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RACE DETERMINATION FROM METRIC AND NON-METRIC METHODS IN CRANIUM

(PENENTUAN RAS DARI METODE METRIK DAN NON-METRIK PADA KRANIUM)

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ABSTRACT

Race or ancestry estimation plays a crucial role in forensic anthropology for identifying unknown individuals through skeletal analysis. The cranium, as the most diagnostic part of the skeleton, provides essential morphological indicators that vary among racial groups. This literature review aims to summarize current findings on race determination using both metric and non-metric methods of the cranium. Metric analysis relies on quantitative anthropometric measurements such as cephalic and nasal indices, while non-metric analysis focuses on morphological traits including nasal aperture shape, zygomatic arch prominence, palatal form, and the presence of torus palatinus. Various studies indicate that combining both methods yields more reliable results compared to using either alone. Although no single cranial feature can definitively determine race, a combination of multiple cranial and dental traits enhances the accuracy of ancestry estimation. Repeated measurements and observer agreement are necessary to minimize subjective bias and improve forensic reliability. This article review will describe race determination from the cranium in the odontology field.

Keywords: forensic anthropology; race determination; metric analysis;

non-metric traits

ABSTRAK

Penentuan ras atau asal keturunan memainkan peran penting dalam antropologi forensik untuk mengidentifikasi individu yang tidak dikenal melalui analisis skeletal. Kranium, sebagai bagian skeletal yang paling banyak digunakan untuk diagnosis, memiliki indikator morfologis yang bervariasi di berbagai kelompok ras. Tinjauan literatur ini bertujuan untuk merangkum temuan terkini mengenai penentuan ras menggunakan metode metrik dan non-metrik pada kranium. Analisis metrik bergantung pada pengukuran antropometri kuantitatif seperti indeks sefalik dan hidung, sementara analisis non-metrik berfokus pada ciri morfologis termasuk bentuk apertura hidung, tonjolan arkus zigomatikus, bentuk palatum, dan keberadaan torus palatinus. Berbagai studi menunjukkan bahwa menggabungkan kedua metode menghasilkan hasil yang lebih akurat dibandingkan menggunakan salah satunya saja. Meskipun tidak ada satu pun karakteristik kranial yang dapat menentukan ras secara meyakinkan, kombinasi beberapa karakteristik kranial dan dental meningkatkan akurasi estimasi keturunan. Pengukuran berulang dan kesepakatan pengamat diperlukan untuk meminimalkan bias subjektif dan meningkatkan keandalan forensik.

***Kata kunci**: antropologi forensik; penentuan ras; analisis metrik; ciri-ciri non-metrik;*

INTRODUCTION

A collection of identified human skeletal remains is crucial for determining the estimated sex, age at death, race or ethnicity in the field of forensic anthropology. Forensic anthropology requires ante mortem data to be matched with postmortem data to reconstruct the body before death. In political, social and economic aspects, race or ethnicity is an important factor in identifying unidentified bodies.[1]

The terms "race" and "ethnicity" can be used alternatively. The term ‘race’ is used when discussing the history of the concept or when referring to the

classification of human groups, both from a biological and social perspective. The term ‘ethnicity’ is used to refer to modern thinking about human variation. In addition, the term ‘-oid’ (i.e., Caucasoid, Mongoloid, and Negroid) refers to a specific purpose. When talking about current ancestry estimates, the terms that are currently popular are "European," "Asian," and "African," because these terms specifically refer to the main geographical regions of origin, rather than to taxonomic classifications that have social significance.[2]

Race or ethnicity can be identified using metric and non-metric analysis methods. Metric analysis involves anthropometric measurements of the skull or soft tissue, while non-metric analysis involves observation or examination focused on the characteristics of the skull or soft tissue.[2]

Careful examination of physical, skeletal and dental structures can support the determination of an individual's race; it is impossible to determine anatomical characteristics that are exclusive to a particular race. Skin, hair, head shape, facial type, eyes, nasal bone size, and teeth are considered distinguishing features in racial studies. However, racial characteristics are not diagnostic features; they are considered supporting factors in determining an individual's racial origin. Orofacial and dental features are crucial in determining racial type or ancestry.[3]

METHOD

Measurement Methods

Racial identification methods can be carried out in two ways, namely non-metric and metric. Researchers such as Chevraud et al. and Bennett Howells use non-metric methods for analysis because they require less equipment and can be carried out relatively quickly. Other researchers, such as Gilbert and Gill, Fisher and Gill, prefer metric analysis. According to Chevraud et al., both metric and non-metric analyses tend to show similar results when determining race or ancestry. To obtain specific results, several methods are needed to identify the race or ancestry of an individual.[4]

Non-metric Measurement

Race determination can be determined using anthroposcopic, or non-metric, methods. Many physical characteristics found in the skull can be analysed non-metrically to assess an individual's race. When attempting to identify a person's race, most anthropological methods tend to focus on the craniofacial region of the skull. The best features for determining race tend to be

found in and around the nose and oral features.[4]

Cranium Shape

The Caucasoid cranium is tall, narrow and high. The sagittal profile is rounded and shows a slightly sloping forehead compared to the Negroid or Mongoloid cranium. The Caucasoid race also has a rounded occipital profile.[4,5]

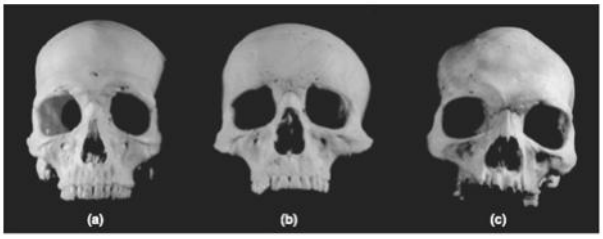


Figure 1. Cranium shape can be assessed from the frontal view. a. Kaucasoid, b. Mongoloid, c. Negroid[5]

The Mongoloid skull is long in shape but often appears rounded rather than elongated. The Mongoloid skull is broad and of medium height, falling between the tall Caucasoid skull and the low Negroid skull. The occipital profile appears angular. The sagittal profile is curved due to a 'curve' in the surface of the skull.[4,5]

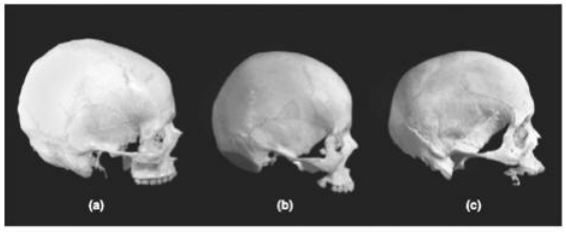


Figure 2. Lateral cranium aspect from race differences. a. Kaukasoid, b. Mongoloid, c. Negroid[5]

The Negroid skull is elongated, narrow, and short. The sagittal profile is flat, and the occipital protuberance is quite rounded. The uneven surface on the sagittal section is caused by a post-bregmatic depression, which is a characteristic often found in Negroid skulls.[4,5]

Orbita Foramen

In Caucasians, the orbital foramen is square in shape with curved corners. In Mongoloids, the orbital foramen tends to be rounded with blunt corners on all sides. In Negroid individuals, the orbital foramen is square or rectangular in shape with more pronounced corners than in Caucasians.[6]

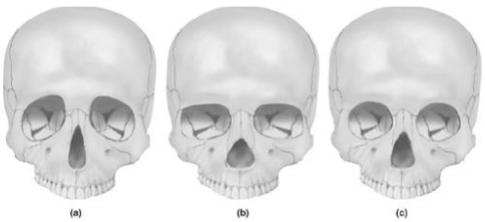


Figure 3. Foramen orbita shape. a. ras kaukasoid, b. ras mongoloid c. ras negroid [5]

Nasal

The nasal foramen of Caucasoids tend to be longer and narrower. In Mongoloids, the nasal foramen tends to be wider and shorter than in Caucasoids and has a heart-shaped nasal foramen. In Negroid races, the nasal foramen is short, wide and round.[4,5]

Figure 4. Foramen nasal shape from left to right as Kaukasoid, Mongoloid and Negroid.[5]

The nasal spine is a bony protrusion at the bottom of the nasal cavity. In Caucasians, the nasal spine is prominent. In Mongoloids, the nasal spine tends to be smaller. And in Negroid races, the nasal spine is smoother and blunter.[4,5]

Figure 5. Nasal spine from left to right as Kaukasoid, Mongoloid and Negroid.[5]

Hefner and Ousley, in their 2014 study, introduced a method known as Optimised Summed Scored Attributes (OSSA). This method groups individuals into black and white groups based on specific anatomical points. The anatomical points used are the anterior nasal spine, width of the nasal aperture, inferior nasal aperture, contour of the nasal bone, interorbital width, and postbregma depression, which can be seen in figure 6-11.[7]

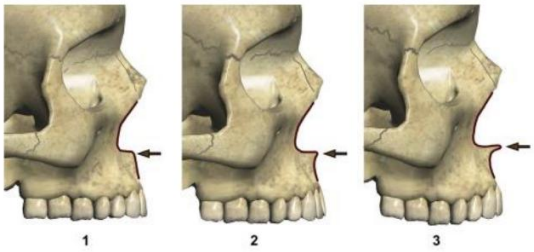


Figure 6. Anterior nasal spine.[7]

Figure 7. Width of the nasal aperture.[7]

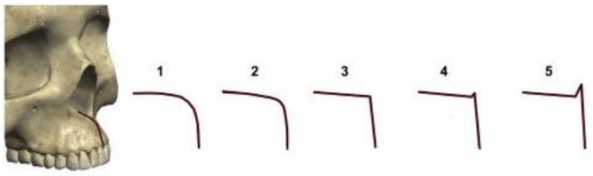


Figure 8. Inferior nasal aperture.[7]

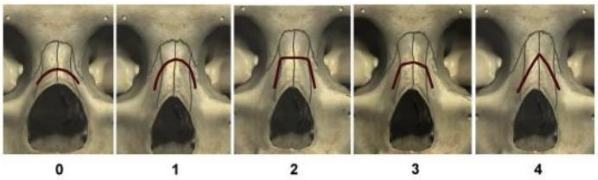


Figure 9. Nasal bone contour.[7]

Figure 10. Interorbita width.[7]

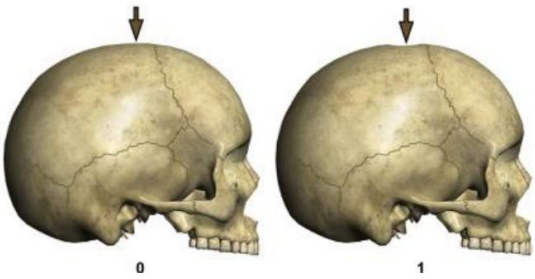


Figure 11. Postbregmatic depression.[7]

The scores that have been recorded will then be added up and interpreted. If the total score is greater than 3, the measurement results indicate that the individual is of the Caucasian race or descent. If the measurement results indicate a score of less than 3, then the individual is of African race or descent. In scoring, it is necessary to obtain the opinions of other researchers to obtain optimal results.[7]

Zygomatic Arch

The zygomatic arch is the bone that runs between the cheekbone and the ear. In Caucasians, the zygomatic arch tends to be shorter. In Mongoloids, the zygomatic arch tends to be wider, and in Negroid races, the zygomatic arch is more pronounced than in the other two races.[4,8,9]

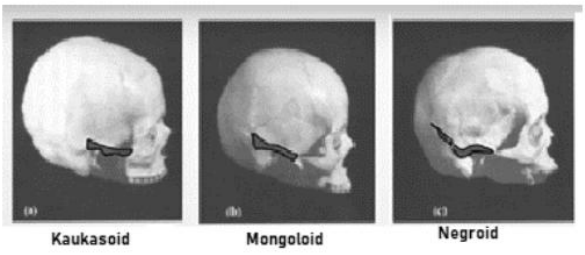


Figure 12.Zygomatic arch from Caucasoid, Mongoloid and Negroid.[9]

Frontal and Lateral Aspect

When viewed from the front and side, the Mongoloid race has an orthognathic facial profile with a moderate nasal spine. The zygomatic bone is more prominent with tubercles at the lower edge of the zygomatic bone. The Mongoloid race sometimes has edge-to-edge occlusion.[8]

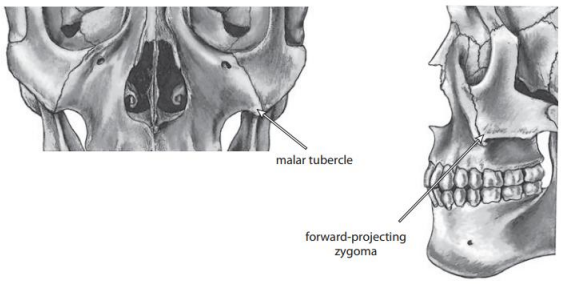


Figure 13. Frontal and lateral aspect of Mongoloid cranium[8]

The Caucasoid race has an orthognathic facial profile with a prominent nasal spine. The angular nasal aperture is accompanied by a single, sharp nasal margin. The Caucasoid race has crowded teeth and an overbite.[8]

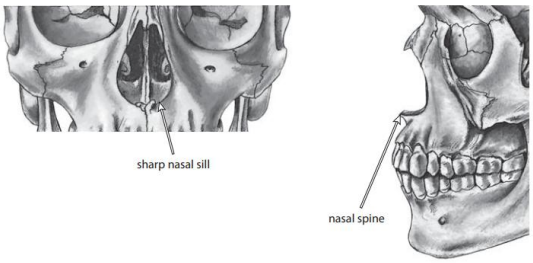


Figure 14. Frontal and lateral aspect from Caukasoid cranium.[8]

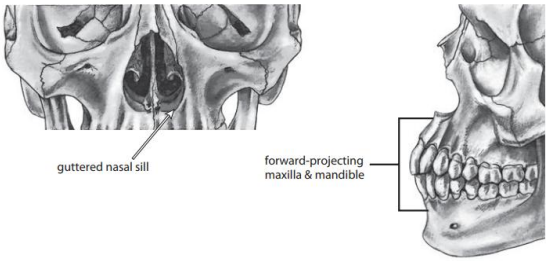


Figure 15. Frontal and lateral aspect from Negroid cranium.[8]

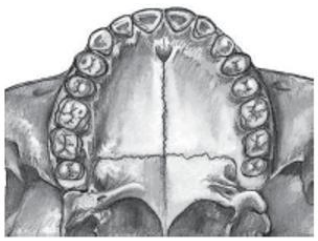
The Negroid race has a prognathic facial profile. The nasal spine is small and

barely visible. The nasal aperture is large and wide, accompanied by double nasal margins at the bottom. The Negroid race generally has teeth that are not crowded.[8,9]

Palatum

The palatum is one of the anatomical parts that describes the facial traits of each individual to determine race/ancestry. Distinctive features on the palatum can be observed and assessed quickly, without calculation/measurement. Features on the palatal part reflect differences in facial traits. Thus, it is very important to examine the palatum.[8]

In the Mongoloid race, the palate is broad, rounded and horseshoe-shaped. It has a straight palatal suture. In the Caucasoid race, it is more pointed. The palate curve is parabolic with an irregular palatal suture. In the Negroid race, the palate is broad and arched. The shape of the palate is more U-shaped than in the Caucasoid and Mongoloid races. The palatal suture is not straight but tends to be curved.[5,8]



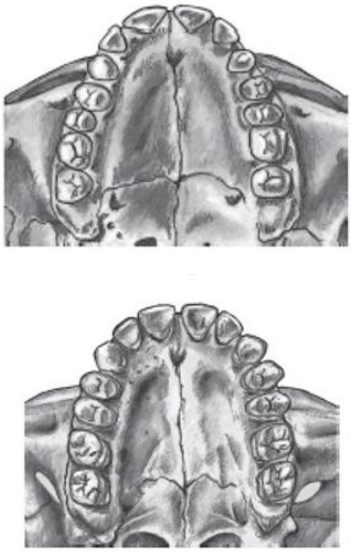


Figure 16. Palatum shape from left to the right Mongoloid, Caucasoid and Negroid[8]

In the palate region, in addition to its shape, the presence of a palatal torus can also be examined. A palatal torus is a bony protrusion or exostosis located in the posterior part of the hard palate. The exact cause of the torus is unclear. The most widely accepted theory at present is genetic. However, it does not always show the autosomal dominant nature of its appearance. Other causes include superficial injury or its appearance as a functional response in individuals with well-developed chewing muscles, or in patients with teeth that are worn down due to occlusion.[8]

Metric Measurement

To examine human differences more closely, anthropologists have created indices, one of which is the cephalic index

and the nasal index. An index is a number used as an indicator to explain a particular condition or a proportional ratio that can be inferred from a series of continuous observations.[7]

Cephalic Index

Metric measurement methods have been used since around 1900's. For more than 150 years, cranial indices and cephalic indices have been used as tools to study human variation and to classify individuals into races or ethnicities. The cranial index or cephalic index is defined as the width of the skull divided by the length of the skull multiplied by 100. The cephalic index is measured and calculated based on the skull directly.[5]

Cephalic index measurements are classified in a table. Dolichocephaly (long skull) with a cephalic index of 70-75 is typically found in Caucasians and Negroid races. Mesocephaly (medium skull) with a cephalic index of 75-80 is typically found in Caucasians and Mongoloids. Brachycephaly (short skull) with a cephalic index of 80-85 is typically found in Mongoloid.[9]

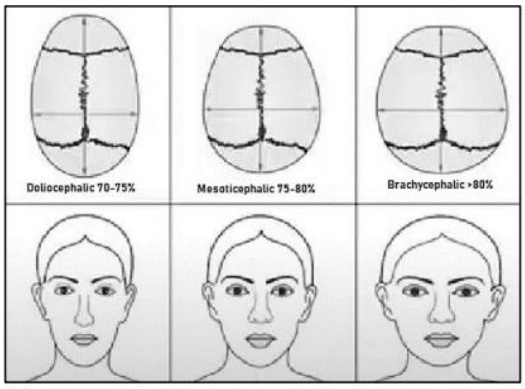


Figure 17. cranium shape from cephalic index measurement.[9]

Nasal Indeks

The nasal index is an index obtained by calculating the ratio between the width of the nose and the length of the nose multiplied by 100. This index describes the shape of the nose. The nasal index can be used to help determine a particular race or ethnicity. Measurements to be taken: 1. Nose height, which is the distance between the nasion (n) and subnasal (sn); 2. Nose width, which is the distance between the right and left alae, is measured in millimetres (mm) using a sliding calliper. [10]

Measurements were taken in the Frankfort plane with the subject in an upright sitting position and a comfortable sitting position. More than one measurement was required for hyperleptorine, lepthorine, mesorhine, platyrrhine, hyperplatyrhine, [10]

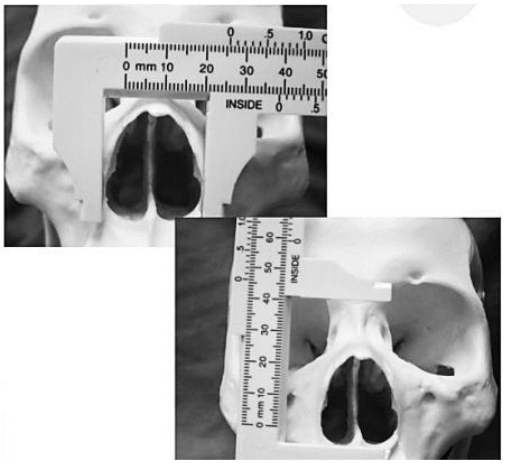


Figure 18. Nasal index measurement using a sliding calliper.[9]

Anatomical Landmark Point

Race/ancestry can be determined based on anatomical points on the skull. Byers presents several anatomical points that can be used as a reference for determining the race/ancestry of an individual in the table 1.[8]

Table 1. Anatomical landmark point

No.	Abbrv	Landmark	First point	End Point
1.	**GOL**	Maximum cranium height	Glabella (g)	Opisthocranion (op)
2.	**XCB**	Maximum cranium width	Euryon (eu)	Euryon (eu)
3.	**ZYB**	Byzigomatic width	Zygion (zy)	Zygion (zy)
4.	**BBH**	Maximum cranium point (basion-bregma length)	Basion (ba)	Bregma (b)
5.	**BNL**	Basis cranium length	Basion (ba)	Nasion (n)
6.	**BPL**	Basion-prosthion length	Basion (ba)	Prosthion (pr)
7.	**MAB**	Maksilo-alveolar width	Ectomolare (ecm)	Ectomolare (ecm)
8.	**MAL**	Maksilo-alveolar length	Prosthion (pr)	Alveolon (al)
9.	**AUB**	Bilateral width	Zygomatic processus	Zygomatic processus
10.	**UFHT**	Upper facial height	Nasion (n)	Prosthion (pr)
11.	**WFB**	Minimum frontal width	Frontotemporal (ft)	Frontotemporal (ft)
12.	**UFBR**	Upper facial width	Sutura frontozigomatikus	Sutura frontozigomatikus
13.	**NLH**	Nasal height	Nasion (n)	Nasospinalis (ns)
14.	**NLB**	Nasal width	Alare (al)	Alare (al)
15.	**OBB**	Orbital width	Dacryon (d)	Ectoconchion (ec)
16.	**OBH**	Orbital height	Superior margin	Inferior margin
17.	**EKB**	Biorbital width	Ectoconchion (ec)	Ectoconchion (ec)
18.	**DKB**	Interorbital width	Dacryon (d)	Dacryon (d)
19.	**FRC**	Frontal chord	Nasion (n)	Bregma (b)
20.	**PAC**	Parietal chord	Bregma (b)	Lambda (l)
21.	**OCC**	Occipital chord	Lambda (l)	Opisthion (o)
22.	**FOL**	Foramen magnum length	Opisthion (o)	Basion (ba)
23.	**FOB**	Foramen magnum width	Lateral end of the foramen magnum	Lateral end of the foramen magnum

24.	**MDH**	Mastoideus width	Porion	Mastoidale
25.	**ASB**	Biasteron width	Asterion	Asterion
26.	**ZMB**	Zygomaxillary width		
27.	**MOW**	Midorbital width		
28.	**Gn-id**	Chin height	Gnathion	Infradentale
29.		Foramen mental height		
30.		Foramen mental thickness		
31.	**cdl-cdl**	Bicondylus width	Condylion	Condylion
32	**Go-go**	Bigonial width	Gonion	Gonion
33.		Minimum ramus width		
34.		Maximum ramus height	Gonion	Superior condylar surface
35.		Mandibular width		
36.		Mandibular angle		

A mandibulometer is required to measure maximum ramus height, mandibular width and mandibular angle.[8]

DISCUSSION

Race or ethnicity can be identified using metric and non-metric analysis methods. Metric analysis involves anthropometric measurements of the skull or soft tissue, while non-metric analysis involves observation or examination focused on the characteristics of the skull or soft tissue. Non-metric determination is based solely on the observer's subjectivity, unlike metric measurements, which can be interpreted into numbers and categories. Metric measurements can be categorized into indices.[11]

Riza Rivani et al. measured the cephalic index in the Sundanese and Batak populations in Indonesia. In addition to race or ethnicity, this study also compared based on gender. The results showed that the head shape of Sunda men and women was hyperbrachycephalic, while Batak men and women were brachycephalic. These differences may be caused by complex interactions between genetic and environmental factors, race, ethnicity, tradition, nutrition, environment, climate influence, age changes, and eating habits.[12]

Research conducted by Marini et al. in 2020 on the Dayak Kenyah tribe population in Indonesia stated that the nasal morphology of the Dayak Kenyah tribe has a mesorhin nose shape. This study is in line with research conducted by Agus and I Putu in 2019, which showed that the average nasal index obtained in this study was 64.17 mm for women and 66.12 mm for men. This study is directly proportional to research on the Jingpo population in China, which shows that the dominant Mongoloid race has a mesorhin nasal shape. This is due to

similar geographical and climatic conditions.[12,13]

Similar results were revealed by Shah, who divided the research subjects into black and white races. The results showed that black people had the highest nasal index, followed by Asians and Latinos. White people had the lowest nasal index.[14]

In the oral cavity, the palate plays a role in determining an individual's race or ancestry. According to research conducted by El Sergani et al., individuals of African descent have a higher palatal depth, with the maximum depth located more posteriorly and have a wider and shorter palate. Meanwhile, individuals of European descent have a narrower and longer palate with the maximum palatal depth located more anteriorly. Individuals of East Asian descent show the shallowest palatal depth.[15]

In addition to palatal morphology, a bony protrusion commonly known as the palatine torus can be found. In Saudi Arabia, the prevalence of palatine and mandibular toruses is 17.59%. Of this number, 36.36% are in the 60-69 age group. In terms of gender, Saudi Arabian men are more dominant at 19%, compared to 15.94% in women. In addition, in terms of shape, the flat palatine torus is found at a percentage of 57.58%, while the bilateral solitary torus is the most common type of mandibular torus at a percentage of 39.76%.[16]

According to the results of the study, the palatine torus is commonly found in populations in Germany, Norway, Croatia, Thailand, and Malaysia. Mandibular torus is more commonly found in populations in Japan, Spain, and Ghana. In a study conducted by Reichart et al., they found a significant correlation between the occurrence of torus and the presence of attritional teeth in Thailand, but not in Germany.[17]

CONCLUSION

Each individual has a different anatomical morphology of the skull. It is very difficult to determine the racial affiliation of an unknown individual using only one anatomical point on the skull. There are several skull characteristics that are dominant in one racial group that aid in the process of racial identification. Some dental morphological variations can also aid in racial determination, in addition to the skull.

There are methods for estimating race through the skull, namely non-metric and metric methods. Each method has its advantages and disadvantages. It is advisable to use more than two parameters to estimate an individual's race. Repeated

measurements by different researchers are also needed to obtain accurate results.

CONFLICT OF INTEREST

No conflict of interest.

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