Original Research Paper

Sex Determination from Anthropological Measurements of Thyroid Cartilage in the Population of Punjab

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Abstract

In the era of nanotechnology, with the advancement of scientific technologies, the extraordinary task of establishing identity of an individual has been simplified in the developed countries. However the application of such modern technologies in developing countries is still a distant dream owing to its affordability. In such countries, anthropometric analysis for the identification of unknown bodies is comparatively fruitful and cost effective. The aim of this study was to correlate the anthropological measurements of the thyroid cartilage with the sex of the individual. Thyroid cartilages from 300 cases of Punjab population were studied. A total of seventeen parameters were measured in each thyroid cartilage and the observations were compared between both sexes. Significant difference between two groups was found only in six variables (length of right and left thyroid lamina, breadth of right and left thyroid lamina, ventral thyroid height and angle between thyroid laminae). Discriminant function equation for determination of sex with group centroid value for each gender group was obtained. The measurements were again cross validated with the obtained discriminant function equation and further classified into male and female groups with a success rate of 92.3%.

Key Words: Thyroid cartilage, Anthropological measurements, Sex, Discriminant analysis

Introduction:

Establishing the identity of an individual is the need of the hour in various medico-legal cases and it is the duty of the Forensic expert in establishing the same in a given case scenario.

The various parameters for establishing the identity of an individual that are in current practice are Age, Sex, Height, weight, Race, Religion, caste, General configuration, Congenital peculiarities, Dactylography, Anthropometry, Acquired and personal peculiarities, Photographs, Superimposition test and D.N.A finger printing.

Of these, sex determination of an individual is one of the most basic requirements for establishing the identity of the individual.

Currently most of the studies have relied on the anthropological measurements of long bones for identifying the sex of an individual.

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Very few studies [1-10] have compared the anthropometric measurements of thyroid cartilage with the sex of an individual.

It has an added advantage of being present in a superficial anatomical location and does not require tedious process like removal and preparation as in case of any other long bone. The aim of this study was to determination of sex from the anthropometric measurements of the thyroid cartilage.

Materials and Methods:

This was a prospective analytical Study conducted from July 2012 to December 2013 in department of Forensic Medicine, PGIMER, Chandigarh. With a valid informed consent of the legal heirs of the deceased, a total of 300 cases of both genders were studied as per the inclusion and exclusion criteria. Cases above the age of 18 years and Residents of Punjab having at least two generation ancestors from Punjab were included in this autopsy based study.

Cases with traumatic injury to thyroid cartilage, advanced decomposition changes and with discrepancy in history related to residing place were not excluded from this study.

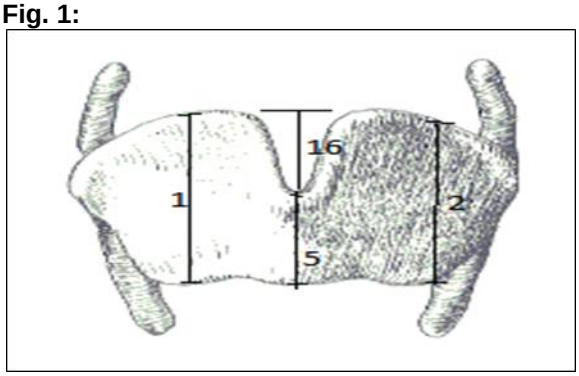
Anthropometric Evaluation:

Layer by layer dissection of the neck was carried out at autopsy and thyroid cartilage was removed with great care avoiding damage to the superior and inferior horns. Manual removal of all the gross attachments was

attempted followed by soaking in warm caustic soda solution until all the remaining muscular and ligamentous attachments were sloughed off.

After completely clearing the attachments on the dissected thyroid cartilage, the following 17 parameters were measured with the help of thread, Vernier calliper and goniometer either singly or in combination. (Table 1, Fig. 1, 2 & 3)

Fig. 1:

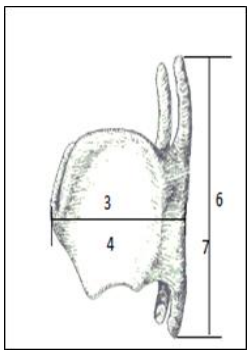


Statistical Evaluation:

Statistical analysis was done using IBM SPSS Statistics Version 20 software package. A P value of 0.05 was considered statistically significant. Gender wise correlation of all anthropometric measurements was done based on student t-test statistics.

Discriminant analysis was conducted between variables which showed significant difference between two genders. Group centroid values for each gender groups and discriminant equation for further prediction of group membership were determined.

Fig. 2&3



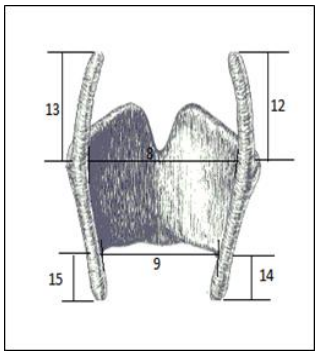


Table 1
Points of Measurement for Each Parameter of Thyroid Cartilage and Instruments Used for Measurement (Fig. 1-3)

S N.	Parameter	Point of measurement -1	Point of measurement -2	Instrument used
1	Length of right thyroid lamina	Midpoint of upper border of right thyroid lamina	Midpoint of lower border of right thyroid lamina	Vernier calliper
2	Length of left thyroid lamina	Midpoint of upper border of left thyroid lamina	Midpoint of lower border of left thyroid lamina	Vernier calliper
3	Breadth of right thyroid lamina	Anterior thyroid prominence	Midpoint of posterior border of right thyroid lamina	Vernier calliper
4	Breadth of left thyroid lamina	Anterior thyroid prominence	Midpoint of posterior border of left thyroid lamina	Vernier calliper
5	Ventral thyroid height	Deepest point of Superior thyroid incisures	Prominent point of Inferior thyroid incisures	Vernier calliper
6	Dorsal right thyroid height	Tip of right superior horn	Tip of right inferior horn	Thread, Vernier calliper
7	Dorsal left thyroid height	Tip of right superior horn	Tip of right inferior horn	Thread, Vernier calliper
8	Upper thyroid breadth	Outermost point of base of right superior thyroid horn	Outermost point of base of left superior thyroid horn	Vernier calliper
9	Lower thyroid breadth	Outermost point of base of right inferior thyroid horn	Outermost point of base of left inferior thyroid horn	Vernier calliper
10	Maximum thyroid Breadth at superior thyroid tubercle.	Outermost prominent point of right superior tubercle	Outermost prominent point of left superior tubercle	Vernier calliper
11	Maximum thyroid Breadth at inferior thyroid tubercle.	Outermost prominent point of right inferior tubercle	Outermost prominent point of left inferior tubercle	Vernier calliper
12	Length of right superior horn	Tip of right superior horn	Base of right superior horn	Thread, Vernier calliper
13	Length of left superior horn	Tip of left superior horn	Base of left superior horn	Thread, Vernier calliper
14	Length of right inferior horn	Tip of right inferior horn	Base of right inferior horn	Thread, Vernier calliper
15	Length of left inferior horn	Tip of left inferior horn	Base of left inferior horn	Thread, Vernier calliper
16	Depth of superior thyroid notch	Highest level of thyroid lamina	Deepest point of superior thyroid notch	Vernier calliper
17	Angle of thyroid	Posterior surface of right lamina	Posterior surface of left lamina	Goniometer

Results:

Out of the 300 samples of thyroid cartilage analyzed, 238 belonged to males and 62 were females. The age at death in males ranged from 18 to 80 years with a mean of 39.24 yrs. (S.D= 13.63). In females, age at death ranged from 18 to 80 years with a mean of 40.95 yrs. (S.D= 16.35).

The mean values of all the anthropometric measurements in males were correspondingly higher than the mean values of female, except for depth of superior thyroid notch and angle between thyroid laminae. (Table 2, 3, 4) The mean depth of superior thyroid notch was higher in females (10.71) when compared with that of males (10.21) though the difference was not statistically significant. (Table 4) The mean angle between thyroid laminae was also higher in females (87.53) when compared to males (83.88). (Table 4)

A significant difference ($p < 0.05$) between the values of both groups were found only in six variables namely length of right thyroid lamina (LRTL), Length of left thyroid lamina (LLTL), Breadth of right thyroid lamina (BRTL), Breadth of left thyroid lamina (BLTL), Ventral thyroid height (VHT) and Angle between two thyroid lamina (ANGLE).These six variables were further utilized for discriminant analysis for determination of sex.

Discriminant Function Analysis undertakes the same task as multiple linear regression analysis by predicting an outcome. The main purpose of a discriminant function analysis is to predict group membership based on a linear combination of the variables. In our study the discriminant function equation obtained was

D=0.720(LRTL) - 0.358(LLTL) + 0.035(BRTL) + 0.080(VHT) - 0.007(ANG) - 11.379

A way of interpreting discriminant analysis results was to describe each group in terms of its profile, using the group means of the predictor variables. In our study, females had a group mean of 1.960 while males had a group mean of 0.511. Cases with scores near to a group means were predicted as belonging to that group. All the data of each variable were applied in discriminant function equation and the output compared with the group centroid values and again classified. With the discriminant function analysis, we were able to classify 92.3% of original data correctly.

Discussion:

Out of the 17 anthropological parameters of the thyroid cartilage studied in the present study, majority of the parameters measured greater in males except for the angle of thyroid and depth of superior thyroid notch.

The mean values of these two parameters were found to be more in females than males. The angle of thyroid lamina was found to be more in females in present study (male 83.88, female 87.53). This was consistent with the findings of the studies conducted by Ajmani et al [2, 10], Harjeet and Jit [3], Sprinzl et al [5], Pereira et al [7] and Monica and Dhall. [8]

In present study the length of superior thyroid horn was more in males than females. This fact was consistent with other studies conducted by Harjeet and Jit [3], Sprinzl et al [5], Zielinski R [6] and Monica and Dhall. [8] It was conflicting with the studies conducted by Ajmani et al [10], Ajmani et al [2] and Eckel et al [4]

The studies of Ajmani et al [2] and Eckel et al [4] were conducted in Nigeria and Germany respectively. The difference in the geographical location of these studies can be hypothesized to be the reason for the greater length of superior thyroid horn in females. In Ajmani et al [10] study, the total number of samples was 150 with age of samples ranging from 16 to 55 years, whereas in the present study the sample size was 300 with the age ranging from 18 years to 80 years. Moreover in the present study there were 60(25%) samples whose ages were above 55 years. The difference in the sample size as well as the wide age range of the present study could have led to the differences in observations in comparison with other studies.

The depth of superior thyroid notch in present study though not significant was slightly on higher side among females. This observation was not consistent with the studies conducted by Ajmani et al [10], Ajmani et al [2], Harjeet and Jit [3], Ecket et al [4], Zielinski R [6] and Monica and Dhall. [8] The difference in geographical location, the sample size and age range of samples can be attributed to difference in the observations between previous studies and the present study. (Table 6)

Conclusion:

In the era of nanotechnology, with the advancement of scientific technologies like DNA fingerprinting, the extraordinary task of establishing the identity of an unknown individual has been simplified in the developed countries.

However in many developing countries, application of such modern technologies is still a distant dream owing to its affordability. In such countries, anthropometric analysis for the identification of unknown bodies is comparatively fruitful and cost effective.

As per the present study, the sex of any individual, which proves to be a primary data for establishment of identification, can be determined from a single cartilage, which is comparatively easy to study. It has an added advantage of being present in a superficial anatomical location and does not require tedious process like removal and preparation as in case of any other long bone.

Thus to conclude , in the present study all the measurements of thyroid cartilage were more in males than females except for the depth of superior thyroid notch and Angle between thyroid laminae.

Discriminant equation for determination of sex with group centroid values for each gender was derived for all the parameters showing significant gender differences. All the data were further cross validated and classified again with the derived discriminant equation with a success rate of 92.3 %.

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Table 5: Mean Length of Superior Thyroid Horn among Different Genders and Its Comparison with Other Studies

	Male (mm)	Female (mm)
Present study	16.36	15.90
Harjeet and Jit [3]	14.07	12.04
Sprinzl et al [5]	9.0	6.4
Zielinski R [6]	21.5	19.5
Monica and Dhall [8]	19.10	13.10
Ajmani et al [10]	15.40	16.10
Ajmani et al [2]	20.70	20.92
Eckel et al [4]	12.90	13.10

Table 6: Mean Depth of Anterior Thyroid Notch among Different Genders and its Comparison with Other Studies

Studies	Male (mm)	Female (mm)
Present study	10.21	10.71
Ajmani et al [10]	9.50	6.40
Ajmani et al[2]	11.68	10.20
Harjeet and Jit [3]	11.87	8.28
Ecket et al [4]	9.00	6.40
Zielinski R [6]	10.55	9.70
Monica and Dhall [8]	11.20	9.70

Table 2
Gender-Wise Anthropological Measurements of Thyroid Cartilage Measurements

Sex		LRTL (mm)	LLTL (mm)	BRTL (mm)	BLTL (mm)	VHT (mm)	DRRTHT (mm)
Male	Mean	27.42	27.43	36.50	36.48	16.48	34.85
	SD	±2.47	±2.49	±7.56	±7.49	±2.90	±7.59
Female	Mean	21.58	21.58	32.44	32.52	14.04	34.41
	SD	±2.75	±2.82	±8.18	±8.21	±2.20	±8.39
t value		17.647	8.789	3.699	3.628	7.218	0.392
P value		0.0001***	0.0001***	0.0001***	0.0001***	0.0001***	0.695

L RT L - Length of right thyroid lamina, L LT L - Length of left thyroid lamina, B RT L - Breadth of right thyroid lamina, B LT L - Breadth of left thyroid lamina, V HT - Ventral thyroid height, DR RT L - Dorsal right thyroid height

Table 3
Gender-Wise Anthropological Measurements of Thyroid Cartilage Measurements

Sex		DRLTHT (mm)	UBR (mm)	LBR (mm)	BSTB (mm)	BITB (mm)	RTSHR (mm)
Male	Mean	34.87	45.76	38.70	45.74	29.52	16.11
	SD	±7.66	±7.51	±5.96	±7.61	±5.29	±4.55
Female	Mean	34.58	45.39	38.54	45.37	29.27	15.80
	SD	±8.61	±8.64	±7.77	±8.68	±6.20	±4.97
t value		0.262	0.304	0.148	0.308	0.296	0.460
p value		0.794	0.762	0.883	0.759	0.768	0.646

DR LT L - Dorsal left thyroid height, U BR -Upper thyroid breadth, L BR - Lower thyroid breadth, BR S TB - Maximum thyroid Breadth at superior thyroid tubercle, BR I TB - Maximum thyroid Breadth at inferior thyroid tubercle, RT S HR - Length of right superior horn

Table 4
Gender-Wise Measurements of Different Thyroid Cartilage

Sex		LTSHR (mm)	RTIHR (mm)	LTIHR (mm)	DEPTH (mm)	ANGLE (deg)
Male	Mean	16.62	10.37	10.38	10.21	83.88
	S.D.	±4.70	±2.67	±2.59	±3.45	±11.38
Female	Mean	16.00	9.80	9.79	10.71	87.53
	S.D.	±4.52	±2.47	±2.42	±2.87	±12.89
t value		0.924	1.522	1.605	1.157	2.183
p value		0.350	0.129	0.110	0.250	0.030*

LT S HR - Length of left superior horn, RT I HR - Length of right inferior horn, LT I HR - Length of left inferior horn, DEP - Depth of superior thyroid notch, ANG- Angle between two thyroid lamina