A Survey of Metopic Suture Persistence in the Published Literature

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ABSTRACT

The metopic suture separates the two halves of the frontal bone. This suture typically fuses by the second year of life, but in some instances, persists beyond that. This project examines the published literature to explore these rates of persistence for examining its utility in biological anthropological contexts, such as forensic anthropology or bioarchaeology, for ancestry estimation and in clinical settings so it is not confused with a fracture.

The metopic suture can show variation in the timing of when it closes, but when it persists permanently, may take on a variety of shapes. Additionally, the metopic suture is believed to persist most commonly in populations with European and Asian ancestries. A global survey paper authored by Hanihara and Ishida (2001) served as the impetus to further explore published rates on metopism, or the prevalence of the metopic suture. This project relied on a literature review through academic search engines such as GoogleScholar, OneSearch, and Science Direct to find additional sources examining metopism. Fourteen articles were located that listed metopism rates with respect to specific ancestry groups.

Results demonstrated that metopism does vary according to population, with persistence rates being as high as 63.2% in certain ancestral groups. Generally, the metopic suture persists most commonly in populations with European and Asian ancestry, as expected, but was also found in rates as high as 7.5% in historic African American samples. These results provided some insight as to how future studies relying on population history could explore the influence of genetics and environment on the prevalence of cranial morphological traits such as the metopic suture, as there is still a great deal unknown about why certain traits are more common in some ancestry groups than others.

Introduction

Biological anthropology often relies on methodologies to estimate various aspects of a person's identity, known as the biological profile. These aspects include biological sex, age, ancestry, and stature. Ancestry estimation typically relies upon examining patterns of various suites of cranial and/or dental morphological traits or measurements that exist on a spectrum of expression or size, respectively (Christensen et al. 2019). The expression of phenotypic traits tends to follow clinal variation; that is, traits and size differences for genetically influenced physical features vary based on geography or environmental conditions (Christensen et al. 2019). Understanding the variation of phenotypic traits and measurements can inform the observer about the region an individual, or their ancestors, may have originated from. This current project explores the prevalence of one cranial morphological trait, the metopic suture, within the published literature to examine its utility within the suite of cranial non-metric traits for ancestry estimation.

The metopic suture is an articulation between the two halves of the frontal bone (White and Folkens 2005), which fuses from two separate bones during growth and development. The metopic suture appears during the first two months *in utero* (Mayo Gòss 1988) and is visible at birth (Romanes 1972; Basmajian 1975; Hamilton 1976). The suture usually disappears during early childhood when the frontal bones undergo intramembranous ossification. However, it can persist into late adulthood after other sutures are obliterated (Piersol 1916). The cause of persistent metopic sutures, or metopism, is unknown. There has been considerable debate in osteology regarding precisely when the

metopic suture closes. Some researchers report that the suture closes between the first and second years of life (Keith 1948; Basmajian 1975), while Warwick and Williams (1980) state that it begins to close at two years and is obliterated by the eighth year. Piersol (1916) states that the metopic suture closes at the end of the fourth year, while Romanes (1972), Togerson (1951) and Hamilton (1976) report that the suture closes between five and seven years. Very little is known regarding why metopism is observed in some ancestral groups but is absent in others. That being said, one of the most widely accepted factors for metopism is the influence of genetics (Torgersen 1951). Metopism can present in a variety of shapes. A true persistent metopic suture is one that is simple and linear in shape (Fig.1a) above the nasion, a cranial landmark indicating the articulation of the two nasal bones with the frontal bone (White et al. 2012). Persistent lower metopic sutures (Fig. 1b) may be obliterated superiorly with "wide, side to side excursions" on the inferior part of the suture (Ajmani et al. 1983). Complete metopism occurs when the suture is present from the nasion to the bregma. Further, metopism can be described as V-shaped (Fig. 1c), H-shaped (Fig. 1d), Inverted U-shaped, N-shaped, or double incomplete. The metopic suture can also be completely obliterated, which is described as absent. As the presence of the metopic suture beyond childhood can help to inform ancestry estimations in conjunction with other cranial or dental morphological traits, it is important to regularly review the relevant literature to be aware of any shifts in its prevalence patterns. Additionally, clinicians should be aware of this cranial non-metric trait, so it is not mistaken for a fracture or indication of trauma.

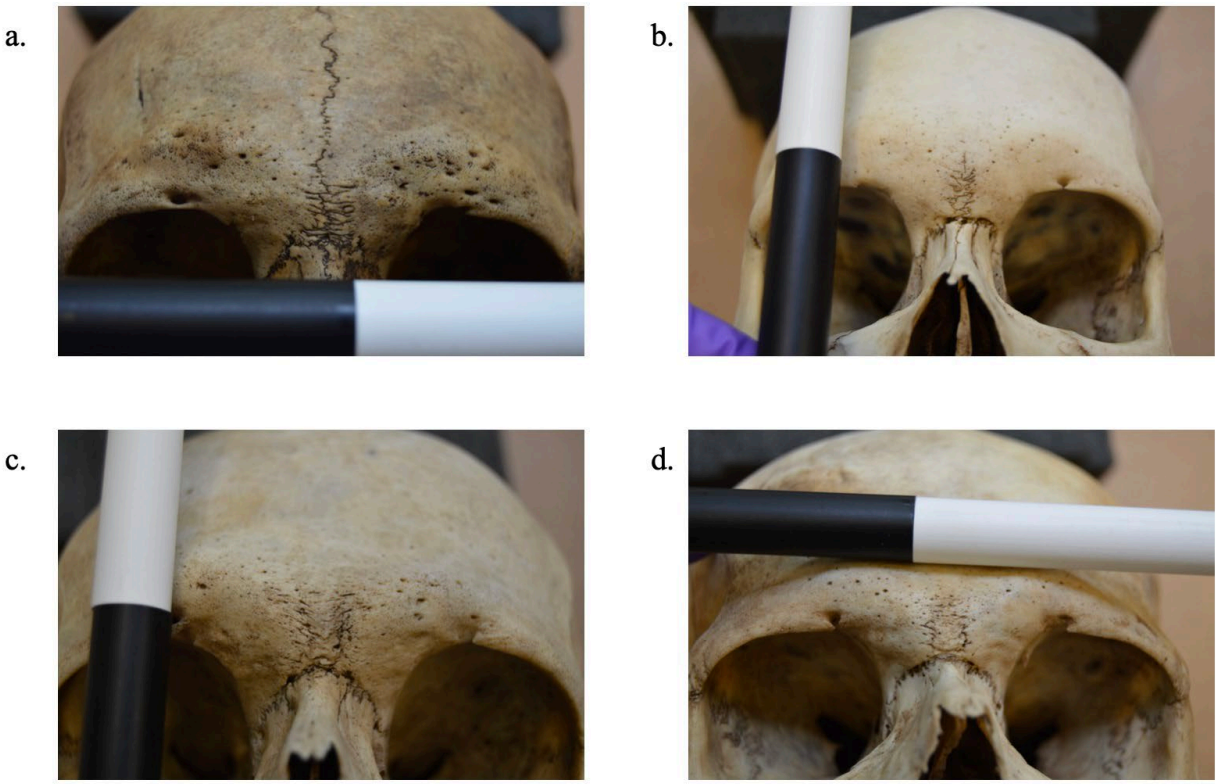

Figure 1. Types of metopism. (a) True persistent metopic suture (complete metopism). (b) Persistent lower metopic suture (incomplete metopism). (c) V-shaped metopic suture (incomplete metopism). (d) H-shaped metopic suture (incomplete metopism).

Materials and Methods

The impetus for exploring the prevalence of metopism originated from reviewing a paper by Hanihara and Ishida (2001) examining the prevalence of cranial non-metric traits on a global scale. As this paper is two decades old, an updated review of the published literature was deemed critical for understanding if metopism still holds value within biological anthropology contexts. Research was conducted through the compilation and analysis of peer-reviewed articles found through online scholarly sources; these included GoogleScholar, the OneSearch feature the University of Nevada, Reno's Knowledge Center, ScienceDirect. Search terms included "metopic suture," "metopism," "metopism and ancestry," and "persistent metopic suture." Twelve articles were included in this literature review as a result of this research. Articles had to include information regarding the sample size and prevalence rates presented by ancestral groups. Other articles located utilizing the specified search terms were not appropriate for inclusion as they lacked critical information necessary to perform comparisons of metopism within ancestral groups. The global data from Hanihara and Ishida (2001) were utilized as a baseline of what populations were expected to have the highest prevalence of metopism. These data are summarized in Table 1. It is anticipated that populations with Asian and/or European ancestry will have the highest prevalence rates for metopism.

Results

As was anticipated based on the Hanihara and Ishida (2001) results, there are expected variations in rates of metopism by ancestral group (Mathijissen et al. 1996), though it is interesting to note that the lowest global rates of metopism were found in individuals of African and Australian ancestries (Bryce 1915; Bryce and Young 1917; Brethnach 1958). Figure 2 (below) presents a graphic display of the results of metopism by ancestry from eight articles included in this literature review. A 1948 study completed by Jit and Shah found that out of the 80 Punjabi skulls examined, 66 showed metopism (82.5%). Four of those 66 skulls (5.0%) were classified as complete, while 62 (45.0%) were classified as incomplete. Woo (1949) studied samples of "Mongoloid," "American Negro," and "American White" skulls. Of the 229 "Mongoloid" skulls studied, 45 showed metopism (19.6%). Twenty-one of those skulls exhibited complete metopism (9.17%), and 24 demonstrated incomplete (10.48%) metopism. Of the 237 "American Negro" skulls, 21 exhibited metopism (8.86%): three were complete (1.26%) and 18 were incomplete (7.59%). Of the 185 "American White" skulls, 21 showed metopism (11.35%), with seventeen (9.19%) classified as complete and four (2.16%) as incomplete. Out of the 206 Nigerian skulls studied by Ajmani et al. (1983), 72 showed metopism (34.95%). Seven skulls exhibited complete metopism (3.40%), while 65 showed incomplete metopic sutures (31.57%). DelSol and colleagues (1989) studied populations from Brazil and found that the highest prevalence of metopism in their samples was in the Alpine group, which refers to individuals living in mountainous regions in this study. 115 of the 400 skulls studied exhibited metopism. Eleven (2.75%) of the skulls studied showed complete metopism, while 115 exhibited incomplete metopism (28.75%). In their 2010 study, Yadav and colleagues examined 1,020 skulls belonging to individuals from North India. Of those 1,020 skulls, 184 showed metopism (18.04%); thirty-six (3.53%) exhibited complete metopism with 148 (14.5%) exhibiting incomplete metopism. In their study of Thai individuals, Khamanarong et al. (2015) found that 53 out of the 706 skulls studied exhibited metopism (7.51%), with 20 of the skulls (2.83) being classified as complete metopism and 33 classified as incomplete metopism (4.67%). Maskey and colleagues (2020) found eight out of the 104 Korean skulls studied presented with the metopic suture (7.69%) with three of those skulls exhibiting complete metopism (2.88%). Five skulls (4.81%) showed incomplete metopism. Of the Nepalese skulls, thrirty-three out of 121 (27.3) showed a metopic suture. Two of those skulls (1.65%) were complete and thirty-one (25.6%) were incomplete. In one study, only rates of complete metopism were presented. Bryce (1915) described complete metopism presenting as: European, 8.70%; "Mongolian," 5.10%; "Negro," 1.20%, Australian, 1.00%; and Scottish, 9.50% (note that Scotland, while a European country, has a much higher rate of complete metopism, thus it is listed on its own).

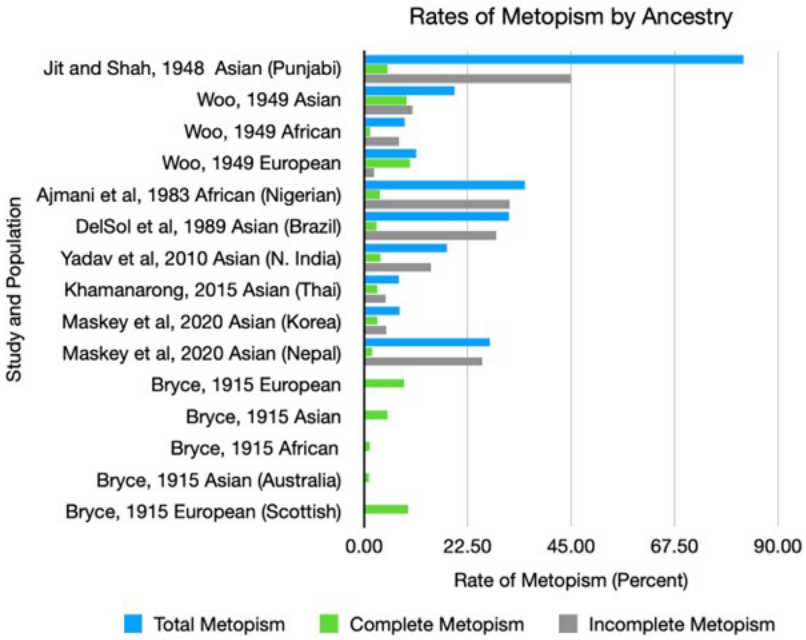

Figure 2. Rates of metopism by ancestry, according to eight studies.

A study by Vitek (2012) demonstrated how metopism rates changed in two American populations over time (Fig. 3). In historic European American samples, the rate was 5.5% and dropped in modern European American samples to 3.6%. In historic African American samples, the rate of metopism was 7.5% and dropped to 5.1% (Vitek 2012). This study is important as it shows how these rates can differ in forensically significant populations, as well as in different areas and populations of the world. For example, African American populations, in the studies reviewed, have a higher prevalence for metopism than African populations.

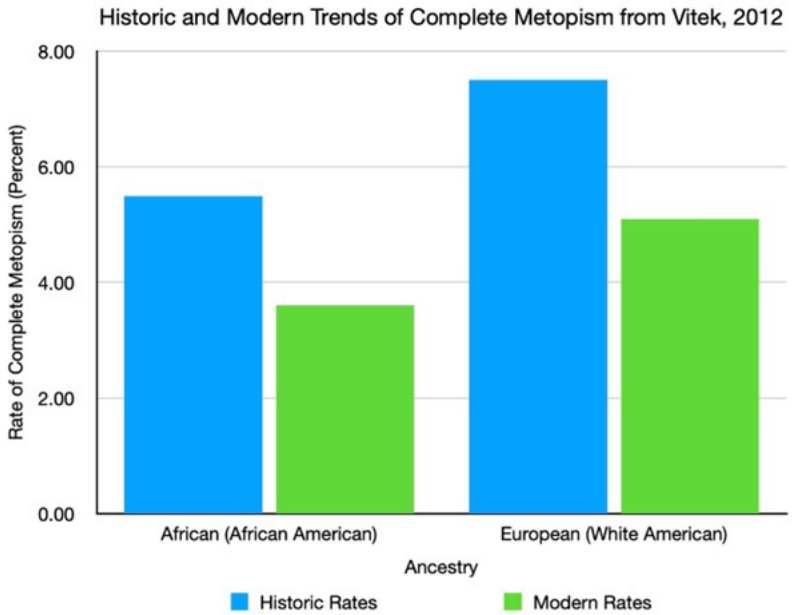

Figure 3. Historic and modern trends of complete metopism among African American and European American populations; based on the study by Vitek (2012).

There were also sex differences between males and females (Fig. 4) denoted in these three articles: Woo (1949), del Sol et al. (1989), and Khamanarong et al. (2015). Woo's study (1949) included twenty-three "Mongoloid" male and twenty-two female skulls. Fifteen of the males (65.2%) and six of the females (27.3%) exhibited complete metopism, while eight of the males (34.8%) and sixteen of the females (72.7%) exhibited incomplete metopism. Of the "American Negro" skulls, ten were male and eleven were female (Woo 1949). Two males (0.20%) and one female (9.09%) were classified as complete metopism, while eight males (80.0%) and ten females (90.9%) were described as exhibiting incomplete metopism. There were twenty "American White" male skulls and one female skull expressing metopism (Woo 1949). Seventeen of the males (85.0%) were classified as having complete metopism. Three males (15.0%) and the one female (100%) were described as exhibiting incomplete metopism. del Sol et al. (1989) studied 135 female skulls and 265 male skulls of Brazilian individuals. Of the females, four showed complete metopism (2.96%) and twenty-seven (0.20%) showed incomplete metopism. Seven males (2.64%) exhibited complete metopism and eighty-eight (33.2%) had an incomplete expression of the trait. The study by Khamanarong et al. (2015) included twenty-nine female skulls and twenty-nine male skulls of Thai individuals. Nine females (31.0%) were classified as having complete metopism and 15 (51.7) as incomplete expression of the trait. Of the males, eleven (37.9%) expressed metopism completely, while eighteen (62.1%) had an incomplete metopic expression.

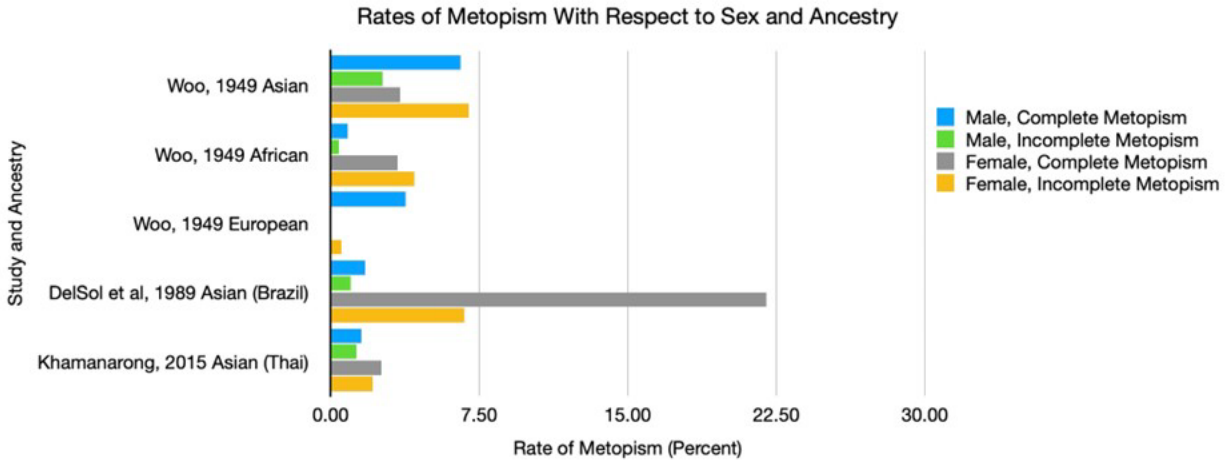

Figure 4. Rates of metopism in relation to sex and ancestry; based on the studies by Woo (1949), DelSol et al (1989), and Khamanarong (2015).

Discussion and Conclusion

Per the majority of the twelve reviewed articles, there is consensus with Hanihara and Ishida (2001) that the rates of metopism are highest among populations with European and Asian ancestries. The exception to this, though, is Vitek's (2012) study, which demonstrated that it cannot be accepted as fact that simply having a European ancestry indicates a higher prevalence of metopism while having African ancestry is indicative of a lower rate. The population history of modern populations – such as their migration paths and history of interactions with other groups – must be considered as this information can explain why there are differences in prevalence rates. For example, there was an 1.9% increase in the United States between the 2010 and 2020 Census results of individuals reporting their social race as "White only or in combination" with another race and an 11.7% increase in individuals reporting their social race as "Black or African American only or in combination" with another race (Census.gov). These changes can provide insight as to why previously observed patterns in phenotypic traits may shift over time, while also serving to remind anthropological researchers to utilize appropriate collections and data for the questions they are trying to answer. As additional modern populations continue to be examined for metopism, the utility of this trait can be explored further

for its use in conjunction with other non-metric cranial and dental traits in ancestry estimation. Metopism continues to be an important trait in bioarchaeological contexts as it has known patterns of prevalence that could assist with population affinity. As previously mentioned, it is also helpful to understand the prevalence of metopism for clinical settings, as it is important to be aware of the persistence of the metopic suture as it may be confused for the sagittal suture or even a cranial fracture (Ajmani et al. 1983; del Sol et al. 1989; Hauser et al. 1991). There is still work to be done exploring the genetic underpinnings of the metopic suture and its failure to close in some populations. The trait shows clinal variation across Europe and Asia indicating that metopism may have some heritability among these populations, though there has been no clear evidence indicating what the genetic or environmental components of this heritability may be. As this trait is examined in modern groups, though, the genetic underpinnings should continue to be explored as there is an ongoing shift within forensic anthropology to ensure that ancestry estimation methodologies do not rely on typological traits, but those grounded in genetic differences among populations (Bethard and DiGangi 2020). The retention of the metopic suture, regardless of this uncertainty, is still a fascinating trait to explore the prevalence of in populations both past and present for its utility in both anthropological and clinical settings.

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