

Morphometric Characteristics of Thyroid Cartilage in People of Eastern Croatia

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ABSTRACT

The aim of this research was to describe thyroid cartilage morphometry in the population of Eastern Slavonia in detail. The research was carried out on 68 samples of adult thyroid cartilages. There was statistically significant difference between all analysed parameters in male and female samples, except for the distance between the superior horns tips. All parameters had greater values in men, except for the thyroid angle, which was greater in women. There was significant correlation between most of the measured parameters. The strongest correlation was noticed in the distance between the horns at all measured levels and between the pairs of parameters measured for the left and right side respectively. The difference of our results in comparison to the results obtained by other researchers is probably caused by the fact that the measurements were taken on the samples obtained from different populations.

Key words: thyroid cartilage, morphometry, sexual dimorphism, Eastern Croatia

Introduction

Thyroid cartilage consists of two laminae that are joined at a greater or lesser angle. Superior pair of horns is attached to the hyoid bone, and the inferior pair to the cricoid cartilage¹. There are few scientific works that precisely research the thyroid cartilage morphometry. Apart from the fact that dimensions of the thyroid cartilage are larger in men than in women, up-to-date morphometric research has proved that the thyroid angle is greater in women than in men. The conclusions were different only in regard to the length of superior horns, which is greater in men according to some authors, while in other authors' works it is greater in women. However, the correlations between the parameters have not been closely investigated yet, except in the research carried out by Maure and Dickinson². Furthermore, there has not been any scientific research work on thyroid cartilage morphometry in Croatian population.

The aim of this research is to describe thyroid cartilage morphometry in the population of Eastern Slavonia in detail, compare the obtained results with the results of other authors, as well as to determine similarities and

differences in thyroid cartilage morphology in our population and in other ethnic groups in which similar research has been conducted thus far. Taking into consideration relatively frequent fracture of the thyroid cartilage in strangulation, as well as the fact that hanging is the most common form of committing suicide in our region³, one of the aims of this research is to provide detailed description of thyroid cartilage morphology that will be used in further research to determine the connection between the location of the thyroid cartilage fracture in strangulation and the level of ossification and the force applied in strangulation.

Materials and Methods

Thyroid cartilage samples used in this research were of known age and sex, taken randomly from the Department of Anatomy collection at »J. J. Strossmayer« University of Osijek, School of Medicine. The research was carried out on 68 samples of adult thyroid cartilages, 39

male and 29 female. The average age of male samples was 62 (± 36) and of female samples 70 (± 26).

Soft tissues were removed from the thyroid cartilage samples and the preparations were then fixed in 10% formalin during 48 hours. Morphometric measurements were then taken using the methodology determined in the previously conducted similar research⁴. The measurements were taken directly on preparations using a digital calliper with the precision of 0.03 mm. Thyroid

angle was determined with an optical goniometer with the precision of 0.08°. In order to precisely describe the morphology of the thyroid cartilage, 12 standards parameters were measured (bilateral parameters separately for the left and the right side) (Figures 1 and 2).

AA – the distance between the tips of the superior horns
 BB – the distance between the roots of the superior horns
 CC – the distance between the roots of the inferior horns
 DD – the distance between the tips of the inferior horns

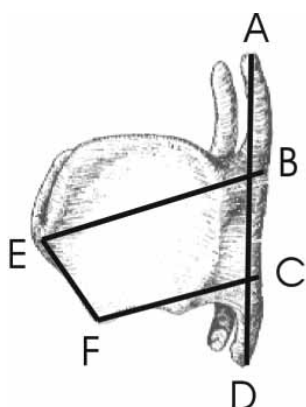


Fig. 1. Measured parameters, lateral view. AD – the posterior height of the thyroid cartilage; AB – the length of the superior horns; BC – the posterior height of the lamina; CD – the length of the inferior horns; BE – the superior width of the thyroid cartilage; CF – the inferior width of the thyroid cartilage; EF – the anterior height of the thyroid cartilage.

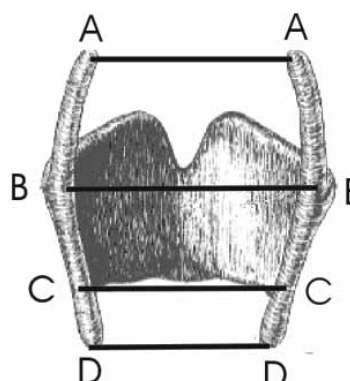


Fig. 2. Measured parameters, frontal view. AA – the distance between the tips of the superior horns; BB – the distance between the roots of the superior horns; CC – the distance between the roots of the inferior horns; DD – the distance between the tips of the inferior horns; α – the thyroid angle.

TABLE 1
 AVERAGE VALUE OF MEASURED PARAMETERS

	Men		Women	
	$\bar{X} \pm SD$	Range	$\bar{X} \pm SD$	Range
AdAs (mm)	40.19 \pm 7.97	18.87–52.80	36.91 \pm 7.41	20.27–53.63
BdBs (mm)	45.75 \pm 6.12*	26.80–56.12	39.19 \pm 6.12*	24.75–57.54
CdCs (mm)	39.82 \pm 4.91*	23.18–49.91	33.25 \pm 5.00*	21.62–46.06
DdDs (mm)	35.85 \pm 5.08*	17.77–44.26	29.62 \pm 4.94*	19.73–41.20
AdDd (mm)	45.31 \pm 5.08*	32.76–55.81	37.14 \pm 5.32*	27.88–50.06
AsDs (mm)	45.39 \pm 4.46*	33.14–52.50	37.60 \pm 4.87*	26.94–46.98
AdBd (mm)	18.55 \pm 4.34*	8.15–28.42	15.29 \pm 3.52*	7.82–22.87
AsBs (mm)	17.89 \pm 3.71*	7.60–24.56	15.34 \pm 3.52*	8.31–21.56
CdDd (mm)	13.61 \pm 2.07*	9.08–17.05	11.67 \pm 2.09*	7.96–15.38
CsDs (mm)	14.37 \pm 2.23*	9.80–18.20	12.27 \pm 1.66*	9.08–14.94
BdCd (mm)	13.13 \pm 3.15*	6.63–19.45	10.18 \pm 3.49*	2.71–17.62
BsCs (mm)	13.13 \pm 3.31*	3.99–19.42	9.99 \pm 3.37*	3.37–18.14
BdE (mm)	39.17 \pm 4.00*	25.68–48.21	30.04 \pm 4.00*	23.26–41.90
BsE (mm)	39.46 \pm 4.09*	24.88–45.61	29.51 \pm 3.75*	23.43–41.32
CdF (mm)	33.87 \pm 2.92*	24.62–39.00	26.43 \pm 3.61*	21.29–36.52
CsF (mm)	33.28 \pm 3.31*	24.45–39.11	25.98 \pm 3.50*	20.68–35.70
EF (mm)	19.35 \pm 2.51*	11.27–23.46	15.00 \pm 2.83*	11.29–22.60
α (°)	78.83 \pm 12.05*	60.46–103.38	94.19 \pm 15.86*	61.50–122.25

*p<0.01

TABLE 2
DISTRIBUTION OF THYROID CARTILAGES ACCORDING TO DIVERGENCE/CONVERGENCE OF SUPERIOR AND INFERIOR HORNS

	All samples		Men		Women	
	Divergent (N)	Convergent (N)	Divergent (N)	Convergent (N)	Divergent (N)	Convergent (N)
Superior horns	12	56	4	35	8	21
Inferior horns	3	65	3	36	0	29

AD – the posterior height of the thyroid cartilage (the distance between the tips of the superior and inferior horns)
 AB – the length of the superior horns
 CD – the length of the inferior horns
 BE – the superior width of the thyroid cartilage (the distance between the superior incisure and the roots of the superior horns)
 CF – the inferior width of the thyroid cartilage (the distance between the inferior incisure and the roots of the inferior horns)
 EF – the anterior height of the thyroid cartilage (the distance between the superior and inferior incisure).
 α – the thyroid angle.

Using these parameters we calculated the following:

BC – the posterior height of the lamina (BC=AD-(AB+CD)).

The obtained values were statistically analysed with a computer programme SPSS 13.0 for Windows. In statis-

tical analysis we applied descriptive statistics, Student T-test for independent samples and bivariate correlations for the measured parameters.

Results

The average values for measured parameters in male and female thyroid cartilages, as well as their minimal values are presented in Table 1.

The obtained results showed that there was statistically significant difference between all analysed parameters in male and female samples, except for the distance between the superior horns tips. It was also noticed that all parameters had greater values in men, except for the thyroid angle, which was greater in women than in men (94.19±15.86° and 78.83±12.05°, respectively).

Superior and inferior horns in some cartilages converge, which means that the distance between the horn tips is lesser than the distance at the base, and in some cartilages diverge. The distribution of the cartilages according to divergence and convergence of the superior and inferior horns for male and female samples and in total was presented in Table 2. It is evident that superior horns diverge more frequently than inferior horns, and also that superior horns diverge more frequently in women, and inferior horns in men.

Furthermore, we analysed the correlation between single measured parameters (Table 3).

There was significant correlation between most of the measured parameters. However, some parameters showed no statistically significant correlation. The distance between superior horns correlated with the other distances and with the horizontal values, while it did not

TABLE 3
SIGNIFICANT CORRELATIONS (R) BETWEEN THE MEASURED PARAMETERS (p<0.01 AND p<0.05*)

	AdAs	BdBs	CdCs	DdDs	AdDd	AsDs	AdBd	AsBs	CdDd	CsDs	BdCd	BsCs	BdE	BsE	CdF	CsF	
BdBs	0.784																
CdCs	0.728	0.911															
DdDs	0.660	0.814	0.934														
AdDd	0.267*	0.546	0.639	0.605													
AsDs	0.240*	0.540	0.606	0.608	0.813												
AdBd		0.392	0.428	0.373	0.778	0.620											
AsBs		0.353	0.404	0.375	0.600	0.772	0.687										
CdDd	0.286*	0.361	0.489	0.440	0.499	0.434	0.255*	0.274*									
CsDs		0.317	0.438	0.425	0.371	0.533		0.438	0.689								
BdCd		0.300*	0.345	0.379	0.576	0.464											
BsCs		0.341	0.325	0.365	0.512	0.547					0.685						
BdE	0.436	0.707	0.779	0.796	0.707	0.722	0.442	0.403	0.486	0.446	0.452	0.511					
BsE	0.457	0.714	0.782	0.757	0.729	0.705	0.492	0.439	0.506	0.481	0.419	0.427	0.943				
CdF	0.425	0.737	0.809	0.786	0.707	0.724	0.451	0.459	0.533	0.434	0.411	0.467	0.900	0.891			
CsF	0.450	0.701	0.765	0.732	0.663	0.653	0.384	0.381	0.555	0.475	0.397	0.402	0.843	0.852	0.925		
E-F	0.424	0.627	0.675	0.652	0.588	0.576	0.321	0.295*	0.368	0.376	0.461	0.421	0.727	0.731	0.698	0.615	
α													-0.277*	-0.383	-0.417	-0.379	-0.374

correlate with vertical values of the posterior side of the cartilage and the thyroid angle. The thyroid angle showed negative correlation with the total posterior height of the lamina and the horizontal values, while it did not correlate with other parameters. Horizontal values correlated with all parameters, and in vertical values there was no statistically significant correlation between the length of superior and inferior horns as well as between the posterior height of lamina and the length of superior and inferior horns. Also, vertical values, except for the posterior height of lamina, did not correlate with the thyroid angle.

The values obtained in this research in the population of Eastern Slavonia were compared with the values obtained by other authors (Table 4).

Discussion and Conclusion

This research provided detailed morphometric description of the thyroid cartilage in the population of Eastern Slavonia and comparison of obtained values with the data obtained in the research carried out in other ethnic groups.

Comparison of dimensions obtained on samples of different sexes showed the presence of sexual dimorphism. There was statistically significant difference in all measured values, except in the distance between the tips of the superior horns. All measured values were greater in men than in women, except for the thyroid angle. The thyroid angle was on average 78.83° with the range $60.46\text{--}103.38^\circ$ in men and 94.19° with the range $61.50\text{--}122.25^\circ$ in women.

Comparison of our results with the results obtained by other authors showed that they were similar in regard to sexual dimorphism. The values obtained in this research are similar to the results obtained in the research carried out by Tayama et al.⁶. In comparison to the results obtained by other authors, there are noticeable differences in the length of the superior and inferior horns as well as in the anterior height of the thyroid lamina. The anterior height of the thyroid lamina was a little greater in male samples in the research carried out by Ajmani⁸ and Sprinzl et al.⁵. The lengths of both superior and inferior horns were greater in the research carried out by Ajmani⁸, while the length of inferior horns was lesser in the research conducted by Sprinzl et al.⁵ and Ajmani et al.⁷. Also, in those three research works there

TABLE 4
COMPARISON OF VALUES FOR MEASURED PARAMETERS IN OUR RESEARCH WITH THE VALUES OBTAINED IN THE RESEARCH OF OTHER AUTHORS

Parameter	Our research (Eastern Slavonia)	Sprinzl et al. (Germany) ⁵	Tayama et al. (USA) ⁶	Maue et al. (USA) ²	Ajmani et al. (India) ⁷	Ajmani (Nigeria) ⁸
AA	M	40.19	38.3	35.50	36.25	–
	F	36.91	36.9	40.77	32.54	–
BB	M	45.75	–	41.65	39.43	–
	F	39.19	–	34.05	32.15	–
CC	M	39.82	–	–	–	–
	F	33.25	–	–	–	–
DD	M	35.85	35.9	34.80	31.83	–
	F	29.62	29.9	25.44	34.92	–
AD	M	45.35	44.5	44.73	44.34	–
	F	37.37	36.2	35.79	38.09	–
AB	M	18.22	14.7	–	–	15.5
	F	15.32	13.2	–	–	16.1
BC	M	13.13	24.3	–	–	–
	F	10.09	18.6	–	–	–
CD	M	13.99	8.6	–	–	9.6
	F	11.97	7.6	–	–	8.8
BE	M	39.32	–	37.27	–	–
	F	29.78	–	28.91	–	–
CF	M	33.58	–	29.70	–	–
	F	26.21	–	22.90	–	–
EF	M	19.35	23.8	19.24	37.15	–
	F	15.00	15.0	13.59	26.04	–
α	M	78.83	65.75	77.17	–	78.7
	F	94.19	80.68	89.90	–	106.1

was no statistically significant difference in the length of horns between male and female samples. Superior horns were more frequently divergent than inferior horns, especially in women, while inferior horns were more frequently convergent, and in women there was not a single sample with divergent inferior horns.

The values of the thyroid angle in male samples (78.83°) were similar to the values obtained by Tayama et al.⁶ – 77.17° and by Ajmani et al.⁷ – 78.7°, while this angle was a little greater in the research conducted by Ajmani⁸ – 89.92°. The value of the thyroid angle in female samples (94.19°) was greater than the value obtained by Tayama et al.⁶ (89.90°) but lesser than the values obtained by Ajmani⁸ and Ajmani et al.⁷ (106.38° and 106.1°, respectively).

The existence of sexual dimorphism may be used in determining the sex in unidentified remains, which has already been researched on scapula and femur samples^{9,10}.

Having compared all parameters we found strong correlation between most of the measured parameters. The strongest correlation was noticed in the distance between the horns at all measured levels and, as expected, between the pairs of parameters measured for the left and right side respectively.

Since the thyroid cartilage is directly attached to the hyoid in which sexual dimorphism is also present¹¹, it is

our intention to continue this research further to determine the connection between the hyoid bone angle, the thyroid angle and the divergence or convergence of the superior horns. Analysing the correlation of the parameters measured on the thyroid cartilage, it was determined that there was correlation between most of the parameters, but the thyroid angle correlated with the least parameters and showed only negative correlation with the total posterior height of the lamina and with horizontal values.

The difference of our results in comparison to the results obtained by other researchers is probably caused by the fact that the measurements were taken on the samples obtained from different populations, which only emphasizes the necessity to obtain data that will provide morphological description of the thyroid cartilage in the population of our region. Furthermore, this research provides some completely novel information, especially regarding the presence of asymmetry in thyroid cartilage, distribution of thyroid cartilage according to divergence/convergence of superior and inferior horns and correlation between single parameters, which is rarely or not at all present in the research of other authors. This research, with its detailed morphometric data, also provides a basis for future biomechanical and forensic research that will be conducted on these samples.

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MORFOMETRIJSKE KARAKTERISTIKE ŠTITNE HRŠKAVICE U LJUDI IZ ISTOČNE HRVATSKE

SAŽETAK

Cilj ovog istraživanja bio je detaljno opisati morfometriju štitne hrškavice na populaciji Istočne Slavonije. Istraživanje je provedeno na uzorku od 68 odraslih štitnih hrškavica. Uočena je statistički značajna razlika među svim analiziranim parametrima između muških i ženskih uzoraka, osim udaljenosti između vrhova gornjih rogova. Svi parametri pokazali su veće vrijednosti u muškaraca, osim tiroidnog kuta, koji je veći u žena. Uočena je značajna korelacija među većinom mjerenih parametara. Najznačajnija korelacija primjećena je kod udaljenosti između rogova na svim mjerenim razinama i među parovima parametara mjerenih na lijevoj i desnoj strani. Razlika u našim rezultatima u usporedbi s rezultatima drugih autora vjerojatno je uzrokovana činjenicom da su mjerenja provedena na uzorcima iz različitih populacija.