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CLINICAL STUDY

Human race as indicator of 3D planning of soft tissue of face and multidisciplinary approach

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ABSTRACT

OBJECTIVE: The aim of this study was to determine the optimal parameters for 3D soft tissue planning for ortognatic treatment by gender and increases the effectiveness of multidisciplinary cooperation.

METHODS: Craniofacial parameters which were analysed: nose breadth (al-al), bi-entocanthion breadth (en-en), bi-zygomatic breadth (zy-zy), bi-gonial breadth (go-go), total facial height (n-gn), mouth breadth (ch-ch), morphologic face height (sn-gn), upper-lip height (Ls-Stm), lower-lip height (Stm-Li) and pupils – mid-face (right). The statistically significant level was determined at p values < 0.05.

RESULTS: We have determined the optimal parameters of chosen proportions for men and women as the common goal for ortodontist and maxilofacial surgeon. The gender and age influenced the variability of following parameters: bi-gonial breadth, total facial height and morphologic face height.

CONCLUSION: The soft tissue values for craniofacial parameters can be used to identify the surgical-orthodontic goal for patient – europoid race. Due to the immigration and the mix of races it is necessary to take this fact into account *(Tab. 3, Fig. 1, Ref. 41)*. Text in PDF *www.elis.sk.*

KEY WORDS: multidisciplinary work, soft tissue, orthodontic, surgery, three-dimensional scan, face aesthetic, human races.

Introduction

Morphometric measurements are widely used in diagnosis, follow-up and treatment of the diseases (1).

Anthropometry provides an objective mean of assessing the facial shape and can detect shape changes over time. Although the term anthropometry covers measurement of any aspect of human form, the term surface anthropometry is used in this paper to refer to the measurement of the facial surface features (2).

The ideal or attractive face of one generation is different from another and depends on large measure on racial, ethnic, national, personal, as well as gender preferences to name a few of the important factors involved in the determination of beauty (3).

The quantitative assessment of the size and shape of the facial soft tissue is widely used in several medical fields such as orthodontics, maxillofacial and plastic surgery, and clinical genetics for diagnosis, treatment planning, and postoperative assessment. Several oral health (4–17), orthodontic (18), periodontosis (19, 20), craniofacial (21) and malocclusion (22–25) studies have been conducted.

Craniofacial anthropometry is very suitable for identification and quantification of clinical features, treatment planning, moni-

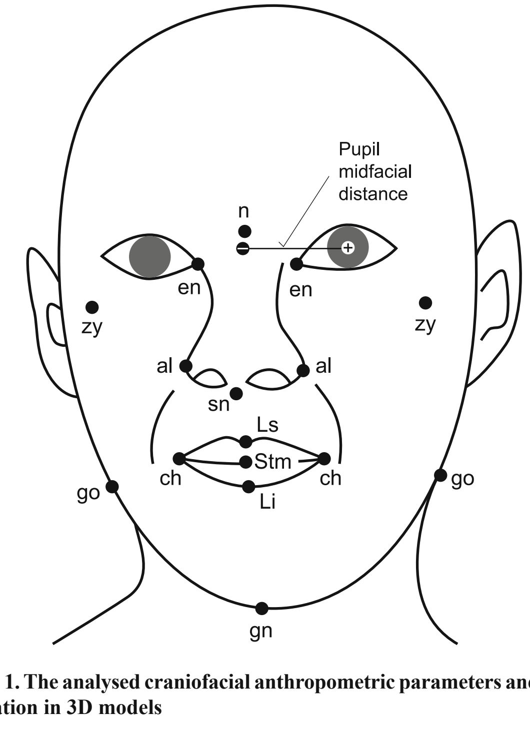

Fig. 1. The analysed craniofacial anthropometric parameters and their location in 3D models

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Tab. 1. The mean values of craniofacial parameters in the PADA and the PA3DS according to gender and age (n = 100).

Craniofacial parameters	Variables		Study groups				p
			PDAA		P3DAS		
			n	x (SD)	n	x (SD)	
al-al (cm) nose breadth	Gender	Male	31	3.75 (0.34)	19	3.58 (0.32)	0.083
		Female	34	3.24 (0.20)	16	3.33 (0.29)	0.265
	Age [years]	≤ 24	58	3.48 (0.36)	18	3.46 (0.34)	0.817
		> 25	7	3.51 (0.57)	17	3.47 (0.33)	0.867
en-en (cm) bi-entocanthion breadth	Gender	Male	31	2.94 (0.23)	19	3.26 (0.44)	**0.007**
		Female	34	2.74 (0.25)	16	3.27 (0.37)	**0.000**
	Age [years]	≤ 24	58	2.86 (0.25)	18	3.46 (0.33)	**0.000**
		> 25	7	2.67 (0.34)	17	3.06 (0.39)	**0.039**
zy-zy (cm) bi-zygomatic breadth	Gender	Male	31	13.65 (0.68)	19	12.41 (0.90)	**0.000**
		Female	34	12.33 (0.76)	16	10.88 (2.97)	0.072
	Age [years]	≤ 24	58	13.01 (0.98)	18	11.46 (2.99)	**0.045**
		> 25	7	12.57 (0.91)	17	11.97 (0.93)	0.171
go-go (cm) bi-gonial breadth	Gender	Male	31	10.42 (0.21)	19	12.91 (0.61)	**0.000**
		Female	34	10.95 (0.59)	16	11.49 (0.64)	**0.008**
	Age [years]	≤ 24	58	10.71 (0.51)	18	12.16 (0.87)	**0.000**
		> 25	7	10.61 (0.65)	17	12.37 (1.04)	**0.000**
n-gn (cm) total facial height	Gender	Male	31	11.98 (0.40)	19	13.00 (0.51)	**0.000**
		Female	34	10.87 (0.62)	16	12.04 (0.51)	**0.000**
	Age [years]	≤ 24	58	11.41 (0.73)	18	12.36 (0.74)	**0.000**
		> 25	7	11.33 (1.09)	17	12.78 (0.59)	**0.012**
ch-ch (cm) mouth breadth	Gender	Male	31	5.43 (0.23)	19	5.34 (0.36)	0.358
		Female	34	4.79 (0.25)	16	4.75 (0.55)	0.776
	Age [years]	≤ 24	58	5.09 (0.41)	18	5.04 (0.65)	0.758
		> 25	7	5.14 (0.33)	17	5.10 (0.42)	0.846
sn-gn (cm) morphologic face height	Gender	Male	31	6.50 (0.32)	19	7.29 (0.66)	**0.000**
		Female	34	5.68 (0.49)	16	6.45 (0.32)	**0.000**
	Age [years]	≤ 24	58	6.09 (0.57)	18	6.81 (0.65)	**0.000**
		> 25	7	5.94 (0.78)	17	7.01 (0.69)	**0.011**
Ls-Stm (cm) upper-lip height	Gender	Male	31	0.83 (0.13)	19	0.44 (0.14)	0.256
		Female	34	0.79 (0.18)	16	0.48 (0.16)	**0.000**
	Age [years]	≤ 24	58	0.81 (0.16)	18	0.48 (0.17)	**0.000**
		> 25	7	0.85 (0.16)	17	0.43 (0.12)	**0.000**
Stm-Li (cm) lower-lip height	Gender	Male	31	1.02 (0.12)	19	1.06 (0.13)	0.256
		Female	34	1.10 (0.19)	16	0.98 (0.17)	**0.047**
	Age [years]	≤ 24	58	1.07 (0.16)	18	0.99 (0.17)	0.095
		> 25	7	0.92 (0.18)	17	1.06 (0.13)	0.124
Pupils-mid face (right) (cm)	Gender	Male	31	3.63 (0.08)	19	3.23 (0.32)	**0.000**
		Female	34	3.39 (0.34)	16	3.19 (0.24)	**0.021**
	Age [years]	≤ 24	58	3.52 (0.28)	18	3.31 (0.29)	**0.012**
		> 25	7	3.41 (0.26)	17	3.16 (0.27)	0.051

toring of operative outcomes, and assessment of long term change (26). Although the role of conventional anthropometry has already been well recognized by clinicians working with the maxillofacial complex, the use of computerized anthropometry is more recent and not widespread (27, 28). In the recent times, non-invasive 3D scanning has become more popular and reliable method of analysing craniofacial complex (29, 30).

The number of potential craniofacial measurements is almost limitless. In clinical studies, you may feel limited by the availability of normal comparative data for your analysis of dysmorphology (31).

In past, Farkas determined the optimal proportions of the face soft tissues. Due to the fact that this research passed nearly 50 years ago, we tried to verify the validity of this analysis. The aim of this study was to find the mean values of craniofacial parameters according to gender and age and determine the outcome of cooperation of orthodontics and maxillofacial surgery. We are aware of the migration of other races and possible variations in optimal proportions depending on the main features of the races.

Material and methods

Ethical issues (including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

The study sample was recruited from patients attending dental surgeries in Bratislava, the data were collected from November

Tab. 2. The mean, minimum and maximal values of craniofacial parameters according to gender and age (n = 100).

Craniofacial parameters	Subgroups (PDAA and P3DAS)		n	Mean x (SD)	Median	Min	Max	p
al-al (cm) nose breadth	Gender	Male	50	3.69 (0.34)	3.70	3.08	4.60	**0.000**
		Female	50	3.26 (0.23)	3.30	2.64	3.90	
	Age [years]	≤ 24	76	3.47 (0.35)	3.40	2.64	4.40	0.896
		> 25	24	3.49 (0.40)	3.43	2.90	4.60	
en-en (cm) bi-entocanthion breadth	Gender	Male	50	3.06 (0.36)	3.05	2.37	3.80	**0.047**
		Female	50	2.91 (0.38)	2.85	2.30	4.00	
	Age [years]	≤ 24	76	3.00 (0.37)	2.95	2.30	4.00	0.612
		> 25	24	2.95 (0.41)	3.12	2.30	3.60	
zy-zy (cm) bi-zygomatic breadth	Gender	Male	50	13.18 (0.97)	13.40	10.70	15.80	**0.000**
		Female	50	12.08 (0.81)	12.00	10.50	13.50	
	Age [years]	≤ 24	76	12.78 (1.04)	12.80	10.50	15.80	**0.007**
		> 25	24	12.15 (0.94)	12.15	10.70	14.20	
go-go (cm) bi-gonial breadth	Gender	Male	50	11.36 (1.29)	10.60	10.00	13.80	0.241
		Female	50	11.12 (0.65)	11.00	10.00	12.60	
	Age [years]	≤ 24	76	11.05 (0.87)	10.80	10.00	13.80	**0.006**
		> 25	24	11.86 (1.23)	12.10	10.00	13.80	
n-gn (cm) total facial height	Gender	Male	50	12.37 (0.67)	12.20	11.20	13.70	**0.000**
		Female	50	11.24 (0.80)	11.30	9.50	13.00	
	Age [years]	≤ 24	76	11.63 (0.83)	11.80	10.00	13.70	**0.003**
		> 25	24	12.35 (1.00)	12.60	9.50	13.70	
ch-ch (cm) mouth breadth	Gender	Male	50	5.40 (0.29)	5.38	4.75	6.00	**0.000**
		Female	50	4.77 (0.37)	4.80	3.41	5.81	
	Age [years]	≤ 24	76	5.08 (0.48)	5.00	3.41	6.00	**0.700**
		> 25	24	5.11 (0.39)	5.23	4.30	5.92	
sn-gn (cm) morphologic face height	Gender	Male	50	6.80 (0.61)	6.69	5.50	8.31	**0.000**
		Female	50	5.93 (0.57)	6.10	4.60	6.90	
	Age [years]	≤ 24	76	6.26 (0.66)	6.30	4.80	8.10	**0.028**
		> 25	24	6.70 (0.86)	6.74	4.60	8.31	
Ls-Stm (cm) upper-lip height	Gender	Male	50	0.69 (0.23)	0.75	0.17	1.04	0.897
		Female	50	0.69 (0.23)	0.68	0.10	1.20	
	Age [years]	≤ 24	76	0.73 (0.21)	0.75	0.10	1.20	**0.002**
		> 25	24	0.56 (0.23)	0.52	0.20	1.04	
Stm-Li (cm) lower-lip height	Gender	Male	50	1.03 (0.13)	1.03	0.56	1.40	0.397
		Female	50	1.06 (0.19)	1.08	0.70	1.50	
	Age [years]	≤ 24	76	1.06 (0.17)	1.04	0.56	1.50	0.417
		> 25	24	1.02 (0.15)	1.02	0.70	1.40	
Pupily-mid face (right) (cm)	Gender	Male	50	3.49 (0.27)	3.60	2.80	3.94	**0.010**
		Female	50	3.33 (0.32)	3.30	2.50	4.00	
	Age [years]	≤ 24	76	3.47 (0.29)	3.60	2.50	4.00	**0.001**
		> 25	24	3.23 (0.29)	3.25	2.70	3.70	

2013 to February 2016. The selection criterion for patients' inclusion in the study was being over 18 years of age (without any ontogenetic changes in face area) and their diagnosis (malocclusion). The data was collected anonymously and a privacy of patients was respected, participation in the study was voluntary.

The whole sample was divided into the two study groups (PDAA and P3DAS) according to gender and age. The sample consisted of 100 patients (50.0 % men, 50.0 % women) in age between 18–32 years (the mean age 23.09±2.70 years). The majority of respondents were in the age less than 24 years (76.0 %).

In this paper the following craniofacial parameters were analysed: nose breadth (al-al), bi-entocanthion breadth (en-en), bi-zygomatic breadth (zy-zy), bi-gonial breadth (go-go), total facial height (n-gn), mouth breadth (ch-ch), morphologic face height (sn-gn), upper-lip height (Ls-Stm), lower-lip height (Stm-Li) and pupils – mid-face (right) and the same were analysed by Farkas.

Study groups were divided into the two subgroups. In the first subgroup, patients were analysed by a directed anthropometry (PDAA) (n = 65). In the second subgroup, patients were analysed from 3D scan (P3DAS) (n = 35).

The study group, which was analysed by PDAA, was measured sitting on a chair and looking forward with a straight face. The face was not covered by hair. The measuring tools were sliding caliper and digital caliper.

The group with 3DCT scans was analysed in three vertical planes. The defined anthropometric parameters were the base for analyses according to which we circumscribe the measured lines, which cover each part of the face (Fig. 1). We used the special system – 3D Dimensional Imaging's Standard DI3D. It works on the principle of passive stereophotogrammetry (DI3D capture software) with four cameras. Distance from the patient's scanner was determined by displaying the faces of DI3D capture software.

The data were analysed by the statistical program SPSS. Descriptive statistics (percentages, averages, standard deviations, median, minimum and maximal value) were used. A two-sample t-test was applied to compare the mean value of craniofacial parameters (cm) in subgroups according to gender and age. The statistically significant level was determined as p values < 0.05.

Results

The differences between the PDAA and the P3DAS had a significant effect on the evaluation of bi-entocanthion breadth (2.84 ± 0.26 cm vs 3.27 ± 0.41 cm; p = 0.000), bi-zygomatic breadth (12.96 ± 0.97 cm vs 12.02 ± 0.91 cm; p = 0.000), bi-gonial breadth (10.70 ± 0.52 cm vs 12.26 ± 0.95 cm; p = 0.000), total facial height (11.40 ± 0.77 cm vs 12.56 ± 0.70 cm; p = 0.000), morphologic face height (6.07 ± 0.59 cm vs 6.91 ± 0.67 cm; p = 0.000), upper-lip height (0.81 ± 0.16 cm vs 0.46 ± 0.15 cm; p = 0.000), and pupils-mid face (right) (3.51 ± 0.28 cm vs 3.24 ± 0.29 cm; p = 0.000).

The mean values of craniofacial parameters in the PDAA and the P3DAS are presented in the Table 1.

The differences in parameters bi-entocanthion breadth between the PADA and the PA3DS according to gender (females: 2.74 ± 0.25 cm vs 3.27 ± 0.37 cm; p = 0.000) and age (≤ 24 years: 2.86 ± 0.25 cm vs 3.46 ± 0.33 cm; p = 0.000) were statistically significant.

In the study groups, the variables gender and age influenced the parameters bi-gonial breadth, total facial height and morphologic face height.

Optimal craniofacial parameters in a europoid race population are presented in the Table 2.

Males had a higher parameters than females with statistically significant differences (nose breadth: males = 3.69 ± 0.34 cm and females = 3.26 ± 0.23 cm; bi-entocanthion breadth: males = 3.06 ± 0.36 cm and females = 2.91 ± 0.38 cm; bi-zygomatic breadth: males = 13.18 ± 0.97 cm and females = 12.08 ± 0.81 cm; bi-gonial breadth: males = 11.36 ± 1.29 cm and females = 11.12 ± 0.65 cm; total facial height: males = 12.37 ± 0.67 cm and females = 11.24 ± 0.80 cm; mouth breadth: males = 5.40 ± 0.29 cm and females = 4.77 ± 0.37 cm).

Some measurements, however, showed no difference between gender, like upper-lip height: males = 0.69 ± 0.23 cm and females = 0.69 ± 0.23 cm; lower-lip height: males = 1.03 ± 0.13 cm and females = 1.06 ± 0.19 cm. The differences in the mean values obtained were not statistically significant except according by age for parameters nose breadth, bi-entocanthion breadth, lower-lip height.

Discussion

Currently we have two basic methods for the measurement of the soft tissues on the face in three-dimensional direction – direct and digital. The importance is given to the proportions of the soft tissue before treatments and the evaluation of the soft tissue after orthodontic-surgery treatments; so one of these methods should be used (PDAA, P3DAS). Digital craniometry could save 3D scans of the face soft tissues, so the specialists of maxillofacial surgery, plastic surgery or other orthodontic have the possibility to send this 3D scans.

Our measurements were based on the measurements by Farkas, which was conducted in humans of the europoid race. We compared his measurements with our results (Tab. 3). Farkas confirmed the slightly enlarged lower third of the face. This parameter (sn-gn), according to Farkas was 7.2 cm for men and 6.6 cm for women. These values were different from our measurements (male = 6.69 cm, female = 6.10 cm) by 0.5 cm, but with insignificant deviation. Almost the same values were in the width of the mouth (ch-ch) in men by Farkas (5.3 cm) and in our results (5.38 cm) and the height of the ruddiness of the lower lip (Stm-Li) in men by Farkas (1.04 cm) and in our results (1.03 cm). Very little discrepancy (0.1 cm) between our and Farkas `s measurement was found in the measurement of ruddiness of the lip height of the lower lip in women (Stm-Li), the amount of ruddiness of the upper lip for men (Ls-Stm), facial height (n-gn), both men and women. A slightly higher discrepancy (0.2 to 0.3 meters) with Farkas found our study in assessing the width of the nose (al-al) in men and women, the distance between the inside corner of the eye (en-en) in women, the amount of ruddiness of the upper lip (Li-Stm) and the width of the mouth (ch-ch) in women, and the distance between the centre of pupil face in men and women. The biggest difference between Farkas´s measurements and our measurements divided into the groups of Caucasians respondents from Central Europe were common in women in the measurement of the width of the jaw (go-go), where the measurement value reached 11 centimeters, as measured by Farkas (described 9.1 cm, representing a discrepancy 1, 9 cm). In men, the situation was similar. Values according to Farkas (9.7 cm) were different from our value (10.6 cm) with discrepancy 0.9 cm. A similar situation was encountered

Tab. 3. Comparison of our results with Farkas study.

Craniofacial parameters	Gender	Median	FARKAS	Difference
al-al (cm)	Male	3.70	3.5 (0.26)	**0.2**
nose breadth	Female	3.30	3.1 (0.19)	**0.20**
en-en (cm)	Male	3.70	3.3 (0.27)	**0.40**
bi-entocanthion breadth	Female	3.05	3.2 (0.24)	**0.15**
zy-zy (cm)	Male	13.40	13.7 (0.43)	**0.30**
bi-zygomatic breadth	Female	12.00	13.0 (0.53)	**1.00**
go-go (cm)	Male	10.60	9.7 (0.58)	**0.9**
bi-gonial breadth	Female	11.00	9.1 (0.59)	**1.9**
n-gn (cm)	Male	12.20	12.1 (0.68)	**0.1**
total facial height	Female	11.30	11.2 (5.2)	**0.1**
ch-ch (cm)	Male	5.38	5.3 (0.33)	**0.08**
mouth breadth	Female	4.80	5.0 (3.2)	**0.20**
sn-gn (cm)	Male	6.69	7.2 (0.6)	**0.51**
morphologic face height	Female	6.10	6.6 (4.5)	**0.50**
Ls-Stm (cm)	Male	0.75	0.89 (0.15)	**0.14**
upper-lip height	Female	0.68	0.84 (0.13)	**0.2**
Stm-Li (cm)	Male	1.03	1.04 (1.9)	**0.01**
lower-lip height	Female	1.08	0.97 (0.13)	**0.11**
Pupily-mid face (right)	Male	3.60	3.3 (0.2)	**0.30**
(cm)	Female	3.30	3.1 (0.18)	**0.20**

in measuring the width of the face (zy-zy) in women, where measurement by Farkas (13 cm) differed from our measurements (12 cm) with discrepancy 1 cm (32).

Many researchers deal with digital and direct craniometry. Study by Weinberg et al (33) analysed these two methods by measuring the defined distances of facial points with labelling the points and without. They found that positioning the points before measurements improve the accuracy of both methods (direct and digital craniometry). Respectively, higher result of measurement's accuracy was confirmed by digital craniometry. On the other hand, the difference was not significant (2 mm). Both methods are quite accurate, but it depends on the labelling the craniometrical points and thus the precision of the method depends on measurements calibration.

This equivalence theory of direct and digital craniometry confirmed the study by Mollow (20). They found higher measurements accuracy, when measuring individuals than when measuring more examinants. No calibration of two and more examinants is leading to measurements errors (34).

Winder et al (35) compared 20 linear measurements on the live models (examinants) and by using the software. The mean difference between direct and digital measurements was 0.62 mm (maximum 1.43 mm and minimum 0.06 mm).

Higher values of nose breath (al-al) were observed in groups of males (3.69 ± 0.34 cm) than in groups of females (3.26 ± 0.23 cm). Studies by Kusugal et al (30) (Indian females: 3.23 ± 0.28 cm and Malaysian females: 3.55 ± 0.36 cm) confirmed differences in parameters of nose breath. In our study, differences in values al-al in the PDAA and the P3DAS were found. Our results were confirmed in the Netherland study by Fourie et al (26).

A possible limitation of this study was the sample size and its representativeness, which could pose problems in terms of generalizing the results.

Patients with facial asymmetry requiring orthodontic treatments and/or orthognathic surgery are more focused on their appearance and may be more concerned about facial asymmetry (37). One of the major reasons patients seek orthodontic treatment is to improve their facial appearance (38, 39). Precise analysis and diagnosis are important for orthodontic treatment planning and require a high-quality (40).

At present, due to extensive migration of European population we can be considered as a diverse mix of people of different origins.

The most important morphological ethnic differences are:

a) Morphological differences in the overall shape of the head – the overall shape of the head is determined by ratio between height and width. Relatively large overall shape of the head is typical especially for residents of northern Asia (Mongols), American Indians and eastern Asians. Long overall shape of the head is on the contrary typical for central European populations, Northern Europeans and African populations.
b) Morphological differences in the overall shape of the face – distinguishes between two extreme types of shapes: short and wide face (euryprosopnic type) typical of Asians, Mongols, Indians, Africans, and a long narrow face (leptoprosopnic type), which is typical for Europeans Caucasian nations Tatars.
c) Morphological differences in the shape of the nose – from an evolutionary point of view, we attach great nose adaptations to dry and cold air in Europe during the Ice Age or larger nose to warm up better during the breathing. Very large and protruding nose is typical for all of the European population. The description of the European or Caucasian face morphology is significant compared to the relatively flat and at least a protruding nose typical of the population of Central Africa and Asia. The overall shape of the nose is evaluated according to the proportion of length and width. Straight nose is in our, European population, considered to be attractive and also in the past it was a distinctive mark belonged to the ancient ideal of beauty. Straight nose is quite common in males of Northern European populations. The Mediterranean region is predominantly found with a nose gable – depth with the tip facing upwards in women. Bridge of nose is usually wide; side walls are small and pass smoothly in the face. The Europeans have relatively long, narrow nose and significantly rises above the level of the face. Both side walls converge at a sharp angle. Nostrils are elliptical with the long axis going antero-posterior. Asians have the angle of the walls of nose obtuse and nostrils are round. Broad nose of Africans is highly flattened and therefore nostrils stored to cross. The noses of Asians and Africans are usually short and wide.
d) The most significant internationals differences in shape of lips are in the size of the outer red part of the lips. In the European and Asian populations are developed relatively few in comparison with the African population.
e) Morphological differences in shapes of the eye slits: distinguish four basic spindle-shaped and half spindle-shaped typical for European populations. Almond and half almond shaped eyes are typical for Asian population. The differences are also in the total size of the eye slit. We recognize ocular slit narrow, medium and wide. Outside North Asian populations occurs narrow rather than in African populations (41).

Conclusion

The values of craniofacial parameters in our population can be used for the comparison of subjects with malocclusions, indicating areas of facial disharmony. After comparison with Farak `s study, we did not record almost any changes in the proportions of the face. Limit on the use of our four results for the 3D planning orthodontic –surgical treatment is the migration rate of the races.

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