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ORIGINAL ARTICLE

Incisal Trait Variations Between Javanese and Chinese-Indonesians in Surabaya

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ABSTRACT

Human teeth are unique since one population's dental pattern might differ from another. Such specific dental characteristics, such as the incisor, are observable in each dentition. **Objective**: his study analyzed the population differences in Javanese and Chinese-Indonesian populations through observations of the incisal traits, namely winging, shoveling, and double shoveling. **Methods**: 50 dental casts (76 Javanese samples and 74 Chinese-Indonesian samples) were obtained from Dr. Myrtati Dyah Artaria's private collection, stored in the Faculty of Medicine, Universitas Airlangga. The traits were observed and scored using the Arizona State University Dental Anthropology System (ASUDAS) and analyzed statistically using crosstab and chi-square methods. **Results**: Only three out of 13 test results exhibit significant differences ($p < 0.05$). **Conclusion**: The dentitions observed in the Chinese-Indonesian samples mirror the immense Chinese acculturation into Javanese cultures through interbreeding that happened generations ago. The gene flow between these two populations appears phenotypically in the dentitions, leading the Chinese-Indonesian samples in this study to express Sundadont traits despite their noticeable facial traits and heritage.

Key words: Chinese-Indonesian, human biodiversity, incisor, Javanese, nonmetric dental traits

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INTRODUCTION

Population genetics is highly significant in the study of human biological variation.[1,2] Changes or variations in human genetics stimulate what is now known as evolution.[3,4] Such variation in human genotypes is expressed in several phenotypical characteristics—one of which is expressed in dental traits. Both metric and nonmetric dental traits are influenced by environmental factors, even though genetics and heredity most likely play a much bigger part.[5-8] Conclusively, both environmental and genetic factors contribute to shaping variations of dental morphology within the human species, where certain distinctions can be noticed within a single population or between populations.[9] Hence, it is highly possible to determine a certain individual or population's familial and evolutive relation with other populations through advanced research on dental trait differences.[10,11]

Dental anthropology is a subdiscipline in biological anthropology that works with information derived from dental data, whether it is derived from living or non-living individuals.[12,13] The teeth are deemed a reliable source of information due to their perseverance and stability.[14] The said "stability" is relevant in dental morphology, where the traits of human dentition are more likely to be caused by hereditary and genetic forces instead of the environment.[15] Therefore, the teeth might give us insights into population genetics and interpopulation kinship.[16,17]

Not just the teeth, many biological traits will point out certain populations' general characteristics, such as the rates of epicanthus fold, labial thickness, femoral length, nasal concave, cranial shape, eye color, hair texture, and facial soft tissue thickness.[18-20] A specific combination of the aforementioned traits is hereditary, which became a foundation for their identification.[21] These specific biological characteristics belonging to the average members of the popula-tion are called population affinity or ancestry.[22,23] Despite its

significance as a biological identifier of a population, it is important to acknowledge that these traits are indeed highly variable between members of a specific population, meaning that some people within the population might not conform to the general rule of biological traits among the population.[24,25] Hence, the individual might seem "anomalous" com-pared to the rest of the population, often resulting in social discrimination.[26,27]

According to Turner, Chinese immigrants originally came to Surabaya to seek fortune. Eventually, they settled permanently and married the locals.[28] Up to this day, the Chinese ethnic group coexists with others and is an integral part of Surabaya's culture. Acculturation of Chinese and local cultures can be seen in various places, especially in the Chinatown area.[29]

The intermarriage between Javanese and Chinese is deeply rooted in society.[30,31] Together, they developed a new, modified culture commonly referred to as Peranakan Chinese culture.[32-34] Biologically speaking, the Chinese-Javanese are also unique in regard to their phenotypic expressions, showing a mixture of Chinese and Javanese characteristics—most noticeable in their craniofacial features.[35,36]

The increasing access to migration and mobilization, along with the amalgamation of the two populations, motivated this study to be conducted.[30,37] The objective of this study is to explore and compare the non-metric dental traits between the Javanese and Chinese-Indonesian populations in Surabaya, Indonesia. The traits discussed in this study include winging, shoveling, and double shoveling in the incisors, as dis-played in Figures 1, 2, and 3, respectively.[38,39] Hopefully, this study will contribute to the scientific and the-oretical development of dental anthropology, which is scarce, especially in Indonesia.

Figure 1. Winging of the central incisors (left-right: mild winging, severe winging).

Figure 2. Dental casts of shovel-shaped incisors (left-right tooth: grade 3 shoveling; grade 4 shoveling).

Figure 3. Dental casts of double shoveled incisors (left-right tooth: grade 5 double shovel, grade 6 double shovel).

METHODS

Research design

This study utilized the quantitative approach to explain correlations, differences, and significances of two or more variables.[40] A structured observation method was conducted to collect the data used in this study. This data collection method relies on direct observations of the object done by the authors. It is referred to as "structured" because the authors are well-equipped with aspects of observation, and in this study's context, the authors utilized the Arizona State University Dental Anthropology System (ASUDAS) to grade the expression rates of dental traits observed.[38,41]

Data collection

The samples of this study involved 150 dental casts, consisting of 76 Javanese and 74 Chinese-Indonesian sample groups. The samples were obtained from the private collection of Dr. Myrtati Dyah Artaria, all of which were stored in the Physical Anthropology Section, Laboratory of Anatomy and Histology, Faculty of Medicine, Universitas Airlangga. The dental casts were donated by the respondents, along with their identity and biological profile (sex, age, and ancestry). To confirm their ancestry, the respondents were first asked whether they were the descendants of a Javanese or a Chinese-Indonesian ancestor for at least the past three generations. Due to the strong genetic factors and slow evolutionary change of the human dentition, three generations were deemed reasonable for ancestry estimation.[15,42] For ethical considerations, the authors already received approval from the Faculty of Social and Political Sciences to carry out the research.

The authors observed the winging traits on the upper right central incisor (URI1) and upper left central incisor (ULI1); shoveling on the upper right central incisors (URI1), upper right lateral incisors (URI2), upper left central incisors (ULI1), upper left lateral incisors (ULI2), lower right central incisors (LRI1), lower right lateral incisors (LRI2), lower left central incisors (LLI1), and lower left lateral incisors (LLI2); and double shoveling on upper right central incisors (URI1), upper right lateral incisors (URI2), upper left

central incisors (ULI1), and upper left lateral incisors (ULI2). All authors were involved in the observation process. The scoring was carefully done according to the ASUDAS. Multiple checking was conducted to minimize biases and observer errors in the observation process.

Data analysis

The data analysis steps involved scoring the dental cast samples using the standard of ASUDAS dental plaques, and then completed with the authors' own formulation system that was inspired by ASUDAS. After that, the data was statistically analyzed using the IBM Statistical Package for Social Science (SPSS) v.26.0. The chi-square and crosstab methods were utilized to measure the significance values and frequency distribution of the two sample groups and all 13 variables. A trait is considered "significant" if the chi-square scores are less than 0.05 ($p < 0.05$).

RESULTS

Based on the frequency distribution of the occurrence of winging incisors on Javanese and Chinese-Indonesian samples, a uniform occurrence trend is observed (see Table 1). Both groups showed that most of the samples scored 1—17.1% of the Javanese samples and 17.6% of the Chinese-Indonesian samples. Both sample groups, however, do not show a distinct sign of winging, as shown by 76% of the Javanese samples and 73% of the Chinese-Indonesians. No significance was found between the two sample groups in terms of winging trait expression.

Both sample groups have different expression patterns on the lower shoveling incisor trait (see Table 2). The Chinese-Indonesian samples have a wider occurrence spectrum than the Javanese samples. Based on the overall frequency of shoveling incisor expression, the Chinese-Indonesian samples' score range is 0-3, while the Javanese samples' score only ranged from 0-2. The frequency distribution of shoveling incisors from both sample groups displayed a uniform occurrence trend. However, the Chinese-Indonesians have a larger amount of frequency scoring 3 or higher. The expression of shoveling on URI2 also showed a similar pattern in both sample groups. Based on the significance analysis, only two teeth (LRI1 and LLI1) expressed significant differences ($p < 0.05$), with p-values of 0.034 and 0.016, respectively. Meanwhile, the other six teeth (URI1, URI2, ULI1, ULI2, LRI2, and LLI2) did not show any significant differences ($p > 0.05$).

The frequency of the double shovel incisor trait of both sample groups displayed a consistent trend on all four teeth observed—URI1, URI2, ULI 1, and ULI2 (see Table 3). The Chinese-Indonesian samples have a lower frequency on double shovel incisors in comparison to the Javanese samples. The URI1, for example, is about three times more likely to occur in Javanese individuals. Moderate grades (3-4) of double shovel were found more in Chinese-Indonesian samples on all four teeth, while the Javanese showed no grade 4 double shovel incisors even on one tooth. The frequency and percentage of grades 1 and 2 on all four teeth showed a similar result in both samples. Based on the significance analysis, only URI1 showed a significant difference ($p < 0.05$), with a p-value of 0.022.

Table 1. Percentage, frequency, and significance of winged incisors on Javanese and Chinese-Indonesians.

Population	Grade	n	%
Javanese	0	58	76.3
	1	13	17.1
	2	4	5.3
	3	1	1.3
Chinese-Indonesian	0	54	73.0
	1	13	17.6
	2	6	8.1
	3	1	1.4
Sig.			0.915

DISCUSSION

Based on the 13 variables analyzed between the two sample groups, only three are proven to be significantly different, namely the LR1IS, LL1IS, and UR1IDS. Several traits even expressed similar trends in occurrence, as observed on UR2IS, UR1IS, UR2IDS, UL2IDS, and UW. In theory, the dental traits of the Chinese populations should be significantly different from the Javanese since they have very different ancestry—one traced their origin from Sino-America and the other from Sunda-Pacific.[39,43-45] These two populations are characterized by their unique sets of dental trait variations that are classified as Sinodonty for the Sino-American populations and Sundadonty for the Sunda-Pacific populations.[28,39] These varia-tions, according to Turner & Scott, are a part of the larger "Mongoloid dental complex" which is distributed in the Eastern Eurasian and American regions.[39] Continuous waves of migrations and evolutionary pro-cesses, such as mutation, gene flow, and genetic drift, in these respective geographical regions, allow for a divergence in dental traits to occur.[46-50] Hence, the Sundadont-Sinodont variations in the "Mongoloid" regions.[28]

The Chinese-Indonesians can trace their origin back to the 14-15th century Majapahit era of the Nusantara

Table 2. Percentage, frequency, and significance of shovel-shaped incisors on Javanese and Chinese-Indonesians.

Population	Grade		UR1IS	UR2IS	UL1IS	UL2IS	LR1IS	LR2IS	LL1IS	LL2IS
Javanese	0	n	1	3	0	2	31	25	31	25
		%	1.3	1.9	0	2.6	40.8	32.9	40.8	32.9
	1	n	5	15	6	11	33	40	33	40
		%	6.6	9.7	7.9	14.5	43.4	52.6	43.4	52.6
	2	n	37	52	36	24	11	10	11	10
		%	48.7	33.5	47.4	31.6	14.5	13.2	14.5	13.2
	3	n	30	52	30	27	0	0	0	0
		%	39.5	33.5	39.5	35.5	0	0	0	0
	4	n	3	24	3	9	0	0	0	0
		%	3.9	15.5	3.9	11.8	0	0	0	0
	5	n	0	1	0	1	0	0	0	0
		%	0	0.6	0	1.3	0	0	0	0
	6	n	0	0	0	1	0	0	0	0
		%	0	0	0	1.3	0	0	0	0
	7	n	0	0	0	1	0	0	0	0
		%	0	0	0	1.3	0	0	0	0
Chinese-Indonesian	0	n	1	2	1	1	15	12	13	12
		%	1.4	2.7	1.4	1.4	20.3	16.2	17.6	16.2
	1	n	3	5	3	5	46	45	46	46
		%	4.1	6.8	4.1	6.8	62.2	60.8	62.2	62.2
	2	n	32	26	32	27	10	15	10	14
		%	43.2	35.1	43.2	36.5	13.5	20.3	13.5	18.9
	3	n	34	26	34	26	1	1	1	1
		%	45.9	35.1	45.9	35.1	1.4	1.4	1.4	1.4
	4	n	2	13	3	13	0	0	0	0
		%	2.7	17.6	4.1	17.6	0	0	0	0
	5	n	1	0	0	0	0	0	0	0
		%	1.4	0	0	0	0	0	0	0
	6	n	0	0	0	1	0	0	0	0
		%	0	0	0	1.4	0	0	0	0
	7	n	0	0	0	1	0	0	0	0
		%	0	0	0	1.4	0	0	0	0
Sig.			0.813	0.684	0.652	0.723	0.034	0.077	0.016	0.085

Note: UR1IS = upper right central incisor shoveling, UR2IS = upper right lateral incisor shoveling, UL1IS = upper left central incisor shoveling, UL2IS = upper left lateral incisor shoveling, LR1IS = lower right central incisor shoveling, LR2IS = lower right lateral incisor shoveling, LL1IS = lower left central incisor shoveling, LL2IS = lower left lateral incisor shoveling.

archipelago.[51,52] During that era, many Chinese traders traveled to Nusantara in groups.[53] Since the journey requires an abundance of time and effort, the traders settled in Indonesia to gain fortune and conserve their resources, forming communal clusters in the process.[54] It is also important to mention that these trad-ers are predominantly males. Due to the absence of Chinese females, many of them got romantically and sexually involved with Indonesian females instead.[54,55] The amalgamation of Chinese and Indonesians, then, is associated with the formation of Chinese-Indonesian identity and culture. These people are now referred to as Peranakan Chinese.[52,56,57] Since the nineteenth century, many Chinese people have migrated to Indonesia, while the Peranakan population itself has been steadily growing.[58] Since then, Chinese-Indonesian people began to marry among themselves again.[34,59]

Due to this phenomenon, foreign genes were introduced to the Chinese population in Indonesia, making their

Table 3. Percentage, frequency, and significance of double-shoveled incisors on Javanese and Chinese-Indonesians.

Population	Grade		UR1IDS	UR2IDS	UL1IDS	UL2IDS
Javanese	0	n	15	16	13	16
		%	19.7	21.1	17.1	21.1
	1	n	31	32	32	32
		%	40.8	42.1	42.1	42.1
	2	n	27	22	27	23
		%	35.5	28.9	35.5	30.3
	3	n	2	4	2	3
		%	2.6	5.3	2.6	3.9
	4	n	0	0	0	0
		%	0	0	0	0
	5	n	0	0	0	0
		%	0	0	0	0
	6	n	0	0	0	0
		%	0	0	0	0
Chinese-Indonesian	0	n	5	8	5	10
		%	6.8	10.8	6.8	13.5
	1	n	36	31	35	32
		%	48.6	41.9	47.3	43.2
	2	n	22	25	23	24
		%	29.7	33.8	31.1	32.4
	3	n	8	8	9	7
		%	10.8	10.8	12.2	9.5
	4	n	2	0	1	0
		%	2.7	0	1.4	0
	5	n	0	0	0	0
		%	0	0	0	0
	6	n	0	0	0	0
		%	0	0	0	0
Sig.			0.022	0.243	0.051	0.392

Note: UR1IDS = upper right central incisor double shoveling, UR2IDS = upper right lateral incisor double shoveling, UL1IDS = upper left central incisor double shoveling, UL2IDS = upper left lateral incisor double shoveling.

phenotypes "stray" from most mainland Chinese individuals. This gene flow affected the phenotypic expressions of the Chinese-Indonesians' dentition.[46,60] Thus, referring to them as having an admixed or intermixed dentition is more proper since an insignificant difference was found in most variables ana-lyzed.[61]

The case of admixture shown in the dentition is hardly new. Sharma studied the Punjab population in In-dia. In their study, they found that many Punjabis have a relatively high amount of shoveling incisors, when ideally, the Western Eurasian population typically expressed a lower amount of shoveling incisors.[62] The study, then, found that the higher amount of shoveling incisors found in the Punjab population is closely related to the migration of Tibetans from North to South India due to ethnic conflicts with the Chi-nese.[62]

Turner compared the dental morphology of Ainu, Jomon, An-Yang Chinese, and modern Japanese populations.[63] The modern Japanese population shares more similar traits with the An-Yang Chinese, which is a migrant population originating from mainland China. The An-Yang is an ancient Chinese population in Northern China who had lived since 3,000 years ago.[63] Kaburagi et al. found that the seven centuries-long migration from North East Asia transformed the Japanese dentition.[64] The gene flow was major since the modern Japanese population is significantly different from their indigenous population (Ainu and Jomon).[64]

These cases are different from the Naxi, Dai, and Hani populations in China. Yamazaki & Matsuno's study mentioned that according to Smith's Mean Measure of Divergence (MMD) using 17 dental traits, the Naxi population is closer to the Dai and Hani population in comparison to the modern Han Chinese popu-lation.[65] Uniquely, the three tribes share prevalent Sundadont traits despite their geographic locations. The authors hypothesized that even though the Naxi population is genetically close to the Southeast Asian populations, their environmentally induced traits are also related to the Han Chinese.[65] They argued that the complex interaction between genetic and environmental factors is reflected in a population's dental morphological variation, though previous studies confirmed that nonmetric dental traits are more related to genetics than environment.[42]

In Taiwan, different phenomenon occurs involving indigenous minority populations. The Bunun, Ami, and Yami populations share similar variations of Sinodonty, although some degree of Sundadonty was also found in some traits in the Bunun population.[66,67] This study is very curious yet interesting since the indige-nous Taiwanese populations are Austronesian speakers, similar to the Javanese.[68] However, even though they share the same language, their dental traits are significantly different from each other.[66,67]

In addition, Jin et al.'s study explained that the phylogenetic relationship between the indigenous Taiwan-ese populations is closely related to their geographic distribution, but not their language classification.[69] This result can be understood as proof of different patterns of genetic and cultural distribution resulting from the Austronesian expansion during the prehistoric era.[69] Their findings are curious since Taiwanese and Javanese ancient populations are on the same language classification but are genetically much more complex.[70] Previous studies also mentioned that the Javanese populations share a similar mtDNA with the Taiwanese, but their Y chromosome is not as close in relation.[71,72] Thus, it can be inferred that only certain sexes and tribes participated in the Austronesian expansion to Java.

Furthermore, this study proves Turner's theory on "Mongoloid" dental variations in East Asian popula-tions, where East Asian populations are more likely to have a similar set of trait variations—later coined as Sinodonty.[28] In comparison to Yamazaki & Matsuno's study, this study further strengthened the theory that some minority groups share different origins due to various factors, such as isolation and migration.[65] These factors are attributable to the degree of expression in their dentition.[65]

Moreover, the result of this study offers a more particular insight into biogeographic peopling in Indonesia. The findings in this study can be utilized as a more particular reference when a forensic odontologist or bioarchaeologist is examining the incisors in conducting an ancestry estimation of the remains.[16,73] Prior studies have highlighted the role of dental anthropologists in unveiling a set of unique dental morphological variations in forensic odontological and bioarchaeological cases.[9,74] However, minimum studies have been found regarding this issue in Indonesia.[42,75] It is with high hope that this study will act as a motivation to stimulate more studies on the role of dental anthropology within a forensic odontological and bioarchaeo-logical context.

To close, we would like to emphasize that "pure" Chinese samples in Indonesia were hard to find since the Chinese communities have integrated themselves into local communities. Therefore, we recognize this is-sue as a limitation in this study. We recommend recording the participants' ancestral origin as specific as possible, for example, a researcher should note whether a participant is a first-, second-, third-, or fourth-generation Chinese, or whether a participant is a mainland Chinese or Peranakan Chinese. Collaborations with Chinese or East Asian institutions are also encouraged so that the morphological comparison between the Sinodont and Sundadont is more observable.

CONCLUSION

Out of the 13 nonmetric dental traits analyzed in this study, only three showed a significant difference between the two populations. In conclusion, the findings of this study indicated that the dental morphology of the Chinese-Indonesian population is not significantly different from the Javanese population. Previous studies have confirmed that gene flow or any other form of genetic admixture is highly in altering the typicality of a population's dental morphology. Therefore, it is inferred that the Chinese-Indonesians' lower incisal trait grades were caused by a gene flow from the Javanese population, hence setting them apart from the typical native Northeast and East Asians. The gene flow also allowed the Chinese-Indonesian samples to express a lesser degree of their typical Sinodont traits. Further study should consider using first-generation Chinese-Indonesians as samples to better understand the difference between Sinodont and Sundadont patterns to describe and analyze the correlation between nonmetric dental traits, inheritance patterns, and dentition evolution.

CONFLICT OF INTEREST

All authors declared no conflict of interest.

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