J, K, L; anti-Helix superior crus represented by M, N, O.

Frequency of Darwin Tubercle and Ear Protrusion

Three distinct types of Darwin tubercles were identified within the research population: absent, degree, and prominent. In the research group, the prevalence of Darwin tubercle was absent 70.0% individuals, in (21.7%) was degree and 8.3% was prominent. In the study population, female Darwin tubercle absenteeism was found in (50.0%) of cases; the degree was (36.4%), and the prominent gender was (12.7%). Conversely, in the case of male Darwin tubercle absenteeism was (86.2%), the degree was (9.2%), and the prominent gender was (2.6%). Three sizes of ear protrusion were identified: large, medium, and tiny. The population's ear protrusions were divided into three categories: medium (90.8%), large (5.8%), and Small (3.4%) as shown as in table3 and morphological characteristic as shown in figure S4.

Figure S4

Structure of Darwin Tubercle and Ear Protrusion. Darwin Tubercle are Three types Represented by A, B and C. Ear Protrusion is represented by D, E and F.



Correlation between Lengths of Both Ears with Gender

Pearson correlation was use to find out correlation between gender and different parameter of both ears. Most of the length of both ear parameters is significantly associated with gender Ear length below tragus (L), ear breadth (L) in, Lobule height (L), Ear length below tragus (R), Ear breadth (R), Concha breadth (R), Lobule height (R), Lobule width (R) as shown as bold in table S1and S2.

Table S1

Pearson Correlation Table of Left Ear Bold Value Indicated Significant Correlation between Parameter, Gender and also among the Parameter

Parameters	Pearson Correlation Test	Gender	Ear Length	Length Above Tragus	Length Below Tragus	Tragus Length	Ear Breadth	Concha Length	Concha Breadth	Lobule Height	Lobule Width
Gender	P Correlation	1	.282**	-.301**	.005**	-.323**	-.048**	-.262**	-.191*	.019**	-.142**
	Sig. (2-tailed)		.002	.001	.958	.000	.605	.004	.036	.841	.122
	N	120	120	120	120	120	120	120	120	120	120
Total Ear Length	P Correlation	-.282**	1	.146	-.232*	-.218*	.269**	.368**	-.028**	.201*	.165
	Sig. (2-tailed)	.002		.111	.011	.017	.003	.000	.764	.028	.072
	N	120	120	120	120	120	120	120	120	120	120
Ear Length Above Tragus	P Correlation	-.301**	.146	1	.093	-.314**	.332**	.114	.034	.166	-.295**
	Sig. (2-tailed)	.001	.111		.314	.000	.000	.216	.709	.070	.001
	N	120	120	120	120	120	120	120	120	120	120

Ear Length Below Tragus	P Correlation	.005	-.232*	.093	1	-.298**	.052	.143	.052	-.395**	-.223*
	Sig. (2-tailed)	.958	.011	.314		.001	.573	.119	.571	.000	.014
	N	120	120	120	120	120	120	120	120	120	120
Tragus Length	P Correlation	-.323**	.218*	.314**	.298**	1	.004	.246**	-.025	.210*	.032
	Sig. (2-tailed)	.000	.017	.000	.001		.963	.007	.788	.022	.732
	N	120	120	120	120	120	120	120	120	120	120
Ear Breadth	P Correlation	-.048	-.269*	-.332**	.052	.004	1	-.129	-.079	.066	-.419**
	Sig. (2-tailed)	.605	.003	.000	.573	.963		.161	.388	.474	.000
	N	120	120	120	120	120	120	120	120	120	120
Concha Length	P Correlation	-.262**	-.368**	.114	.143	-.246**	-.129	1	.101	.097	.111
	Sig. (2-tailed)	.004	.000	.216	.119	.007	.161		.270	.293	.228
	N	120	120	120	120	120	120	120	120	120	120
Concha Breadth	P Correlation	-.191*	-.028	.034	.052	-.025	-.079	.101	1	.028	.114
	Sig. (2-tailed)	.036	.764	.709	.571	.788	.388	.270		.765	.216
	N	120	120	120	120	120	120	120	120	120	120
Lobule Height	P Correlation	.019	.201*	.166	.395**	.210*	.066	.097	.028	1	.340**
	Sig. (2-tailed)	.841	.028	.070	.000	.022	.474	.293	.765		.000
	N	120	120	120	120	120	120	120	120	120	120
Lobule Width	P Correlation	-.142**	.165	-.295**	-.223*	.032	-.419**	.111	.114	-.340**	1
	Sig. (2-tailed)	.122	.072	.001	.014	.732	.000	.228	.216	.000	
	N	120	120	120	120	120	120	120	120	120	120

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table S2

Pearson Correlation Table of Right Ear Bold Value Indicated Significant Correlation between Parameter, Gender and also among the Parameter

Parameters	Pearson Correlation test	Gender	Ear Length	Length Above Tragus	Length Below Tragus	Tragus Length	Ear breadth	Concha Length	Concha Breadth	Lobule Height	Lobule Width
Gender	P Correlation	1	-.281**	-.316**	.105	-.277**	-.098	-.337**	-.103**	.002	-.068**
	Sig. (2-tailed)		.002	.000	.253	.002	.291	.000	.262	.980	.459
	N	120	120	120	120	120	119	120	120	120	120
Total Ear Length	P Correlation	-.281**	1	.185*	.233*	.214*	.203*	.398**	.036	.212*	.205*
	Sig. (2-tailed)	.002		.043	.010	.019	.027	.000	.700	.020	.024
	N	120	120	120	120	120	119	120	120	120	120
Ear Length Above Tragus	P Correlation	-.316**	.185*	1	-.010	.282**	.464**	.126	.092	.124	.358**
	Sig. (2-tailed)	.000	.043		.911	.002	.000	.170	.320	.177	.000
	N	120	120	120	120	120	119	120	120	120	120
Ear Length Below Tragus	P Correlation	.105	.233*	-.010	1	.208*	-.046	.118	.165	.401**	.230*
	Sig. (2-tailed)	.253	.010	.911		.022	.621	.200	.072	.000	.012
	N	120	120	120	120	120	119	120	120	120	120
Tragus Length	P Correlation	-.277**	.214*	.282**	.208*	1	.033	.208*	.070	.143	.071
	Sig. (2-tailed)	.002	.019	.002	.022		.724	.022	.450	.120	.440
	N	120	120	120	120	120	119	120	120	120	120
Ear breadth	P Correlation	-.098	.203*	.464**	-.046	.033	1	-.143	-.178	-.011	.400**
	Sig. (2-tailed)	.291	.027	.000	.621	.724		.120	.052	.909	.000
	N	119	119	119	119	119	119	119	119	119	119
Concha Length	P Correlation	-.337**	.398**	.126	.118	.208*	-.143	1	.124	.046	.005
	Sig. (2-tailed)	.000	.000	.170	.200	.022	.120		.177	.621	.960
	N	120	120	120	120	120	119	120	120	120	120
Concha Breadth	P Correlation	-.103	.036	.092	.165	.070	-.178	.124	1	.088	.072
	Sig. (2-tailed)	.262	.700	.320	.072	.450	.052	.177		.340	.436
	N	120	120	120	120	120	119	120	120	120	120
Lobule Height	P Correlation	.002	.212*	.124	.401**	.143	-.011	.046	.088	1	.318**
	Sig. (2-tailed)	.980	.020	.177	.000	.120	.909	.621	.340		.000
	N	120	120	120	120	120	119	120	120	120	120
Lobule Width	P Correlation	-.068	.205*	.358**	.230*	.071	.400**	.005	.072	.318**	1
	Sig. (2-tailed)	.459	.024	.000	.012	.440	.000	.960	.436	.000	
	N	120	120	120	120	120	119	120	120	120	120

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

DISCUSSION

Individuals may be quickly recognized by their distinctive qualities, which include their size, form, skin tone, and genetic makeup. Forensic investigations commonly include physical characteristics and biometric measures, such as fingerprints, facial features, footprints, human pigmentation like eye color and gait patterns, in addition to DNA testing (Alexander *et al*.

2011; Osunwoke *et al*. 2018; Rahat *et al*.,2020; Rahat *et al*.,2022). Anatomical characteristics include hand geometry, the external ear, teeth, and the skull are used to identify and differentiate humans. Ear prints are comparable to fingerprints and have been shown to be useful by the forensic community in differentiating even identical twins (Gibelli *et al*. 2012, Kumar and Singla 2013; Krishan and Kanchan 2015, Verma *et al*. 2016; Rubio *et al*. 2017). Study on external ear identification extends back to Bertillon and Iannarelli in the 19th century (Swift and Rutty 2003; Abbas and Rutty 2005; Krishan and Kanchan, 2019; Purkait *et al*., 2016). This study may be done on both living and deceased individuals. Forensic science is unique and individualistic, focusing on identifying and exploiting abnormalities within classes, unlike regular science which focuses on establishing regularities. Its fundamental premise is that items differ enough to be unrecognizable upon close examination. Forensic identification is crucial in understanding human development (Saks & Solomon 1998). Farkas (1978) and Kalciolglu (2023) suggest that the full ear length is reached by age 13 for females and 15 for males, while Susanne (1977) observed a 22-year rise in ear length of 5.89 mm in 44 Belgian men. Meijerman and Ito's research showed a lifelong increase in ear measures for both genders, with auricular length rising by 0.18 mm/year in males and 0.16 mm/year in women (Ito *et al*., 2001).

According to the results of the current study, the mean lengths of the left and right ears in men were determined to be differently. Same result is reported where Male and female ear lengths and widths differed significantly, with males having larger averages for both left and right ear measurements, according to (Ahmed and Omer's, 2015; Murgod *et al*. 2013; Sforza *et al*. 2009; Muteweye and Muguti 2015; Taura *et al*. 2013; Sharma and Nanda 2009; Deopa *et al*. 2013), the right ear is wider than the left ear and the left ear is longer. This information is important for diagnosing congenital disorders like microtia, Down's syndrome, hearing loss, cleft lip and palate, and Crouzon and Apert syndromes. (Kalcioglu *et al*. 2023) discovered no discernible variation in ear widths in the both sexes. Since each human ear is different, its structure and characteristics add to its uniqueness. This makes it possible to identify suspects as criminals and allows for individualization during forensic tests (Cameriere *et al*. 2011; Guyomarc'h and Stephan 2012; Swift and Rutty 2003; Singh and Purkait 2009).

All these variable components and the individualistic/special qualities of the ear may also contribute to the subject's individualization in the crime scene CCTV film. The literature has a few research on the morphological characteristics of the ear and its show diversity between groups (Rubio *et al*. 2017; Cameriere *et al*. 2011; Purkait, 2016; Verma *et al*. 2016; Purkait and Singh 2008; Alexander *et al*. 2011). The results of this study's analysis of the morphological features of the ear may be compared to a few other similar studies that have been conducted worldwide. We were unable to identify an oval ear shape in the participants of the current investigation. According to (Krishan and Kanchan, 2019) 65% of Americans had ears that were oval in shape. The findings from the previous study about round-type ears in the males (20%) and females (17–18%) can be compared to the Dutch males' (3%) and Americans' (2%), results According to Chattopadhyay and Bhatia (2009), male Indian Brahmins have a higher proportion of oblique-type ears (63.89%); yet, males in the earlier study had a percentage of 22–29% for oblique-type ears. Additionally, 27.19% of respondents had long, narrow ears, 46.49% had medium ears, 26.31% had short, broad ears, and 36.11% had vertical ears, according to their study. Singh and Purkait observed that 47–52% of persons in Central India had oval ears, 26–30% had rectangular ears, 26–35% had triangular ears, and 23–59% had round ears in their study on the region's population. These outcomes differ from the current study.

The current study found that large number of participants had medium-sized earlobes, compared to large and small lobes. Non-significant Differences were observed in lobe sizes each gender. In the both cases, the proportion of large ear lobes and small was low as compared to, medium lobes. The three most common lobe shapes in the population were observed tongue form accounted high, followed by square shapes and triangle shapes but the percentages are different in both genders. Most of the participant had free form of ear lobe they are not attached with the faces followed by partially attached and fully attached. Difference was seen in male and female participants as compared male with female the male had high percentage of free form of ear lobe followed by partially and attached. Similarly to the present study same result was founded by, (Chattopadhyay and Bhatia, 2009; Rani, *et al*., 2020.

The current investigation distinguished three types of posterior helix rolling based on the diversity of helix structural characteristics: underfolded (6.7%), partially folded (46.7%), and overfolded (46.7%). The percentage of male posterior helices with partial folds of 50.8% and underfolds of 3.1% was 46.2%, compared to 47.3% in the female population. There was 51.7% partial folding, 45.8% over folding, and 2.5 percent under folding during the superior helix rolling process. According to the study, 80.8% of participants had crus helix expression, small in 15% of instances, extended in 3.3%, and partial anti-helix folding in 50.8% of people; over folding occurred in 43.3% of cases and under folding in 5.8% of cases. 53.8% of research participants were underfolded, 43.3% were overfolded, and 50.8% were partially anti-helix folded, according to anti-helix folding. The anti-helix superior crus were 44.2%, the flat was 1.7%, and the extended was 54%. When compared to these findings, the study's outcomes were different from those of prior research (Singh and Purkait, 2006; Singh and Purkait, 2009; Krishan and Kanchan, 2019).

Three unique forms of the tragus were found to be undeveloped, prominent, and absent. There were the following proportions of prominent is high, followed by undeveloped and absent. Small differences in percentages were seen in male and female participant. The current investigation discovered three kinds of anti-tragus: prominent, average, and absent. Three categories of anti-tragus were identified: prominent was high as compared to absent and average. In contrast to the percentage of males who were prominently anti-tragus (73.8%), averagely anti-tragus (21.5%), and absently anti-tragus (4.6%), the percentage of females who were prominently anti-tragus was 45.5%. In comparison, round form tragus was found in 2.3% of females and 22.2% of males in the Kinnaur population, whereas single knob tragus was found in 72.75% of men and 94.85% of females ((Krishan and Kanchan, 2019). Yet, the prevalence of round forms is lower in this group than in others ((Krishan and Kanchan, 2019).

In the Three distinct kinds of Darwin tubercles were observed in the study population. Within the present investigation, large number of participants had Darwin tubercle is absent, followed by degree of tubercle, and small number had a prominent case. A substantial percentage difference was seen in male and female participant. Large, medium, and small ear protrusions were present in three different sizes. Three percent had small protrusions, five percent had large ones, and ninety-eight percent of the population had medium ones. According to Singh and Purkait, Darwin's tubercle was discovered in 43.57% of male Thakurs and 39.43% of female Thakurs in Central India (Rani, *et al.*, 2020). Singh and Purkait (2009) discovered that the present study's male and female percentages were, respectively, 58.45% and 42.03%. Three distinct kinds of Darwin's tubercle can occur: small, large, and medium. In the prior population, small was the most prevalent type, present in 88.03% of males and 90.58% of females, whereas medium was the least frequent, present in 1.41% of males and 0.00% of females (Rani, *et al.*, 2020). The study conducted by Singh and Purkait produced disparate findings (Singh and Purkait, 2006). According to Jung HS & Jung HS (2003), the ear has been extensively studied for use in biometrics and ergonomic design of ear-related equipment, such as helmets, headphones, hearing aids, earrings, etc. These studies will be considerably more beneficial to the reconstruction of the external ear features.

CONCLUSION

The study found that both male and female participants had a triangle ear shape, with different tragus shapes on the left and right sides. The earlobe was found to be connected to the face in more cases, demonstrating the uniqueness of each human ear due to its outward anatomy. The study provides new insights into ear variability in a swat population, aiding in forensic examinations and facial image identification. Researchers are encouraged to explore similar variations in other global populations.

Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declarations

We confirmed that this work is original and has not been published elsewhere, nor is it currently under consideration for publication elsewhere.

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Availability of Data and Materials

All data will be provided if needed

*Authors' Contributions

MAR and SA developed and designed the project. MK, WS conducted the experiment and IK, AU arranged the experimental resources. FA and MI analyzed and interpreted the data. AI and ZH took the lead in writing the manuscript for its submission and NA and WK added Conceptualization in the manuscript; MAR and SA provided critical feedback. All the authors approved this manuscript to be published.

All the authors reviewed the manuscript.

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