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Age–Related Changes of the Sella Turcica Morphometry in Adults Older Than 20-25 Years

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***Abstract*—**Age determination of unknown dead bodies in forensic personal identification is a complicated process which involves the application of numerous methods and techniques. Skeletal remains are less exposed to influences of environmental factors. In order to enhance the accuracy of forensic age estimation additional properties of bones correlating with age are required to be revealed. Material and Methods: Dimensional examination of the sella turcica was carried out on cadavers with the cranium opened by a circular vibrating saw. The sample consisted of a total of 90 Russian subjects, ranging in age from two months and 87 years. Results: The tendency of dimensional variations throughout life was detected. There were no observed gender differences in the morphometry of the sella turcica. The shared use of the sella turcica depth and length values revealed the possibility to categorize an examined sample in a certain age period. Conclusions: Based on the results of existing methods of age determination, the morphometry of the sella turcica can be an additional characteristic, amplifying the received values, and accordingly, increasing the accuracy of forensic biological age diagnosis.

***Keywords*—**Age–related changes in bone structures, forensic personal identification, Sella turcica morphometry, body identification.

I. Introduction

FORENSIC medical examination of unknown corpses is a specific and complex process of identification that still presents considerable difficulties. The need for personal identification arises in cases of putrefaction, skeletonization and destruction of corpses when identification is complicated or impossible. Besides criminal reasons, this may be consequence of fires, hostilities, accidents in transport, industrial accidents and also natural disasters. Individual characteristics of the head, trunk and extremities are described in cases of decomposition, as well as in cases of deliberate disfiguring of the face, caused by criminals with the purpose of obstructing identification. Skeletal remains do not change its features over time and have sufficient information. Age, race, gender, portrait and other characteristics can be estimated by further examination of the skull, teeth and postcranial skeleton [1], [2]. The new methods, organs and systems of the research are required for personal identification to use them with existing ones, to narrow the range of the suppositional age of examined human remains.

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II. Aims and Objectives

The aim of this study was to establish the biological "bone" age of the unidentified dead persons, using morphometric parameters of the sella turcica, namely its depth and length.

III. Materials and Methods

The cranium was opened by a circular vibrating saw at the craniometric points: Metopion, Euryon–Euryon, Inion [3] at the Moscow Bureau of Forensic Medicine autopsy room. After extraction of the brain, a complete separation of the dura mater and cautious selection of the pituitary gland with surgical scalpel the depth and length of the sella turcica were measured with a vernier caliper (ШЦ-I-125-0.1-1 GOST 166-89 with internal and external jaws for measuring external and internal dimensions and depth gauge), I – type (two-sided with a depth gauge); 125 – measuring range is from 0 to 125 mm; 0,1 – accuracy of readings (vernier scale interval) in mm; 1 – accuracy class of caliper. Depth was measured by the depth gauge, the length — with the jaws for internal dimensions. There was no pathology of the sellar region of examined samples. A total of 90 skulls of Caucasoids (eastern Slavs) were examined: 70 samples belonged to men, and other 30 belonged to women. The age ranged from two months to 87 years. Depth was built from a straight line formed between two points, one in the central part of the dorsum sellae apex and one situated on the tuberculum sellae, between the anterior clinoid processes (Figs. 1 and 2). The perpendicular was lowered from the formed line to the deepest point of the sella turcica floor (Fig. 1). The length was measured from the most concave area of the inner surface of the dorsum sellae to the most remote point of the inner surface of the anterior wall of the sella turcica (Fig. 2) [4]. The width of the skull (transverse diameter) was measured at points Euryon-Euryon — the most protruding points of the lateral surfaces of the skull using ruler with the division value 1 millimeter. Also up-length of the Sella turcica was measured from an area on the tuberculum sellae between the anterior clinoid processes and the central part on the apex of the dorsum sellae, using ruler with the division value 0.5 millimeter. The data were processed in the program IBM SPSS Statistics.

IV. Results

Distribution of the obtained values of the sella turcica depth, length demonstrated in Fig. 5: The samples were categorized into age groups (classification approved at VII All-Union Conference on the age morphology, physiology and biochemistry, Moscow 1965) for both genders. In the

literature there are a lot of reports of age-related changes of the sella turcica in the range from birth to 18-25 years. Some of authors conclude that after 20-25 years the morphometry of the sella turcica is stable, other authors determine age-related changes in morphometry but regard them negligible. That is why the present research focuses on identification of the age ranges in which it is possible to classify a particular sample in adults older than 20-25 years. In adulthood, age period I (22-35 years), depth mainly prevails over the length of the sella turcica, in adulthood, age period II (36-60 years), values of depth and length are approximately equal with a slight tendency of the length predominance over depth, in early old age (61-74 years), depth and length abruptly increase its values with the prevalence of depth over length, in the middle old age (75-90 years), length prevails over the depth, values are slightly decreased in comparison with the early old age, although the average values of length increase in comparison with adulthood age periods I, II and early old age.

Fig. 1 Top view of the sella turcica

Fig. 2 Top view of the sella turcica.

Figs. 1 and 2, 1 — anterior clinoid process; 2 — dorsum sellae; dots indicate: An area on the tuberculum sellae between the anterior clinoid processes and the central part on the apex of the dorsum sellae

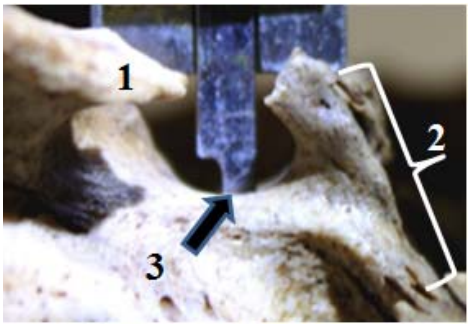

Fig. 3 Side view of the sella turcica. Depth measurement

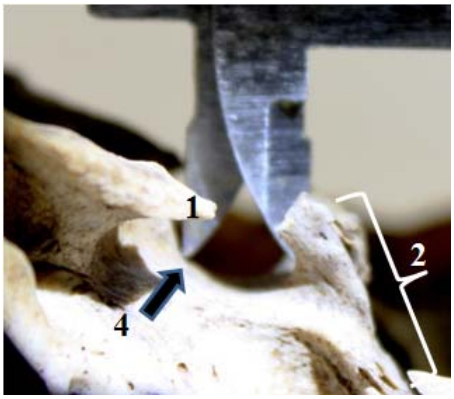

Fig. 4 Side view of the sella turcica. Length measurement

Figs. 3 and 4: (1) — anterior clinoid process; (2) with the curly brace — dorsum turcica sellae; (3) with an arrow — the most profound point of the Sella turcica floor; (4) with an arrow — point of the inner surface of the anterior wall of the sella turcica, which is the most remote point from the concave area of the dorsum sellae. Thus, our results confirm a tendency of phasic development of human being — growth/maturation, stabilization and involution.

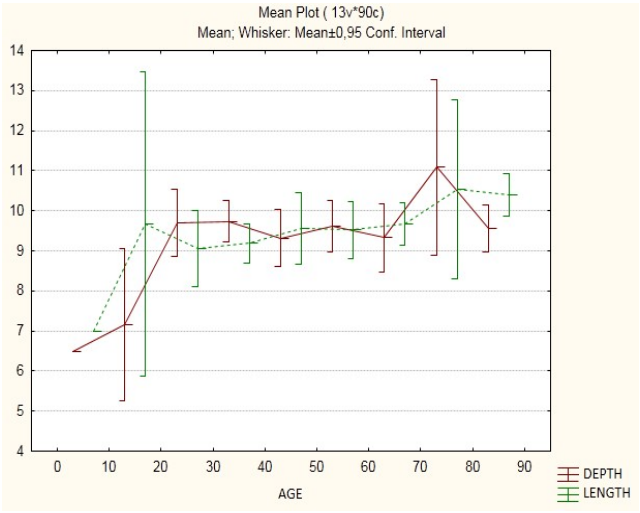

Fig. 5 Mean plot of depth and length distribution Solid line — depth; dash line — length

TABLE I
STATISTICAL PARAMETERS OF AGE AND VARIABLES OF THE SELLA TURCICA SIZES FOR BOTH GENDERS

Variables (N=90)	Min	Max	M	m	σ	Coefficient of skewness	Kurtosis	Coefficient of variation
DEPTH	6,5	13,5	9,55	0,14	1,36	0,23	0,48	14,19%
LENGTH	6	13	9,57	0,14	1,34	0,09	0,16	14,02%

TABLE II
COMPARISON TABLE OF THE SELLA TURCICA DEPTH, LENGTH, UP-LENGTH VALUES, AND SKULL WIDTH IN MEN AND WOMEN

GENDER	f			m			p_1	p_2	p_3
	M	σ	m	M	σ	m			
AGE	54,40	20,0	4,47	50,07	18,71	2,24	0,372	0,382	0,391
DEPTH	9,42	1,59	0,35	9,59	1,29	0,15	0,626	0,333	0,751
LENGTH	9,55	1,18	0,26	9,57	1,39	0,17	0,932	0,849	0,875
Up-Length	10,95	1,78	0,40	12,11	1,84	0,22	0,014	0,014	0,052
Skull Width	***139,10***	***7,56***	***1,69***	***144,17***	***8,99***	***1,07***	***0,024***	***0,001***	***0,004***

Depth ranged within 6.5–13.0 mm in men and within 7.0-13.5 mm in women. Length varied within 6.0-13.0 mm in men and within 7.0-11.0 mm in women. As a conclusion, men have higher values of length and women have higher values of depth. Table I shows that the coefficient of skewness of the studied parameters is quite small, and therefore, the arithmetic mean corresponds to the typical value of variables. For all the variables the kurtosis is small, it means that parametric methods are applicable.

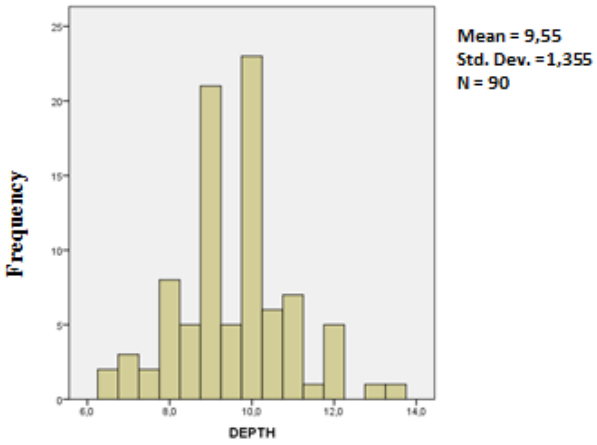

Fig. 6 A histogram of the Sella turcica depth frequency distribution

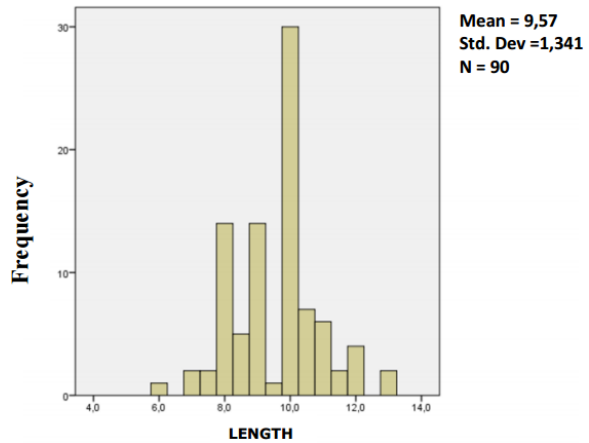

Fig. 7 A histogram of the Sella turcica length frequency distribution

A total of 70 skulls belonged to the men, 30 skulls belonged to women (77.8%Conf.Int.:69.0%–84.9%). As a number of female samples are small in comparison to the men's samples, it is possible to use the methods of parametric and non-parametric statistics.

In Table II, p_1 – Statistical significance of the difference sample means calculated using analysis of variance, p_2 – significance of difference of mean ranks calculated using the Mann-Whitney criterion, p_3 – significance of the difference in distribution is calculated using the Kolmogorov-Smirnov test. Table II demonstrates negligible gender differences only in skull width.

TABLE III
CORRELATION COEFFICIENTS BETWEEN THE SELLA TURCICA VARIABLES AND AGE

Variable	r	p
DEPTH	***0.230***	***0.029***
LENGTH	***0.353***	***0.001***
Up-Length	0.122	0.252
Skull Width	***0.246***	***0.020***

Table III shows significant correlations with age only in the variables depth, length, and skull width. There was no correlation with age in the up-length dimensions. The results of multivariate data analysis reveal the best prediction model using linear regression method — two–factor model forecasting the depth and length.

Regression analysis has been used to predict the age in individuals older than 20-25 years from the variables of the sella turcica length and depth. All variables added statistically significantly to the prediction, $p < 0.05$. The sella turcica length and depth can be easily measured in the forensic medical examination.

TABLE IV
REGRESSION MODEL OF AGE PREDICTION

	Unstandardized coefficients		Standardized coefficients
	V	Standard error	Beta
(Constant)	-18.6	17.712	
LENGTH	4.648	1.403	0.328
DEPTH	2.635	1.388	0.188

According to Table IV the expected value of the age is:

Forecast = -18.6+4.648× LENGTH+2.635× DEPTH

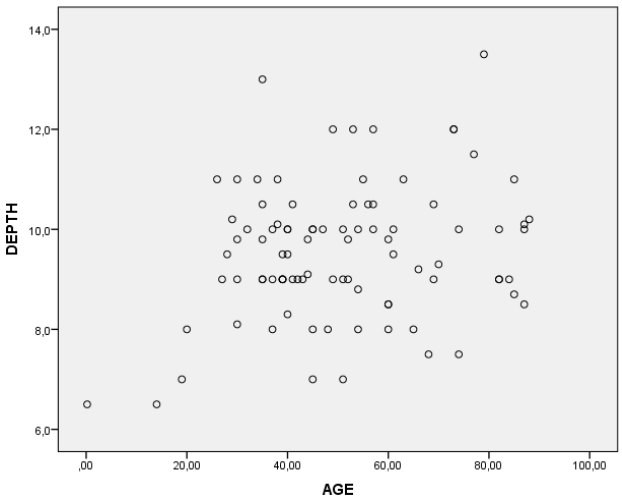

Fig. 8 Joint distribution of age and the sella turcica depth

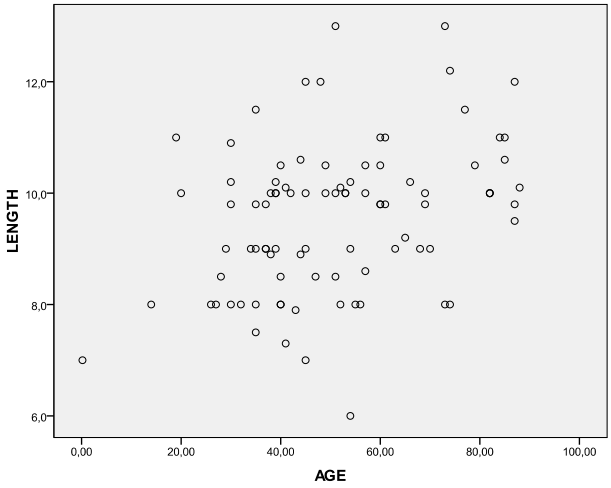

Fig. 9 Joint distribution of age and the sella turcica length

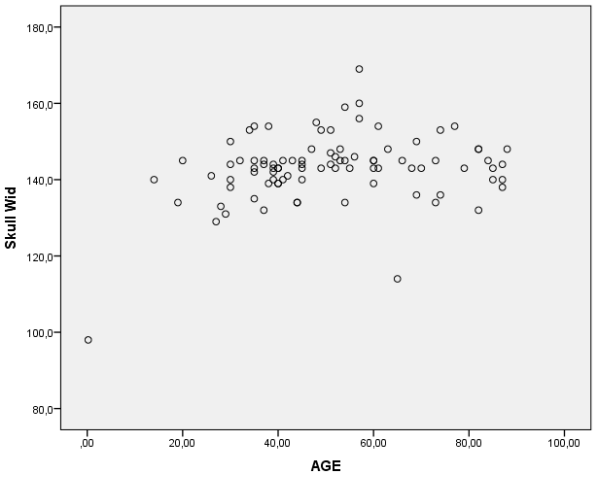

Fig. 10 Joint distribution of age and the skull width

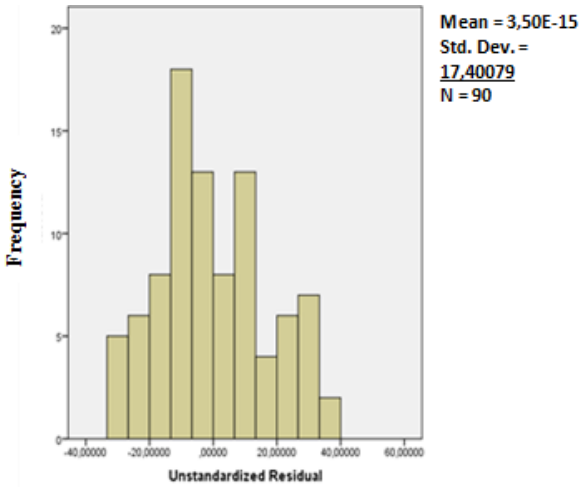

Fig. 11 Distribution of the prediction error magnitude

Fig. 11 demonstrates that mean value of the difference between the predicted and actual age is 17.4 years. So, it is possible to categorize an examined sample in a certain age period.

V. Discussion

Choi et al. [5] investigated Korean patients ranging in age six years to 42 years and revealed a dimensional growing of length (in the present study — up–length), height (in the present study — depth), and width (in the present study — length) only until 25 years. Axelsson et al. [6] studied the dimensions of the sella turcica in a Norwegian sample between the age groups of six and 21 years old. The results were as follows: the length (in present study — up–length) was almost constant throughout the observation period, whereas depth increased with age. Similarly, statistically significant values were derived from the study of Nagaraj [7] in age groups between eight and 30 years, where the depth increased with age, but in length (in the present study — up-length) there was no significant correlation with age. The same results are represented in our study. Abu Ghaid et al. [8] studied the sella turcica dimensions of Jordanians ranging from 10 years to 40 years old and performed significant differences between means of width (in the present study — length), but not height (in the present study – depth) between adult (20-40 years) male and adult female age groups. The differences between the variables of adolescent (10-19 years) and adult female age groups were significant for width (in the present study — length). Differences between adolescent and adult male age groups were significant for width (in the present study — length), height (in the present study – depth). Brock-Jacobsen et al. [9] examined morphometry of the sella turcica and revealed correlations in dimensions of the sella turcica between the two twin individuals in the same twin pair. In conclusion, the size of the sella turcica is not only genetically determined, but can also change due to environmental factors. Sathyanarayana [10] concluded that the linear dimensions of the sella turcica in southern Indian populations have a tendency to increase with age in the period

9 years to 27 years, but only with reference to gender and skeletal type. Subhadra Devi [11] also investigated the Indian population between the ages of 11 years and 70 years and detected significant correlation in depth changes, but only with reference to gender.

The variety of reported results can be explained in the different measurement techniques applied and the different approaches of investigation (radiographic, dry skulls etc.). In our study measurements were made on corpses at once after dissection.

In the present study, there were no observed significant difference in all dimensions of the sella turcica in males and females. This result is correlating with studies done by Yassir et al. [12] in the Iraq population, Shah et al. [13] in the Pakistan population, Chavan et al. [14] in the Maharashtra population, Osunwoke et al. [15] in the Nigerian population, Karatas et al. [16] in the Turkish population and Abu Ghaid et al. in the Jordanian population 2016 [8], where no differences were detected in the morphometry of the sella turcica between genders.

VI. Conclusions

Morphometric characteristics of the sella turcica, namely its length and depth overall, stabilize in the adulthood I, adulthood II age periods, early old age and middle old age, however, there is a tendency of dimensional variations throughout life. Because the properties of bones do not remain constant with age, it is possible to classify an examined sample in a certain age period. Thus, further research is needed to establish the best combination of quantitative and qualitative features of bones for the prediction of age.

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