HSOA Journal of
Forensic, Legal & Investigative Sciences

Research Article

Estimating Ancestry from a Recovered Cranium Using the FORDISC 3.I Computer Program: A Possible Case of Admixture-Case Report

Conrad B Quintyn*

Department of Anthropology, Criminal Justice and Sociology, Commonwealth University, Pennsylvania, USA

Abstract

On November 16, 2012, two people searching for cans and bottles in a wooded area off Alden Mountain Road in Newport Township, Luzerne County, Pennsylvania, discovered a partially buried human cranium without the mandible. The police found no other skeletal elements. The biological anthropologist subsequently collected craniometric data on the cranium using digital calipers and then entered it into the FORDISC 3.1 discriminant functions computer program for processing. The unknown cranium was classified into the Hispanic Female (HF) reference group with a posterior probability of 0.468 but had comparable posterior probability in the White Female (WF) reference group (0.393). The typicality R probability, which ranks a cranium within a group, is higher for the Hispanic reference group than the White group. Hispanics are culturally and genetically heterogeneous, with several ancestral populations such as Africans, Native Americans, and Europeans. In essence, this unknown cranium could belong to a mixed-race individual.

Keywords: Admixture; Craniometrics; FORDISC 3.1; Mixed race; Osteometric landmarks; Posterior probabilities; Typicality probabilities

Introduction

On February 20, 2008, this biological anthropologist presented a paper titled "Admixture and the Growing List of Racial Categories: Clarity or Confusion for Law Enforcement (and the Public)" at the

***Corresponding author:** Conrad B Quintyn, Department of Anthropology, Criminal Justice and Sociology, Commonwealth University, Pennsylvania, USA, E-mail: cquintyn@commonwealthu.edu

Proceedings of the American Academy of Forensic Sciences 60th Anniversary Scientific Meeting in Washington, DC. The biological anthropologist expressed the general point that in publicizing missing people, law enforcement must be able to use racial categories that are most familiar to the general public to increase the likelihood of finding these missing people and thus bring closure for families [1]. While the goal of bringing closure for families remains sacrosanct, immigration and racial admixture (i.e., interracial ancestry) are blurring the familiar racial categorical lines.

Race" is a convenient social tool that law enforcement employs for many practical purposes, an important one being to find people when they go missing. However, the steady increase in biracial or triracial population groups and the constant flow of immigrants to the United States in the past sixty years have complicated the racial picture to the point where it is becoming difficult to fit people into their neat racial categories as depicted on job application forms (Figure 1).
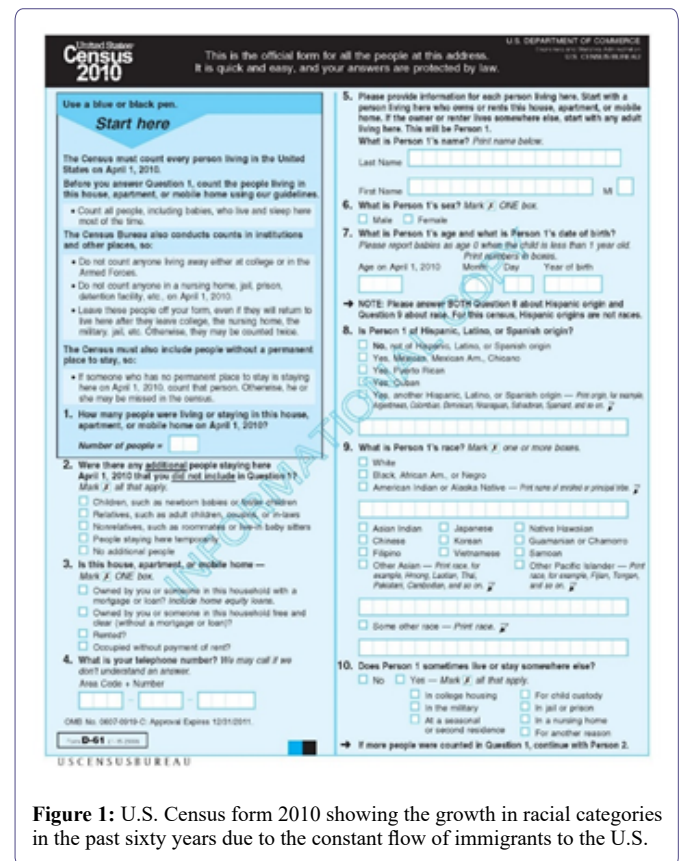

Figure 1: U.S. Census form 2010 showing the growth in racial categories in the past sixty years due to the constant flow of immigrants to the U.S.

Racial admixture in the United States goes back to the seventeenth century [2]. In the aftermath of the civil rights movement in the late 1960s and 1970s and subsequently enlightened attitudes about race, interracial relationships have steadily increased, accompanied by a parallel increase in the population of biracial children. With the multicultural mix added by immigrants (Figure 1), the US Census Bureau

(in coordination with the federal and state governments) has further subdivided racial categories to reflect the growing multiracial mix. For example, relatively new racial categories include Guamanian, Chamorro, Samoan, Laotian, Hmong, Fijian, Tongan, Cambodian, and Pakistani, to name a few [3]. While this attempt to document the reality of the US population's composition is laudable-because popular categories of race are already biologically a questionable concept-it adds to the already difficult task of the police in finding missing people and pinpointing admixture phenotypically [4-11]. For example, in looking at a photograph, the police might by default lump the Guamanian, Chamorro, Fijian, Tongan, and Pakistani ethnic groups into the familiar categories of Native American, Hispanic, Latino, or Mexican—the categories Hispanic, Latino, and Mexican have their own ambiguity—and lump the Laotian, Hmong, and Cambodian ethnic groups into the Asian category.

In November 2012, this biological anthropologist collected craniometric data from a cranium found in a wooded area of Newport Township in Luzerne County, Pennsylvania. He processed the measurement data with the FORDISC 3.1 computer program, which indicated admixture, specifically a mixed-race individual.

Materials and Methods

Case report (PO4-0744558)

On November 16, 2012, two people searching for cans and bottles in a wooded area off Alden Mountain Road in Newport Township, Luzerne County, Pennsylvania, discovered a partially buried human cranium. Investigators from Pennsylvania State Police Troop P Shickshinny station designated the case as PO4-0744558. The biological anthropologist arrived at the scene within twenty-four hours of the discovery and aided in the search for additional biological and nonbiological materials. Unfortunately, the search was unsuccessful because detectives did not give a clear provenience for the cranium within the 2,125-acre wooded area. A cadaver dog was enlisted in the search to find remains, but nothing was found. A quick visual assessment of the cranium indicated a slightly weathered cranium with no mandible and possible animal gnawing on the frontal, parietal, and occipital bones (Figure 2a-b). The cranium was transferred to the custody of the anthropologist for analysis on November 21, 2012, several days after the county coroner completed his examination (Figure 3).
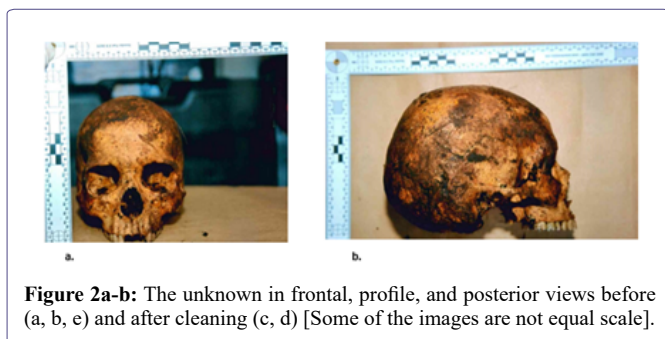

Figure 2a-b: The unknown in frontal, profile, and posterior views before (a, b, e) and after cleaning (c, d) [Some of the images are not equal scale].

The biological anthropologist gently cleaned the cranium with a soft bristle brush and manicure sticks to remove sediment (very dark brown sediment—7.5YR 2.5/3 on the Munsell scale), small dry leaves, and tiny root structures from the respective foramina of the cranium [12] (Figure 2c–d). He then documented and collected this material (Figure 4). Soil embedded in cranial foramina indicated previous, either natural or unnatural, burial of the remains [13].

Figure 3: Pennsylvania State Police Property Record form with case incident number P04-0744558 and signatures showing chain of custody.

Figure 2c-d: The unknown in frontal, profile, and posterior views before (a, b, e) and after cleaning (c, d) [Some of the images are not equal scale].
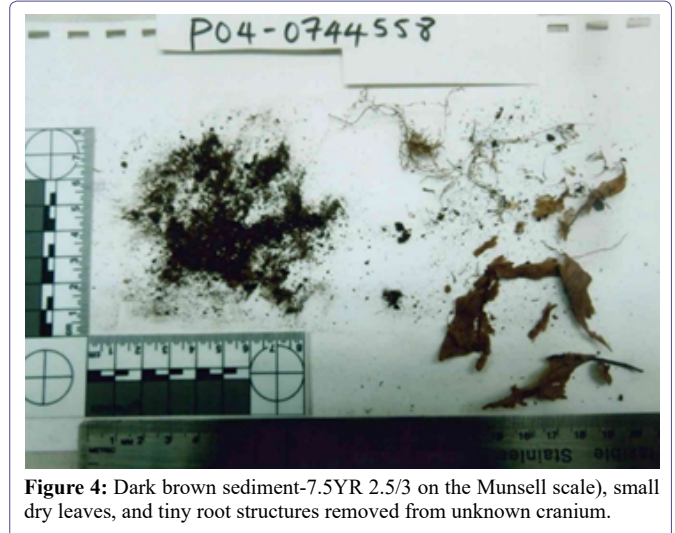
Figure 4: Dark brown sediment-7.5YR 2.5/3 on the Munsell scale), small dry leaves, and tiny root structures removed from unknown cranium.

A detailed visual assessment of the cranium showed the skull was small with moderate brow ridges, sharp orbital rims, a non-projecting mastoid process, and a smooth nuchal region. Additionally, the facial profile was straight, with receding cheek bones and a triangular nasal opening with a narrow nasal root and large nasal spine. Finally, the teeth indicated minimal wear-the incisors were blade-shaped and the third molars not fully erupted (Figure 2e).

Craniometrics

The biological anthropologist used conventional instruments (i.e., sliding digital calipers and digital and traditional spreading calipers)
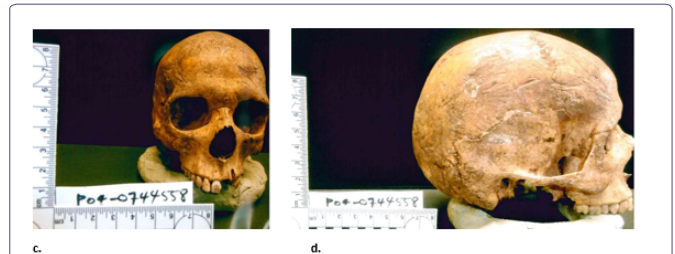
Figure 2e: The unknown in frontal, profile, and posterior views before (a, b, e) and after cleaning (c, d) [Some of the images are not equal scale].

to collect the metric measurements on the cranium in November 2012 (Figure 5). Craniometrics have proved valuable in assessing large-scale relationships among populations, conducting small-scale analyses among populations, and, in the forensic context, aiding in the identification of unknown skeletal remains [14-16]. In hindsight, the biological anthropologist would have used a MicroScribe digitizer to better capture cranial size and shape, and three-dimensional (3D) osteometric landmark coordinate data as used in his current research [17]. Nevertheless, the craniometric measurements used in this case are described in (Table 1), and the corresponding cranial landmarks are shown in Figure 6a–c. These cranial measurements are found in the FORDISC 3.1 computer program for several comparative reference groups. Specifically, there are fifty-six landmarks (forty-two measurements) in the Forensic Data Bank (FDB) and thirty-nine new measurements (in addition to the fifty-six landmarks) in the William W. Howells Craniometric Data Set. Only cranial measurements in the FDB will be used in this analysis.
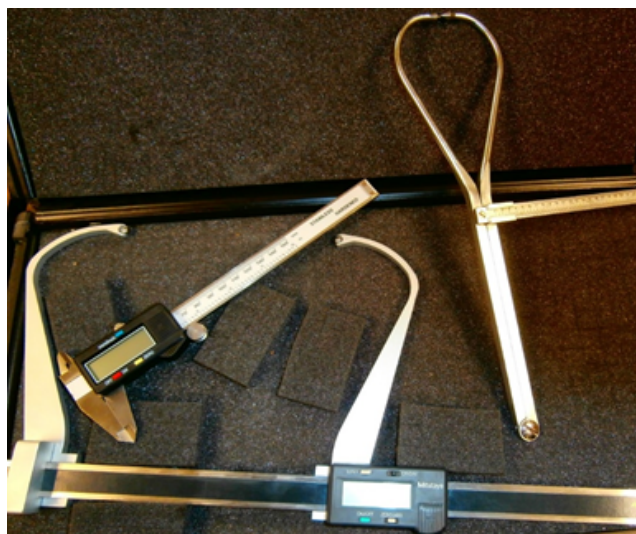

Figure 5: Spreading and sliding digital calipers used in collection of craniometric measurements.

Landmark	Measurement	Brief Description
Prosthion-Howells	**BPL** (Basion-Prosthion Length)	Most anterior point in midline on the alveolar process of the maxilla
Prosthion-Martin	**UFHT** (Upper Facial Height)	Midline at the inferior tip of the alveolar process (between central incisors) of maxilla
Alare L/R	**NLB** (Nasal Breadth)	The most lateral point on the margin of nasal aperture
Inferior nasal border L/R	**NLH** (Nasal Height)	Floor of the nasal cavity taken inside the nasal aperture
Lower & Upper	**OBH** (Orbital Height) [inf. & sup.]	The height between the upper and lower borders of the orbits, perpendicular orbital border L/R to the long axis of the orbit
Ectoconchion L/R	**OBB** (Orbital Breadth)	The intersection of the most anterior surface of the lateral border of the orbit
	EKB (BI-Orbital Breadth)	and a line bisecting the orbit along its axis
Dacryon L/R	**DKB** (Inter-Orbital Breadth)	Anterior border or apex of lacrimal fossa
Nasale superius L/R		The most superior point where the nasal touches the maxilla
Zygion L/R	**ZYB** (Bi-Zygomatic Breadth)	Maximum extent of zygomatic arch
Frontomalare temporale	**UFBR** (Upper Facial Breadth)	Point where the frontozygomatic suture crosses the temporal line L/R
Frontotemporale L/R	**WFB** (Minimum Frontal Breadth)	Point anterior and medial on temporal line
Nasion	**NOL** (Naso-Occipital length)	Point of intersection of the nasofrontal suture and the mid-sagittal plane
Nasion	**NLH** (Nasal Height)	From nasion to the most exterior margin of nasal bones notch
Glabella	**GOL** (Maximum Cranial Length)	The most forwardly projecting point in the mid-sagittal plane
Bregma	**FRC** (Frontal Chord) **PAC** (Parietal Chord) **BBH** (Basion-Bregma Height)	Point where the coronal and sagittal sutures intersect
Lambda	**PAC** (Parietal Chord) **OCC** (Occipital Chord)	Point where the sagittal and lambdoidal sutures meet
Asterion L/R	**ASB** (Bi-Asterionic Breadth)	Where the lambdoidal, parietomastoid, and occipitomastoid sutures mee
Eurion L/R	**XCB** (Maximum Cranial Breadth)	Maximal cranial breadth
Porion L/R	**MDH** (Mastoid Height)	Point at the most superior aspect of EAM
Opisthion	**FOL** (Foramen Magnum Length)	Midline point at the posterior margin of the foramen magnum
Basion	**BBH** (Basion-Bregma Height)	Midline point at the anterior margin of the foramen magnum
	BNL (Cranial Base Length)	
FOB Point L/R	**FOB** (Foramen Magnum Breadth)	Foramen magnum breadth

Alveolon	**MAL** (Maximum Alveolar Length)	Point on the interpalatal suture where a line drawn between the posterior ends of the alveolar ridges-midline (rubber band is used)	
Ectomolare L/R	**MAB** (Maximum Alveolar Breadth)	Widest part of the alveolar maxilla at second molar	

Table 1: Craniometric landmarks used in the FDB in FORDISC 3.1 listed by abbreviation, measurement, and brief description (Adapted from Fleischman and Crowder 2019; Buikstra and Ubelaker 1994).

Statistical Analysis
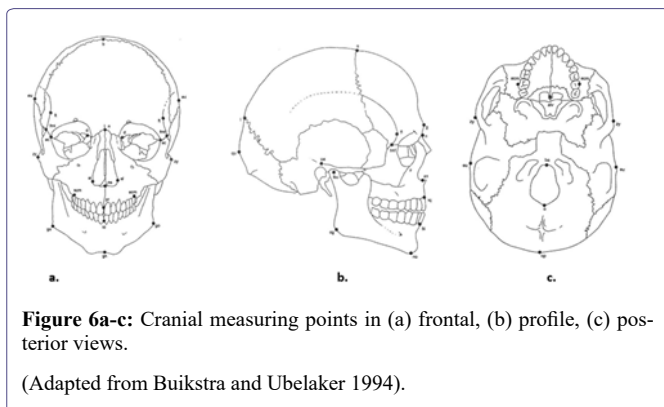
Figure 6a-c: Cranial measuring points in (a) frontal, (b) profile, (c) posterior views.

(Adapted from Buikstra and Ubelaker 1994).

FORDISC 3.1 generates an unknown cranium's posterior and typicality probability of membership in each reference group in the database. Posterior probabilities sum to 1 (100 percent) and are based on the unknown cranium's relative similarities (all Mahalanobis distances [D^2]) to all groups [18]. A high posterior probability, which in turn creates a small distance, indicates a greater similarity than to other groups. Typicality probabilities (Typ), in contrast, are the unknown cranium's probability of membership in each group, based on its absolute similarity. The percentage of correct group allocations-or groups with the *typical profile* of the unknown's case—is an indication of how well groups can be separated using the available variables. The word "typical" used above is important because distance probabilities or "typicality probabilities" can be calculated to ascertain whether an individual is typical for a specific group (and not assumed to belong to a respective group, as in posterior probabilities). When the typicality probabilities are uniformly low (i.e., less than 0.01 for each group), the posterior probabilities and classification should be disregarded because classification accuracy is critical in biological evidence for affiliation [19]. An important result is that the D^2 values will follow a chi-square distribution with a *p* degree of freedom.

Additionally, FORDISC 3.1 uses canonical variates to display data in graphic form. Canonical variate analysis is most effective in problems where many variables are used to compare differences among and within many reference groups. This analytical technique uses raw data to produce coefficients (or eigenvectors), which are used to obtain new variables called canonical variates that maximize the among-groups variation (eigenvalues) relative to the standardized within-groups variation [20]. The variables (or measurements) are combined into a reduced number of functions to maximize the separation between groups. Such plots provide visual information about which sample means (or centroids) are close to or distant from one another in multivariate space. Moreover, multidimensional data space transforms confidence "intervals" into confidence "spheroids"

(or ellipses), which are equidistant with regard to the within-group dispersion. Finally, there are usually several canonical variates independently holding biological information. However, it is the earlier variates that will contain information such as differences in overall shape and size.

Results and Discussion

Analysis of unknown cranium

After collecting the craniometric measurements from the cranium, the anthropologist recorded them in the FDB in FORDISC 3.1 (Table 2). The biological anthropologist used all cranial and FORDISC 3.1-calculated measurements (i.e., NAA, PRA, BAA, NBA, BBA, BRA) in the FDB (Table 2). Because there was no clear information on ancestry and sex for this cranium, all female reference groups (i.e., White, Black, Hispanic, American Indian, and Japanese) and all male reference groups (i.e., White, Black, Hispanic, Guatemalan, American Indian, Japanese, Vietnamese, and Chinese) were used in the analysis. The term "American Indian" (as opposed to Native American) is the language used in the FORDISC 3.1 FDB.

Craniometric data (mm)			
GOL	178	OCC	101
XCB	126	FOL	41
ZYB	120	FOB	35
BBH	137	MDH	27
BNL	102	NAA	68∞
BPL	98	PRA	75∞
MAB	61	BAA	36∞
MAL	56	NBA	83∞
AUB	122	BBA	49∞
UFHT	62	BRA	48∞
WFB	87		
UFBR	99		
NLH	46		
NLB	24		
OBB	39		
OBH	32		
EKB	94		
DKB	21		
FRC	104		
PAC	109		

Table 2: Craniometric data collected from cranium and recorded in FDB in FORDISC 3.1∞.

∞Additional Measurements automatically calculated and only found in FDB in FORDISC 3.1:

NAA: Nasion angle; PRA: Prosthion angle; BAA: Basion angle; NBA: Nasion angle; BBA: Basion Angle; BRA: Bregma Angle

On the initial computing of measurements, FORDISC 3.1 classified the cranium into the Hispanic female (HF) reference group with a posterior probability of 0.468 (Table 3). The typicality probabilities were 0.136 (Typ F, which is dependent on sample size), 0.093 (Typ Chi, which is not dependent on sample size), and 0.200 (Typ R, where the cranium was ranked twenty-fourth out of thirty individuals within the group). In essence, this cranium is typical of 80 percent of Hispanic females. Additionally, this cranium is within the range of variation

of White females with a posterior probability of 0.393. Regardless, the typicality R is higher for the Hispanic female reference group than the White female reference group (0.110). In other words, this unknown cranium fits better into the Hispanic female range of variation than in the White female range.

| Group$^\alpha$	Classified Into	Distance From	Posterior	Probabilities		Typ R
				Typ F	Typ Chi	
HF	**HF**	34.8	0.468	0.136	0.093	0.200(24/30)
WF		35.1	0.393	0.106	0.086	0.110 (145/163)
BF		38.0	0.093	0.065	**0.046**	0.131 (53/61)
AF		40.6	0.025	**0.045**	**0.025**	0.107 (25/28)
WM		41.6	0.015	**0.026**	**0.020**	0.063(254/271)
HM		43.7	0.005	**0.017**	**0.012**	0.057(148/157)
BM		49.0	0.000	0.005	0.003	**0.043 (90/94)**
JF		49.1	0.000	0.004	0.003	0.009(113/114)
GTM			0.000	0.003	0.002	**0.015 (66/67)**
JM			0.000	0.001	0.001	0.005(183/184)
CHM			0.000	0.001	0.000	**0.014 (73/74)**
AM			0.000	0.000	0.000	0.020 (48/49)
VM			0.000	0.000	0.000	**0.078 (47/51)**
Current case is closest to HFs						

Table 3: FORDISC 3.1 classification of unknown cranium in the FDB (all male and female reference groups). Multigroup Classification of Current Case.

α Reference groups: HF = Hispanic females; WF = White females; BF = Black females; AF = American Indian females; WM = White males; HM = Hispanic males; BM = Black males; JF = Japanese females; GTM = Guatemalan males; JM = Japanese males; CHM = Chinese males; AM = American Indian males; VM = Vietnamese males

BOLD & red: unknown cranium not typical for these groups

A graph of the results depicted in a 3D canonical space showed this variation (Figure 7). Surprisingly, the unknown cranium, (indicated by the bold "X" in the graph) is closest to the White female reference group's centroid, but the ellipses of the White and Hispanic reference groups overlap, and the Hispanic group's centroid is within the ellipse of the White reference group. See Supplement 1 for additional FORDISC 3.1 descriptive data. In this analysis, 61.2 percent of the reference groups in FORDISC 3.1 were classified correctly.
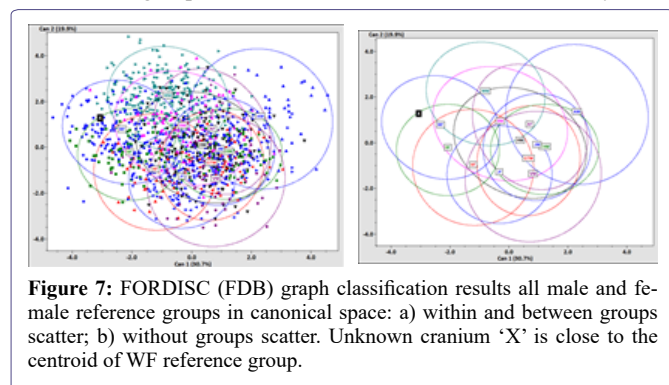
Figure 7: FORDISC (FDB) graph classification results all male and female reference groups in canonical space: a) within and between groups scatter; b) without groups scatter. Unknown cranium 'X' is close to the centroid of WF reference group.

The FORDISC 3.1 classification results for this unknown cranium indicate that posterior probabilities are distributed among Hispanics and Whites. This is often associated with mixed-race groups, and Hispanics are culturally and genetically heterogeneous, with

European, Native American, and African ancestral populations [21-22]. In admixture genetic analyses research (1991 and 2003) using samples of six autosomal DNA markers from nine Hispanic populations from different regions of the United States, geneticists generated the following admixture coefficients: 82.89 percent European (Pennsylvania); 84.49 percent European (New Jersey); 65.60 percent European (San Antonio); 68.30 percent European (Arizona); 83.40 percent European (Los Angeles); 17.11 percent African (Pennsylvania); 6.38 percent African (New Jersey); 2.50 percent African (Arizona); 9.14 percent Native American (New Jersey); 34.40 percent Native American (San Antonio); and 16.60 percent Native American (Los Angeles) [23-24]. In essence, this cranium could belong to an individual who is of mixed race.

Conclusion

In waiting eleven years to write this case report, the biological anthropologist was hoping for a resolution of this case to compare an actual photograph of the victim (phenotype—social race) to the results that FORDISC 3.1 generated (craniometrics—biological or ancestry). DNA extracted from the cranium in 2013 generated no match on the Combined DNA Index System used by law enforcement. To date, this case has not been resolved.

References

1. Quintyn C (2008) Admixture and the growing list of racial categories: Clarity or confusion for law enforcement (and the public). Proceedings of the American Academy of Forensic Sciences 60th Anniversary Scientific Meeting 14: 347.

2. Katarzyna B, Durand EY, Macpherson JM, Reich D, Mountain JL (2015) The genetic ancestry of African Americans, Latinos, and European Americans across the United States. Am J Hum Genet 96: 37-53.

3. https://www.census.gov/programs-surveys/decennial-census/technical documentation/questionnaires.2020_Census.html

4. Brace CL (2005) Race is a four-letter word: The genesis of the concept. New York: Oxford University Press.

5. Graves JL (2004) The race myth: Why we pretend race exists in America. New York: Penguin Books.

6. Cartmill M (1999) The status of the race concept in physical anthropology. Am Anthropol 100: 651-660.

7. Goodman AH, Armelagos GJ (1996) The resurrection of race: The concept of race in physical anthropology in the 1990s. In: Larry T. Reynolds and Leonard Lieberman (eds.). Race and Other Misadventures: Essays in Honor of Ashley Montagu in his Ninetieth Year: 174-186.

8. Gordon CC (1993) Why classify race? In: Claire Gordon (ed.). Race, Ethnicity, and Applied Bioanthropology: 1-6.

9. Gordon CC, Bell NA (1993) Problems of racial and ethnic self-identification and classification. Race, Ethnicity, Applied Bioanthropology 34-47.

10. Sauer NJ (1993) Applied anthropology and the concept of race: A legacy of Linnaeus. In: Claire Gordon (ed.). Race, Ethnicity, and Applied Bioanthropology 79-83.

11. Sauer NJ (1992) Forensic anthropology and the concept of race: If races don't exist, why are forensic anthropologists so good at identifying them? Soc Sci Med 4: 107-111.

12. Munsell (2000) Soil color charts. New Windsor, New York: GretagMacbeth.

13. Ubelaker DH (1997) Taphonomic applications in forensic anthropology In: William D. Haglund and Marcella H. Sorg (eds.). Forensic Taphonomy: The Postmortem Fate of Human Remains 77-90.

14. Ousley SD, Ashley M (2001) Three-dimensional digitizing of human skulls as an archival procedure. In: Emily Williams (ed.). Human Remains: Conservation, Retrieval, and Analysis: Proceedings of a Conference held in Williamsburg 173-184.

15. Howells WW (1973) Cranial variation in man: A study by multivariate analysis of patterns of difference among recent human populations. Papers of the Peabody Museum of Archaeology and Ethnology 67.

16. Jantz RL (1971) Microevolutionary change in Arikara crania: A multivariate analysis. Am J Phys Anthropol 38: 15-26.

17. Quintyn CB (2022) Questionable affiliation of five curated human crania: Using microscribe 3D digitizer and FORDISC 3.1 computer program to estimate ancestry and sex. J Forensic Res 13: 516-526.

18. Ousley SR, Hollinger E (2009) A forensic analysis of human remains from a historic conflict in North Dakota. In: Dawnie W. Steadman (ed.). Hard Evidence: Case Studies in Forensic Anthropology 91-102.

19. Jantz RL, Stephen DO (2005) Fordisc 3.0: Personal Computer Forensic Discriminant Functions. Knoxville, TN: The University of Tennessee.

20. Albrecht G (1980) Multivariate analysis and the study of form, with special reference to canonical variate analysis. Am Zool 20: 679-693.

21. Chakraborty BM, Fernández-Esquer ME, Chakraborty R (1999) Is being Hispanic a risk factor for non-insulin dependent diabetes mellitus (NIDDM)? Ethn Dis 9: 278-283.

22. Sans M (2000) Admixture studies in Latin America: From the 20th to the 21st century. Hum Biol 72: 155-177.

23. Bertoni B, Budowle B, Sans M, Barton S, Chakraborty (2003) Admixture in Hispanics: Distribution of ancestral population contributions in the continental United States. Hum Biol 75: 1-11.

24. Long JC, Williams RC, McAuley JE Medis R, Partel R, et al. (1991) Genetic variation in Arizona Mexican Americans: Estimation and interpretation of admixture proportions. Am J Phys Anthropol 84: 141-157.

Advances In Industrial Biotechnology | ISSN: 2639-5665

Advances In Microbiology Research | ISSN: 2689-694X

Archives Of Surgery And Surgical Education | ISSN: 2689-3126

Archives Of Urology

Archives Of Zoological Studies | ISSN: 2640-7779

Current Trends Medical And Biological Engineering

International Journal Of Case Reports And Therapeutic Studies | ISSN: 2689-310X

Journal Of Addiction & Addictive Disorders | ISSN: 2578-7276

Journal Of Agronomy & Agricultural Science | ISSN: 2689-8292

Journal Of AIDS Clinical Research & STDs | ISSN: 2572-7370

Journal Of Alcoholism Drug Abuse & Substance Dependence | ISSN: 2572-9594

Journal Of Allergy Disorders & Therapy | ISSN: 2470-749X

Journal Of Alternative Complementary & Integrative Medicine | ISSN: 2470-7562

Journal Of Alzheimers & Neurodegenerative Diseases | ISSN: 2572-9608

Journal Of Anesthesia & Clinical Care | ISSN: 2378-8879

Journal Of Angiology & Vascular Surgery | ISSN: 2572-7397

Journal Of Animal Research & Veterinary Science | ISSN: 2639-3751

Journal Of Aquaculture & Fisheries | ISSN: 2576-5523

Journal Of Atmospheric & Earth Sciences | ISSN: 2689-8780

Journal Of Biotech Research & Biochemistry

Journal Of Brain & Neuroscience Research

Journal Of Cancer Biology & Treatment | ISSN: 2470-7546

Journal Of Cardiology Study & Research | ISSN: 2640-768X

Journal Of Cell Biology & Cell Metabolism | ISSN: 2381-1943

Journal Of Clinical Dermatology & Therapy | ISSN: 2378-8771

Journal Of Clinical Immunology & Immunotherapy | ISSN: 2378-8844

Journal Of Clinical Studies & Medical Case Reports | ISSN: 2378-8801

Journal Of Community Medicine & Public Health Care | ISSN: 2381-1978

Journal Of Cytology & Tissue Biology | ISSN: 2378-9107

Journal Of Dairy Research & Technology | ISSN: 2688-9315

Journal Of Dentistry Oral Health & Cosmesis | ISSN: 2473-6783

Journal Of Diabetes & Metabolic Disorders | ISSN: 2381-201X

Journal Of Emergency Medicine Trauma & Surgical Care | ISSN: 2378-8798

Journal Of Environmental Science Current Research | ISSN: 2643-5020

Journal Of Food Science & Nutrition | ISSN: 2470-1076

Journal Of Forensic Legal & Investigative Sciences | ISSN: 2473-733X

Journal Of Gastroenterology & Hepatology Research | ISSN: 2574-2566

Journal Of Genetics & Genomic Sciences | ISSN: 2574-2485

Journal Of Gerontology & Geriatric Medicine | ISSN: 2381-8662

Journal Of Hematology Blood Transfusion & Disorders | ISSN: 2572-2999

Journal Of Hospice & Palliative Medical Care

Journal Of Human Endocrinology | ISSN: 2572-9640

Journal Of Infectious & Non Infectious Diseases | ISSN: 2381-8654

Journal Of Internal Medicine & Primary Healthcare | ISSN: 2574-2493

Journal Of Light & Laser Current Trends

Journal Of Medicine Study & Research | ISSN: 2639-5657

Journal Of Modern Chemical Sciences

Journal Of Nanotechnology Nanomedicine & Nanobiotechnology | ISSN: 2381-2044

Journal Of Neonatology & Clinical Pediatrics | ISSN: 2378-878X

Journal Of Nephrology & Renal Therapy | ISSN: 2473-7313

Journal Of Non Invasive Vascular Investigation | ISSN: 2572-7400

Journal Of Nuclear Medicine Radiology & Radiation Therapy | ISSN: 2572-7419

Journal Of Obesity & Weight Loss | ISSN: 2473-7372

Journal Of Ophthalmology & Clinical Research | ISSN: 2378-8887

Journal Of Orthopedic Research & Physiotherapy | ISSN: 2381-2052

Journal Of Otolaryngology Head & Neck Surgery | ISSN: 2573-010X

Journal Of Pathology Clinical & Medical Research

Journal Of Pharmacology Pharmaceutics & Pharmacovigilance | ISSN: 2639-5649

Journal Of Physical Medicine Rehabilitation & Disabilities | ISSN: 2381-8670

Journal Of Plant Science Current Research | ISSN: 2639-3743

Journal Of Practical & Professional Nursing | ISSN: 2639-5681

Journal Of Protein Research & Bioinformatics

Journal Of Psychiatry Depression & Anxiety | ISSN: 2573-0150

Journal Of Pulmonary Medicine & Respiratory Research | ISSN: 2573-0177

Journal Of Reproductive Medicine Gynaecology & Obstetrics | ISSN: 2574-2574

Journal Of Stem Cells Research Development & Therapy | ISSN: 2381-2060

Journal Of Surgery Current Trends & Innovations | ISSN: 2578-7284

Journal Of Toxicology Current Research | ISSN: 2639-3735

Journal Of Translational Science And Research

Journal Of Vaccines Research & Vaccination | ISSN: 2573-0193

Journal Of Virology & Antivirals

Sports Medicine And Injury Care Journal | ISSN: 2689-8829

Trends In Anatomy & Physiology | ISSN: 2640-7752

Submit Your Manuscript: https://www.heraldopenaccess.us/submit-manuscript