Mediterranean Archaeology and Archaeometry, Vol. 16, No 1,(2016), pp. 169-183

DOI: 10.5281/zenodo.35530

SUPRAORBITAL FORAMEN AND HYPOGLOSSAL CANAL BRIDGING IN ANCIENT/MODERN ANATOLIAN POPULATIONS: IMPLICATIONS FOR WORLDWIDE POPULATION DISTRIBUTION

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Received: 03/12/2015
Accepted: 02/01/2016

ABSTRACT

Supraorbital foramen (SOF) and hypoglossal canal bridging (HGCB) show variation in their morphology and frequency in different populations. It is established that the frequency distribution of these traits are efficient to distinguish major human populations. In this study, the prevalence of SOF and HGCB in 11 Anatolian populations from distinct time periods and locations was examined. Frequency differences of SOF and HGCB were evaluated for different age and sex groups. Following Dodo and Sawada (2010) for SOF and HGCB population correlations, this study is the first to present the place of Anatolian populations among world populations.

Although significant differences in major human populations were observed by previous studies, there were no significant differences found amongst the Anatolian populations (Today Turkey) in relation to SOF. Similarly, supraorbital edge over the number of holes in size and position showed no significant difference. Though there was an age-related increase in frequency, evaluated data demonstrated no statistical difference between distinct age and sex groups in relation to SOF. The results of evaluation of SOF frequency within HGCB Anatolian people seem to cluster together most similarly with Europeans, in concordance with recent molecular genetic studies, among the 72 world populations. At the end, this study concludes that the frequency distribution of SOF and HGCB is an effective tool to distinguish genetically distant major human populations in large scale, but it is ineffective in comparing chronologically, geographically, and genetically proximate local populations. It is seen that this results are valid for ancient and modern populations.

KEYWORDS: Anatolia, supraorbital foramen, hypoglossal canal bridging, non-metric traits, modern human grouping

1. INTRODUCTION

The supraorbital margin of the orbit is formed entirely by the frontal bone and it may show notches, foramina (Fig. 1), or both in varying positions, quantities, and sizes (Hauser and De Stefano, 1989). The medial third of the supraorbital margin is marked by the *incisura/foramen supra orbitalis* and smooth vessels and nerves (Scheuer et al., 2000). The supraorbital artery, supplies the skin and muscles of the upper eyelid, forehead, and scalp, and the supraorbital nerve, largest terminal branch of the frontal nerve, pass through the supraorbital foramen or notch. The supraorbital nerve supplies palpebralfi laments to the upper eyelid and conjunctiva (Gray and Standring, 2008). Considering this, supraorbital elements are important not only in anatomical and anthropological studies but also in clinical practice.

Figure 1. Number of skull: HA 3, Supraorbital foramen

The embryological formation of the supraorbital foramen is known (Guidotti et al., 1985). By the end of the first trimester in utero, the supraorbital foramen becomes recognizable. The frontale's front edge thickens to form the orbital margin, potentially displaying a supra-orbital notch (Scheuer et al., 2000). Additional research supports the indication that the supraorbital foramen develops in fetuses (Dodo, 1979; 1980), prematurely born, mature infants (Hauser et al. 1984), and children (Cesnys, 1985). Based on computer tomography analysis on data obtained from living humans, Saitou et al. (2011) demonstrate that cranial anatomy can be used to score 19 nonmetric cranial variations including SOF. The effects genetic factors have in the formation of this variation in the occipital bone have been shown in both animal (Self and Leamy, 1978; Cheverud and Buikstra, 1981) and human (Sjovold, 1984) studies. SOF, like other non-metric traits, has been used to determine the biological distance of past populations (Berry and Berry, 1967; Hanihara et al., 2003; Kellock and Persons, 1970; Corruccini, 1974; Isida and Dodo, 1993; 1997; Nakashima et al., 2010; Dodo 1974; 1987; Dodo and Sawada, 2010, etc.).

SOF studies carried out on Modern Turkish-Anatolian populations groups (Keskil et al., 2003; Saylam et al., 2003); and Ancient Anatolian populations (Today Turkey) (Cırak et al., 2014; Cırak and Cırak, 2010; Yigit et al., 2007; Ozer et al., 1999; Ricaut and Waelkens, 2008) specify what details this study shows that the others do not. Dodo (1987) and Dodo and Sawada (2010) showed that the combination of SOF and HGCB frequencies appear to be particularly effective in discriminating among major group varieties of human populations. However, data from Anatolia (Asia Minor) has not yet been included in such research. In this study, SOF is recorded in detail according to the schemes developed by Dodo (1974; 1987) and Hauser & De Stefano (1985; 1989). Changes in SOF frequency have been recorded according to each Anatolian population in terms of age and sex. Finally, the main aim of this study is to compare SOF frequencies in Anatolian populations according to a) hypoglossal canal (HGCB) frequencies recorded by Eroglu (2010) combined with the data from the individual counting method in this study b) identify the characteristic frequency among the 71 populations of 13 major regions of the world (Dodo and Sawada, 2010).

2. MATERIALS AND METHODS

The material of this study is comprised by 388 adult skeletons. These skeletons belong to individuals from 11 Anatolian populations who inhabited different areas during various historical periods ranging from the Early Bronze age to the first quarter of the 20th century. These skeletons are stored and protected in the Anthropology Laboratory of Hacettepe University.

The skeletons were recovered from archaeological sites and sondage excavations (Hakmehmet) in several geographic regions of Anatolia including Marmara (İznik, Hagios Aberkios), Central Anatolia (Aşıklı, Andaval), East Anatolia (Hakmehme, Erzurum), the Black Sea (İkiztepe, Kovuklukaya), the Aegean (Cevizcioğlu, Yortanlı), and the Mediterranean (St. Nicholas).They are dated individually on the basis of proximate archaeological findings on location (Figure 2). The time periods attributed to each population and the numbers of individuals from each population are shown in Table 1.

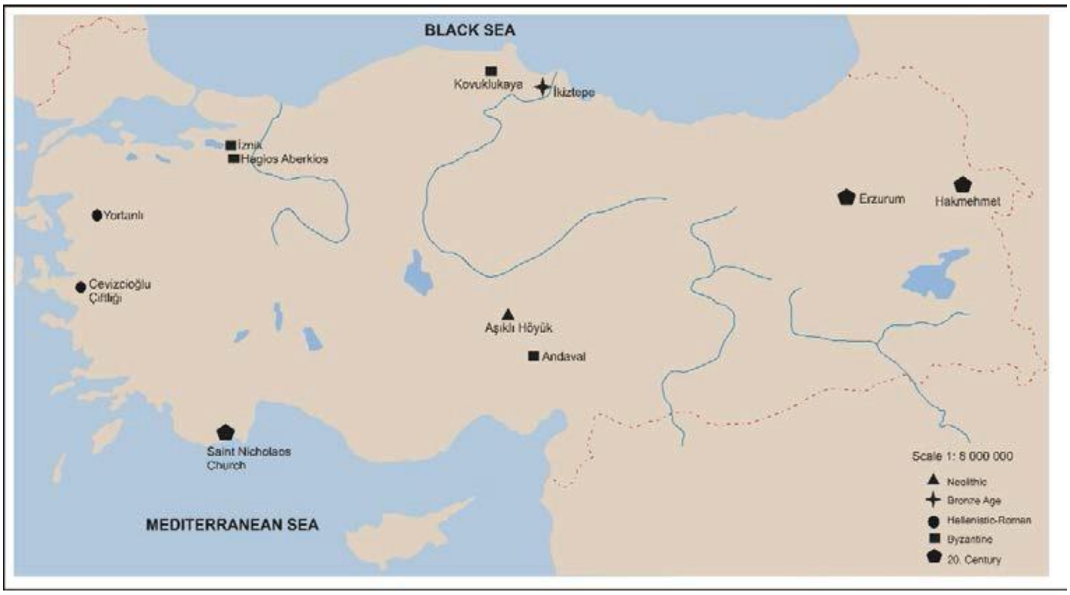

Figure 2. Location of the Anatolian cultural sites, where the human skeletal remains were recovered

Table 1. Anatolian populations constituting the database and number of individuals

Populations	Periods	References	Number of individuals
Aşıklı	Neolithic	Esin, 2000	5
Ikiztepe	Early Bronze	Bilgi, 2001	87
Cevizcioğlu	Hellenistic, Roman	Ozkan and Atukeren, 1999	50
Yortanlı	Byzantine	Yaras, 2002	13
Kovuklukaya	Early Byzantine	Ozcan et al., 2003	25
Andaval	Early Byzantine	Pekak, 1998	25
Iznik	Late Byzantine	Yalman, 1983	93
H.Aberkios	Late Byzantine	Erdal, 2000	18
St Nicholas	20th century	Ötüken, 1995	17
Hakmehmet	20th century	Unpublished data	13
Erzurum	20th century	Bilgin et al., 1994	39
Total			388

The sex of individuals in each sample was determined through the combined evaluation of long bones and body bones, with an emphasis on the anatomical details of the pelvis and the skull (Workshop of European Anthropologists, 1980). The joint processes of the long bones to the body, the particular joints of costa to sternum, the degrees of closure of the seams of the skull, and the degrees of deformation to the symphysis pubis (Buikstra and Ubelaker, 1994) were used to determine the age of the individuals. In determining the correlation between the individual's age and supraorbital foramen, the individuals were grouped into three general age categories: 18-29, 30-44 and 45+.

The presence or absence of SOF was recorded in detail according to the criteria outlined in Dodo (1974; 1987). Any foramen on the supraorbital margin of the frontal bone opening to the orbital cavity was scored as SOF present (Figure 1). In addition, SOF was recorded according to the classifications of Hauser and De Stefano (1989): 1. Position= medial or lateral, 2. Number, 3. Size = external apertures of canals: a) small = wires of 0.3 mm enter, b) medium = wires of 1 mm enter, c) large = wires of 1.2 mm enter, d) excessive = wires of 2 mm enter. Data obtained from the skulls of the 11 Ancient Anatolian populations were evaluated using IBM SPSS 20 software. While the X^2 *test* was used for the identification of differences in populations, sex, age and time periods. *Fisher's Exact* X^2 *test* was employed in cases where fewer than 5 samples were available. Furthermore IBM SPSS 20 software was used for the diagrams of SOF and HGCB incidences belonging to 71 populations world (Dodo and Sawada, 2010) and Anatolia in the population (Table 2 and 3).

Table 2. Cranial samples and frequencies of the supraorbital foramen (SOF) and hypoglossal canal bridging (HGCB)

Geographical Devision	**Cranial sample**	**SOF**		**HCGB**	
		n	%	*n*	%
Sub-Saharan Africa	Ibo/southern Nigeria	160	26,9	155	14,8
	Ghana (Ashanti)*	127	26,8	127	11,8
	Ghana (Ashanti)*	127	26,8	127	11,8
	Tanzania*	92	26,1	90	5,6
	Keniya*	145	25,5	133	15
	South Africa*	133	42,1	132	22
	Khoisan*	68	44,1	63	14,3
North Africa	Pre-Dynastic Egypt	240	35,4	231	30,7
	26th-30th Dynastic Egypt	184	37,5	184	33,2
	Erigavo/Somalia*	76	40,8	67	17,9
	Kerma/Sudan*	225	36,9	191	27,7
	Nubia*	226	46	214	29,9
Europe	Russia*	121	38,8	116	34,5
	Greece*	67	44,8	60	25
	East Europe*	123	38,2	124	29,8
	Italy*	204	34,8	180	29,4
	Finland/Ural*	80	38,8	79	29,1
	Scandinavia*	65	33,8	65	29,2
	Germany*	71	40,8	70	15,7
	France*	108	44,4	93	31,2
	Spitalfields, UK*	353	39,9	346	27,2
	Ensay, UK*	114	35,1	111	33,3
	Poundbury, UK*	167	37,1	151	26,5
South Asia	Assam/Sikkim*	65	44,6	65	21,5
	East India*	124	46,8	123	24,4
	South India*	184	44,6	181	23,3
	Northwest India *	175	39,4	173	26,6
	Tibet/Nepal*	124	43,5	121	14,9
Southeast Asia	Myanmar	186	41,9	188	19,1
	Mainland Southeast Asia	190	47,9	184	14,1
	Thai*	131	58	130	13,8
	Java*	137	49,6	133	20,3
	Philippines*	217	44,7	207	19,8
	Borneo*	152	41,4	137	21,9
	Lesser Sunda*	65	40	64	12,5
	Andaman/Nicobar*	122	49,2	119	16,8
East Asia	Main-Island Japan*	171	52	172	16,9
	Korea*	73	69,9	71	22,5
	North China*	165	61,2	165	20,6
	South China *	92	56,5	88	11,4
	Hokkaido Ainu*	231	26,4	242	35,5
	Jomon*	221	18,1	159	28,9
Central Asia	Tagar*	146	56,8	121	32,2
	Kazakh*	120	60	120	30,8
	Mongol*	180	57,8	180	19,4
	Buryat*	150	70,7	149	22,1
East Siberia	Amur Basin*	164	70,7	163	23,3
	Neolithic Baikal*	78	67,9	70	28,6
	Yakut*	65	72,3	64	25
Arctic	Ekven*	108	64,8	98	32,7
	Chukchi*	74	79,7	73	26
	Aleut*	116	71,6	104	28,8
	Asian Eskimo*	132	73,5	125	32,8
	Greenland Inuit*	167	70,1	166	26,5
Americas	Northwest Coast *	92	66,3	90	31,1
	Northwest America*	84	53,6	72	36,1
	Northeast America*	77	66,2	76	36,8

	Peru*	183	49,7	176	41,5
	Tierra del Fuego/Patagonia*	67	52,2	61	39,3
Melanesia	Papua New Guinea*	332	34,3	312	12,2
	Torres Strait*	101	41,6	97	15,5
	Northern Island Melanesia*	307	42,3	293	13,3
	Southern Island Melanesia*	193	45,6	188	17
Australia	East Australia*	139	23	126	11,9
	Southwest Australia*	369	23,3	267	9
Polynesia	Hawaii*	156	64,1	153	13,1
	Easter*	156	65,4	145	5,5
	Marquesas*	106	64,2	99	13,1
	Society*	72	54,2	64	20,3
	Maori*	198	62,1	175	20
	Moriori*	108	47,2	105	13,3
Asia Minor	**ANATOLIA****	**802**	**38,9**	**545**	**30,5**

*Dodo and Sawada (2010)
**Present study

Table 3. The frequencies of SOF and HGCB calculating the individual count method in Anatolia populations

Anatolian Populations	SOF		HGCB	
	F/N	%	F/N	%
Aşıklı Höyük (Present study)	2/5	40	-	-
Ikiztepe (Present study)	47/87	54	27/68	39,7
Cevizcioglu (Present study)	19/50	38	19/46	41,3
Yortanlı (Present study)	4/13	30,8	2/11	18,2
Kovuklukaya (Present study)	10/25	40	10/26	38,5
Andaval (Present study)	13/28	46,4	9/21	42,9
Iznik (Present study)	41/93	44,1	25/74	33,8
H. Aberkios (Present study)	16/18	88,9	4/14	28,6
Aziz Nikolas (Present study)	6/17	35,3	9/18	50,0
Hak Mehmet (Present study)	6/13	46,2	5/11	45,5
Erzurum (Present study)	19/39	48,7	14/35	40,0
Modern Tukish (Keskil et al., 2003)	78/200	39,0	32/200	16,0
Datça/Burgaz (Cırak et al., 2014)	1/12	8,3	-	-
Minnetpınarı (Yigit et al., 2007)	9/45	20	-	-
Karagündüz (Özer et al., 1999)	33/125	26,4	-	-
Kalenderis (Cırak and Cırak, 2010)	8/32	34,8	-	-
Sagalassos (Ricaut and Waelkens, 2008)	-	-	10/21	47,6
Total	312/802	38,9	166/545	30,5

3. RESULTS

3.1 *Frequency of SOF*

While SOF frequency in Anatolian populations ranged between 28% and 40% on the left side, it ranged between 20% and 38.5% on the right side with the exception of one population (H. Aberkios). SOF frequency in Neolithic Period (Aşıklı) and Early Bronze Age (Ikiztepe) is 40% (on right side), in Helenistic-Roman Period (Cevizcioglu) is 28% (on both right and left), in Byzantine Period (Yortanlı, Kovuklukaya, Andaval, Iznik and H. Aberkios) ranged between 23.1% and 72,2% (on the left side). SOF frequency is ranged between 29,4% and 38,5% in the 20th century populations (St Nicholas, Hakmehmet and Erzurum). An overall evaluation shows that there were no statistically significant differences between the groups (Pearson X^2: Right =,6,691, df=10 , p=,754 / Left = 14,591, df= 10, p= ,148). The highest SOF frequency (72,20 %) was detected in the H. Aberkios populations. There were no significant differences in terms of the SOF frequency on either side among the Anatolian populations (Table 4). Considering the number of holes in the SOF, while the frequency of having two holes on the right side was higher than the left side, the frequency of having three holes on the left side was more frequent. This difference, however, was not statistically significant.

When sex was taken into account, both right (39, 2%) and left (37,5%) sides on females showed higher frequencies than males. However, the difference was not statistically significant (Table 5).

SOF frequency shows a steady increase with age group: 16-29, 30-45, and 50+. As Table 6 indicates, although SOF frequency shows a slight increase with age, characteristic frequency increased more in the 50+ age group when compared to the previous group. This increase in frequency is higher on the left side. However, this difference was not found statistically significant.

When SOF frequency was evaluated according to time period, a significant change was not observed in terms of characteristics despite different frequencies on both left and right sides (Table 7). A similar situation was observed in the size and position of the SOF for the same periods.

In this study, the number, size, and position of SOF were also analyzed according to the sex, age and period parameters of each population. The appearance of two holes on the right side was more frequent than on the left, but three holes were found more frequently on the left side. A statistically significant difference was found on the left side at the size of SOF in terms of populations. SOF placement was found most prevalent on the medial side both on the right and left. SOF frequency on the lateral side was found 3.4% on right and 2,8% on left. However, this difference was not significant (Table 8).

The frequencies for occurence, size, and position of SOF each do not show statistically significant differences in terms of sex (Table 8). The size and position frequencies of SOF did not display significant differences in terms of age. Although the sample size is minimal the presence of 3 holes on the left side showed a significant difference in frequency from the right (X^2= 14,552, df= 6, p= ,024) (Table 8). Additionally, the size of SOF and the position of SOF frequency did not show statistically significant difference in periodic evaluation (Table 8).

3.2 Frequency Distribution of SOF and HGCB in Anatolia and the World populations

Table 2 shows the results of SOF and HGCB frequency in Anatolian populations (Table 3) in comparison with Dodo and Sawada's (2010) 71 world populations categorization.

The frequency distributions of SOF and HGCB in Anatolian populations with 71 populations of 13 major regions of the world can be found in Figure 3. In this diagram, Anatolian populations are clustered with European and North African populations rather than Central Asian populations.

SOF and HGCB frequencies in Anatolia were recalculated according to the individual count method. The list of available study results and other studies conducted in Anatolia are given in Table 3.

The scatter diagram displays the frequency distribution SOF and HGCB from 10 different Anatolian populations. Two populations dated to the Byzantine period, Yortanlı and H. Aberkios, are clustered far from the other Anatolian groups (Figure 4).

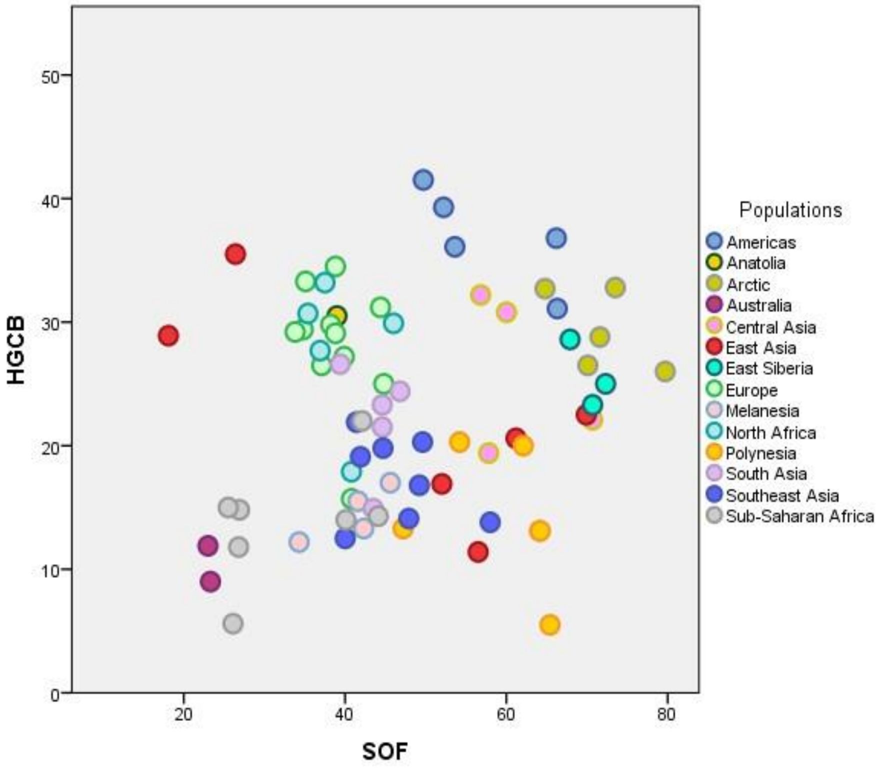

Figure 3. Frequency distribution of the supraorbital foramen (SOF) and hypoglossal canal bridging (HGCB) in 72 cranial samples from 13 major regions of the world

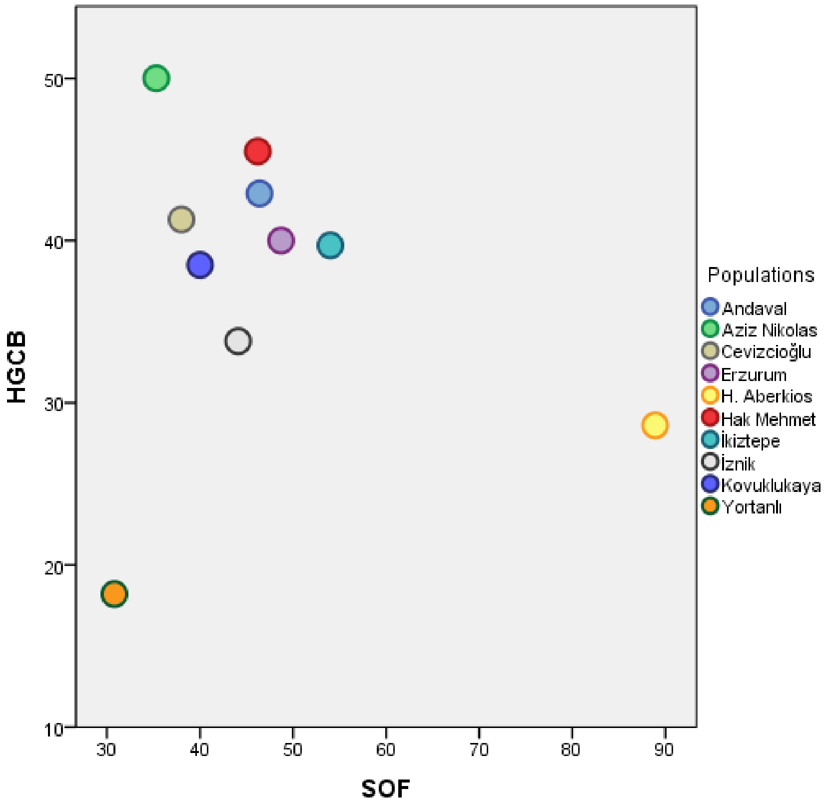

Figure 4. Frequency distribution of the supraorbital foramen (SOF) and hypoglossal canal bridging (HGCB) in Anatolia populations

Table 4. The frequency of supraorbital foramen in Anatolian samples

Populations		Right				Left			
		Absence		Presence		Absence		Presence	
	N	n	%	N	%	N	%	n	%
Aşıklı	5	3	60,0	2	40,0	4	80,0	1	20,0
Ikiztepe	87	52	59,8	35	40,2	55	63,2	32	36,8
Cevizcioğlu	50	36	72,0	14	28,0	36	72,0	14	28,0
Yortanlı	13	9	69,2	4	30,8	10	76,9	3	23,1
Kovuklukaya	25	18	72,0	7	28,0	17	68,0	8	32,0
Andaval	28	16	57,1	12	42,9	20	71,4	8	28,6
Iznik	93	65	69,9	28	30,1	62	66,7	31	33,3
H.Aberkios	18	9	50,0	9	50,0	5	27,8	13	72,2
St Nicholas	17	12	70,6	5	29,4	12	70,6	5	29,4
Hakmehmet	13	9	69,2	4	30,8	8	61,5	5	38,5
Erzurum	39	25	64,1	14	35,9	26	66,7	13	33,3
Total	388	254	65,5	134	34,5	255	65,7	133	34,3

Right X^2=,6,691, df=10 , p=,754 / Left X^2= 14,591, df= 10, p= ,148

Table 5. The frequency of supraorbital foramen according to sex

Sex	N	Right				Left			
		Absence		Presence		Absence		Presence	
		n	%	n	%	n	%	n	%
Male	268	181	67,5	87	32,5	180	67,2	88	32,8
Female	120	73	60,8	47	39,2	75	62,5	45	37,5
Total	388	254	65,5	134	34,5	255	65,7	133	34,3

Right X^2= 1,648, df= 1, p= ,199, exact= .122 / Left X^2=,800, df= 1, p= ,371, exact= ,218

Table 6. The frequency of supraorbital foramen according to age

Age	N	Right				Left			
		Absence		Presence		Absence		Presence	
		n	%	n	%	N	%	N	%
16-29	141	92	65,2	49	34,8	95	67,4	46	32,6
30-45	201	133	66,2	68	33,8	133	66,2	68	33,8
50+	46	29	63,0	17	37,0	27	58,7	19	41,3
Total	388	254	65,5	134	34,5	255	65,7	133	34,3

Right X^2= ,166, df= 2, p= ,920 / Left X^2=1,197, df= 2, p= ,550

Table 7. The frequency of supraorbital foramen according to period

Period	N	Right				Left			
		Absence		Presence		Absence		Presence	
		n	%	n	%	n	%	N	%
Neolithic	5	3	60,0	2	40,0	4	80,0	1	20,0
Bronze	87	52	59,8	35	40,2	55	63,2	32	36,8
Hellenistik-	63	45	71,4	18	28,6	46	73,0	17	27,0
Byzantine	181	120	66,3	61	33,7	116	64,1	65	35,9
20.Century	2 52	34	65,4	18	34,6	34	65,4	18	34,6
Total	388	254	65,5	134	34,5	255	65,7	133	34,3

Right X^2= ,2,361, df= 4, p= , 670 / Left X^2=2,399, df= 4, p= ,663

Table 8. The number, size and position of supraorbital foramen observed according to population, sex, age and period

Population	**Right**	**Left**
The number of supraorbital foramen	X^2=21,397, df=30 , p=,875,	X^2= 42,863, df= 30, p= ,060
Size of supraorbital foramen	X^2=27,435, df=40 , p=,934	X^2= 61,430, df= 40, p= ,016*
Position of supraorbital foramen	X^2=14,858, df=30 , p=,991	X^2= 29,096, df= 30, p= ,513
Sex		
The number of supraorbital foramen	X^2=2,541, df=3 , p=,468	X^2= 1,023, df= 3, p= ,796
Size of supraorbital foramen	X^2= 3,293, df= 4, p= ,510	X^2=,2,662, df= 4, p= ,616
Position of supraorbital foramen	X^2=2,435, df=3 , p=,487	X^2= 1,550, df= 3, p= ,671
Age		
The number of supraorbital foramen	X^2=1,183, df=6 , p=,978	X^2= 14,552, df= 6, p= ,024*
Size of supraorbital foramen	X^2= 3,729, df= 8, p= ,881	X^2=3,433, df= 8, p= ,904
Position of supraorbital foramen	X^2=3,433, df= 8, p= ,904	X^2= 7,189, df=6, p= ,304
Period		
The number of supraorbital foramen	X^2=11,745, df=12 , p=,466	X^2= 23,947, df= 12, p= ,021*
Size of supraorbital foramen	X^2= 10,615, df= 16, p= ,833	X^2=8,925, df= 16, p= ,916
Position of supraorbital foramen	X^2=4,263, df=12, p=,978	X^2= 6,036, df=12, p= ,914

*$P \leq 0,05$

4. DISCUSSION

4.1 *Frequency of SOF*

SOF is one of the supraorbital structures that arteries and nerves pass through. Hanihara and Ishida (2001a) include this feature in the group of vessel and nerve related variations. It has been suggested that, like other non-metric features, genetic and environmental factors affect the presence of this feature (Berry and Berry, 1967; Self and Leamy, 1978; Cheverud and Buikstra, 1981). This variation gives a lower heritability value compared with hyperostotic features identified in studies of mice (Richtsmeier and McGrath, 1986) and macaque monkeys (Cheverud and Buikstra, 1981; 1982). Sjovold (1984) found a relatively high heritability ($h^2 = 0.378 \pm 0.83$) in the skulls of 2 to 20 family members from a total of 91 pedigrees. The observation of this feature in fetuses (Dodo, 1979; 1980), prematurely born mature infants (Hauser et al., 1984), and children (Cesnys, 1985) refer to its genetic origin.

Among the different models that attempt to clarify the genetic etiology of nonmetric skull traits, such as SOF, Grüneberg's (1952) quasi-continuous model has received the widest acceptance by researchers (Hanihara et al., 2003; Rösing, 1982; Sjovold, 1984;

Cheverud and Buikstra, 1978; Saunders, 1989). Many non-metric characteristics such as SOF have been used to estimate the biological distance of the people who lived in the past (Hanihara and Isida, 2001b; Ossenberg, 1970; Isida and Dodo, 1998; Berry and Berry 1967; Hanihara et al., 2003; Kellock ve Persons, 1970; Corruccini, 1974; Isida and Dodo, 1993; 1997).

This study represents the most detailed work of its kind. As shown in Table 3, previous studies on populations of Anatolia (Keskil et al., 2003; Cırak et al., 2014; Cırak and Cırak, 2010; Yigit et al., 2007; Ozer et al., 1999; Ricaut and Waelkens, 2008) have only focused on determining SOF frequency. Findings in this study show that in 11 ancient Anatolian populations SOF frequency varied from one population to the other population (28-40 % on the right side, 20 to 38.5 % on the left) at a frequency of 70 % (H. Aberkios). It is has been concluded that H. Aberkios and Yortanlı differ from other Anatolian groups (Figure 4).

The number, size, and position of SOF in the supraorbital region was evaluated separately for the right and left side in terms of population, sex, and period (Table 6). No significant difference in the four parameters was observed on the right side. However, the size of SOF located on the left side was found statistically significant (X^2= 61,430, df= 40, p= ,016) between Anatolia populations. The incidence of three holes on the left side in the 45+ age group was higher than other age groups. This revealed a statistically significant difference (X^2= 14,552, df= 6, p= ,024). A similar situation has arisen in the comparison between periods. However, the identification of three holes in one out of the 5 total individuals from the Neolithic at Aşıklı Hoyuk has formed significant differences (X^2= 23,947, df= 12, p=, 021). However, this has no statistically significant mean because of the minimal sample size at Asikli Hoyuk.

There was no significant relation found between sex and SOF (Eroglu and Erdal, 2008; Eroglu 2008; 2010; 2011) nor any other features (Right X^2= 1,648, df= 1, p= ,199, exact= ,122 / Left X^2=,800, df= 1, p= ,371, exact= ,218). However, some researchers (Corruccini, 1974; Scarsini et al., 1980; Cesyns, 1985; Tur, 2011; Hanihara and Ishida, 2001a; Brasili-Gualandi and Gualdi-Russo, 1989) have also noted that SOF frequency was found higher in females than males. According to Hauser and De Stefano (1989) significant differences in SOF presence by sex did not emerge in studies that used more detailed methodology.

A significant relationship has not generally been observed between age and SOF. Brasili-Gualandi and Gualdi-Russo (1989) found no correlation between age and SOF in their study on seven different age groups. Perzonius (1979) also concluded that non-metric traits are independent from age (groups compared: 25-50 and 71-100). A similar conclusion was reached by Corruccini (1974). In the present study, a higher SOF frequency was found in 45+ age groups (41,3 %). However, no significant difference was identified between SOF and age.

Table 9. The frequency of unilateral and bilateral expression in Anatolia populations

Right/Left	N	%
-/-	205	52,8
-/+	49	12,6
+/-	50	12,9
+/+	84	21,6
Total	388	100,0

Symmetry/asymmetry has been one of the parameters of nonmetric traits attracting a great deal of attention. Although many non-metric features are morphologically bilateral, they do not always occur bilaterally (Ossenberg, 1981; Korey, 1980; McGrath et al., 1984; Hallgrimsson et al., 2005; Dodo, 1974; 1987). As it can be seen in Table 9, the occurrence of SOF frequency varies depending on the population. The frequency of bilateral expression of features (21.6%) is higher than that of singularly right (12.9%) or left side (12.6%) expression. There was no statistically significant differences between both sides, in fact they were quite close in frequency to each other (Pearson Chi-Square = ,006 df= 1, P= ,940). Similar findings have been reported by a number of researchers (Molto, 1984, Birkby, 1973; Brasili-Gualandi and Gualdi-Ruso, 1989). However, Dodo (1974) and Perizonius (1979) found a higher frequency on the left side. It has been suggested that the appearance of non-metric traits on both sides stems from genetic factors, (Hallgrímsson et al., 2005; Ossenberg, 1981; Trinkaus, 1978; Korey, 1980; McGrath et al., 1984, Brasili-Gualandi and Gualdi-Russo, 1989), while the appearance of a trait on only one side is due to environmental factors (Trinkaus, 1978; Korey, 1980; Ossenberg, 1981; McGrath et al., 1984, Brasili-Gualandi and Gualdi-Russo, 1989). The unilateral expression of SOF in this study can be associated with environmental factors. As can be seen in table 9, the frequency of asymmetrical SOF occurrence is not high for in the Anatolian populations. In comparison with SOF, Eroglu (2010) found a significant difference between the frequency of hypoglossal canal bridging and numbers of bridging (Pearson Chi-Square= 16.716, df= 4, P= ,002) in HGCB. This asymmetry in findings can be attributed to environmental factors.

4.2 Frequency Distribution of SOF and HGCB in Anatolia and the World populations

Ossenberg et al. (2006) report frontal bone traits, including SOF, provide excellent separation between Jomon, Wajin, and Ainu. Hanihara and Isida (2001a) showed that the frequency of SOF for Hokkaido Ainu is comparable with Australians and Sub-Saharan Africans. Dodo and Sawada (2010) investigated SOF and hypoglossal canal bridging (HGCB) by using the data of 71 cranial samples from different regions of the world. They confirmed that two traits are effective in distinguishing between major human populations. Eroglu's study (2010), based on frequency of HGBC, does not find significant differences between Anatolian populations even though it found significant differences between populations outside Anatolia. In this study, the frequency distribution of the SOF presence by population ranged from (Cırak et al., 2014) 88.9 to 8.3% in Anatolia, calculated based on the individual counting method. However, despite such a wide frequency range, there were no significant differences among populations. Therefore, all data on Anatolia groups was analyzed together and compared with the world population (Fig.3).

Due to Anatolia's geographical role as a bridge between Asia and Europe, Anatolian populations have been effected by constant changes and exchanges in gene flows due to migration events since the Palaeolithic (Khun, 2002; Richards et al., 2000; Ricaut and Waelkens, 2008). Anatolian populations have displayed a relatively homogeneous morphological pattern from the Neolithic Period up to the Bronze Age, which suggests following this historical period a heterogenic structure came into existence (Cappieri, 1969; 1970; 1972; Ozbek, 1994). Further, anthropological (Krogman, 1937; Cappieri, 1969; 1970; 1972; Senyurek, 1941; Ozbek, 1994; Eroglu ve Erdal, 2008, 2006; Eroglu, 2008; 2009; 2010; Clement et al., 1974; Wittwer-Backhofen, 1986), archaeological, and historical data (Umar, 1998; Uzuncarsılı, 1981; Koprulu, 1980) indicate that Anatolia has been subjected to migrations, invasions, and battles since the Bronze Age.

Historical data shows that from the 11th century, a regular genetic flow took place towards Anatolia from Central Asia (Koprulu, 1981; Uzuncarsılı, 1982). Investigations on the morphological traits of skulls and teeth also indicate that these traits, related to Asians, increased after the 11th century (Erdal 1992; Erdal and Eroglu, 2000; Eroglu ve Erdal, 2008; Eroglu, 2012). The frequency of palatine torus, observed in ancient Anatolian skeletal populations from the early Bronze Age to the first quarter of the 20th century, (Table 1), indicates a Mongoloid gene flow (Eroglu and Erdal, 2008). It was found that the frequency of palatine torus was particularly high during the Ottoman period. This data is supported by a recent DNA study conducted on people living in Anatolia (Di Benedetto et al., 2001). A DNA analysis carried out on people from 4 cities in Anatolia (Ankara, Antalya, Izmit, and Van) indicates the presence of a continuous gene flow from Central Asia to Anatolia since the 11th century AD. This study shows that the Anatolian gene pool contains a substantial fraction of alleles of Asian origin (Di Benedetto et al., 2001). The most reliable estimates suggest roughly a 30 % Central Asian admixture for both mitochondrial and Y chromosome loci. That figure is compatible with both a substantial immigration accompanying the arrival of the Turcoman armies and with continuous gene flow from Asia into Anatolia, at a rate of 1 % for 40 generations (Di Benedetto et al., 2001). However, it was identified that Anatolian populations dating to 20th century (Erzurum and Hakmehmet) show a lower frequency of palatine torus than that found in earlier populations. This situation indicates that the gene flow into Anatolia has continued into the 20th century; however, the direction of the migration has altered eastwards, from Europe to Anatolia. Indeed, it is stated that many immigrants from Romania, Bulgaria, Greece and Yugoslavia came to Turkey and genetically intermixed with the Anatolian populations in the 20th century, especially after the establishment of the Turkish Republic in 1923 (Umar, 1998; Kılıcoglu et al., 1988).

On the other hand, the frequency of metopism observed in the same populations where the frequency of palatine torus was detected, have shown similarity with Europeans (Eroglu, 2008). According to the results of the study on hypoglossal canal bridging, Anatolian populations lie within the range of variation for Caucasoid (Eroglu, 2010), in concordance with the metopism results. The material represented in this study from three of the Anatolia populations shows a frequency of shovel shaped teeth at 23.7%, found in a high proportion of Asians, (Eroglu, 2012), and a frequency of carabelli at 53.3%, occurring widely in European populations (Eroglu, 2009). These results suggest migration from Asia to Anatolia, however, they also show a stronger genetic correlation to Europeans. Ricaut and Wilkens (2008) found a low biological affinity between the Sagalassos (Southwestern Turkey) population and populations from Central Asia. Seguchi et al. (2010) studied Turkish population substructure and history by examining craniofacial diversity through several temporal periods framed within a population genetic model. According to this study, if the region of Anatolia has been used as a migratory corridor by peoples spanning disparate geographic areas (Balkans, Central Asia, and East Asia), then due to these migration events and inherent genetic admixture, gradual craniofacial change is more expected. But their results indicate minimal Turkic-Central Asian genetic influence on Anatolian population structure.

Similarly, most genetic studies on people living in Turkey suggest that Anatolian populations are closer to the European populations than Central Asian populations (Comas et al., 1996; Calafell et al., 1996; Cinnioglu et al., 2004; Rolf et al., 1999; Berkman et al., 2008; Richards et al., 2000; Gonzalez-Perez et al., 2010). Comas et al. (1996) analyzed the hypervariable segment I control sequence in mitochondrial DNA (mtDNA) on 45 unrelated individuals from Anatolia. This study suggests a demographic expansion occurring in the Middle East, spreading through Turkey into Europe. After initial expansion, high levels of migration (gene flow) during the Neolithic age must have contributed to a homogenization of the genetic landscape of the Europe. Calafell et al. (1996) find similar results in their study of thirty Bulgarians and twenty-nine Turks. Cinnioglu et al. (2004) find, in their analysis of biallelic polymorphisms for Turkish Y chromosomes, that major haplogroups (combination of linked alleles at linked loci that share a common ancestral mutation) were shared with the European and Middle Eastern populations (94.1%), with only minor sharing of central Asian (3.4%), Indian (1.5%), and African (1%) haplogroups. Their findings suggest several patterns correlating to latitude expansion into Europe, gene flow into Europe, and affinity to geographically close Caucasoid groups. They also find detectable, yet weak (<9%), signals of paternal gene flow from Central Asia. King et al. (2008) found similar results. Another study based on analyses of six STR loci in 88 Y-chromosomes from Turkey suggests only a 10% contribution (Rolf et al., 1999). Using *Alu* insertion polymorphisms, Berkman et al. (2008) find a similar central Asian genetic contribution to Anatolia, estimating ~13% admixture. Gonzalez-Perez et al. (2010) analyze the relationships between human groups in 15 Mediterranean populations, including Turkey. They use the variation of 18 Alu polymorphisms and 3 linked STRs. Researchers find a close relationship between Turkey and Greece. MtDNA studies on populations in the Europe and the Middle East find similar results (Richards et al., 2000).

5. CONCLUSION

According to present findings among the Ancient Anatolian populations no significant differences in data obtained from SOF were identified. In contrast, after Anatolian series were pooled, differences between Anatolian and other world populations were recognized. As shown in Fig. 3, the results of SOF and HGCB frequency show that Anatolia populations are more similar to West Eurasian and ancient northeast African populations than to Central and East Eurasian populations. The results of SOF and HGCB frequencies are in concordance with findings in anthropological and genetic studies on Anatolia populations. As in Dodo and Sawada's (2010) findings, this study found SOF and HGCB incidences effective in the separation of major population groups but ineffective in comparing chronologically and geographically proximate local populations.

ACKNOWLEDGEMENTS

I thank the anonymous reviewers for their constructive comments. I would like to express my gratitude to Dr Nilgun Coskun for map in the figure 1. I am also grateful to Ali Rıza Can, Anna Heumann Kaya and Ferhat Kaya for their help in improving the English of this paper.

REFERENCES

Berkman, C.C., Dinc, H., Sekeryapan, C. and Togan, I. (2008) Alu insertion polymorphisms and an assessment of the genetic contribution of Central Asia to Anatolia with respect to the Balkans. *American Journal of Physical Anthrophology*, 136: 11-18.

Berry, A.C. and Berry, R.J. (1967) Epigenetic variation in the human cranium. *Journal of Anatomy,* 101(2), 361-379.

Bilgi Ö,. (2001) *Prehistorik Çağda Orta Karadeniz Bölgesi Madenciliği; Hint-Avrupalıların Anavatanı Sorununa Yeni Bir Yaklaşım.* TASK Vakfı Yayınları:4 Monografi Serisi:1 Istanbul.

Bilgin, T., Sülün, T., Ozbek, M. and Beyli, M. (1994) Yakınçağ Anadolu Insanlarında Dişlerin Biyometrik ve Patolojik Açıdan Analizi. *Istanbul Diş Hekimliği Fakültesi Dergisi*, 28(3):169-179.

Brasili-Gualandi, P. and Gualdi-Russo, E. (1989) Discontinuous traits of the skull: Variations on sex, age, laterality. *Anthropologischer Anzeiger,* 47(3): 239-250.

Buikstra, J.E. and Ubekaler, D.H. (Eds). (1994) *Standards: For Data Collection from Human Skeletal Remains.* Arkansas Archeological Survey Research Series, No 44.

Calafell, F., Underhill, P., Tolun A., Anglicheva D. and Kalaydjieva, L. (1996) From Asia to Europe: mitochondrial DNA sequence variability in Bulgarian and Turks. *Annals of Human Genetics*, 60: 35-49.

Cappieri, M. (1969) The Mediterranean race in Asia before the Iron Age. In: Field H. (ed.) *Occasional Paper 8. Published by Field Research Projects*, Miami, Florida.

Cappieri, M. (1970) The Anatolians of the late Neolithic and Chalcolithic age. *Belleten*, 34: 509-558.

Cappieri, M. (1972) Genotypical and phenotypical homogeneity of the ancient population of Anatolia. In: Field H, Laird EM, (eds.) *Occasional Paper 64. Published by Field Research Projects*. Miami, Florida.

Celement, F.M., Dabagihan, E., Ferembach, D. and Jouanneau, J. (1974) Les alpins de Çatal Höyük (Néolithique, Turquie). Aplication d'une analyse en composante principale normée á la définition de leur origine. *Biométrie Humaine (Paris)*, IX: 53-69.

Cheverud, J.M. and Buikstra, J.E. (1978) A Study of Intragroup Biological Change Induced by Social Group Fission in Macaca mulatta Using Discrete Cranial Traits. *American Journal of Physical Anthropology*, 48: 41-46.

Cheverud, J.M. and Buikstra, J.E. (1981) Quantitative genetics of skeletal nonmetric traits in Rhesus Macaques on Cayo Santiago. I. Single trait heritability. *American Journal of Physical Anthropology*, 54: 43-49.

Cheverud, J.M. and Buikstra, J.E. (1982) Quantitative genetics of skeletal nonmetric traits in the rhesus macaques of Cay0 Santiago. III. Relative heritability of skeletal nonmetric and metric traits. *American Journal of Physical Anthropology*, 59 (2): 151-155.

Cinnioglu, C., King, R., Kivisild, T., Kalfoğlu, E., Atasoy, S., Cavalleri, G.L., Lillie, A.S., Roseman, C.C., Lin, A.A., Prince, K., Oefner, P.J., Shen, P., Semino, O., Cavalli-Sforza, L.L. and Underhill, P.A. (2004) Excavating Y-cromosome haplotype strata in Anatolia. *Human Genetics*, 114:127-148.

Cirak, A. and Cirak, M.T. (2010) Kelenderis Toplumunda Nonmetrik Varyasyonlar 32. Uluslararasi Kazi, *Arastirma ve Arkeometri Sempozyumu*, Istanbul.

Cirak, A., Arihan, S.K., Erkman, A.C., Cirak, M.T. (2014) Epigenetic features of human skulls from Datca-Burgaz excavations. *Mediterranean Archaeology and Archaeometry*, 14: 13-24.

Comas, D., Calafell, F., Mateu, E., Pérez-Lezaun, A. and Bertranpetit, J. (1996) Geographic variation in human mitochondrial DNA control region sequence: the population history of Turkey and its relationship to the European populations. *Molecular Biology and Evolution*, 13: 1067-1077.

Corruccini, R.S. (1974) An examination of the meaning of cranial discrete traits for human skeletal biological studies. *American Journal of Physical Anthropology*, 40: 425-446.

Di Benedetto, G.D., Güven, A., Stenico, M. and Bertonelle, G. (2001) DNA diversity and population admixture in Anatolia. *American Journal of Physical Anthropology*, 115: 144-156.

Dodo, Y. (1974) Non-metrical cranial traits in the Hokkaido Ainu and the northern Japanese of recent times. *Journal of the Anthropological Society of Nippon*, 82: 31-51.

Dodo, Y. (1987) Supraorbital foramen and hypoglossal canal bridging: the two most suggestive nonmetric cranial traits in discriminating major racial groupings of man. *Journal of the Anthropological Society of Nippon*, 95: 19-35.

Dodo, Y. and Sawada, J. (2010) Supraorbital foramen and hypoglossal canal bridging revisited: their worldwide frequency distribution. *Anthropological Science*, 118(1): 65-71.

Erdal, Y.S. (1992) İznik geç Bizans dönemi insanlarının kafatası yapıları. *Türk Arkeoloji Dergisi*, 30: 51-69.

Erdal, Y.S., Eroglu, S. (2000) Bazı Anadolu topluluklarında diş varyasyonlarının dağılımı. *2. Ulusal Biyolojik Antropoloji Sempozyumu.* Ankara: October 25-26, 2000.

Erdal, Y.S. (2000) Hagios Aberkios Kilisesi İskelet Topluluğunun Antropolojik Açıdan Incelenmesi. *Belleten*, 64(239): 23-41.

Eroglu, S. (2008) The frequency of metopism in Anatolian populations dated from the Neolithic to the first quarter of the 20th Century. *Clinical Anatomy*, 21: 471-478.

Eroglu, S. (2009) Üç eski Anadolu topluluğunda carabelli sıklığı. *Edebiyat Fakültesi Dergisi*, 26(2): 115-132.

Eroglu, S. (2010) Variations in the form of the hypoglossal canal in ancient Anatolian populations: Comparison of two recording methods. *Homo*, 61(1): 33-47.

Eroglu, S. (2011) The incidence of mylohyoid bridging in prehistoric and historic Anatolian populations. *Eurasian Journal of Anthropology*, 2(1): 15-26.

Eroglu, S. (2012) Eski Anadolu Toplumlarında Kürek Biçimli Diş Sıklığı. *Ankara Üniversitesi DTCF 75. Kuruluş Yıldönümü Anı Kitabı: Biyolojik Antropoloji*. E. Güleç, I. Özer. M. Sagır, B.K. Özer (eds). Ankara Üniversitesi DTCF Yayınları: 410. Ankara.

Eroglu, S. and Erdal, Y.S. (2006) Ikiztepe insanlarının Anadolu ve Anadoluya yakın topluluklarla biyolojik ilişkisi. *Arkeometri Sonuçları Toplantısı*, 21:41-50.

Eroglu, S. and Erdal YS. (2008) Why did the frequency of palatine torus increase in the ancient Anatolian populations? *Homo*, 59: 365-382.

Esin, U. (2000) Aşıklı Höyük Kazıları. In: Belli O (ed.), *Türkiye Arkeolojisi ve İstanbul Üniversitesi*, İstanbul, p. 20–29.

Ferembach, D. (1972) Les hommes du gisement neolithique de Çatal Höyük." *Ankara, Türk Tarih Kurumu Kongresi Yayınları*, pp. 15-21.

González-Pérez, E., Esteban, E., Via, M., Gayà-Vidal, M., Athanasiadis, G., Dugoujon JM. and Moral P. (2010) Population relationships in the Mediterranean revealed by autosomal genetic data (Alu and Alu/STR compound systems). *American Journal of Physical Anthropology*, 141(3): 430-439.

Gray, H. and Standring, S. (2008) *Gray's anatomy: the anatomical basis of clinical practice*. Elsevier/Churchill Livingstone.

Grüneberg, H. (1952) Genetical studies on the skeleton of the Mouse. IV. Quasi-continuous variations. *Journal of Genetics*, 51:95-114.

Guidotti, A., Bastianini, A., De Stefano, G.F, and Hauser, G. (1986) Variations of supraorbital bony structures in Sienese skulls. *Cells Tissues Organs*, 127(1): 1-6.

Hallgrímsson, B., Donnabhain, B. O., Blom, D. E., Lozada, M. C. and Willmore, K. T. (2005) Why are rare traits unilaterally expressed?: trait frequency and unilateral expression for cranial nonmetric traits in humans. *American Journal of Physical Anthropology*, 128(1): 14.

Hanihara, T. and Ishida, H. (2001a) Frequency variations of discrete cranial traits in major human populations. IV. Vessel and nerve related variations. Journal of Anatomy, 199 (03): 273-287.

Hanihara, T. and Isida, H. (2001b) Frequency variations of discrete cranial traits in major human populations. III. Hyperostotic variations. *Journal of Anatomy* 199: 251-272.

Hanihara, T., Isida, H. and Dodo, Y. (2003) Characterization of Biological Diversity through Analysis of Discrete Cranial Traits. *American Journal of Physical Anthropology*, 121: 241-251.

Hauser, G. and De Stefano, G.F. (1989) *Epigenetic Variants of the Human Skull.* Stuttgart: Schweizerbart.

Hauser, G. and De Stefano, G.F. (1985) Variations in form of the hypoglossal canal. *American Journal of Physical Anthropology*, 67:7-11.

Hauser, G., De Stefano, G.F., Bastianini, A. and Guidotti, A. (1984) Supraorbital minor skeletal variants in fetuses and newborns. *Anthrop. Kozl.*, 28: 63-70.

Ishida, H. and Kida, M. (1991) An anthropological investigation of the Sakhalin Ainu with special reference to nonmetric cranial traits. *Journal of the Anthropological Society of Nippon*, 99: 23-32.

Ishida, H. and Dodo, Y. (1993) Nonmetric cranial variation and the populational affinities of the Pacific peoples. *American Journal of Physical Anthropology*, 90(1), 49-57.

Isida, H. and Dodo, Y. (1997) Cranial variation in prehistoric human skeletal remains from the Marianas. *American Journal of Physical Anthropology*, 104, 399-410.

Kellock, W.L. and Parsons, P.A. (1970) A comparisons of the incidence of minor nonmetrical cranial variants in Australian Aborigines with those of Melanesia and Polynesia. *American Journal of Physical Anthropology*, 33: 235-240.

Keskil, S., Gözil, R. and Çalgüner, E. (2003) Common surgical pitfalls in the skull. *Surgical neurology*, 59(3): 228-231.

Kılıcoglu, S., Araz, N. and Devrim, H. (eds.) (1988) *Meydan-Larousse Göç*. Meydan Yayınları. Istanbul.

King, R.J. Özcan, S.S., Carter, T., Kalfoğlu, E., Atasoy, S., Triantaphyllidis, C. and Underhill PA. (2008) Differential Y-chromosome Anatolian Influences on the Greek and Cretan Neolithic. *Annals of Human Genetics*, 72(2): 205-214.

Koprulu, F. (1981) *Osmanlı İmparatorluğunun Kuruluşu*. Ötüken Yayınevi. Istanbul.

Korey, K.A. (1980) The incidence of bilateral nonmetric skeletal traits : a reanalysis of sampling procedures. *American Journal of Physical Anthropology*, 53: 19-23.

Krogman, W.M. (1937) Cranial types from Alishar Hüyük and their relations to other racial types, ancient and modern of Europe and Western Asia. In *The Alishar Hüyük, Seasons of 1930-32.* Ed. H.H. Von der Osten, Part III of Oriental Institute, Chicago. 30: 213-293.

Kuhn, S.L. (2002) Paleolithic archeology in Tukey. *Evolutionary Anthropology*, 11: 198-210.

McGrath, J.W., Cheverud, J.M. and Buikstra, J.E. (1984) Genetic correlations between sides and heritability of asymmetry for nonmetric traits in rhesus macaques on Cayo Santiago. *American Journal of Physical Anthropology*, 64: 401-411.

Nakashima, A., Ishida, H., Shigematsu, M., Goto, M. and Hanihara, T. (2010) Nonmetric cranial variation of Jomon Japan: implications for the evolution of eastern Asian diversity. *American Journal of Human Biology*, 22(6): 782-790.

Ossenberg, N.S. (1970) The influence of artificial cranial deformation on discontinuous morphological traits. *American Journal of Physical Anthropology*, 33: 357-372.

Ossenberg, N.S. (1981) An argument for the use of total side frequencies of bilateral nonmetric skeletal traits in population distance analysis: the regression of symmetry on incidence. American Journal of Physical Anthropology, 54: 471-479.

Ossenberg, N.S., Dodo, Y., Maeda, T. and Kawakubo, Y. (2006) Ethnogenesis and craniofacial change in Japan from the perspective of nonmetric traits. *Anthropological Science*, 114(2): 99-115.

Otuken, Y. (1996) 1995 Yılı Demre, Aziz Nikolaos Kilisesi. *Kazısı. Kazı Sonuçları Toplantısı II*, 18: 471-488.

Ozbek, M. (1988) Çayönü Insanları ve Sağlık Sorunları**.** *Arkeometri Sonuçları Toplantısı*, 4: 121-152.

Ozbek, M. (1992) Aşıklı Höyük Neolitik Çağ Insanları. *Arkeometri Sonuçları Toplantısı*, 8: 201-212.

Ozbek, M. (1993) Aşıklı Höyük Insanları 1990 ve 1992 Buluntuları. *Arkeometri Sonuçları Toplantısı*, 9: 23-32.

Ozbek, M. (1994) Anadolu'da insan ırklarının tarihsel gelişimi. *Türk Tarih Kongresi*, 11: 45-68.

Ozcan, M., Dereli, F. and Dönmez, Ş. (2003) Kovuklukaya Kurtarma Kazısı. *Türk Eskiçağ Bilimler Enstitüsü, Haberler*, 15:21-22.

Ozer, I., Sugihara, K., Pehlevan, C., Sevim, A. and Gulec, E. (2000) Karagunduz Toplumunda Epigenetik Karakterler. *Arkeometri Sonucları Toplantısı*, 15: 101–109.

Ozkan, T. and Atukeren, S. (1999) Cevizcioğlu Çiftliği Nekropolü Kazıları. *Tahtalı Barajı Kurtarma Kazısı Projesi*, Izmir.

Pekak, S. (1997) Niğde-Andaval (Aktaş)'daki Konstantin-Helena Kilisesi. *Kazı Sonuçları Toplantısı II,* 19: 567-592.

Perizonius, W.R.K. (1979) Non-metric Cranial Traits: Sex Difference and Age Dependence. *Journal of Human Evolution*, 8: 679-684.

Ricaut, F.X. and Waelkens, M. (2008) Cranial discrete traits in a Byzantine population and eastern Mediterranean population movements. *Human Biology*, 80(5): 535-564.

Richards, M., Macaulay, V., Hickey, E., Vega, E., Sykes, B., Guida, V. and Bandelt, H.J. (2000) Tracing European founder lineages in the Near Eastern mtDNA pool. *The American Journal of Human Genetics*, 67(5): 1251-1276.

Richtsmeier, J.T. and McGrath, J.W. (1986) Quantitative genetics of cranial nonmetric traits in random bred mice: Heritability and etiology. *American Journal of Physical Anthropology*, 69: 51-58.

Rolf, B., Röhl, A., Forster, P. and Brinkmann, B. (1999) On the genetic origins of the Turks study of six Y-cromosomal short tandem repeats. In: *Papiha S, Deka R, Chakraborty R, (eds.). Genomic diversity: applications in human population genetics*. New York: Kluwer Academic/Plenum, pp. 75-82.

Rösing, F.W. (1982) A critical review of quasi-continuous variation of the human skeleton. *Homo,* 33: 100-125.

Saitou, N., Kimura, R., Fukase, H., Yogi, A., Murayama, S. and Ishida, H. (2011) Advanced CT images reveal nonmetric cranial variations in living humans. *Anthropological Science*, 119(3): 231-237.

Saunders, S.R. (1989) Nonmetric skeletal variation. Işcan MY. and Kennedy KAR. (Ed.), *Reconstruction of Life from the Skeleton,* Alan R. Liss. Inc., pp. 95-108.

Saylam, C., Ozer, M.A., Ozek, C. and Gurler, T. (2003) Anatomical variations of the frontal and supraorbital transcranial passages. *Journal of Craniofacial Surgery*, 14(1): 10-12.

Scarsini, C., Rossi, V. and Messeri, P. (1980) Caratteri cranici discontinui in Sardi di Nuoro. *Seminario di Scienze Anropologiche*, 2: 1-68.

Scheuer, L., Black, S. and Cunningham, C. (2000) *Developmental juvenile osteology*. Academic Press.

Self, S.G. and Leamy, L. (1978) Heritability of quasi-continuous skeletal traits in a random bred population of house mice. *Genetics,* 88: 109-120

Senyurek, M.S. (1941) Anadolu Bakır Çağı ve Eti sekenesinin kraniolojik Tetkiki. *Belleten*, 5(19): 220-253.

Sjøvold, T. (1984) A report on the heritability of some cranial measurements and non-metric traits. In: Van Vark, G.N. and Howells. W.W. (eds.) *Multivariate Statistical Methods in Pysical Anthropology*. Boston, pp. 223-246.

Trinkaus, E. (1978) Bilateral asymmetry of human skeletal non-metric traits. *American Journal of Physical Anthropology*, 49: 315-318.

Tur, S.S. (2011) A Nonmetric Cranial Study Of The Andronovo Series from The Altai. *Archaeology, Ethnology and Anthropology of Eurasia*, 39(1): 147-155.

Umar, B. (1998) Türkiye Halklarının Ortaçağ Tarihi. Inkılap Kitapevi Yayın Sanayi ve Tic. A.Ş, Ankara.

Uzuncarsılı, I.H. 1982. *Osmanlı Tarihi*. Cilt:1 TTK Yayınları, Ankara.

Wittwer-Backofen, U. (1986) Anthropologısche untersuchungen der Nekropole İkiztepe/Samsun**.** *Araştırma Sonuçları Toplantısı*, 3: 421-428.

Workshop of European Anthropologists. (1980) Recommendations for age and sex diagnoses of skeletons. *Journal of Human Evolution*, 9: 517-549.

Yalman, B. (1982) İznik Tiyatro Kazısı 1981. Kazı Sonuçları Toplantısı, 4: 229-235.

Yaras, A. (2001) 2000 Yılı Allianoi Kazısı. Kazı Sonuçları Toplantısı I, 23: 463-478.

Yigit, A., Gozluk-Kirmizoglu, P., Durgunlu, O., Ozdemir, S. and Sevim-Erol, A. (2007) Kahramamaras/Minnetpinari Iskeletlerinin Paleoantropoloji Acidan Degerlendirilmesi. *Arkeometri Sonuclari Toplantisi*, 23: 91–110.