Age Estimation Of Ancient Skeletons Based On The Molar Teeth Attrition

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ABSTRACT

Background: *Two ancient skeletons (Subang Men) were excavated at the Subanglarang site, Subang Regency, West Java, Indonesia. The partial jaw containing set of teeth from the two skeletons was examined to determine the level of dental attrition present which was then used to estimate age at death.*
Objective: *The aim of this study was therefore to determine the pattern of attrition on the molar teeth and use this to estimate the age at death of the Subang Men.*
Methods: *The pattern of attrition in each cusp of the first molar (M1) and second molar (M2) was examined clinically and then compared with the Average Stage of Attrition (ASA) method. Estimated age was then estimated using formulas that are outlined in the Average Stage of Attrition (ASA) method.*
Results: ***T****he results showed that the level of attrition that occurred in the M1 and M2 teeth of the two ancient men was significant. The estimated age at death calculated based on the attrition pattern of molar teeth for skeleton 1 was 38.9 and skeleton 2 was 61.9-64.6.*
Conclusion: *Dental attrition which is caused by physiologic and pathologic teeth friction is related to age. Therefore, age estimation can be determined based on the attrition pattern that occurs in the teeth.*

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INTRODUCTION

Human skeletons from the paleo metallic era were excavated at the Subang Larang Site in Subang Regency, West Java, Indonesia. Archaeological excavations were carried out in 2016 by the West Java Archaeological Center led by one of the authors (LY). This excavation resulted in the discovery of several artifacts in the form of fragments of pottery, beads, several fragments of pig's teeth as well as two human skeletons.[1] Further excavation was carried out in 2018 and a further three human skeletons were found. These skeletons are commonly referred to as Subang Men. There were some dental remains on two of the five skeletons. One of the authors (LY) conducted a carbon dating process that resulted in an estimated age for the human skeletons of 45 BC.

Dental remains can be used to examine health conditions and diseases that occurred among ancient man.[2] Examination of the Subang Men, dentition revealed the presence of dental wear.[2] Dental wear is a general term that describes the loss of hard tissue from the tooth surface caused by factors other than dental caries, trauma, and developmental disorders. Dental wear can be divided into three categories; attrition, abrasion, and erosion.[3] Dental attrition is the loss of tooth hard tissue caused by contact between teeth and associated with chewing movements.[3,4]

Examination of human remains can also be used to obtain information about their biological profiles such as sex, age, height, and ancestry.[5] Age is an important thing to establish when seeking to reveal a person's identity. Age estimation of human skeletal remains can be made using dental and non-dental methods.[6] Teeth are one of the tools that can be relied on in the process of identifying age and are often preferred over skeletal analysis as they are less influenced by environmental factors. In the developmental period, the stage of tooth development is considered as an accurate indicator of biological age. Once adulthood is reached, another way to estimate the age from the dentition is by considering the attrition that occurs in the teeth.[5,7] Ji and Li (1995) made a new method called Average Stage of Attrition (ASA). The Average Stage of Attriton (ASA) method provides an estimated age of death using dental attrition patterns on the first and second molar, either maxillary or mandibular, regardless of sex. The aim of the study was to estimate the age of the Subang Men based on the pattern of attrition that occurs in molar teeth using the Average Stage of Attrition (ASA) method.

LITERATURE REVIEW

Age estimation holds significant importance in medical forensics and odontology, particularly in identifying deceased victims and assisting in crime and accident investigations. It plays a crucial role in reconstructing the biological profile of human skeletal remains. Estimating age at death, along with determining the sex of the victim, serves as a pivotal guide in the identification process. Teeth stand out as one of the most dependable tools in age identification.[8] Teeth have the advantage of being resistant to high temperatures, making them very useful in identifying burn victims. This is due to the minimal amount of organic tissue they contain. Teeth are resistant to external influences and undergo minimal biological changes, making them suitable for identification. Furthermore, teeth serve as a means of identification because they are the hardest part of the human body.[9] The stage of tooth development proves to be a reliable indicator for estimating age.

Age estimation can be performed using both dental and non-dental methods. Non-dental estimation measurements can be conducted using skeletal parts such as pubic bones, long bones, skull sutures, costal cartilages, and laryngeal cartilages. Dental age estimation methods are divided into those applicable to children and adults.[6,8] Techniques for determining age estimation in adults are generally categorized into three categories: morphological methods, radiological methods, and destructive methods.[6,10] After the development of most teeth has ceased, this period provides an opportunity for age estimation in adults. Visual examination can assess the presence of tooth wear; these nondestructive methods have become popular due to their applicability in both living and deceased individuals, as well as in archaeological studies or certain legal contexts that prohibit the collection of tissue from human remains. They make use of dental radiographs, thereby eliminating the need to extract or section teeth. The size of the dental pulp cavity decreases as a result of secondary dentin deposition, and measuring this reduction can be used as an indicator of age. Destructive techniques are less likely to be applied to living individuals because they require sacrifices of vital teeth, but in some situations, individuals may be willing to sacrifice their teeth to use this technique.[6,10]

Tooth wear is defined as the condition characterized by the loss of hard tooth tissue surface, which occurs due to factors other than dental caries, trauma, and developmental disorders. Tooth wear can be classified into four types: attrition, abrasion, erosion, and abfraction.[11] Erosion involves the loss of hard tooth tissue due to the influence of acids, either intrinsically or extrinsically. Abrasion is the loss of hard tooth tissue surface that occurs due to a mechanical process. Abfraction is the loss of hard tooth tissue at the cemento-enamel junction due to occlusal pressure, which causes stress on the cervical part. Attrition is the loss of tooth surface structure due to contact between teeth and opposing teeth.[4] Dental wear provides valuable insights into various aspects of prehistoric human habits. Dental attrition, in particular, can offer information about diet, food preparation techniques, and habits impacting teeth. It also serves as a significant indicator of age structure in prehistoric populations. Given that prehistoric humans predominantly consumed coarse foods containing gravel, tooth wear was accelerated, resulting in a clear correlation between age and the degree of attrition. Conversely, in modern humans, the relationship between attrition and age is less discernible due to the prevalence of smoother-textured foods that are less abrasive, thereby obscuring the influence of age.[12,13]

Tooth wear has been used by many researchers to estimate chronological age with varying degrees of success. Occlusal tooth wear has been a characteristic feature of adult teeth throughout time. The attrition rate is closely related to diet, especially the food preparation process. The severity of tooth wear that occurs is proportional to a person's age, but the degree of wear varies greatly between cultures.[12,14] Murphy (1959) was one of the first to develop a method for assessing attrition through the morphology of each type of tooth and creating its scale. The research conducted by Murphy (1959) on the Aboriginal population of Australia yielded positive results for that population but did not correlate well when applied to other population groups. There are many factors that can influence the level of attrition in a population, especially differences in populations geographically and culturally, including the number of teeth, angulation, size and position, bruxism, size and shape of the mandibular condyle, presence of dental restorations, habitual factors such as pipe smoking or toothpick biting, and diet. Tooth wear is related to the variability of populations that can affect differences in the patterns of attrition that occur. Therefore, Miles (1963) developed a method from archaeological samples that could be used for various populations. Miles hypothesized that tooth wear occurs continuously throughout the

functional life of the teeth, attrition occurring on the third permanent molars has similar levels and patterns, and the relationship between attrition and diet is the same in various populations. The level of attrition can then be assessed, and age estimation can be determined.[6] In 1965, Brothwell simplified Miles's method by basing the assessment on the extent of wear by examining the remaining dentin pattern on the occlusal surface.[15] Smith (1984) modified Murphy's original method, producing a diagram and description of eight stages of attrition for comparison. Stage one with little or no wear and progressing to stage eight, where the crown is completely worn.[16] A comparable but more detailed scale was developed by Lovejoy (1985).[17] Most age estimation measurements through tooth wear are conducted on prehistoric humans.

Li and Ji have developed a new method for age estimation using permanent molar teeth called the Average Stage of Attrition (ASA) method. The Average Stage of Attrition (ASA) method provides an estimation of age at death from just one molar, either M1 or M2, regardless of whether it's in the upper or lower jaw, without distinguishing between sexes. Research findings indicate that the Average Stage of Attrition (ASA) method can reflect the condition of attrition across the entire occlusal surface more objectively than some methods using tooth attrition, as the attrition levels are estimated by averaging the attrition stages of all cusps rather than just one or some cusps. The final measurement results using this method are the average attrition on all first and second molar cusps, which have been determined for their attrition levels on each cusp. The average attrition stage obtained from each cusp is then determined, and the average attrition stage, or Average Stage of Attrition (ASA), is then entered into the formula developed by Li and Ji to obtain the estimated age at death.[18]

METHODS

The samples used in this study were human teeth excavated from the Subang Larang Site in Subang Regency, West Java, Indonesia. The dental remains had an intact shape and were measurable. Skeleton 1 possessed the left mandibular second molar (47) and Skeleton 2 possessed the right maxillary first molar and second molar (16 and 17). The crown height was measured in each molars and then compared to the modern humans.

First molar (M1) and second molar (M2) were used to determine the estimated age based on the level of attrition that had occurred on the occlusal surface of the molar. The attrition of the remaining teeth was assessed using the Average Stage of Attrition (ASA) method found by Ji and Li (1995) where there are 10 stages that can be measured based on the amount of hard tooth tissue eroded on the occlusal part of M1 or M2 tooth. Each cusp of the tooth was assigned an attrition stage, then the results were added and divided by the number of cusps exist to provide an overall score for tooth attrition.[18] The attrition stage based on the Average Stage of Attrition (ASA) method is divided into 10 stages.[18] Stage 0-7 describes the dental wear that occurs on each tooth cusp.[18] Stages 8 and 9 describe the dental wear that occurs throughout the tooth cusp.[18] The assessment of the attrition stage assessed from each cusp was averaged for each tooth. The attrition stage was assessed by two independent raters, with one rater conducting assessments twice with a one-week interval. The average stage of attrition (ASA) obtained was then entered into the formula made by Ji and Li (1995) to obtain the estimated age at death.

RESULTS

Figure 1 shows the right mandibular second molar of skeleton 1 which was found separated from the mandible. The crown of the tooth was still intact, and the root part of the tooth could not be visualized as it was covered by mineral deposits that were attached to the tooth. Figure 2 shows the right maxillary first molar and second molar from skeleton 2 which are in situ with the first premolar, second premolar, and third molar in a fragmentary portion of the maxillary bone.

Despite being buried in the ground for an extremely extended period, three permanent molars remained in good condition. The crown heights of Subang Men were relatively shorter than those of the modern humans (Table 1). The assessment focused on four cusps from each molar to determine their stage of attrition, leading to the calculation of an Average Stage of Attrition value. Subsequently, these calculated values were inputted into the respective formulas to estimate the ages, resulting in an estimated age of 38.9 years for skeleton 1 and 61.9-64.6 years for skeleton 2 (Table 2-3).

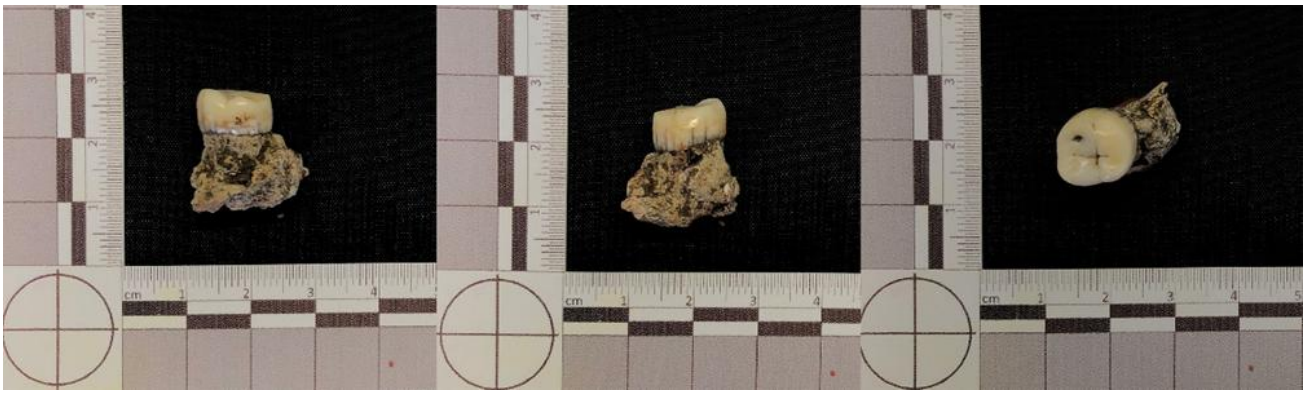

Figure 1. The right mandibular second molar (47) of ancient man (i) (left: buccal view, middle: lingual view, right: occlusal view)

Figure 2. The right maxillary first molar and second molar (16 and 17) of ancient man (ii) (left: buccal view, middle: lingual view, right: occlusal view)

Table 1. Crown height comparison between skeleton 1 and 2 with modern human

Skeleton	Tooth	Crown height of Subang Man (mm)	Crown height of modern human (mm)[19]	Difference (mm)
1	**47**	**5,37**	**7**	**1,63**

2	**16**	**4,72**	**7,5**	**2,78**
	17	**5,92**	**7**	**1,08**

Table 2. Dental attrition stage of skeleton 1 and skeleton 2

Skeleton	Tooth	Cusp	Attrition Stage			Average Stage of Attrition (ASA)
			Intra-observer		Inter-observer	
			Observer 1	Observer 1	Observer 2	
1	47	mesiobuccal	4	4	5	3.25
		mesiolingual	3	4	4	
		distobuccal	4	4	4	
		distolingual	2	2	2	
2	16	mesiobuccal	8	8	8	8
		mesiopalatal	8	8	8	
		distobuccal	8	8	8	
		distopalatal	8	8	8	
	17	mesiobuccal	7	7	7	6.75
		mesiopalatal	7	7	7	
		distobuccal	6	6	6	
		distopalatal	7	7	7	
Overall agreement			91,7%		83,33%	

Table 3. Age estimation of skeleton 1 and 2

Skeleton	Tooth	ASA	Formula[18]		Age estimation
1	47	3.25	Y = 15.31 + 7.27M_2	Y = 15.31 + 7.27(3,25)	38.9
2	16	8	Y = 11.42 + 6.32M_1	Y = 11.42 + 6.32(8)	61.9
	17	6,75	Y = 14.44 + 7.44M_2	Y = 14.44 + 7.44(6.75)	64.6
			Y = 12.23 + 4.11M_1 + 2.75M_2	Y = 12.23 + 4.11(8) + 2.75(6.75)	63.6

$\boldsymbol{M_1}$: Average Stage of Attrition (ASA) on M1 tooth
$\boldsymbol{M_2}$: Average Stage of Attrition (ASA) on M2 tooth

DISCUSSION

The results of the dental analysis from the Subang Men showed that there was attrition in the occlusal parts of the first and second molars of skeleton 1 and 2. The attrition stage of the right maxillary first molar (16) of skeleton 2 was higher than the attrition stage of right maxillary second molar (17). This can be related to the eruption time of the teeth so that the first molars are the teeth that function first. Tooth attrition patterns are associated with certain populations.[2,20] There are several factors that can influence tooth attrition patterns, including habits, environment, diet, type of food intake, method of chewing, and the method of preparation of food.[21,22] Populations with a diet consisting of abrasive, unprocessed foods may exhibit increased levels of attrition.[22] Therefore, the attrition pattern in each population is different and can be related to specific cultural practices in different populations.

The dental analysis of the Subang Men yielded results indicating attrition in the occlusal regions of the first and second molars in Skeletons 1 and 2. Notably, the attrition stage observed in the right maxillary first molar (16) of Skeleton 2 exceeded that of the right maxillary second molar (17). This disparity can be linked to the eruption sequence of these teeth, with first molars typically assuming functional roles ahead of second molars. It's crucial to recognize that tooth attrition patterns exhibit associations with specific populations.[2,20] Multiple factors contribute to these patterns, encompassing habits, environmental conditions, dietary practices, the nature of consumed foods, and chewing methods.[21] Consequently, each population tends to exhibit unique attrition patterns that can be attributed to distinct cultural practices within their respective communities.

The prehistoric Subang Man population primarily consumed foods characterized by their large, hard, and coarse nature, often containing sand and gravel residues. Despite utilizing fire in food processing, their techniques were notably less advanced than those of modern humans, as documented by Yondri (2020). They relied on rudimentary tools, namely fragments of animal bones, and, interestingly, still employed their teeth as auxiliary tools, a practice elucidated by Molnar (2011).

Dental wear on the occlusal surfaces of teeth represents a physiological condition linked to age, and this has prompted the development of various methods for age estimation.[15] Age estimation for Subang Man was conducted employing the ASA method, given the availability of the first and second molars in Skeleton 2 and the second molars in Skeleton 1. Notably, the ASA method offers the advantage of being non-destructive, preserving tooth integrity, and circumventing costs associated with radiographic examination, making it amenable for field applications.

The observation of low levels of caries in the molars of Subang men suggests a minimal to zero exposure to harmful sugars during the period under study. This finding underscores the potential importance of dietary habits and oral hygiene practices prevalent during that time. However, it is essential to consider the broader context of food processing techniques or the lack thereof in this population. The absence of advanced food processing methods could have led to the consumption of gritty or tough foods, which might have contributed to the high levels of attrition observed in the molars. This presents a potential confounding factor that warrants further investigation to better understand the interplay between diet, dental health, and cultural practices in the Subang population. Addressing these factors is crucial for obtaining a comprehensive understanding of oral health patterns and their underlying determinants in this context.

However, it's worth noting that findings from the Average Stage of Attrition (ASA) method suggest that modern humans have adopted a more refined diet compared to their ancient counterparts. Consequently, age

estimation for ancient individuals utilizing tooth attrition methods designed for modern humans may yield overestimations of age. Additionally, this method may not fully account for potential pathological factors contributing to attrition levels.

The presence of several skeletons at the Subang Larang site awaiting exhumation presents an exciting opportunity for future research. One particularly intriguing aspect of this investigation will be the examination of the dental conditions of these individuals in relation to their anthropological characteristics. Teeth offer valuable insights into an individual's diet, lifestyle, and overall health throughout their lifetime. By analyzing dental features such as caries, attrition, and enamel hypoplasia, researchers can gain a deeper understanding of the dietary habits, oral hygiene practices, and potential health challenges faced by the Subang Larang population. Additionally, comparing dental characteristics among individuals of different ages, genders, and socio-economic statuses can shed light on broader patterns of health and social dynamics within this ancient community. Overall, the forthcoming research promises to enrich our understanding of the lives and experiences of the people who once inhabited the Subang Larang site.

The successful exploration of the Subang Larang site and the comprehensive analysis of the skeletons unearthed will undoubtedly require collaborative efforts between established researchers in the field and local experts. This collaboration is essential for enriching the interpretation of findings and providing a deeper understanding of the historical and cultural context surrounding the site. Local experts possess invaluable knowledge of regional history, traditions, and practices, which can offer crucial insights into the lives and experiences of the individuals whose remains are being studied. By combining the expertise of established researchers with the insights of local experts, the research efforts can effectively bridge the gap between academic inquiry and lived experiences, thus bringing greater context and authenticity to the exploration of the past. Ultimately, this collaborative approach serves as a vital step in unraveling the mysteries of dental and oral health history and contributing to a more informed and nuanced understanding of the past for the betterment of future generations' dental and oral health.

CONCLUSION

Notably, the choice to utilize the Average Stage of Attrition (ASA) approach for Subang Man's age estimation was influenced by the presence of intact first and second molars. The user-friendly nature of the ASA method is evident, although it's important to recognize its association with distinct population patterns in dental attrition.

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