Population affinity estimation of an unidentified individual using nonmetric dental traits: a case report

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ABSTRACT

Due to their strong correlation to heredity, nonmetric dental traits are deemed useful to estimate an individual's population affinity. This case report demonstrates the use of the rASUDAS2 application for estimating a decedent's population affinity when other primary identification methods proved insufficient. Initial examinations showed that the decedent (referred to as KF230565 or Mr X) was a 42-year-old male whose death was caused by non-homicidal drowning. Due to slight deviations from the typical Western Indonesian craniofacial characteristics, his nonmetric dental traits were graded to confirm his population affinity. After grading the dental traits according to the Arizona State University Dental Anthropology System (ASUDAS), the data were entered into the rASUDAS2 software. Based on the analysis, the decedent was estimated to be of Western Eurasian (46.24%) or Southeast Asian (20.58%) affinity. This information was then passed to forensic artists and law enforcement, and a facial approximation sketch was constructed using the appropriate population-specific soft tissue thickness dataset. The sketches were then disseminated to the public to aid recognition. After receiving additional reports from the public, positive identification of the decedent was confirmed through primary identifiers. This report encourages the use of multidisciplinary methods in forensic identification, as well as further studies on dental morphology.

INTRODUCTION

Nonmetric dental traits refer to unique morphologies of the human tooth concerning its orientation, absence or presence, and its position within the oral cavity. These morphological characteristics can be found in several dental anatomies, such as the cusps, grooves, tubercles, and ridges. Dental morphology is mostly affected by genetics (up to 80%) and does not experience significant post-eruptive alteration, hence its potential use in biodistance analysis of both living and deceased individuals.[1–3]

Studies have documented differences in the frequencies of dental traits among biogeographic populations.[4] For example, Carabelli's trait and protostylid are more common in Western Eurasian populations and not in Asian and African populations.[5,6] Meanwhile, bilaterally winged and shovel-shaped incisors displayed higher frequencies in Asian and Asian-derived populations, unlike Western Eurasian populations.[7–9]

These variations were possibly related to evolutionary factors that affect gene flow and adaptation across and within populations.[10,11]
Given its potential forensic value, an application based on the Arizona State University Dental Anthropology System (ASUDAS) was developed. Called the rASUDAS2 (available at https://osteomics.com/rASUDAS2/), the software utilised naïve Bayesian methods to predict the biogeographic affinity of an individual, which can be useful for forensic cases. When used on all seven populations, it correctly assigned 51.8% of individuals, confirming its validity.[12,13]
The following case report aims to display the use of rASUDAS2 to help the investigators in estimating an unidentified individual's population affinity. This report highlights a multidisciplinary approach for constructing an accurate biological profile of the decedent. As of this report's publication, this report is the only documented case involving rASUDAS2 in a forensic case in Indonesia. Therefore, this case calls for further investigations and explorations on dental morphology and its applicability in actual forensic cases.

CASE

A body was found in the Rolak River, Gunungsari, Jambangan, Surabaya City, by an excavator operator. The witness discovered a floating body on November 23, 2023, at 2:30 PM (GMT+7) when he was cleaning up water hyacinths. He reported the discovery to 112 (Indonesia's emergency hotline) and retrieved the body from the river using his excavator.
The body was handled by the Sectoral Police Force of Jambangan District and coded as "KF230565"—also referred to as "Mr X". The body arrived at Dr Soetomo General Hospital's morgue later that day, precisely at 6:05 PM (GMT+7). The Letter of Visum et Repertum Request (No. VER/17/XI/2023/SPKT) was received by the medical examiners along with the body. An external examination was conducted immediately, and a further internal examination was conducted the next day (November 24, 2023, 5:30 PM).
The cause of death was determined as non-homicidal drowning due to positive diatom results, sand particles found in the respiratory system, as well as no corresponding trauma. Primary identification efforts were unsuccessful because of incomplete dental records, destroyed eyeballs, and wrinkled fingers and toes. Therefore, the Police and Hospital requested the consultancy of the corresponding author under Request Letter No. B/224/XI/2023/Reskrim to construct Mr X's biological profile and conduct a two-dimensional (2-D) facial approximation using forensic anthropological methods. Since the craniodental region was the focus of the analysis, maceration and decapitation were performed to facilitate detailed observation and measurement (Figs. 1 and 2).

Figure 1. Maxillary dental arch of Mr X

Figure 2. Mandibular dental arch of Mr X

Based on the robust nuchal line, pronounced glabella, large mastoid processes, robust mandibular morphology, and external genitalia, we concluded that Mr X was assigned male at

birth (AMAB). Cranial suture scores estimated Mr X's age at 42.35 ± 12.05 years. His stature was estimated to be about 165–175 centimetres. Mr X possessed an elongated face, a narrow nasal aperture, and a high nasal spine, which are quite atypical for Western Indonesians. Since population affinity is an important factor in facial approximation, confirmatory analysis using his dental morphology was performed.

Mr X's dental morphology was assessed based on the ASUDAS. Even though both sides were examined, only the right side was reported for further analysis. Since no radiological images or loose focal teeth were obtained, only the crown traits were graded (Table 1). The rASUDAS2 software was utilised for further analysis. The grades were entered into the software and then analysed according to their naïve Bayesian statistics. Based on the analysis, Mr X was most likely of Western Eurasian (46.24%) or Southeast Asian (20.58%) affinity (Table 2).

Table 1. Nonmetric dental traits of Mr X

Trait	Description	Tooth*	Range	Grade
Winging	Rotated maxillary central incisors.	11	0–3	0
Shovelling	Presence of marginal ridges on the lingual side of maxillary incisors.	11 12	0–7 0–7	3 1
Double shovelling	Presence of ridges on the labial side of maxillary incisors.	11	0–6	1
Tuberculum dentale	Presence of enamel elevation on the lingual surface of the anterior teeth.	11 13	0–6 0–7	3 2
Interruption grooves	Distinct grooves interrupting the normal course of the mesial or distal marginal ridges or even the basal cingulum.	12	0, M, D, MD, med	M
Bushman canine	Hypertrophied mesial ridge and a small tubercle that join together on the maxillary canine.	13	0–3	0
Carabelli's trait	Cingular derivative on the lingual surface of the mesiolingual cusp of maxillary molars.	16	0–7	3
Cusp 5	Presence of a fifth cusp on the distal fovea of the maxillary molars.	16 17	0–5 0–5	0 1
Enamel extensions	Enamel extends beyond the cementoenamel junction towards the apex of the roots.	16 46	0–3 0–3	0 0
Hypocone	Size of the distolingual cusp on maxillary molars.	17	0–6	3
Pegged, reduced, or missing	A reduction in size to a missing third molar.	18	0–3	3
Distal accessory ridge	Accessory ridge on the distal portion of the canine.	43	0–5	1
Premolar multiple lingual cusps	Lingual cusp variation of the mandibular premolars.	44 45	0–3 0–3	1 2
Cusp 6	Presence of a sixth cusp on the distal portion of the mandibular molars.	46 47	0–5 0–5	0 0
Cusp 7	Presence of additional lingual cusp of the mandibular molar.	46	0–4	0
Deflecting wrinkle	Incidental ridge on the mesiolingual cusp that changes course as it runs toward the central groove.	46	0–3	0
Protostylid	An extra cusp found on the buccal surface of the mesiobuccal cusp of the mandibular first molar.	46	0–7	1
Groove pattern	Pattern of contact of major cusps of lower molars.	47	X, +, Y	+
Four-cusped molar	Presence of the distal cusp of mandibular molars.	46 47	0–5 0–5	3 2

Upper premolar root number	Root number of the anterior upper premolar.	14	1–3	N/A
Upper second molar root number	Root number of the maxillary second molar.	16	1–3	N/A
Lower canine root number	Root number of the mandibular canine.	43	0–1	N/A
Tome's root	Mesiolingual groove or separation of the roots of the mandibular first premolar.	44	0–5	N/A
Three-rooted lower first molar	Presence of accessory distolingual root of the mandibular first molar.	46	1–3	N/A
One-rooted lower second molar	Presence of root fusion of the mandibular second molar.	47	1–2	N/A

Table 2. Estimated population affinity of Mr X

Biogeographic population	Prior	Posterior	Most likely	Consider
American Arctic and Northeast Asia	0.1429	0.0705		
Australo-Melanesia and Micronesia	0.1429	0.1298		
East Asia	0.1429	0.0341		
North and South America	0.1429	0.0040		
Southeast Asia and Polynesia	0.1429	0.2058		Yes
Sub-Saharan Africa	0.1429	0.0935		
Western Eurasia	0.1429	0.4624	Yes	Yes

Information on Mr X's population affinity was then reported to the assigned forensic artist of this case so that facial approximation sketches could be created using a population-appropriate soft tissue thickness dataset. The sketch was then distributed to the public in the hope of obtaining recognition. After its public dissemination, recognition was achieved. Later, law enforcement was able to confirm the legal identity of Mr X using primary identifiers; however, the specific identifiers and confirmatory documentation were not accessible to the authors. Law enforcement further stated that Mr X was of Indonesian and Pakistani descent and had resided in Surabaya, confirming the rASUDAS2 analysis.

DISCUSSION

The forensic value of nonmetric dental traits is attributable to their ability to accurately estimate the population affinity of an individual when only craniodental remains are available.[14] Previous reports describing the forensic application of nonmetric dental traits have often focused on isolated traits, such as cusp 6,[15] shovel-shaped incisors,[16] hypodontia,[17] and taurodontism.[18] Despite their scientific importance, these pieces of evidence might not hold sufficient value in court. Instead of isolated assessments, constellated analysis of these traits might offer a more statistically probable and medicolegally accepted outcome.[19] This concept underlies the development of the analytical tool rASUDAS2 as a decision support system for biological anthropology.[12]

Results from the rASUDAS2 analysis showed that Mr X was possibly of Western Eurasian (46.24%) or Southeast Asian (20.58%) populations, while others were deemed unlikely by the system. Along with his atypical craniofacial features, this finding further highlights careful interpretation of individual variations that may occur in forensic cases. This case illustrates that a region such as Western Indonesia may be genetically and morphologically heterogeneous. Since nonmetric dental traits are polygenic in nature, slight deviations from the typical can be caused by multiple factors, such as possible admixture, historical gene flow, and individual mutations.[20,21] A study showed that despite falling in the same category of Southeast Asia, Javanese dental patterns show a more similar frequency to Australo-Melanesian (e.g., interruption grooves, cusp 6, and deflecting wrinkle) and East Asian (e.g., cusp 5 and Y-groove patterns) populations.[7,22]

Similar to other forensic anthropological methods, the population affinity of Mr X should be interpreted as a probabilistic affinity instead of

a positive identity.[23] In principle, nonmetric dental traits and rASUDAS2, by extension, provide a statistical possibility instead of absolute group classification. The sole use of nonmetric traits, therefore, is not recommended regardless of the strength of the statistical support.[24] Rather, it should be accompanied by findings from other biological indicators, such as cranial measurements and stable isotopes.[25]

Despite these challenges, nonmetric dental traits remain a robust tool in forensic anthropology and odontology due to their strong genetic basis and resistance to postmortem degradation.[3] When combined with standardised scoring systems such as the ASUDAS and analytical tools like rASUDAS2, they offer a reproducible and relatively objective approach to affinity estimation.[12] In this case, the results were operationally useful, as they informed the selection of population-appropriate soft tissue thickness data for facial approximation, ultimately contributing to public recognition and successful identification.

Nevertheless, several limitations must be acknowledged. The analysis was based on a single individual, and the number of observable traits may have been constrained due to preservation or methodological issues, such as the lack of a medical imaging device. Additionally, the accuracy of rASUDAS2 depends on the representativeness of its reference samples, which may not adequately capture the full spectrum of Southeast Asian dental variations, particularly Indonesian populations.[26] Observer-related variation in trait grading may also introduce bias, although adherence to ASUDAS standards helps mitigate this issue.[27]

Future research should prioritise the expansion of regionally relevant dental morphological databases, particularly for underrepresented populations in Southeast Asia and Indonesia. Studies on dental morphology remain scarce in Indonesia, highlighting the need for further research to establish reliable forensic reference datasets. Integrating nonmetric traits with other lines of evidence, such as dental measurements and genetic phenotyping, would further enhance the reliability of population affinity estimation.

In conclusion, this case demonstrates that a multidisciplinary approach that involves forensic pathology, dental anthropology, and forensic arts can significantly improve identification outcomes in forensic contexts. This case also highlights how estimating a decedent's biological profile serves as a practical tool for police investigations. While the results provide probabilistic estimates rather than definitive identifications, they act as an important filter for narrowing down long lists of missing persons. By identifying specific physical characteristics, law enforcement can focus its efforts on a more relevant group of candidates and speed the recovery of the decedent's legal identity.

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