Mediterranean Archaeology and Archaeometry, Vol. 14, No 1, pp. 13-24

EPIGENETIC FEATURES OF HUMAN SKULLS FROM DATÇA-BURGAZ EXCAVATIONS

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Received: 18/02/2013
Accepted: 06/03/2013
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ABSTRACT

Although Anatolia includes a rich anthropological data source, studies based on nonmeasurable features are limited. Thus, this study, aiming to contribute to this field, compares 30 nonmetric features belonging to 47 skeletons from the Datça Peninsula, dated to the Roman period, with 19 nonmeasurable features on the skulls of individuals belonging to 9 different populations that lived in different geographical areas between the Early Bronze Age to the first quarter of the 20th century. Biological relations between Ancient Anatolian populations were investigated by multivariable statistical processes. Use of epigenetic features is an informative method for determining the degree of biological proximity or distance in ancient populations. The non-measurable features of the cranium are of great value to researchers for the assessment of both hereditary and environmental factors when studying such populations. In this study, 30 nonmetric features of 47 skeletons, dated to the Archaic and Roman periods, excavated from the Datça Peninsula between 1993 and 2001, were investigated. The parietal foramen was the most frequently observed feature (43.7%). The lambdoid bone (23.5%), bone on the asterion (20%), zygomaticofacial foramen (16.6%), foramen ovale (14.2%), and bone on the lambda (12.5%) were among the most frequently encountered epigenetic characters. Cluster analysis showed 2 different groupings. Those findings are remarkable and show the presence of biological and environmental similarities between ancient Anatolian populations.

KEYWORDS: Epigenetic feature, variation, anthropological, nonmetric, Anatolia

INTRODUCTION

Since the beginning of the Neolithic period, the eastern part of the Mediterranean basin, and especially the Anatolian region, has been an area of interaction between cultures and populations from Europe, northeast Africa, the Middle East, and Eurasian steppe (Ammerman & Cavalli-Sforza, 1984; Bellwood & Renfrew, 2002; Richards *et al.*, 2000; Ricaut & Waelkens, 2008). Specifically, ancient settlements found during archeological excavations in Anatolia reveal that the history of this region is highly interactive. The Anatolian population history is thus a result of complex processes involving different population groups. However, the impact and contribution of those populations on the biological diversity of the Anatolian population is relatively unknown. Molecular genetic analysis shows that the modern Anatolian people resemble the Western Eurasian population group, despite the presence of a substantial amount of lineages shared by Central Asian populations and a few specific African lineages (Calafell *et al.*, 1996; Tambets *et al.*, 2000; Di Benedetto *et al.*, 2001; Cinnioglu *et al.*, 2004; Luis *et al.*, 2004; Nasidze *et al.*, 2004; Quintana-Murci *et al.*, 2004). However, these results are limited by the fact that the genetic structure of modern human populations has been influenced by many historic, demographic, and genetic events (migration episodes, gene flow, and genetic drift) that could have obscured the evolutionary history of Anatolian populations. Despite progress in genetic and biochemical analyses, the morphological analysis of human remains is still the most frequently used method, and it is the initial step for studying the variability of ancient human populations.

The use of epigenetic (nonmetric) features, which reflect an anatomical variation rather than a pathological situation, is one of the most informative methods used to display hereditary interrelations between populations (Berry & Berry, 1967). The first literature records of epigenetic features date back to the 19th century (Saunders 1989). Chambellan suggested that those features were anthropological characters, and with the contribution of further studies on the subject, more than 200 epigenetic features related to human skulls have been identified and included into the scientific literature (Berry & Berry, 1967; Ossenberg, 1970, 1976; De Stefano & Hauser, 1989; Mays, 1998). The terms nonmetric, discontinuous, or discrete are frequently used in the relevant scientific context rather than the word "epigenetic".

The determination of similarities or differences of phenotypical variations observed in ancient populations is very important for determining the degree of biological proximity. Since epigenetic features show different frequencies, they can be used to compare ancient populations. This comparison was first done by Berry & Berry (Berry, 1967; Piontek, 1988). Literature reviews, considering research focusing on the epigenetic features of ancient populations, exhibit a scarce number of studies. The first of those studies was the research conducted by Klung & Wittwer-Backofen (1983), including Lidar Hoyuk (Lidar Mound) as well as 10 other sites from Europe and the Near East, comprising 67 nonmeasurable features. Another important study on the subject was carried out by Sugihara (1999) on Kaman-Kalehoyuk skeletons, aiming to determine the frequency of epigenetic features. Ozer *et al.* (2000) reported the frequencies of 44 nonmetric features on the skulls belonging to the Medieval Karagunduz population. In addition to those studies, there is important research contributing to the subject, such as a study presenting torus palatinus (2008) and the determination of the biological proximity among 3 ancient Anatolian populations (2009) by Eroglu & Erdal, the frequency of the prevalence of metopic suture in Anatolian populations by Eroglu (2008), epigenetic studies of Minnetpinari skeletons by Yigit *et al.* (2007) and the degree of prevalence of epigenetic features in the Kelenderis population by Cirak & Cirak (2010). Another study Ricaut & Waelkens (2008) examined cranial discrete traits from a Byzantine population from southwest Turkey, excavated at the Sagalassos archaeological site, which has had human occupation since the 12th millennium B.P. To investigate the biological history of this population, we analyzed the frequency distribution of 17 nonmetric cranial discrete traits from Sagalassos and 27 Eurasian and African populations.

MATERIALS AND METHODS

The skeletons forming our study materials were the human remains obtained from the excavations conducted in Muğla, Datça, between 1993 and 2001, under the supervision of Prof. Numan Tuna. A total of 47 individual skeletons were obtained from 3 different areas following the excavations carried out on the Datça Peninsula. Those areas were: the Sariliman Temple (Archaic period), Burgaz (Roman), and Resadiye (19th century) (Figure 1).

Demographical analysis of the individuals unearthed from the graves was performed at Ankara University Faculty of Language and History-Geography, Department of Paleoanthropology (Sevim 1996).

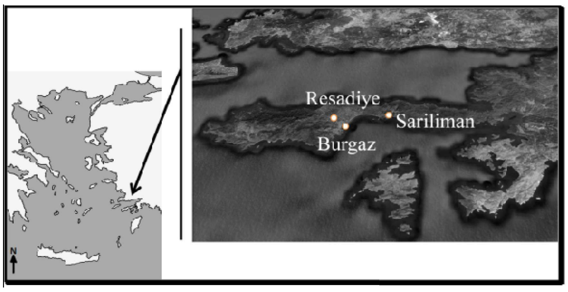

Figure 1. Excavation sites on the Datça peninsula.

Paleodemographical investigation of the skeletons presents a distribution as follows: 38.29% female, 40.42% male, and 21.27% infant and children (Table 1).

Table 1. Paleodemographical distribution of the Datça-Burgaz skeletons (individual).

	Period	Excavation year	Female	Male
Sariliman temple	Archaic	2000	1	1
Burgaz (grave room)	Roman	1994	14	14
Burgaz	Roman	1993	2	3
Resadiye	19th century	1992	1	1
			18	19

Discrete Traits

A total of 30 nonmetric features were investigated according to definitions stated by the authors such as Berry & Berry (1967), Ubelaker (1978), Brothwell (1981) and Buikstra & Ubelaker (1994). The rates of nonmetric features observed on the skulls of Datça-Burgaz population and their frequency of prevalence among sexes are presented in Table 2.

Table 2. Epigenetic properties observed in the skulls of the Datça-Burgaz population.

		General			Female			Male		
	Name of the feature	n	k	%	n	k	%	N	k	%
1	Highest nuchal line	14	-	0	7	-	0	7	-	0
2	Bone in Lambda	16	2	12.5	8	1	12.5	8	1	12.5
3	Lambdoid bone	17	4	23.5	9	2	22.2	8	2	25.0
4	Parietal foramen	16	7	43.7	9	3	33.3	7	4	57.1
5	Bone in Bregma	14	-	0	8	-	0	6	-	0
6	Metopic suture	16	2	12.5	9	1	11.1	7	1	14.2
7	Coronal bone	15	-	0	8	-	0	7	-	0
8	Epipteric bone	15	-	0	8	-	0	7	-	0
9	Inca bone	16	-	0	9	-	0	7	-	0
10	Parietal notch	17	-	0	9	-	0	8	-	0
11	Bone in Asterion	15	3	20.0	8	1	12.5	7	2	28.5
12	Auditory torus	14	-	0	8	-	0	6	-	0
13	Huschke foramen	13	1	7.6	8	1	12.5	5	-	0
14	Exsutural mastoid for.	14	1	7.1	9	1	11.1	5	-	0
15	Posterior condylar channel	14	1	7.1	8	-	0	6	1	16.6
16	Bi-sided condylar surface	13	-	0	8	-	0	5	-	0
17	Precondylar tubercule	14	-	0	9	-	0	5	-	0

18	Foramen ovale	14	2	14.2	9	1	11.1	5	1	20.0
19	Foramen spinozum	14	-	0	8	-	0	6	-	0
20	Accessory palatin for.	11	-	0	7	-	0	4	-	0
21	Palatine torus	11	-	0	7	-	0	4	-	0
22	Maxillar torus	12	-	0	7	-	0	5	-	0
23	Mandibular torus	12	-	0	6	-	0	6	-	0
24	Zygomaticofacial foramen	12	2	16.6	7	1	14.2	5	1	20.0
25	Supra orbital foramen	12	1	8.3	6	-	0	6	1	16.6
26	Frontal foramen	11	-	0	6	-	0	5	-	0
27	Mental foramen	13	-	0	7	-	0	6	-	0
28	Exsutural anterior ethmoid for	10	-	0	5	-	0	5	-	0
29	Posterior ethmoid for.	13	-	0	7	-	0	6	-	0
30	Accessory infraorbital for.	14	-	0	7	-	0	7	-	0

n: number of investigated individuals
k: frequency of epigenetic features

Observed Nonmetric Variations in Ancient Anatolian Populations

The determination of morphological and biological interrelations among populations along the historical time scale is as important as investigating cultural relationships. In this aspect, the epigenetic features of the Datça-Burgaz population are compared with other populations (Table 3). During the comparisons, a total of 15 characters observed on the material are judged at the same standards. However, 4 samples obtained from Resadiye (19th century), belonging to different time periods, and 2 samples from Sariliman (6th century B.C.) (small sample size) were excluded from the table presenting the comparison of Anatolian populations. On the other hand, the nonmetric features of 41 individuals were used for comparison.

Table 3. Observed nonmetric variations in ancient Anatolian populations in chronological order.

Features	Ikiztepe-Old Bronze (Eroglu, 2008; Eroglu & Erdal, 2009)	Kalehoyuk Iron-Bronze (Sugihara, 1999)	Datça-Burgaz (Roman) (Present study)	Cevizcioglu-Hellenistic-Roman (Eroglu, 2008; Eroglu & Erdal, 2009)	Iznik-Late Byzantium (Eroglu, 2008; Eroglu & Erdal, 2009)	Sagalassos-Byzantine (Ricaut & Waelkens, 2008)	Minnet-pinari-Medieval (Yigit et al., 2007)	Karagun-duz-Medieval Ozer et al., 1999)	Kale-hoyuk-Ottoman (Sugihara, 1999)	Kelenderis 19th century (Cirak & Cirak, 2010)
Zygomatico facial for.	65/86	3/17	2/12	35/42	68/96	-	-	10/110	8/33	7/27
Parietal notch bone	11/74	0/14	0/17	10/50	10/87	6/19	-	4/69	2/38	0/25
Inca bone	0/100	0/11	0/16	2/59	1/100	-	-	2/54	0/18	0/26
Bone in lambda	9/91	0/6	2/16	7/58	18/91	3/21	22/45	4/37	3/16	3/33
Lambdoid bone	42/82	9/18	4/17	25/50	47/86	-	-	24/66	10/34	7/34
Bone in asterion	10/75	6/16	3/15	7/50	18/89	4/20	1/45	13/56	10/37	6/28
Parietal foramen	45/95	19/32	7/16	25/60	47/98	-	9/45	45/89	31/64	16/31
Palatine torus	29/65	0/6	0/11	16/27	52/85	-	-	6/27	1/7	0/22
Precondyler tubercul	25/31	5/9	0/14	12/17	62/70	4/21	-	7/67	9/31	2/24
Ovale foramen	3/60	1/11	2/14	2/32	3/79	-	-	-	0/31	5/22

Foramen spinozum	16/70	1/10	0/14	13/33	18/87	-	-	11/48	4/31	6/22
Huschke foramen	17/88	3/22	1/13	9/51	11/98	-	-	25/122	6/44	4/24
Suprorbital foramen	34/93	-	1/12	15/57	35/99	-	9/45	33/125	-	8/23
Exsutural mast.for.	54/77	-	1/14	35/50	86/92	-	3/45	8/68	-	9/33
Metopic suture	6/104	-	2/16	9/63	8/105	0/19	5/45	8/73	-	2/27
Condylar channel	47/63	-	1/14	25/28	57/70	11/19	-	-	-	7/25
Coronal bone	9/57	-	0/15	2/35	4/63	-	-	4/94	-	0/26
Bi-sided condy. surf.	5/73	-	0/13	3/42	7/80	-	-	-	-	7/27
Bone in bregma	2/99	-	0/14	0/56	2/94	-	-	0/51	-	0/30

STATISTICAL METHODS-RESULTS

The epigenetic features of the Datça-Burgaz individuals were assessed for their prevalence observed at the individual level. In order to determine differences among the sexes that were nonmeasurable features, standardized mean measure of divergence (MMD) values were calculated using the R script for Smith's MMD, written by Soltysiak (2011). By using Sjøvold's formula (1973) to achieve the MMD matrix, multidimensional scaling and Ward's hierarchical clustering procedure was applied using Statistica 8 software.

A total of 19 phenotypic variations reported in previous studies, belonging to ancient Anatolian populations, were not detected in the Datça-Burgaz population. Among the sexes, there was a difference in the rates of occurrence of other observed features. The data analyzed with the method used by Soltysiak (2011) shows that the most common epigenetic feature in the Datça-Burgaz population was parietal foramen (Figure 2), at a ratio of 43.7% (female 33.3% and male 57.1%). Among the other features, the lambdoid bone (23.5%), bone in the asterion (20%), zygomaticofacial foramen (Figure 3) (16.6%), foramen ovale (14.2%), and bone in the lambda (12.5%) were the most commonly observed epigenetic features (Table 2).

Figure 2. Parietal foramen (DT94-27)

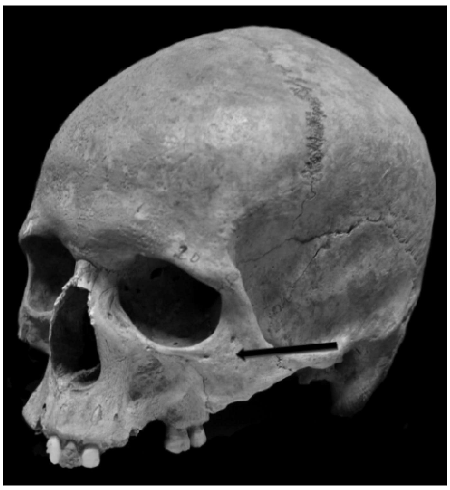

Figure 3. Zygomaticofacial foramen (DT94-20)

The least observed features were as follows: metopic suture (Figure 4) (11.1%), exsutural mastoid foramen (11.1%), and foramen ovale (11.1%). For males, the least observed feature was the bone in the lambda (Figure 5) (12.5%). On the other hand, the parietal foramen (57.1%) was recorded as the most commonly observed epigenetic feature for this sex.

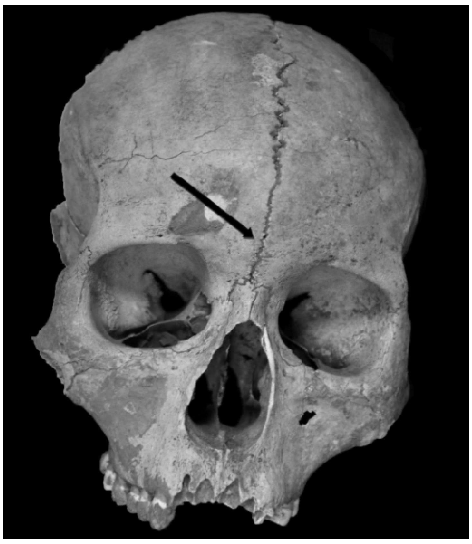

Figure 4. Metopic suture (DT94-8)

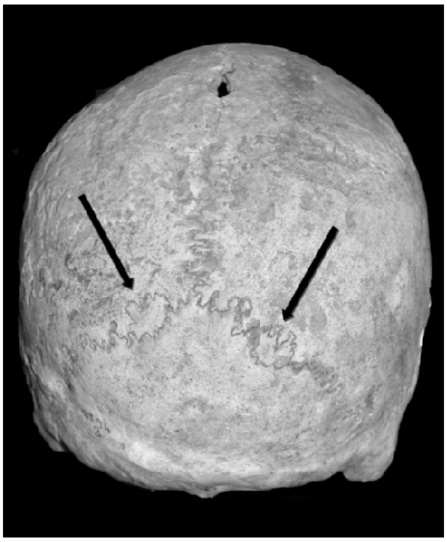

Figure 5. Lambdoid bone (DT94-17)

Table 4. MMD values for different populations.

	Ikiz-tepe	Kalehoyuk-Iron	Datça-Burgaz	Cevizcioglu	Iznik	Minnet-pinari	Kara-gunduz	Kale-hoyuk-Ott.	Kelenderis
Ikiztepe	–0,027	0,278	0,592	0,005	0,0216	0,521	0,437	0,292	0,399
Kalehoyuk-Ir.	0,278	–0,164	0,080	0,400	0,436	0,171	0,055	–0,042	0,057
Datça-Burgaz	0,592	0,080	–0,136	0,671	0,789	0,122	0,024	0,0810	0,031
Cevizcioglu	0,005	0,400	0,671	–0,049	0,030	0,568	0,487	0,3771	0,453
Iznik	0,023	0,436	0,789	0,030	–0,023	0,697	0,604	0,437	0,563
Minnetpinari	0,520	0,171	0,122	0,567	0,697	–0,044	0,115	0,080	0,177
Karagunduz	0,437	0,055	0,024	0,487	0,604	0,115	–0,039	0,050	0,041
Kalehoyuk-Ot	0,292	–0,042	0,081	0,377	0,437	0,080	0,050	–0,075	0,095
Kelenderis	0,399	0,057	0,031	0,453	0,563	0,177	0,041	0,094	–0,075

Table 5. Standard deviations of the MMD values for different populations.

	Ikiztepe	Kalehoyuk-Iron	Datça-Burgaz	Cevizcioglu	Iznik	Minnet-pinari	Kara-gunduz	Kale-hoyuk-Ott.	Kelenderis
Ikiztepe	0,010	0,034	0,028	0,013	0,008	0,012	0,010	0,019	0,017
Kalehoyuk-Ir.	0,034	0,060	0,052	0,038	0,033	0,037	0,035	0,044	0,042
Datça-Burgaz	0,028	0,052	0,046	0,031	0,027	0,030	0,028	0,037	0,035
Cevizcioglu	0,013	0,038	0,031	0,017	0,012	0,016	0,014	0,023	0,021
Iznik	0,008	0,033	0,027	0,012	0,008	0,011	0,009	0,018	0,016
Minnetpinari	0,012	0,037	0,030	0,016	0,011	0,014	0,013	0,021	0,020
Karagunduz	0,010	0,035	0,028	0,014	0,009	0,013	0,011	0,021	0,018
Kalehoyuk-Ott	0,019	0,044	0,037	0,023	0,018	0,021	0,021	0,030	0,026
Kelenderis	0,017	0,042	0,035	0,021	0,016	0,020	0,018	0,026	0,025

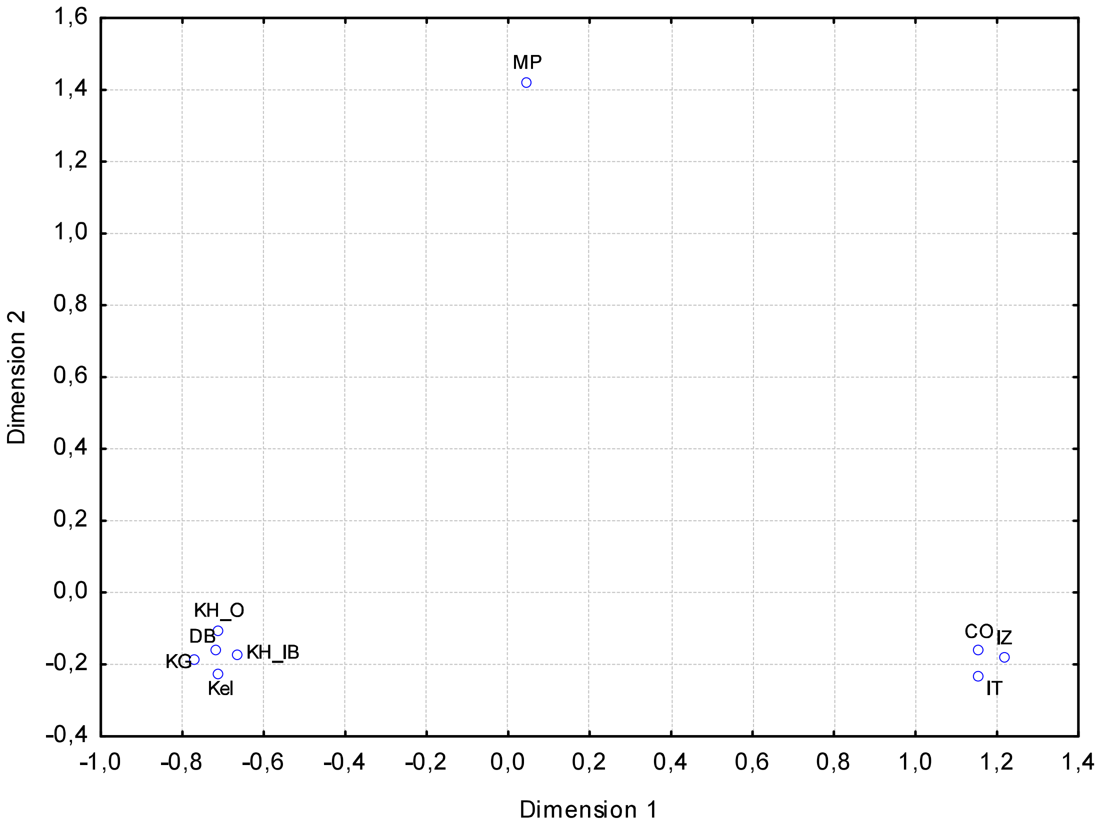

Figure 6. Standardized MMD values.

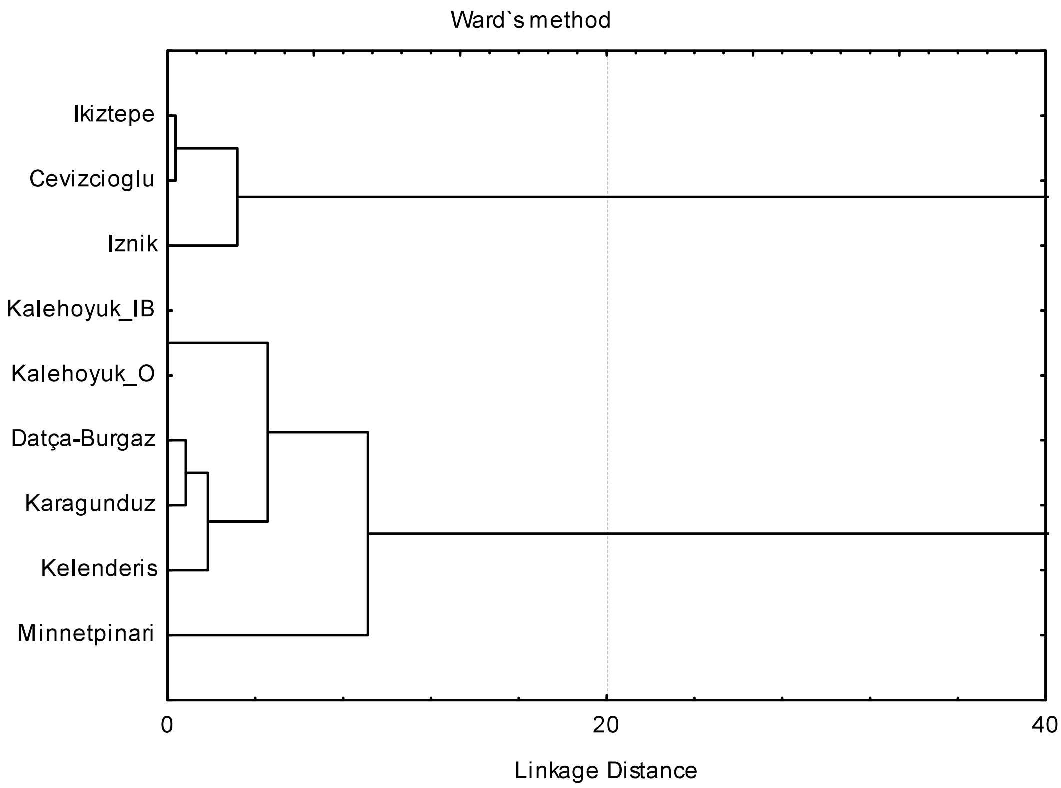

Figure 7. Distance diagram.

DISCUSSION

Biological anthropologists have commonly attempted to reconstruct the biological proximity among people who lived in the past by comparing standardized measurements and observations gathered from the individuals (Ubelaker, 1978; De Stefano, 1973). Therefore, inheritance studies on human populations conducted on skull forms that showed high variability have brought important genetic and epigenetic contributions to nonmeasurable features (Sjovold, 1984; Cheverud & Buikstra, 1978, 1981, 1982; Nakata *et al.*, 1974a, 1974b; Leamy, 1974). If proper traits and correct statistics were chosen in biological distance studies, literature records reveal that epigenetic features make contributions in the measurement of gene frequencies. Most notably, these results show that when suitable features, such as high inheritability, were chosen, the epigenetic parameters can be used safely in biological distance research. In addition, the results show that nonmeasurable traits are capable of presenting biological interrelations, even in groups with small sample sizes (Ossenberg, 1976; Kellock & Persons, 1970a, 1970b; Berry & Berry, 1967; Rubini *et al.*, 1999; Ishida & Dodo, 1993; Hanihara *et al.*, 2003; Stefan & Chapman, 2003; Stefan, 1999). The view that standardized MMD values better represent biological relations in populations with different sample sizes (Sutter, 2000; Sofaer *et al.*, 1986; Sutter & Mertz, 2003) was also applied in this study and the phenograms, depending on standardized MMD values, were determined. When Anatolian populations were assessed according to their epigenetic features, the highest frequency was the occurrence of the parietal foramen. It is of great importance that the epigenetic characters, such as the metopic suture, bone in the asterion, lambdoid, palatine torus, and bone in the lambda, observed in the Datça-Burgaz population, show similarity with other Anatolian populations. The absence of epigenetic characters, such as Inca bone in the Bronze and Iron Age Anatolian populations and its occurrence and increase in distribution during later ages, can be considered as valuable information in the perspective of human population movements (Eroglu & Erdal, 2008). The observation frequency of the features, such as the zygomaticofacial foramen, huschke foramen, and supra orbital foramen, of the Datça-Burgaz population is quite a bit lower than its contemporary populations, whereas the observation frequency of the foramen ovale is higher than in other ancient Anatolian populations. The occurrence of parietal foramen epigenetic features in Anatolian populations in a similar observation frequency suggests that this feature has a long historical background in Anatolia.

Recent improvements in the field of genetics have provided the possibility of investigating the similarities and differences in phenotypic variations in relation to heritance. However, they have also brought new arguments and discussions on concluding which epigenetic features better represent biological proximity or distance relationships (Van Gerven, 1982; Green, 1982). It is suggested, that due to products synthesized by defective genes in certain periods, the observation of different malformations is the result of a recessive or dominant mutation, although its nature of inheritance is not completely known (Wagner, 1999; Rando & Verstrepen, 2007). Skeletal heritability for epigenetic features is suggested to be grouped in certain locations in the cranium, such as the midfacial/orbital region. In addition, traits such as length show more possibility for inheritance than breadth. Features like the neurocranial size were found to have greater chance for heritability than facial dimensions. The adaptation of skeletal structures related to muscles for chewing in a changing diet is an example of possible mechanisms suggested for such inheritabilities (Carson, 2006). Their relation with the occurrence of differentiations of the expressed genes during the development of the individuals is also very important. Last but not the least, care should be taken for extrapolating the results of one group into another, because of the possibility of different heritabilities (Carson, 2006).

The observation frequency of epigenetic features such as the parietal foramen in the first order and then the lambdoid and bone in the lambda, zygomaticofacial foramen, supraorbital foramen, metopic suture, and bone in the asterion are common features adapted among ancient Anatolian populations. Although gene frequencies were randomly affected by the migrational fluctuations among different populations (Relethford, 1996) as well as Anatolian populations, the genetic drift for the Roman period Datça populations, especially for the exsutural mastoid foramen (7.1%), Huschke foramen (7.6%), and the supraorbital foramen (8.3%), was not that great. However, it should also be considered that not only genetic factors but also environmental factors could have contributed to the condition of the observed specimens from the ancient Datça population. Nutritional preferences or diseases related to nutritional status should also be taken into considered as important contributing factors.

In this study, while focusing on the biological distance between 10 Anatolian populations who lived in different time periods and different geographical regions, important findings about 19 variables were recorded and they showed 2 important groupings. Phenograms (Figure 7) constructed from the MMD values based on the nonmeasurable features show some similarity; however, it is clear that they do not completely match. In light of the archaeological findings, clustering of the İkiztepe population, which dates back to the Late Bronze Age period, together with the Hellenistic-Roman Cevizcioglu population and its historical successor, the Iznik population, and their detachment from other Anatolian groups, is very important. However, the temporal distance of Ikiztepe with both Cevizcioglu Çiftliği and other Anatolian populations is remarkable. The Penrose analysis, which was used by Wittwer-Backofer (1986), provided supportive information for our findings, since it showed the biological distance from the İkiztepe population to ancient Anatolian (Alişar and Şeyh Höyük) populations. The Roman period Datça-Burgaz population was grouped in the same cluster as other Anatolian populations. The Karagunduz, located in East Anatolia, and the Kelenderis population, located in the East Mediterranean area, show close clustering, whereas Kalehoyuk and Minnetpınarı gave distant results to this group. Therefore, findings from epigenetic features should be supported by historical and archaeological data, as presented in the study of Ossenberg (1976). Political activity in Anatolia was very intense, especially in the Medieval period.

When we look at the history of the Medieval Age in the region, we will see the struggle between the Roman Empire and the Sasani State. This struggle ended up with the victory of the East Roman Empire, because the Eastern Roman Empire (called the Byzantium in later periods) armies conquered Van in the 4th century. However, the Byzantium reign only lasted for 2 centuries and invasions by the Muslim Arabs intensified after 638. This Arabian period of influence lasted until the 9th century and caused a long diminishing period for the Christian way of life. Following the defeat of Emperor Romanos IV Diogenes (1068–1071) to Seljuk Sultan Alparslan in Malazgirt, in 1071, Turks started to inhabit Eastern Anatolia in search of a new homeland. After which time, the region fell under the dominance of the Great Seljuk.

Turkey constitutes a vastly diverse resource of information on ancient Anatolian populations. Historical, biological, and cultural investigations of people who lived on this land are important for constructing a general picture presenting similarities and differences with its neighboring populations. Although the frequencies of epigenetic properties are determined as percentages, existing data from similar studies are insufficient for concluding statistically meaningful results as of yet. An increase in the number of similar studies will undoubtedly provide valuable findings and important results about ancient Anatolian populations. There are attempts to explain the reason for this change by different adaptation mechanisms, such as mutation pressure, neutral mutation, and natural selection, in different studies (Wang *et al.*, 2006; Rodin *et al.*, 2005; Jablonka & Lamb, 2008).

ACKNOWLEDGMENTS

Authors would like to thank Assoc. Prof. Erdem Karabulut and Biologist Dr. Okan Arihan for their technical contribution to the manuscript.

REFERENCES

Ammerman, A. Cavalli-Sforza, L.L. (1984) *The Neolithic Transition and Genetics of Populations in Europe*. Princeton University Press.

Bellwood, R. Renfrew, C. (2002) *Examining the Farming/Language Dispersal Hypothesis*. Cambridge, U.K.: McDonald Institute for Archaeological Research.

Berry, C. Berry R.J. (1967) Epigenetic variation in the human cranium, *Journal of Anatomy*. 101: 361–379.

Brothwell, D.R. (1981) *Digging up Bones*. BAS Printers, Great Britain.

Buikstra, J. Ubelaker, D. (1994) *Standards: For Data Collection From Human Skeletal Remains*. Arkansas Archeological Survey Research Series No: 44.

Calafell, F. Underhill, P. and Tolun, A. (1996) From Asia to Europe: mitochondrial DNA sequence variability in Bulgarians and Turks. *Annals of Human Genetics* 60: 35–49.

Carson, E.A. (2006) Maximum likelihood estimation of human craniometric heritabilities. *American Journal of Physical Anthropology* 131: 169–180.

Charobellan, M. 1883 Etude Anatomique et Anthropologique sur les Os Wormiens. *Thesis*. Paris. (Quoted by Dorsey, 1897).

Cinnioglu, C. King, R. and Kivisild, T. (2004) Excavating Y-chromosome haplotype strata in Anatolian. *Human Genetics* 114: 127–148.

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

De Stefano, G.F. and Hauser, G. (1989) Epigenetic Variatiants of the Human Skull, Stuttgart.

Di Benedetto, G. Ergüven, A. Stenico, M. Castrì, L. Bertorelle, G. Togan, I. and Barbujani, G. (2001) DNA diversity and population admixture in Anatolia. *American Journal of Physical Anthropology* 115: 144–156.

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

Eroğlu S.and Erdal Y.S. (2009) Dis ve Kafatasi Morfolojisine Dayanarak Uc Eski Anadolu Toplulugunda Biyolojik Uzakliklarin Belirlenmesi. *Hacettepe Dis Hekimligi Fakultesi Dergisi* 33: 78–90.

Green, D.L. (1982) Discrete dental variations and biological distances of Nubian populations. *American Journal of Physical Anthropology* 58: 75–79.

Hanihara, T. Ishida, H. and Dodo, Y. (2003) Characterization of biological diversity through analysis of discrere cranial traits. *American Journal of Physical Anthropology* 121: 241–251.

Isida, 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.

Jablonka, E. and Lamb, M.J. (2008) The epigenome in evoluton: beyond the modern synthesis. *Вестник ВОГиС* 12: 242–254.

Kellock, W.L, and Parson, P.A. (1970a) A comparison of the incidence of minor cranial variants in Australian Aborigines. *American Journal of Physical Anthropology* 33: 409–422.

Kellock, W.L. and Parson, P.A. (1970b) Variation of minor nonmetrical cranial variants in Australia Aborigines with those of Melanesia and Polynesia. *American Journal of Physical Anthropology* 33: 235–240.

Klung, S.T. and Witwer-Backofen, U. (1983) Diskreta im populations vergleich. *Homo*, 34(3–4): 153–168.

Luis, J.R. Rowold, D.J. Regueiro, M. Caeiro, B. Cinnioğlu, C. Roseman, C. Underhill, P.A. Cavalli-Sforza, L.L. and Herrera, R.J. (2004) The Levant versus the Horn of Africa: evidence for bidirectional corridors of human migrations. *American Journal of Human Genetics* 74: 532–544.

Mays, S. (1998) *The Archaeology of Human Bones*. London and New York, Routledge.

Nasidze, I. Ling, E.Y. and Quinque, D. (2004) Mitochondrial DNA and Y-chromosome variation in the Caucasus. *Annals of Human Genetics* 68: 205–221.

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

Ossenberg, N. (1976) Within and between race distance in population studies based on discrete traits of the human skull. *American Journal of Physical Anthropology* 45: 701–716.

Ozer, I. Sugihara, K. Pehlevan, C. Sevim, A. Gulec, E. (2000) Karagunduz Toplumunda Epigenetik Karakterler. XV. *Arkeometri Sonuclari Toplantisi* 101–109.

Piontek J. 1988. Natural selection and non-metric traits in skeletal populations. *Human Evolution* 3(5): 321–327.

Quintana-Murci, L. Chaix, R. and Wells, R.S. (2004) Where west meets east: the complex mtDNA landscape of the southwest and Central Asian corridor. *American Journal of Human Genetics* 4: 827–845.

Rando, O.J. and Verstrepen, K.J. (2007) Timescales of genetic and epigenetic inheritance. *Cell* 128: 655–668.

Relethford, J. (1996) "Genetic drift can obscure population history: problem and solution" *Human Biology* 68: 29–44.

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. Macauley, V. and Hickey, V. (2000) Tracing European founder lineages in the Near Eastern mtDNA pool. *American Journal of Human Genetics* 67: 1251–1276.

Rodin, S.N. Parkhomchuk, D.V. and Riggs, A.D. (2005) Epigenetic changes and repositioning determine the evolutionary fate of duplicated genes. *Biochemistry* (Moscow), 70: 559–567 (translated from *Biokhimiya* 70(5): 680–689.

Saunders, S. (1989) *Nonmetric skeletal Variation, Reconstruction of Life from the Skeleton*. Alan R. Liss. Inc. 95–108.

Sevim, A. (1996) Datça/Burgaz Iskeletlerinin Paleoantropolojik Değerlendirilmesi. *XI. Arkeometri Sonuclari Toplantisi*, Ankara, 1–17.

Sjøvold, T. (1973) The occurrence of minor non-metrical variants in the skeleton and their quantitative treatment for population comparisons, *Homo* 24: 204–233.

Sofaer, J.A, Smith, P. and Kaye, E. (1986) Affinities between contemporary and skeletal Jewish and non-Jewish groups based on tooth morphology. *American Journal of Physical Anthropology* 70(2): 265-275.

Sołtysiak, A. (2011) Technical note: an R script for Smith's mean measure of divergence. *Bioarchaeology of the Near East*, 5: 41–44.

Stefan, V.H. (1999) Craniometric variation and homogeneity in prehistoric/protohistoric Rapa Nui (Easter Island) regional populations. *American Journal of Physical Anthropology* 110: 407–119.

Stefan, V.H, and Chapman, P.M. (2003) Cranial variation in the Marquesas Islands. *American Journal of Physical Anthropology* 121: 319–321.

Sugihara, K. (1999) Nonmetric cranial variants in the human skeletal remains from Kaman-Kalehoyuk, Turkey: a preliminary report. *Anatolian Archaeological Studies*, 8: 167–173.

Sutter, R.S. (2000) Prehistoric genetic and culture change: a bioarchaeological search for pre-Inka Altiplano colonies in the coastal vallets of Moquegues, Peru and Azapa, Chile. *Latin America Antiquity*, 11: 43–70.

Sutter, R.S, and Mertz, L. (2003) Nonmetric Cranial Traits Variation and Prehistoric Bioculturel Change in the Azapa Valley, Chille. *American Journal of Physical Anthropology* 123(2): 130–145.

Tambets, K. Kivisild, D. Metspalu, E. Parik, J. Kaldma K, Laos S, Tolk HV, Gölge M, Demirtas H, Geberhiwot T, Papiha SS, De Stefano, G.F. and Villems, R. (2000) The topology of the maternal lineages of the Anatolian and Trans-Caucasus populations and the peopling of Europe: Some prelimary considerations. In *Archaeogenetic: DNA and the Populations Prehistoric of Europe*, Renfrew C, Boyle K (eds.). McDonald Institute for Archaeological Research: Cambridge, U.K; 219–236.

Ubelaker, D. (1978) *Human Skeletal Remains*. Smithsonian Institution, Aidine Publishing Company, Chicago.

Van Gerven, D.P. (1982) The contribution of time and local geography to craniofacial variation in Nubia’s Batn el, Hajar. *American Journal of Physical Anthropology* 59: 307–316.

Wang, Q. Opperman, L.A. Havill, L.M. Cartlson, D.S. and Dechow, P.C. (2006) Inheritance of sutural pattern at the Pterion in Rhesus monkey skulls. *The Anatomical Record* Part A 288A: 1042–1049.

Wagner, A. (1999) Reduntant gene functions and natural selection. *Journal of Evolutionary Biology* 12: 1–16.

Witter-Backofen, U. (1986) Anthropologisiche untersuchungen der Nekropole Ikiztepe/ Samsun. *III. Arastirma Sonuclari Toplantisi* 421–428.

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