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Dental anthropological analysis of the Byzantine Necropolis of Samantaş (Muğla, Türkiye) *

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Abstract

Samantaş is a Byzantine necropolis discovered during rescue excavations near the ancient city of Stratonikeia and the sanctuary of Hekate at Lagina in Türkiye. We analyzed the dental morphology of the Samantaş population from the 6th to the 12th centuries AD. We scored nine dental traits using the Arizona State University Dental Anthropology System (ASUDAS) in 142 individuals. Dental nonmetric trait frequencies in Samantaş were compared with previously reported world frequencies. In addition, the rASUDAS was used to predict the ancestry of the Samantaş using the trait scores. Results show that traits including shoveling and double-shoveling, hypocone, and Y groove pattern are at low frequencies. In contrast, interruption grooves and tuberculum dentale, Carabelli's cusp, and hypoconulid absence are in moderate to high frequencies. The rASUDAS analysis estimates that most of Samantaş have Western Eurasian ancestry. Results indicate limited dental morphological variation, suggesting minimal gene flow from outside Western Eurasia into Samantaş. More studies of populations in the nearby region are needed to infer the ancestral connections and population history of the Samantaş population.

Keywords: dental anthropology; non-metric dental traits; ASUDAS; Anatolia; Byzantine

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Introduction

The ancient city of Stratonikeia in Caria is located on the Muğla-Milas highway in the Yatağan district of Muğla province. Stratonikeia is 9 km away from the sanctuary of Hekate at Lagina, which is also located in Yatağan. Stratonikeia and the sanctuary of Hekate at Lagina used to be connected by a sacred road in ancient times (1-4). Between Stratonikeia and the sanctuary of Hekate at Lagina, several small settlements and necropolis areas have been discovered during rescue excavations, including Börükçü, Samantaş, Değirmenderesi, and Çapalıbağ (1-4). The Samantaş necropolis is one of the discovered areas, located 750 m northwest of Yeşilbağcılar district, 2 km away from Lagina, and 7 km away from Stratonikeia as the crow flies (Figure 1).

During the surface soil removal works at the Samantaş site conducted in 2016, Yatağan Thermal Energy Production Inc. uncovered graves within its mining license area. Subsequently, they promptly notified the Muğla Museum Directorate about this discovery. The area was believed to be a necropolis, and hence, rescue excavations were conducted between 2016 and 2018. A total of 455 graves were unearthed. The graves were built in east-west and southwest-northeast orientations. Burials generally belonged to a single individual and were buried dorsally (i.e., on their back). However, there is also secondary and tertiary use in some graves. In secondary uses, burials were made side by side or on top of each other. In the burials of three or more individuals, the first individuals buried in the first use were dragged in the grave or collected, and then, the other individuals were buried.

During the excavations, the remains of a small chapel structure associated with the Samantaş necropolis were also unearthed. Coins, terracotta ceramic vessels, iron, bronze, gold, and glass jewelry, and other items were identified in the graves. The dating of the necropolis site was based on a bronze coin found in one of the graves, dated to the Reign of Romanos I, who shared the rule with Constantine VII between 920 and 944 AD. An examination of a bronze coin found in another grave revealed that it belonged to Nikephoros II Phocas, dating it to 963-969 AD. Muğla Museum researchers reported that these coins belonged to the Constantinople mint. Moreover, it is believed that the necropolis has been in use since the Byzantine Period, as some of the grave findings exhibit similar characteristics to those dating back to the 10th

and 11th centuries AD. In addition to archaeological finds, organic samples were also dated. Carbon-14 (C^{14}) analysis was performed using skeletal samples found in three graves in the necropolis area. Results of the C^{14} analysis showed that the first, second, and third skeletal samples from the three graves date to 1035-1159 AD, 879-994 AD, and 771-695 AD, respectively. Overall, the archaeological findings and C^{14} analysis results show that the necropolis was used uninterruptedly from the 6th century AD to the 12th century AD during the Eastern Roman-Byzantine Period.

Teeth are well-preserved in archaeological assemblages, making them the most abundant type of human remains found. Anthropologists have long used dental nonmetric traits as a reliable method for reconstructing population histories and ancestry estimation (5-12). Previous studies have demonstrated that dental morphology is genetically controlled and is determined by neutral genetic processes unaffected by adaptive pressures (13). Due to the widely accepted assumption that dental morphological diversity in a population reflects genetic diversity (8), past studies have used dental non-metric traits as proxies for genetic information when genetic data are unavailable (8, 14). Such studies have shown that dental morphological data can inform us about population continuity and gene flow in ancient human groups (15).

However, recent studies have shown that heritability estimates are moderate for many traits, and even low for some (16). Furthermore, some argue that not all traits are suitable for inferring neutral genetic variation because they reflect non-neutral, nonrandom evolutionary mechanisms, such as natural selection and adaptation (17). Dental development is a highly complex process that involves genetic, epigenetic, and environmental factors working together to form the final phenotype (18,19). Any interruptions during odontogenesis can have a range of consequences, from minor morphological variation to dental disease and even tooth absence (20). According to Riga et al. (2014), environmental stressors such as malnutrition or disease have significant effects on tooth morphology (21). Teeth respond to stress during development, leading to increased morphological variability. Similarly, Blankenship-Sefczek et al. (2024) found that environmental factors, such as nutrition, can influence dental trait expression, including cusp spacing, size, and number (22). Furthermore, Hubbard et al. (2015)

argue that although dental phenotypes can be used as another line of evidence to infer an individual's or a population's genotype, genetic data provide finer resolution than dental data in estimating biodistance between populations (7). Studies employing several dental traits from multiple sites across different time periods, and utilizing multivariate statistical analysis, provide strong analytical resolution for determining genetic admixture among populations, as in Delibaş et al. (2025)'s study (23). The authors of this study included several sites spanning various time periods, from the Neolithic and Chalcolithic to the Early Bronze Age, in Anatolia, to evaluate biological relationships among prehistoric populations. They examined dental metric and nonmetric traits in these Anatolian populations, employing several statistical tests, including diversity and evenness indices, the Mean Measure of Divergence (MMD), Gower's coefficient, and the Mahalanobis distance for mixed data. Their study revealed that the ancient DNA patterns in Anatolia are reflected in the dental morphology (23).

Due to its strategic geographic location, Anatolia has a complicated history, most of which still remains to be explored. Anatolia has been an important bridge that links Asia and Europe, allowing many civilizations to pass through over thousands of years since the Upper Paleolithic (24, 25). Influences from Hellenistic, Persian, Roman, Byzantine, Turkish, and Islamic civilizations are apparent in this area, which has been a melting pot of all these cultures. These groups with different backgrounds have interacted and blended both culturally and genetically (26).

Historical and archaeological records suggest that Anatolia was under Byzantine rule from the 6th to the 12th centuries AD, although the region experienced constant migrations and wars. Dating of the Samantaş necropolis suggests that this is the time period during which the Samantaş people inhabited the south of Anatolia, before the Seljuk Turks arrived in Anatolia in the 11th century. Given the high probability that Samantaş people did not encounter Seljuk Turks, it would be plausible to assume that they likely lacked significant Central Asian Turkish influence in terms of culture and genetics. As a result, the population of Samantaş would probably exhibit a high degree of genetic and morphological uniformity. Genetic support comes from Lazaridis and colleagues' (2022) study, where they tested seven Samantaş individuals (26). The results of their study showed that Samantaş individuals did

not have any admixture from Central or East Asia. In contrast, the Çapalıbağ necropolis, located near Samantaş, but representing a slightly later time period, indicates a different ancestral profile. The Çapalıbağ individuals, who lived on the Aegean coast of Turkey from the 14th to 17th centuries, showed that they had 18% Central Asian ancestry (26).

As Lazaridis et al. (2022)'s study demonstrated, Samantaş individuals exhibit 100% Byzantine ancestry, suggesting a quite low genetic variation (26). Given the low genetic variation previously observed in Samantaş, we hypothesize that Samantaş's dental morphology will show minimal variation, suggesting a homogeneity in their dental characteristics that stems from their shared genetic heritage. In this study, we conducted a dental morphological analysis of individuals from Samantaş. We documented the frequencies of nine dental traits using the Arizona State University Dental Anthropology System (ASUDAS) as a scoring method. We compared frequencies from Samantaş with global dental nonmetric trait frequencies reported previously in the literature (12). We also applied the rASUDAS tool to analyze ancestry composition among Samantaş individuals. This study sheds light on the dental morphological diversity of the Samantaş population.

Materials and methods

Sample

A total of 604 individuals – 326 adults and 278 subadults – were unearthed during the excavations. Of the 604 individuals, only 142 were included in this study due to poor preservation of skeletal remains and severe dental wear. The teeth examined in this study include isolated permanent teeth as well as the teeth intact in the upper and lower jaws. We associated the isolated teeth with a possible maxilla or mandible based on the morphological resemblance. Of the 142 individuals, 67 were adults, and 75 were under 18. Age determination was made based on tooth eruption stages (27). Table 1 shows the age distribution in the sample.

Dental non-metric data collection

Dental non-metric trait expression was scored using the Arizona State University Dental Anthropology System (ASUDAS) (28). Table 2 lists the dental traits scored in this study, including trait descriptions, the specific teeth examined, and the breakpoints indicating the presence or absence of each trait. Only permanent teeth were scored in this study. Teeth

with significant wear were only scored if the trait of interest was visible. The scoring process involved evaluating each trait based on the condition of the teeth on the left side. In cases where a left tooth was absent or extensively worn, the assessment was made based on the corresponding right tooth instead of the left antimer. If both sides could not be examined due to heavy wear or the absence of the tooth, the individual was excluded for the trait. In several subadult individuals, upper and lower jaw bones were heavily damaged, and the unerupted permanent teeth developing inside the jaw bones were either dislocated or visible. Therefore, although they have not erupted yet, we were able to observe and score dental traits for those teeth that have completed crown development but not root development (Figure 2).

Permanent second molars (M2s) erupt approximately at the age of 12. Individuals in the 0-5 age group were counted in the M2 trait frequencies only if their still-developing M2s (with completed crown development) were observable due to the damage to the jawbone. To avoid skewing the results, individuals with unobservable or missing teeth were excluded from trait frequency calculations and rASUDAS analyses in a specific tooth class. For example, if an individual has an observable maxillary central incisor and a missing first molar, this person is counted in the central incisor trait frequencies but excluded from the first molar trait frequencies.

Comparative data

To provide context for the Samantaş dental data, we compared Samantaş dental trait frequencies with the global frequencies reported by Scott et al. (2018) (Table 2) (12). The comparative data were collected by Christy G. Turner, J.D. Irish, A.H. Hubbard, G.R. Scott, and D.E. Hawkey over a period of four decades, encompassing over 30,000 individuals from various time periods globally. This data was reported by Scott et al. (2018) to assist researchers in placing their findings within a broader comparative framework (12). All of the comparative data were obtained using ASUDAS. Labial curvature was excluded from the comparison because this trait was not reported by Scott et al. (2018) (12).

Estimation of ancestry

We employed the rASUDAS tool to analyze the diversity within the Samantaş population. The rASUDAS is a web-based application that estimates an individual's ancestry based on a suite of dental traits (29). The application utilizes

the ASUDAS scores of 21 dental crown and root traits. It uses a Bayes classifier algorithm to assign each individual to seven predefined geographic groups: American Arctic & Northeast Asia (AA.NA), Australo-Melanesia & Micronesia (AM.M), East Asia (EA), American Indian (AI), Southeast Asia & Polynesia (SA.P), Sub-Saharan Africa (SSA), and Western Eurasia (WE). Using the ASUDAS scores for each trait, rASUDAS calculates probability values for each of the seven geographic groups to determine an individual's most likely ancestry. The rASUDAS provides a reliable ancestry estimation thanks to its large sample size from diverse populations, standardized scoring protocols, and thorough classification statistics (30).

We applied the rASUDAS tool to 78 individuals from Samantaş. We chose this number because not all 142 individuals were assessed for every trait included in the rASUDAS. Only individuals who were scored for at least three traits in the rASUDAS were included in the ancestry estimation. Table 3 shows the age distribution of individuals included in the rASUDAS analysis. Dental traits used for rASUDAS analysis included shoveling (UI1), interruption grooves (UI2), hypocone (UM2), Carabelli's cusp (UM1), groove pattern (LM2), and 4-cusped LM2. The reason for using the earlier version of rASUDAS instead of the current one (rASUDAS2) was that only the earlier version of the web-based application was available during data analysis. Recently, a revised version of the application with additional traits as well as backup traits has been introduced (30). Future studies might benefit from using the latest version of rASUDAS (i.e., rASUDAS2) with an improved reference dataset and additional dental traits.

Results

The Samantaş sample comprised 142 individuals. Among 142 individuals, 42 (29.6%) were aged 0-5, 31 (21.8%) were 6-12, 2 (1.4%) were 13-17, and 67 (47.2%) were 18 or older, as detailed in Table 1. Table 4 shows the total number of individuals scored for each trait and also displays the percentage of individuals exhibiting each trait based on the breakpoints specified in Table 2. Table 5 illustrates the dental trait frequencies in each grade.

In upper central incisors (UI1), shoveling was present in 16.7% of the individuals examined (n=11). Double shoveling was absent (0%) among the sample. Labial curvature was more prevalent with 49.1% frequency (n=28), compared to shoveling and double shoveling. In

upper lateral incisors (UI2), we observed interruption grooves in 40.4% (n=19) and tuberculum dentale in 41.6% (n=20) of the individuals.

Hypocone was the most prevalent trait among Samantaş individuals, observed in 98.3% (n=117) of the upper first molars (UM1). This trait occurred less frequently, at 53.1% (n=42), in the upper second molars (UM2). Carabelli's cusp in the upper first molars displayed intermediate frequencies at 43.4% (n=49).

The Y groove pattern and hypoconulid in the lower first molars (LM1) exhibited high frequencies, at 81.4% (n=44) and 86.6% (n=91), respectively. In the lower second molars (LM2), the Y groove pattern was apparent in 12.9% (n=7), and hypoconulid were found in 8.6% (n=6) of the individuals within the sample.

According to the rASUDAS results (Table 6), 65 out of 78 individuals (83.3%) align with Western Eurasia with a mean probability value of 0.5124. A smaller number of individuals were grouped with American Arctic & Northeast Asia (n=4), East Asia (n=3), Australo-Melanesia & Micronesia (n=2), American Indian (n=2), and Sub-Saharan Africa (n=2). No individual was grouped with Southeast Asia & Polynesia.

Discussion

In archaeological remains, teeth are the most commonly found skeletal elements due to their highly mineralized and hard nature. Analysis of teeth can answer a wide range of questions regarding past lifestyles, diet, migration events, biological relatedness, population histories, and so forth (31). In this study, we aimed to describe the dental morphology of the Samantaş population and explore its ancestral composition using the dental nonmetric traits included in the Arizona State University Dental Anthropology System (ASUDAS).

The frequency of shoveling in Samantaş is quite low, at 16.7% (Table 4). As one of the most commonly studied non-metric dental traits, the worldwide variation of shoveling is well established (32, 33). While Sino-Americans exhibit the highest frequencies, Europeans are at the lowest end of the spectrum (34, 35, 36). Samantaş falls in the 'low' range of Scott et al. (2018)'s global frequencies, aligning closely with Western Eurasians for this trait (12). As a trait highly dependent on the shoveling expression, double shoveling of the upper central incisors (UI1) shows similar geographic variation as shoveling variation. As Scott and Irish (2017) reported, this trait was also very rare among

European, Asian, and African samples (37). Notably, we found that double shoveling is absent in Samantaş.

40.4% of the individuals examined in Samantaş had interruption grooves in upper lateral incisors (Table 4), placing them in the moderate range with populations in North Africa, Europe, East, and early Southeast Asia (Table 2). Interruption grooves are most commonly observed in East Asian and New World populations, ranging from 45% to 65%. Western Eurasians exhibit moderate frequencies, whereas this trait is very rare in Sub-Saharan Africa and New Guinea populations (12).

Tuberculum dentale was present in 41.6% of individuals in the Samantaş (Table 4). The world frequency variation of tuberculum dentale shows relatively narrow variation, ranging between 20% and 40% (12). Samantaş is in the moderate category, which is the high end of the spectrum for this trait.

A hypocone grade 3 or higher indicates the presence of a hypocone. Grades lower than 3 indicate a reduction or absence, resulting in a three-cusped upper molar. In Samantaş, a grade 3-5 hypocone was observed in 98.3% of the upper first molars (UM1) and 53.1% of the upper second molars (UM2) examined. In other words, 98.3% and 53.1% of the population had a normal-sized hypocone in their UM1 and UM2, respectively. In the rest of the population, the hypocone was either reduced in size or completely absent. In terms of hypocone expression, upper second molars show the greatest variation (12). In the world range, Samantaş falls in the low end, indicating a relatively high rate of hypocone reduction (Table 2). With 53.1%, Samantaş aligns with populations from Northeast Siberia, the American Arctic, and Europe.

The cusp of Carabelli has gained significant attention in the population affinity studies (38). The Carabelli's cusp has long been recognized as a European trait (39). However, this trait is also common in other regions of the world, including Africa, Mesoamerica, and Australia (40). Ideas regarding which breakpoint should be accepted as the Carabelli's cusp presence differ (12, 41). Earlier studies used 5+ as the breakpoint, recognizing free-standing Carabelli's cusps as the presence of the trait (41). We follow Scott et al. (2018)'s 2+ breakpoint so that we do not miss the wide range of trait variation (12). We observed Carabelli's cusp grade 2 and higher in 43.4% of the population, which falls within the high intermediate category in the global data

(Table 2). This frequency is similar to that reported for populations from East Africa, Eastern Europe, Mesoamerica, Australia, and New Guinea (12).

As the most variable tooth for the Y groove pattern, lower second molars are used as the key tooth for this trait. In Samantaş, we observed a lower second molar (LM2) Y groove pattern in 12.9% of the individuals we examined. Compared to the data reported by Scott et al. (2018), Samantaş is considerably below the lowest frequency groups that are within the 20-25% range (12). As mentioned earlier in the text, Samantaş's teeth are highly worn, making scoring difficult and even impossible for most of the traits, such as the groove pattern. Therefore, this result might be biased and requires a cautious interpretation due to the high level of wear in the sample.

Hypoconulid was the last cusp to be added in hominoid evolution. In the evolutionary process, the absence of hypoconulids became a common phenomenon (37). When this cusp is present, it is almost always present in the first molars and absent in the second molars. The absence of hypoconulid means four-cusped lower molars. 86.6% of Samantaş individuals had hypoconulid in their lower first molars (LM1). For the lower second molars (LM2), the frequency of hypoconulid presence was 8.6%, meaning that the remaining 91.4% of the individuals had four-cusped LM2s. According to Scott et al. (2018), four-cusped LM2 is the most frequently observed in Western Eurasians worldwide (12). The frequency of 91.4% in Samantaş, which is above the highest end of the world variation (Table 2), suggests Western and Eastern European, North African, and Indian affiliations.

Overall, we observed low prevalence of shoveling in UI1, double-shoveling in UI1, hypocone in UM2, and Y groove pattern in LM2. Conversely, certain traits, such as interruption grooves in UI2, tuberculum dentale in UI2, Carabelli's cusp in UM1, and hypoconulid absence in LM2 (four-cusped LM2), were moderate to high in frequency.

The rASUDAS predicts that a majority of Samantaş individuals (83.3%) exhibit Western Eurasian ancestry (Table 6), which is not surprising given their known geographical and historical context. The geographic range of Western Eurasia includes Northern Europe, Western Europe, and North Africa. Scott et al. (2018) indicate that the populations included in Western Eurasians are characterized by four-cusped lower second molars and two-rooted

lower canines (12). Compared to the other dental complexes, Western Eurasian dentition shows the absence or low frequency of many traits, making their teeth less elaborated.

A small number of individuals align with non-Western Eurasian groups (Table 6), which might reflect gene flow due to population movements or stochastic events. In particular, the American Arctic & Northeast Asia and East Asian ancestry found in Samantaş might be explained by shared deep ancestry through ancient contact rather than a recent connection. Likewise, minor affinity with the Sub-Saharan African populations detected could be the result of gene flow from Mediterranean/Levantine contact. However, Australo-Melanesia & Micronesia and American Indian ancestry in Samantaş is very unlikely to be explained by direct connections. Therefore, this result might be due to trait frequency overlap between distinct populations.

One limitation of this study is the small number of dental traits and the lack of multivariate statistical models to identify subtle levels of genetic admixture. This study is based on a single site, limiting our ability to infer broad conclusions regarding genetic admixture and continuity in Samantaş. Another limitation is the lack of comparative evidence to infer genetic and morphological homogeneity and continuity between populations that lived in the region before and after Samantaş. Further anthropological studies in the surrounding region from various time periods, including additional necropolis areas discovered between Stratonikeia and Lagina, such as Börükçü, Değirmenderesi, and Çapalıbağ, are necessary to better understand the levels of genetic continuity and admixture in the region.

As already mentioned, dental morphology is not solely determined by genetics. Instead, environmental disruptions during development can significantly alter dental morphology. Previous work has shown that heritability estimates differ across dental traits. In other words, certain traits have lower heritability estimates than others (16) and therefore might not be well-suited for ancestry identification (17). The rASUDAS analysis places Samantaş within the Western Eurasian groups. However, this finding might result from the specific traits we selected rather than an actual genetic signal. Therefore, ancestry estimations in this study should be considered tentative.

Conclusion

Located near the important cities of Stratonikeia and the sanctuary of Hekate, this site most probably underwent considerable demographic shifts and cultural interactions that characterized this area. The Samantaş necropolis provides a unique opportunity to study population dynamics in southwestern Anatolia during the Byzantine period, prior to Turkic expansions into the region in the 11th century.

Although this region has experienced frequent population movements, the limited degree of dental morphological variation we observed in Samantaş might suggest that it was somewhat confined within the region and minimally influenced by populations outside of Western Eurasia. Dental trait frequencies in our study indicate little Central and East Asian influence in Samantaş's dentition. However, findings in this study should be interpreted cautiously due to the limitations mentioned.

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Conflict of interest statement

None

Author contributions

FNEK – Study conceptualization, methodology, data collection, writing the manuscript; AYY – excavation, sample preparation, review, editing; AİA – excavation, sample preparation, review, editing; EHK – excavation; OA – excavation.

Statement on the use of artificial intelligence in manuscript preparation

The authors declare that artificial intelligence (AI) tools were used solely for language editing, grammar correction, and refining sentence structure. No AI tools were used for study design, data generation and analysis, interpretation of the results, and drawing conclusions. All intellectual content in this study is solely the work of the authors.

Table 1. Age distribution in the sample.

Age	Total	
	N	%
0-5	42	29.6
6-12	31	21.8
13-17	2	1.4
18+	67	47.2
Total	142	100

Table 2. Dental nonmetric trait descriptions used in this study. I: Incisor; M: Molar; U: Upper (Maxillary); L: Lower (Mandibular).

Traits	Trait descriptions and ASUDAS grades	Teeth scored	Breakpoints	World frequency variation. Taken directly from Scott et al. (2018) (12).
Shoveling	Development of the lingual mesial and distal ridges of upper and lower incisors. Grades 0-7.	UI1	2-6	<ol style="list-style-type: none"> 1. Low (10-20%): Western Eurasia. 2. Low moderate (20-25%): Sub-Saharan Africa, New Guinea. 3. Intermediate (50-80%): Sunda-Pacific, Jomon/Ainu, Australia, Melanesia, Central Asia. 4. High (90-100%): all Sino-Americans.
Double-Shoveling	Development of the labial mesial and distal ridges. Grades 0-6.	UI1	2-6	<ol style="list-style-type: none"> 1. Low (0-10%): Sub-Saharan Africa, North Africa, Nubia, India, Australia, New Guinea. 2. Low moderate (10-20%): Western Europe, Jomon/Ainu, Melanesia. 3. Moderate (20-35%): Southeast Asia, Pacific, Eastern Europe. 4. High moderate (40-50%): East Asia, Central Asia, Northeast Siberia, American Arctic, Northwest North America.

				5. High (75-90%): North America, Mesoamerica, South America.
Labial Curvature	The degree of convexity on the labial surface of upper incisors. Grades 0-5.	UI1	2-4	Not reported by Scott et al. (2018) (12).
Interruption Grooves	Depressions or grooves that crosscut mesial or distal marginal ridges of upper incisors. Any expression is scored as present. Grades 0, M (on mesiolingual marginal ridge), D (on distolingual marginal ridge), MD (on both mesiolingual and distolingual marginal ridge), and med (on medial area).	UI2	0: Absent; 1: Present (M, D, MD, med)	<ol style="list-style-type: none"> 1. Low (5-15%): Sub-Saharan Africa, New Guinea. 2. Low moderate (20-30%): Nubia, Australia, Melanesia, Micronesia, Polynesia, Southeast Asia (recent). 3. Moderate (30-40%): North Africa, Europe, East Asia, Southeast Asia (early). 4. High (45-65%): Jomon/Ainu, Northeast Siberia, all New World groups.
Tuberculum Dentale	Lingual cingulum projections as either ridges or tubercles. Grades 0-6.	UI2	2-6	<ol style="list-style-type: none"> 1. Low moderate (20-30%): East Asia, Central Asia, Northeast Siberia, Australia, New Guinea, Polynesia, Southeast Asia (early), Jomon/Ainu, eastern Europe. 2. Moderate (30-40%): all Africans, all New World groups, Southeast Asia (recent), Melanesia, Micronesia, Western Europe, India.
Hypocone	Presence of cusp 4 in upper molars and its expression. Grades 0-6.	UM1, UM2	3-5	<p><u>Hypocone (UM2):</u></p> <ol style="list-style-type: none"> 1. Low (50-65%): Northeast Siberia, American Arctic, Europe, Jomon/Ainu. 2. Intermediate (70-80%): East Asia, North Africa, India, North and South America, Mesoamerica, Micronesia. 3. High (85-95%): Sub-Saharan Africa, Nubia, Sahul-Pacific, Southeast Asia, Polynesia.
Carabelli's Cusp	Cingular feature expressed on the lingual surface of protocone of the upper molars. Grades 0-7.	UM1	2-7	<ol style="list-style-type: none"> 1. Low (10-20%): Northeast Siberia, American Arctic, Jomon/Ainu. 2. Low intermediate (20-30%): San, India, East Asia, Northwest Coast/Na Dene. 3. Intermediate (30-40%): Melanesia, Southeast Asia, Polynesia, North and South America. 4. High intermediate (40-50%): East Africa, Eastern Europe, Mesoamerica, Australia, New Guinea. 5. High (>50%): West and South Africa, Nubia, North Africa, Western Europe.
Groove Pattern	Y pattern (Grade 1): cusp 2 and 3 are in contact; X pattern (Grade 2): cusps 1 and 4 are in contact; + pattern (Grade 3): cusps 1, 2, 3, and 4 are in contact in the center.	LM1, LM2	Present: Grade 1 (Y)	<p><u>Groove pattern (LM2):</u></p> <ol style="list-style-type: none"> 1. Low-frequency groups (20-25%): Western Eurasia, Sino-Americas, Australia. 2. Intermediate (25-40%): Melanesia, Micronesia, Polynesia, New Guinea, Jomon/ Ainu, Nubia. 3. High-frequency groups (60-70%): San, Sub-Saharan Africa.
Hypoconulid	Presence of a fifth cusp on the distal part of the lower molars. Grade 0 indicates four-cusped molar. Grades 0-5.	LM1, LM2	1-5	<p><u>Hypoconulid (absence, LM2):</u></p> <ol style="list-style-type: none"> 1. Low (0-10%): San, Australia, Northeast Siberia, American Arctic, North and South America, Mesoamerica. 2. Low intermediate (25-40%): Sub-Saharan Africa, East Asia, Southeast Asia, Polynesia, Micronesia, Jomon/Ainu. 3. High intermediate (40-60%): New Guinea, Melanesia, Central Asia, Nubia. 4. High (70-80%): Western and Eastern Europe, North Africa, India.

Table 3. Age distribution of individuals in the rASUDAS analysis.

Age group	N	%
0-5	2	2.56
6-17	24	30.77
18+	52	66.67
Total	78	100

Table 4. Frequencies of traits examined in this study. I: Incisor; M: Molar; U: Upper (Maxillary); L: Lower (Mandibular).

Traits	Teeth scored	N	% (n)
Shoveling	UI1	66	16.7 (11)
Double shoveling	UI1	64	0 (0)
Labial curvature	UI1	57	49.1 (28)
Interruption groove	UI2	47	40.4 (19)
Tuberculum dentale	UI2	48	41.6 (20)
Hypocone	UM1	119	98.3 (117)
	UM2	79	53.1 (42)
Carabelli's cusp	UM1	113	43.4 (49)
Groove pattern	LM1	54	81.4 (44)
	LM2	54	12.9 (7)
Hypoconulid	LM1	105	86.6 (91)
	LM2	70	8.6 (6)

Table 5. Frequencies of dental trait grades in Samantaş.

Traits	n	Grade							
		0	1	2	3	4	5	6	7
Shoveling UI1	66	35 (53.03%)	20 (30.30%)	8 (12.12%)	3 (4.55%)				
Double shoveling UI1	64	61 (95.31%)	3 (4.69%)						
Labial curvature UI1	57	13 (22.81%)	16 (28.07%)	14 (24.56%)	10 (17.54%)	4 (7.02%)			
Interruption groove UI2	47	28 (59.58%)	19 (40.42%)						
Tuberculum dentale UI2	48	19 (39.58%)	9 (18.75%)	7 (14.58%)	9 (18.75%)	1 (2.08%)	2 (4.17%)	1 (2.08%)	
Hypocone UM1	119		1 (0.84%)	1 (0.84%)	5 (4.20%)	102 (85.72%)	10 (8.40%)		
Hypocone UM2	79	17 (21.51%)	10 (12.66%)	10 (12.66%)	13 (16.46%)	29 (36.71%)			
Carabelli's cusp UM1	113	58 (51.33%)	6 (5.31%)	3 (2.65%)	6 (5.31%)	13 (11.50%)	11 (9.74%)	10 (8.85%)	6 (5.31%)
Groove pattern LM1	54		44 (81.48%)	6 (11.11%)	4 (7.41%)				
Groove pattern LM2	54		7 (12.96%)	22 (40.74%)	25 (46.30%)				
Hypoconulid LM1	105	14 (13.33%)	2 (1.91%)	2 (1.91%)	24 (22.86%)	51 (48.57%)	12 (11.43%)		
Hypoconulid LM2	70	64 (91.43%)	1 (1.43%)		4 (5.71%)	1 (1.43%)			



Table 6. rASUDAS ancestry estimation results.

Group	Number of individuals (n)	%	Probability range	Mean probability
American Arctic & Northeast Asia	4	5.1%	0.249-0.496	0.4065*
Australo-Melanesia & Micronesia	2	2.6%	0.2549-0.2985	0.2767*
East Asia	3	3.8%	0.2049-0.286	0.2558*
American Indian	2	2.6%	0.1965-0.1997	0.1981*
Southeast Asia & Polynesia	0	-	-	-
Sub-Saharan Africa	2	2.6%	0.3838-0.359	0.3714*
Western Eurasia	65	83.3%	0.2433-0.906	0.5124*
Total	78	100%		

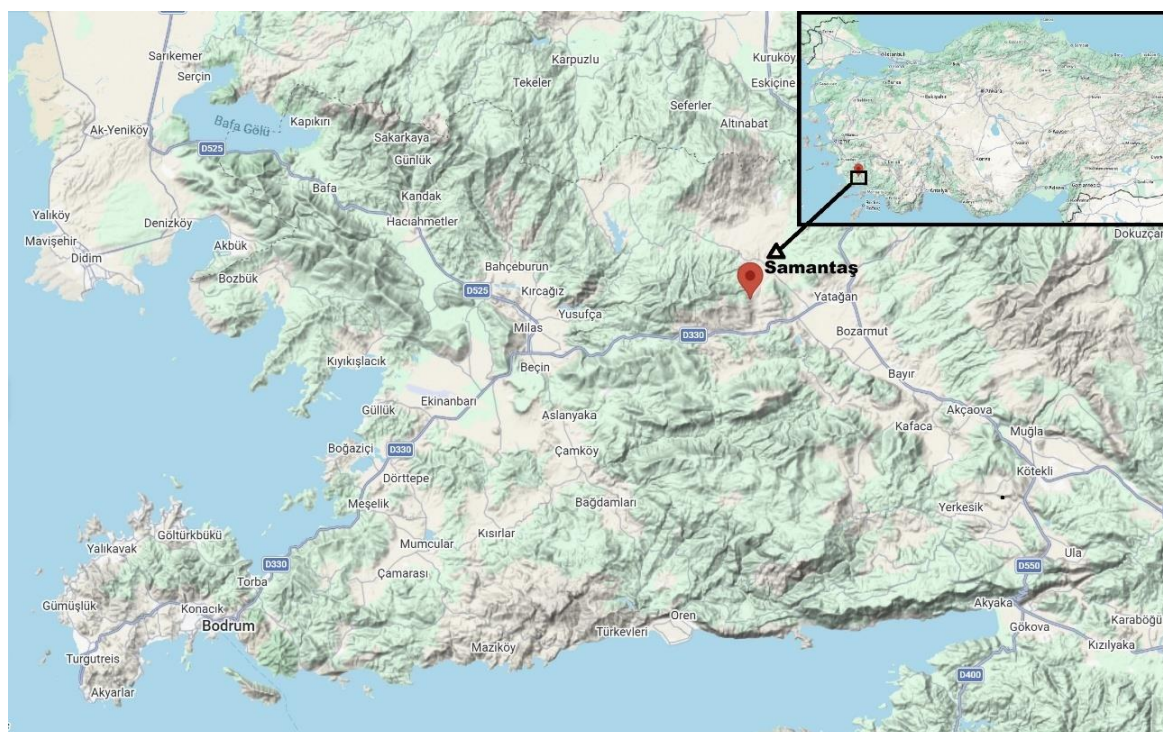


Figure 1. The location of the necropolis of Samantaş.

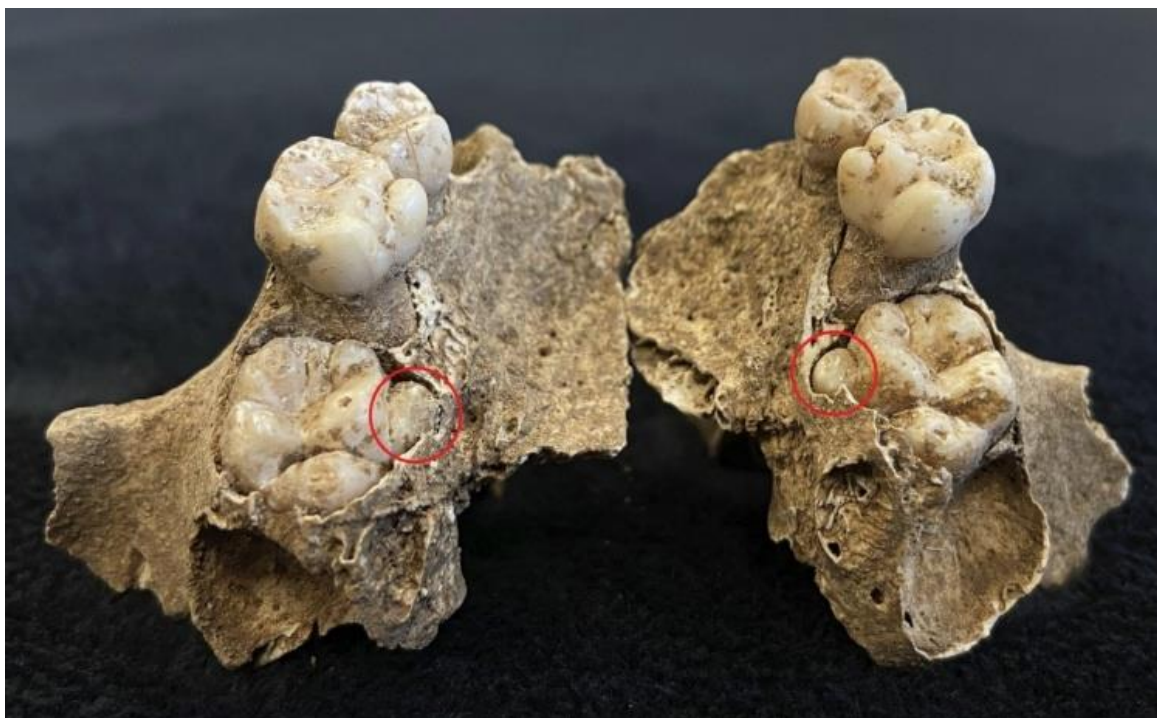


Figure 2. Figure shows maxillary fragments with intact teeth from a subadult in Samantaş. Red circles highlight Carabelli's cusp on the permanent first molars, visible even though the teeth are not fully erupted.

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