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OSTEOARCHAEOLOGICAL INVESTIGATIONS OF METOPIC SUTURE IN THE LATE ROMAN PERIOD IN SPRADON

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ABSTRACT

The ancient city of Spradon, which is located in the Ispartakule area of the district of Avcılar in İstanbul, dates back to the Late Roman period. A total of 90 individuals, including 58 in graves, were found at the excavation site. Osteoarchaeological investigation concerning skull morphology has been focused on metopic suture. Of the 6 metopic suture examples seen in the roman society of Spradon, 5 were observed in young adults, while 1 belonged to a senior adult. A metopic suture was observed in 5 of the 38 females (13.2%) and in 1 of the 31 males (3.2%). The metopic suture rate in the ancient city of Spradon was calculated as 8.7%, and rates were found to be similar with other Roman period populations in Anatolia. When the comparison is made on Old Anatolian Populations, metopic suture is seen especially in coastal regions of Anatolia in geographical sense. In addition, there is less metopic suture in the internal regions. Statistical Analysis supports this hypothesis.

KEYWORDS: Metopic Suture, Late Roman Period, Nonmetric traits, Ancient Anatolian, Human Skeletal Remains.

1. INTRODUCTION

The metopic suture or frontal suture is noted to be between the two frontal bones extending from the nasion to the bregma (Gardner, 2016). The metopic suture (MS) lies on the midline of the forehead and extends from the frontal bone to the root of the nose (Aksu, et al,2014). The metopic suture extends from the nasion to the bregma (Bilgin et al., 2013) (Fig. 1). The occurrence of metopic sutures in adults is known as metopism. Metopism is defined as a condition where 2 frontal bones are unable to fuse together during early childhood (Scheuer et al., 2000; Baaten et al., 2003). The metopic suture generally begins to fuse during the 1st or 2nd year of life; however, studies have also reported that fusion can occur as late as 7 years of age (Scheuer et al., 2000; Baaten et al., 2003). Moreover, some studies have reported different age periods regarding the obliteration of the metopic suture during childhood. According to Werma (2014), a human frontal bone begins to fuse at 2 ossification centers in the 8th week of intrauterine life. Faro et al (2005) also suggested that the onset of fusion of the frontal bones, which starts from the glabella, is evident from the 32nd week of intrauterine life. Other studies have reported that there are several age periods in which the relevant bone fuses, such as at 1 to 2 years of age (Bolk, 1917; Sperber, 1989), 2 to 4 years of age (Scheuer et al., 2000), and 0 to 2.5 years of age (Jit and Banga, 1988). Studies have also stated that closure of the metopic suture can occur as late as 7 or 8 years of age (Sperber, 1989; Hauser and De Stefano, 1989; Buikstra and Ubelaker, 1994). Similarly, a study conducted by Vu et al. on 159 babies aged 1 to 27 months and using a 3D computed tomography scanner showed that the metopic sutures between the glabella and the anterior frontal in 33% of 3-month old babies, 60% of 5-month old babies, and all of 9-month babies were fully ossified (Vu et al. 2001).

Metopism is rarely seen, and its presence is not regarded as a pathology, but considered as variation (non-metric) (Bery and Bery, 1967). However, the premature closure of any cranial suture is a pathological condition called craniosynostosis (Bilgin et al., 2013; Gardner, 2016). Although the reason for metopism is not known exactly, there are different opinions about it. According to Falk (2012), metopism is associated with the abnormal growth of skull bones, hydrocephalus, or inheritance. According to Del Sol, metopism results from the abnormal growth of skull bones, hydrocephalus, growth retardation, gender difference, inheritance, atavism, stenocrotaphia, plagiocephaly, scaphocephaly, the synostosis of cranial sutures, mechanical reasons, and hormonal malfunction (Del Sol,1989).

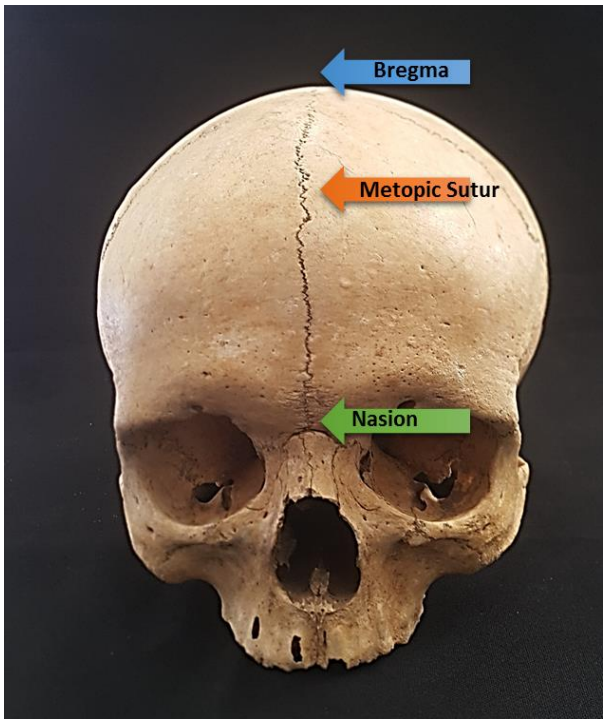


Figure 1: Metopic Suture

It has been stated that metopic sutures can be associated with frontal sinus abnormalities, but this opinion is questionable (Bilgin et al., 2013). According to Scheuer et al. (2000), the main question is why the inter frontal sutures of a small minority of individuals do not close, while they close in most individuals at early ages.

The prevalence of metopic sutures differs between modern and ancient populations (Bolk, 1917; Vecchi, 1968; Knip, 1971; Corruccini, 1974; Muller, 1977; Pietrusewsky, 1977; Agarwal et al., 1979; Ajmani et al., 1983; Baaten et al., 2003; Eroğlu, 2008). According to Berry and Berry (1967), its prevalence is related to ethnic origin at the level of 0% to 7%. Some researchers have found that metopism is more commonly seen in males than in females (Murlimanju et al., 2011; Baaten et al., 2003; Skrzat et al., 2004; Silva et al., 2013). In a study conducted by Castillo (2006), the prevalence of metopism in the world was calculated as 2.75%.

Studies have shown that the prevalence rate of metopism is 5% in today's Asian populations, 9% in European Caucasians, and 1% in Africans (Bergman,1988; Werma, 2014). Bergman stated that approximately 1% to 12% of the skulls had metopism (Bergman, 1988). Agarwal (1979) reported that the prevalence rate of metopism was 38.17% in Indian skulls, Linc (1969) reported it as 11% in Czech skulls, and Woo (10%) stated that its prevalence rate was 10% in Mongoloid skulls.

The prevalence of metopism differs in archaeological populations. Among the Anatolian

populations in which metopism was seen, a low frequency was observed in the Bronze-Age İkiztepe population (5.85%) (Bilgi,2001), while the highest frequencies were observed in the Hellenistic Roman Period Cevizoğlu Farm population (14.3%) (Özkan and Atukeren, 1999).

2. MATERIALS AND METHODS

The skulls discussed in the present study were obtained during excavation work conducted by the Directorate of İstanbul Archaeology Museums in the Ispartakule area of Avcılar in the district of İstanbul (Figure 2).

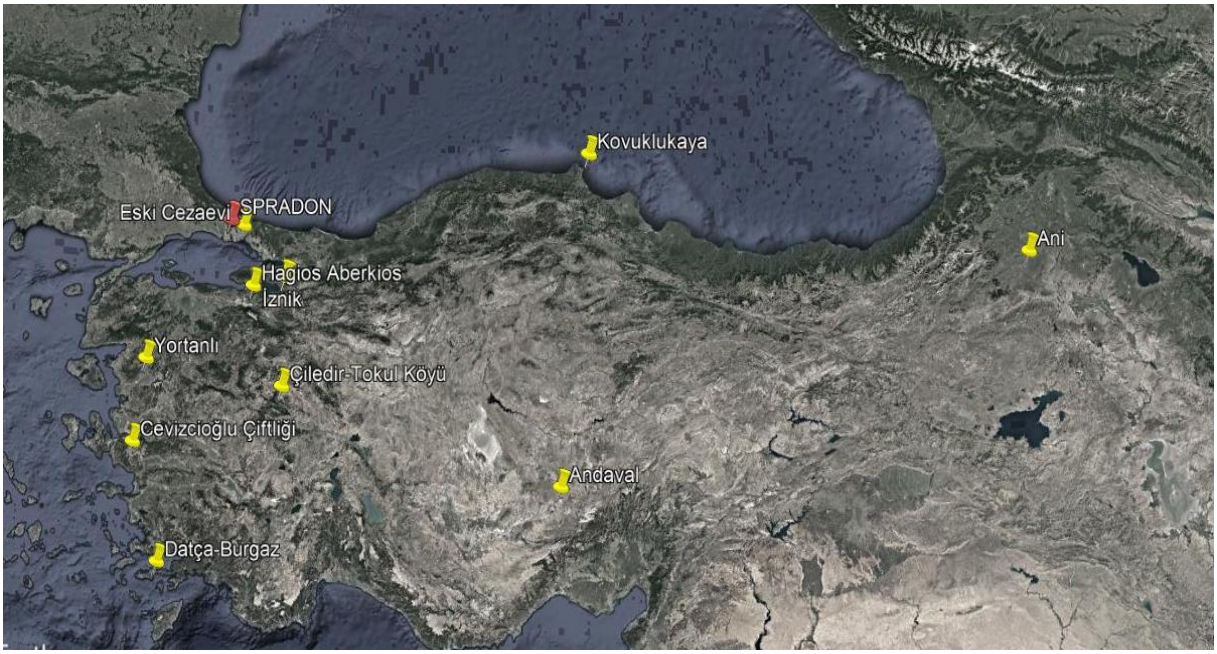


Figure 2: The Ancient City of Spradon

The paleodemographic analyses were conducted for the skeletons according to the methods of Olivier, 1969; Workshop of European Anthropologist, 1980; Brothwell, 1981; Krogman and İşcan, 1986; Bass 1987; Ubelaker, 1989; Kaur ve Jit, 1990; Szilvassy ve Kritscher, 1990; White, 1991; and Bruzek 2002. The sex of the individuals were determined through an evaluation of the long bones and other body bones together, with an emphasis on the anatomical details of the skull and the pelvis (Workshop of European Anthropologists, 1980). The joint processes of the long bones, the articular joints of costa to sternum, the degrees of closure of the seams of the skull, the degrees of deformation of the symphysis pubis related to aging were used for the determination of in the adult individuals age (Buikstra and Ubelaker, 1994).

The results of these analyses showed that the society consisted of 90 individuals. The examination of the society's sex distribution showed that there was 1 fetus (1.11%), 8 babies (8.88%), 7 children (7.78%), 2 adolescents (2.22%), 38 females (42.22%), and 31 males (31%). The sex of 3 individuals could not be determined (Table 1).

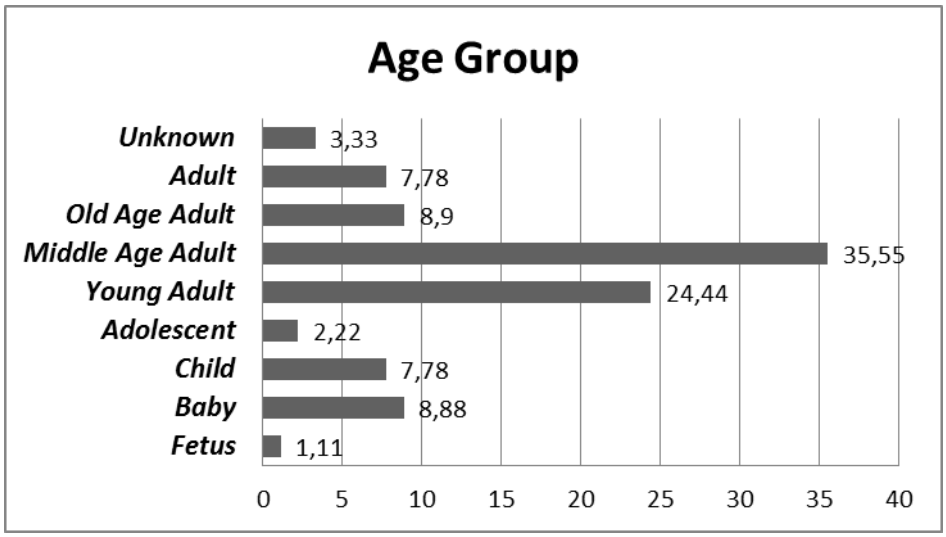
Table 1: Spradon Population Gender Distribution

Gender Distribution	N	%
Fetus	1	1.11
Baby	8	8,9
Child	7	7.78
Adolescent	2	2.22
Female	38	42.22
Male	31	34.44
Unknown	3	3.33
Total	**90**	**100**

The examination of the society's age distribution also showed that there was 1 fetus (1.11%), 8 babies (8.88%), 7 children (7.78%), 2 adolescents (2.22%), 22 young adults (24.44%), 32 middle-aged adults (35.55%), and 8 senior adults (8.88%). Of the individuals, 7 (7.78%) were found to be adults, but they were not divided into any age groups. Moreover, the ages of 3 individuals (3.33%) could not be determined (Table 2), (Graph 1). The age groups were assigned as baby (0 to 3 years), children (3 to 12 years), adolescent (12 to 20 years), young adults (20 to 35 years), middle-aged adults (35 to 50 years), and senior adults (50+) (White, 2012).

Table 2: Spradon Population Age Distribution

Age Distribution	N	%
Fetus	1	1.11
Baby	8	8.88
Child	7	7.78
Adolescent	2	2.22
Young Adult	22	24.44
Middle-aged Adult	32	35.55
Senior Adult	8	8.9
Adult	7	7.78
Unknown	3	3.33
Total	**90**	100

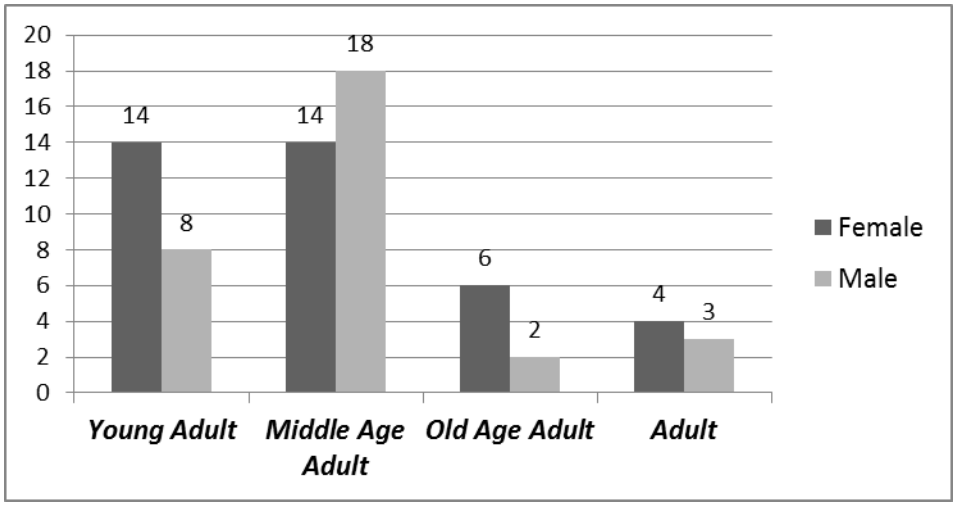


Graph 1: Spradon Population Age Distribution

The age distribution of the females and males was also examined, and it was found that of 38 females, 14 were young adults, 14 were middle-aged adults, 6 were senior adults, and 4 were adults whose age group could not be determined. This study also found that of 31 males, 8 were young adults, 18 were middle-aged adults, 2 were senior adults, and 7 were adults whose age group could not be determined (Table 3),(Graph 2).

Table 3: Sex Distribution of the Spradon Population

	Female	Male	Total
Young Adult	14	8	22
Middle-aged Adult	14	18	32
Senior Adult	6	2	8
Adult	4	3	7
Total	**38**	**31**	**69**



Graph 2: Sex Distribution Graph of the Spradon Population

Table 4: Spradon Population with Metopic Suture

Tomb	Female	Male
M11-1	Young Adult	-
M34	Senior Adult	-
M35-4	-	Young Adult
M35-6	Young Adult	-
M44-3	Young Adult	-
M46-1	Young Adult	-

This study examined 69 individuals, including 38 females and 31 males, of the 90 individuals in the ancient city of Spradon. This study found that 6 of the 69 individuals of the Late Roman period in the ancient city of Spradon had metopic sutures. Of the 6 metopic suture examples observed in the roman society of Spradon, 5 were observed in young adults, while 1 belonged to a senior adult (Figures 3, 4, 5). Metopic sutures were observed in 5 of the 38 females (13.2%) and in 1 of the 31 males (3.2%). Of the females with metopic sutures, 4 were young adults and 1 was a senior adult. The male with metopic suture was also a young adult (Table 4). The presence of metopic sutures in the individuals was determined as a result of the analyses. The frontal regions on the individuals' skulls were examined, and it was noted that there were individuals with a suture running from the nasion to the bregma. This study also found that the sutures of all of the individuals with metopic sutures were not fused completely. Of the individuals with metopic sutures, 5 were females and 1 was male.

In order to determine differences among the sexes that were nonmeasurable features, standardized mean measure of divergence (MMD) values and multidimensional scaling and Ward's hierarchical clustering procedure were calculated using the R "AnthropMMD" package for Smiths MMD written by Frederic Santos (2017).

3. DISCUSSION AND CONCLUSION

Metopism is a condition where 2 frontal bones are unable to fuse together during early childhood, and if it continues to be present after the age of 2, it is called a metopic suture. Metopism is not associated with an anomaly or disorders (Bolk, 1917; Baaten et al., 2003). A metopic suture generally begins to fuse during the 1st or 2nd year of life, but studies have also stated that fusion can occur as late as 7 years of age (Torgensen, 1951; Sjovold, 1984: Cheverud and Buikstra, 1981).

There are different opinions to explain the genetic etiology of nonmetric features in the skull, including metopic suture. Grüneberg stated that nonmetric traits act together with genetic and environmental factors, which have one or more effects (Grüneberg, 1952). Therefore, epigenetic features can reflect the variations in gene frequencies to a certain extent (Cheverud and Buikstra, 1978). Thus, it is possible to obtain information about the gene flow between populations according to the prevalence of metopism in the population.

The rate of metopic sutures in the ancient city of Spradon was calculated as 8.7%, which shows similarity with other ancient Anatolian populations (Table 5).

Figure 3: Metopic Suture in M 46/1 Female Skull

Figure 4: Metopic Suture in M 44/3 Female Skull

Figure 5: Metopic Suture in M 11/1 Female Skull

Table 5: The Distribution of the Metopic Suture Roman and Byzantium Anatolian Population

The Distribution of the Metopic Suture Roman and Byzantium Anatolian Population											
Population	**Period**	**References**	**Female**			**Male**			**Total**		
			n	**k**	**%**	**n**	**k**	**%**	**n**	**k**	**%**
Cevizcioğlu Çiftliği	Hellenistic, Roman	Özkan and Atukeren, 1999	24	5	**20.8**	39	4	**10.3**	63	9	**14.3**
Datça-Burgaz	Roman Period	Çırak, et al., 2014	9	1	**11.1**	7	1	**14.2**	16	2	**12.5**
Spradon	*Late Roman*		*38*	*5*	***13,2***	*31*	*1*	**3.2**	*69*	*6*	***8.7***
Kovuklukaya	Early Byzantine	Özcan et al., 2003	13	1	**7,7**	17	0	**0**	30	1	**3.3**
Andaval	Early Byzantine	Pekak, 1998	9	0	**0**	18	1	**5,6**	27	1	**3,7**

Ani	Byzantine	Karamağralı, 1999	5	0	**0**	4	1	**25**	9	1	**11,1**
Yortanlı	Byzantine	Yaraş, 2002	10	1	**10**	16	2	**12,5**	26	3	**11,5**
Eski Cezaevi	Byzantine	Erdal, 2002	15	0	**0**	16	1	**6,25**	31	1	**3.2**
Hagios Aberkios	Late Byzantine	Erdal, 2000	6	1	**16,7**	15	1	**6,7**	21	2	**9,5**
İznik	Late Byzantine	Yalman, 1983	9	1	**11,1**	96	7	**7,3**	105	8	**7,6**

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

The prevalence of metopic sutures varies from one society to another. Although there are many studies about metopic sutures on modern populations, the number of studies conducted on archaeological materials is limited. Studies have shown that the prevalence of metopic sutures was 7%–10% in Europeans, 5% in Asians, 1% in Africans, and 1% in Australians (Breatnach, 1965; Bergman,1988; Werma,2014). Bergman stated that approximately 1%–12% of the skulls had metopism (Bergman, 1988). A study conducted by Woo showed that 10% of Mongoloid skulls had metopic sutures (Woo,1949).

The prevalence of metopic sutures in today's Anatolian population varies between 4% and 9% (Table 6). This rate varies between 14,3% and 3,2% in the previous periods in Anatolia. The inadequate sample number in populations in which the prevalence of metopic sutures was found to be very high increased its frequency.

Table 6: Metopic Suture Frequencies In Modern Anatolian Populations

Distribution of Metopic Sutures in Modern Anatolian Populations			
Researchers	**Year**	**Population**	**Percentage**
Cireli and Tetik	1985	Anatolia	4.6%
Gümüşburun et al.	1986	Anatolia	7.61%
Sindel et al.	1989	Anatolia	9.14%
Mağden and Müftüoğlu	1989	Anatolia	5.4%
Aycan	1993	Anatolia	7.69%
Süzen et al	1993	Anatolia	9.3%
Aksu et al.	2014	Turkish West Anatolian skulls	7.5%

The comparison of Byzantine subperiods between each other showed that the prevalence of metopic sutures was similar in Eski Cezaevi (3,2%), Kovuklukaya (3.3%); Andaval (3.7%), which dates back to the Early Byzantine period; Datca- Burgaz (12,5%), Yortanlı (11.5%); Ani (11.1%), which dates back to the Byzantine period; İznik (7.6%);%); and Hagios Aberkios (9.5%), which dates back to the Late Byzantine period.

The prevalence of metopic sutures in the Spradon society (8.7%) showed similarity with the İznik Late Byzantine society (7.6%) and Hagios Aberkios Late Byzantine populations (9.5%). This rate was lower compared to those in other Roman populations of the same age with Spradon society. Cevizcioğlu Farm, which is a Hellenistic Roman period society has a higher prevalence of metopic sutures (14.3%) than the ancient city of Spradon.

While the lowest rate of metopism is from the Eski Cezaevi community with 3.2%, the Cevizcioğlu Farm population of Hellenistic Roman period has the highest value among Roman - Byzantine populations. It is significant that the location of the Spradon near these two Byzantine settlements is significant when the metopic suture is considered to be related to the geographical region. Cevizcioğlu Farm, which is a Hellenistic Roman period population has a higher prevalence of metopic sutures (14.3%) than the ancient city of Spradon. The early Byzantine populations, Kovuklukaya (3.3%) and Andaval (3.7%), have low values in the ancient city of Spradon. Metopic suture ratios are thought to be of different values because these 2 regions are geographically distant from the ancient city of Spradon. When the comparison is made on Old Anatolian Populations, metopic suture is seen especially in coastal regions of Anatolia in geographical sense. In addition, there is less metopic suture in the internal regions (Figure 2).

Statistical analysis reveals that the ancient city of Spradon is clustered in close group with İznik, Andaval, Datca Burgaz, Hagios Aberkios and Yortanli. The groups that are statistically distant from the ancient city of Spradon are Ani, Kavuklukaya, Cevizcioğlu and Eski Cezaevi. Despite being close to the ancient city of Spradon, only the Eski Cezaevi was clustered statistically away from these settlements (Graph 3, 4). Ani population is located both geographically and statistically at the furthest distance to Spradon population (Graph 3).

The most important reason for this is that migration through gene flow is likely to be more towards southern or northern regions, ie marine areas (Figure 2). In ancient Anatolian populations, metopic suture is predominant in coastal regions. Genetic factors are the most emphasized among the causes of metopic sutures. The most apparent cause for metopic sutures observed in the Spradon populations was also genetic factors. This study found that 2 females located in the same grave had metopic sutures, which suggests that there might be a kinship relation between them (Figures 6, 7).

Figure 6: Metopic Suture in M 35/6 Female Skull

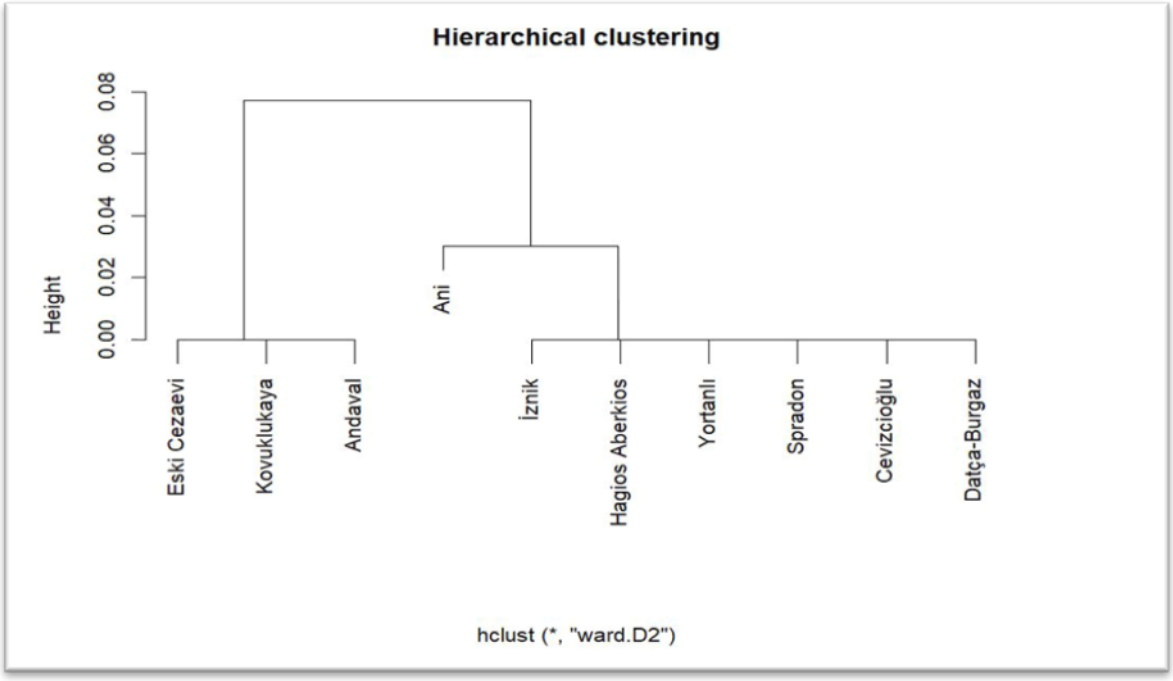
Figure 7: Metopic Suture in M 35/4 Male Skull

Datça - Burgaz, Andaval, Ani, Yortanlı, Eski Cezaevi populations have higher levels of metopic suture in male individuals than in Spradon population. On the other hand, there are more metopic suture ratios in Cevizcioğlu, Hagios Abarkios, İznik community female individuals as in Spradon population. These results show that sexual dimorphism is not in the late Roman and Byzantine period in terms of metopic suture. When we look at the periods except the Byzantine and Roman Periods; In Ottoman

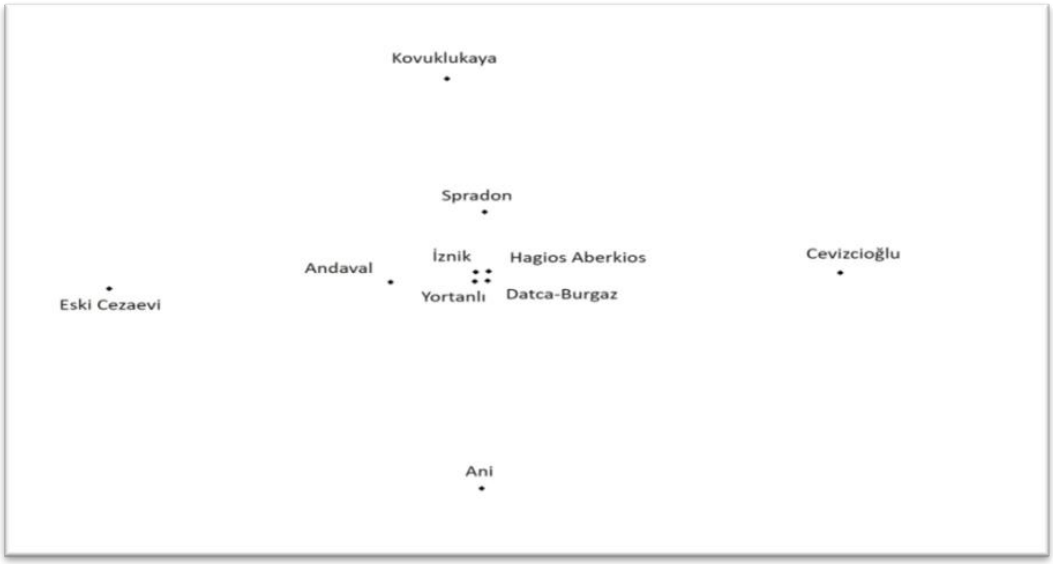
period, metopism rate is 4.62%. In Minnetpınarı highest value (Table 7).
Medieval Population, 11.1% metopism rate is the

Table 7 : The Distribution of the Metopic Suture of Ancient Anatolian Populations

The Distribution of the Metopic Suture Ancient Anatolian Population										
Population	**Period**	**References**	**Female**			**Male**			**Total**		
			n	**k**	**%**	**n**	**k**	**%**	**n**	**k**	**%**
Çayönü	Neolithic	Özbek, 1988	**-**	**-**	**-**	**-**	**-**	**-**	-	-	**10**
İkiztepe	Early Bronze	Bilgi, 2001	42	2	**4,8**	62	**4**	**6,5**	104	6	**5,8**
Klazomenai	BC 6th~5th Century	Güleç, 1985	8	0	**0**	8	**1**	**12,5**	16	1	**6.3**
Spradon	Late Roman		38	5	**13,2**	31	**1**	**3.2**	69	6	**8.7**
Topaklı Population	6th–7th Century	Güleç, 1988	-	-	**-**	-	**-**	**-**	-	-	**5.5**
Karagündüz	Medieval Age	Özer et al., 2000	-	-	**-**	-	**-**	**-**	73	8	**11**
Minnetpınarı	Medieval Age	Yiğit et al., 2007	16	4	**25**	29	**1**	**3.4**	45	5	**11.1**
Anatolia	Ottaman	Özer et al., 1998	-	-	**-**	-	**-**	**-**	-	-	**4.62**
Anatolia	18th Century	Gümüşburun et al., 1998	110	10	**9.1**	192	**10**	**5.2**	302	20	**6.6**
Kızlar Manastırı	14th–19th Century	Yiğit et al., 2009	12	-	**-**	15	**-**	**-**	27	3	**11**
Kelenderis	19th Century	Çırak and Çırak, 2010	11	1	**8.3**	14	**1**	**6.7**	27	2	**7.4**
n: number of investigated individuals k: frequency of epigenetic features											



Graph 3: Hierarchical clustering



Graph 4: Multidimensional scaling of MMD values

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