

# Forensic Anthropology and Human Osteological Collections: Skeletal Admixture, Racial Discrimination, and Calls for A NAGPRA-Like Law for the Remains of Other Historically Discriminated Groups in the United States

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## Abstract:

**Background:** Recently, a sophisticated methodology was used to assess race and sex in an unknown human skull recovered in the Pennsylvania state woods. Unidentified human skeletal materials are kept in police evidence storage lockers similar to museum curated human remains of largely black and brown peoples who were victims of recent violence or whose ancestors suffered violence and hate (i.e., slavery, American Indian Wars, racism, discrimination).

**Materials and Methods:** Thirty craniometric measurements were obtained from this unknown skull and analyzed using the FORDISC 3.1 computer program. Because the skull was unknown, all reference groups in the FORDISC 3.1 forensic data base were used as comparative samples.

**Results and Discussion:** On the initial run, FORDISC 3.1 classified the unknown skull into the white female reference group with a posterior probability of 0.437. But, this skull had posterior probabilities distributed among white, Hispanic (0.334), and American Indian (0.157) reference groups. Also, the typicality probability-*R* is higher for Hispanic (0.267) group than white (0.153), meaning that the skull falls inside that [Hispanic] range of variation more comfortably than white. This is often associated with mixed-race groups, such as Hispanics. A graph of the results depicted in 3D canonical space showed the centroid of unknown skull to be closest to the white female reference group's centroid, despite the fact that the ellipses of the white, Hispanic, and black reference groups overlapped.

**Conclusion:** This skull has not been identified to date and is 'curated' like museum collections in a police evidence storage locker. African Americans and other minority groups are calling for a law like the Native American Graves Protection and Repatriation Act to protect their human and cultural remains.

**Keywords:** ancestry, craniometrics, FORDISC 3.1 FDB, human osteological collections, racism, mixed-race, NAGPRA, typicality probabilities

## 1. INTRODUCTION

Since the early 1960s, researchers using sophisticated statistical analysis of the skull have obtained 76.9% accuracy on average in identifying white, black (African American), and American Indian (Native American) remains [1-2].

Toward the end of the 20th century and the beginning of the 21st, this accuracy (for identifying white and black men and women) improved further, ranging from 85% to 100% when statistical techniques were combined with computer programs [3-4]. These respectable accuracy rates were indicative of single ancestries, meaning that most unknown individuals were not biracial.

However, the steady increase in biracial or triracial population groups along with the constant flow of legal and illegal immigrants to the United States over the past 60 years have complicated the racial picture to the point where accuracy rates have decreased drastically for assigning unknown skulls to single ancestries. Genetic admixture analysis can be used to delineate multiple ancestries by finding DNA markers unique to one population but also present in others (i.e., indicating an admixture). However, DNA analysis takes months, bringing more anguish to the victim's family as they hope for a quick resolution. Further, DNA analysis is

expensive and destructive because the bone is directly analyzed to obtain results.

This intentional destruction may conflict with some cultures' traditional practices (if there is preliminary evidence that the victim may belong to, for example, a Native American group). Computational geneticist Jeffrey C. Long and his colleagues [5] at the University of New Mexico, Albuquerque, found that Hispanics (including Latinos) form a trihybrid population of Europe, Native American, and African ancestries. In essence, statistical standards need to be created to identify admixture in a skull. Therefore, craniometrics can serve as a reasonable proxy for genetic markers.

As colonization and the transatlantic slave trade in the 17th century brought geographically distinct populations from Europe and Africa into contact with the Indigenous peoples of the Americas, the subsequent history of settlement coupled with periods of admixture among these population groups resulted in the current complex and diverse U.S. population. Until 1875, no direct federal legislation restricted admission of immigrants into the country.

Regardless, most immigrants came from Northern and Western Europe until the period between 1880 to 1920, when a large shift toward immigrants from Eastern and Southern Europe occurred [6].

The peak year for admission of new legal immigrants to the United States was 1907, when almost 1.3 million immigrants entered the country and increased its labor force by 3%.

After a reduction in immigration to the United States during World War I, the Great Depression, and World War II, immigration steadily increased in subsequent decades. The 1965 Immigration and Nationality Act could be considered liberalizing changes to immigration legislation because they changed national-origin quotas first established in the Immigration Act of 1924—where Europe and Canada were the dominant sources of immigrants—to a greater proportion of immigrants originating in Latin America and Asia [7]. Specifically, Latin American immigration expanded from 26% of legal immigrants in the 1950s to 40% today, and in the 1980s, Latin Americans accounted for 2.4 million legal immigrants (Table 1).

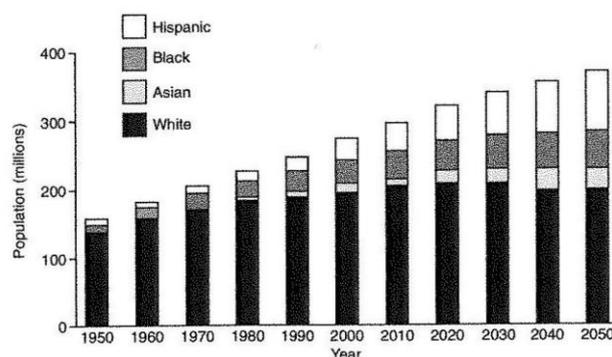
**Table 1.** Region of origin of foreign-born population in the United States, 1850-1990.

| Region of Origin                            | 1850 | 1900 | 1950 | 1970 | 1990 |
|---|------|------|------|------|------|
| Canada & Europe                             | 97%  | 98%  | 89%  | 67%  | 26%  |
| Caribbean & Latin America                   | 1    | 1    | 6    | 19   | 43   |
| Asia  | 0    | 1    | 3    | 9    | 25   |
| All Others <sup>β</sup>                     | 2    | 0    | 2    | 5    | 6    |
| Total Foreign-born Population (in millions) | 2.2  | 10.3 | 10.4 | 9.6  | 19.8 |

<sup>β</sup>The all other category includes Africa, Oceania, Pacific and Atlantic Islands, persons born at sea, and persons no reported region of origin. Adapted from National Research Council 1997.

Fueled by heavy immigration and higher fertility, the Hispanic population will rise from 27 million in 1995 to an estimated 95 million in 2050 [8]. Other findings by the council include that the size of (1) the Asian population (assuming medium net immigration levels) will increase from nine

million in 1995 to 34 million in 2050; (2) the white population will increase from 194 million in 1995 to 211 million in 2025 and then start to fall; and (3) the black population will increase substantially from 32 million in 1995 to 54 million in 2050 (Figure 1).



**Fig 1.** U.S. population by racial/ethnic group: Observed population, 1950-1995; projected population under medium immigration assumption, 1995-2050.

**Forensic Anthropology and Human Osteological Collections: Skeletal Admixture, Racial Discrimination, and Calls for A NAGPRA-Like Law for the Remains of Other Historically Discriminated Groups in the United States**

The growing rate of intermarriage among white, black, Hispanic, and Asian Americans ensures that the United States’ future will not be predominantly composed of a set of distinct cultures, languages, or people having a unique ethnic identification. When combined with increased immigration from developing countries, this means that by 2050, more people will have multiracial parentage and more children will have multiple ancestries, possibly weakening traditional racial boundaries in the United States.

This will also make it difficult for law enforcement to identify a missing individual (i.e., mixed-race individual) and, in the event that skeletal remains are found, to pinpoint race. Additionally, it is these groups—whether they are the increasing number of undocumented migrant fatalities across the U.S.–Mexico border

or at sea between Cuba or Haiti and Miami, or among disenfranchised blacks and Native Americans—whose skeletal remains are extensively represented in morgues and then eventually added to museum collections (Table 2).

This has led to calls from African Americans and Hispanics (including Latinos) for the U.S. government to pass a graves protection and repatriation legislation similar to the Native American Graves Protection and Repatriation Act (NAGPRA) addressing long-standing claims by federally recognized tribes that human remains and cultural artifacts—unlawfully removed from precontact, postcontact, former, or current Native American homelands—be returned to lineal descendants for reburial. This controversy will be discussed later in the paper [9].

**Table 2.** Selected academic and national museums curating forensic and historical human skeletal collections.<sup>Ω</sup>

| Collection Name                                       | Collection Location   | Description  |
|---|---|--|
| Pima County Office of Medical the Examiner Collection | Pima County Office of the Medical Examiner, Tucson, Arizona   | Hispanics (Mexican)—Forensic cases (U.S.-Mexico border crossing) |
| Morphological Collection                              | American Museum of Natural History, New York  | Native American; enslaved African Americans in collection        |
| William Montague Cobb Collection                      | Howard University, W. Montague Cobb Research Laboratory, Washington, D.C.                                 | Enslaved and mid-20 <sup>th</sup> century African Americans      |
| Physical Anthropology Collection                      | Department of Anthropology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. | Native American; enslaved African Americans in collection        |
| Morton Collection                                     | University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, Pennsylvania             | Native American; enslaved African Americans in collection        |
| Hearst Collection                                     | Phoebe A. Hearst Museum of Anthropology, University of California, Berkeley                               | Native Americans-‘Indian Island Massacre’                        |
| Maxwell Museum Documented Collection                  | Laboratory of Human Osteology of the Maxwell Museum of Anthropology, University of New Mexico             | Hispanics: Forensic cases and donated                            |
| Maricopa County Forensic Science Center Collection    | Maricopa County Forensic Science Center, Phoenix, Arizona   | Hispanics: Forensic cases and donated                            |
| Hamilton County Forensic Center Collection            | Hamilton County Forensic Center, Chattanooga, Tennessee   | African Americans, Whites—Forensic cases                         |
| Hamann-Todd Human Collection                          | Department of Physical Anthropology, Cleveland Museum of Natural History, Cleveland, Ohio                 | Dissection cadavers: bodies not claimed                          |

<sup>Ω</sup>*Skeletal Collections Database; Campanacho et al. 2021; Tise et al. 2014*

In this research, craniometrics is used to show possible admixture in an unknown skull. Furthermore, measurements from this skull are compared to the craniometric means of several

reference groups (i.e., white, black, Hispanic, Asian and American Indian) within the FORDISC 3.1 computer data base to find specific measurements which could be important in

identifying admixture. This research is conducted in the framework of forensic anthropology while noting the numerous stolen and unidentified skeletal remains of discriminated and marginalized people historically curated in U.S. museums and academic institutions.

## **2. MATERIALS AND METHODS**

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 skull. Investigators from Pennsylvania State Police Troop P Shickshinny Station designated the case as PO4-0744558. This biological anthropologist arrived at the

scene within 24 hours of the discovery and aided in the search for additional biological and non-biological materials. Unfortunately, the search was unsuccessful because the investigators did not give a clear provenience for the skull within the 2,125-acre wooded area. A cadaver dog was enlisted in the search, but nothing was found.

A quick visual assessment of the skull indicated that it was slightly weathered, with no mandible and possible animal gnawing on the frontal, parietal, and occipital bones (Figure 2a,b). The skull was transferred to the biological anthropologist's custody for analysis on November 21, 2012, several days after the county coroner completed his examination (Figure 2a,b).



(a)



(b)

**Fig. 2 a,b.** The unknown in frontal and profile views before (a, b) cleaning [Some of the images are not equal scale].

Craniometrics have proved valuable in assessing large-scale relationships and conducting small-scale analyses among populations, and, in the forensic context, aiding in unknown skeletal remains' identification [10-12].

Table 3 shows the craniometric measurements collected from this skull, and Figure 3a-c shows the corresponding cranial landmarks. These cranial measurements were found in the FORDISC 3.1 computer program for several comparative reference groups. Specifically, there were 56 landmarks (42 measurements) in the forensic data base (FDB) and 39 new

measurements (in addition to the 56 landmarks) in the William W. Howells Craniometric Data Set. Only cranial measurements in the FDB were used in this analysis. A shape transformation option was chosen in the FDB to account for shape variation in men and women.

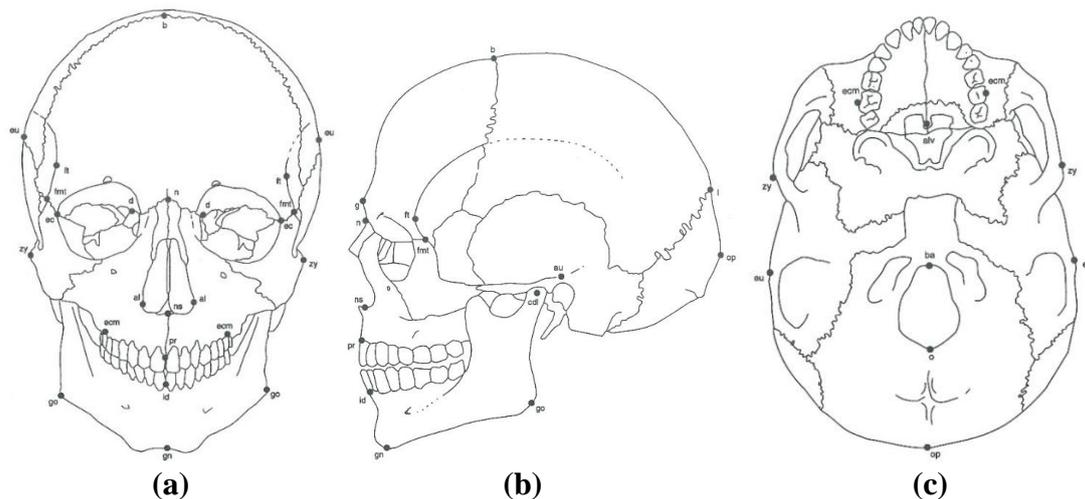
Craniometric means of several sample groups (i.e., white, black, Hispanic, Asian, and American Indian) within FORDISC 3.1 FDB were compared to cranial measurements from the unknown skull to find specific measurements that could be important in identifying admixture.

**Forensic Anthropology and Human Osteological Collections: Skeletal Admixture, Racial Discrimination, and Calls for A NAGPRA-Like Law for the Remains of Other Historically Discriminated Groups in the United States**

**Table 3.** Craniometric landmarks template (minus the mandible) in the FDB in FORDISC 3.1 listed by abbreviation, measurement, and brief description [39-40].

| <b>Landmark</b>                  | <b>Measurement</b>                        | <b>Brief Description</b>  |
|----------------------------------|---|---|
| Prosthion-Howells                | <b>BPL</b> (Basion-Prosthion Length)      | Most anterior point in midline on the alveolar process of the maxilla   |
| Prosthion-Martin                 | <b>UFHT</b> (Upper Facial Height)         | Midline at the inferior tip of the alveolar process (between central incisors) of maxilla   |
| Alare L/R                        | <b>NLB</b> (Nasal Breadth)                | The most lateral point on the margin of nasal aperture  |
| Inferior nasal border L/R        | <b>NLH</b> (Nasal Height)                 | Floor of the nasal cavity taken inside the nasal aperture   |
| Lower & Upper orbital border L/R | <b>OBH</b> (Orbital Height) [inf. & sup.] | The height between the upper and lower borders of the orbits, perpendicular to the long axis of the orbit                           |
| Ectoconchion L/R                 | <b>OBB</b> (Orbital Breadth)              | The intersection of the most anterior surface of the lateral border of the orbit  |
| Bi-orbital                       | <b>EKB</b> (Bi-Orbital Breadth)           | and a line bisecting the orbit along its axis   |
| Dacryon L/R                      | <b>DKB</b> (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                       | <b>ZYB</b> (Bi-Zygomatic Breadth)         | Maximum extent of zygomatic arch  |
| Frontomolare temporale L/R       | <b>UFBR</b> (Upper Facial Breadth)        | Point where the frontozygomatic suture crosses the temporal line  |
| Frontotemporale L/R              | <b>WFB</b> (Minimum Frontal Breadth)      | Point anterior and medial on temporal line  |
| Nasion                           | <b>NOL</b> (Naso-Occipital length)*       | Point of intersection of the nasofrontal suture and the mid-sagittal plane  |
| Nasion                           | <b>NLH</b> (Nasal Height)                 | Point from nasion to the most exterior margin of nasal bones notch  |
| Glabella                         | <b>GOL</b> (Maximum Cranial Length)       | The most forwardly projecting point in the mid-sagittal plane to the most posterior point on occipital bone                         |
| Bregma                           | <b>FRC</b> (Frontal Chord)                | From the most forwardly projecting point to where the coronal and sagittal sutures intersect  |
| Bregma                           | <b>PAC</b> (Parietal Chord)               | Point from bregma to lambda   |
| Cranial height                   | <b>BBH</b> (Basion-Bregma Height)         | Point from basion to bregma   |
| Lambda                           | <b>OCC</b> (Occipital Chord)              | Point from lambda to opisthocranium   |
| Asterion L/R                     | <b>ASB</b> (Bi-Asterionic Breadth)*       | Point where the lambdoidal, parietomastoid, and occipitomastoid sutures meet on both sides  |
| Eurion L/R                       | <b>XCB</b> (Maximum Cranial Breadth)      | Maximal cranial breadth   |
| Porion L/R                       | <b>MDH</b> (Mastoid Height)               | Point at the most superior aspect of EAM  |
| Opisthion                        | <b>FOL</b> (Foramen Magnum Length)        | Points from basion to opisthion   |
| Basion                           | <b>BBH</b> (Basion-Bregma Height)         | Midline point at the anterior margin of the foramen magnum to bregma  |
| Basion                           | <b>BNL</b> (Cranial Base Length)          | Point from basion to nasion   |
| FOB Point L/R                    | <b>FOB</b> (Foramen Magnum Breadth)       | Foramen magnum breadth  |
| Alveolon                         | <b>MAL</b> (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                   | <b>MAB</b> (Maximum Alveolar Breadth)     | Widest part of the alveolar maxilla at second molar   |
| Auriculare L/R                   | <b>AUB</b> (Bi-auricular Breadth)         | Exterior breadth across the roots of the zygomatic processes  |
| Zygomaxillare anterior L/R       | <b>ZMB</b> (Bi-Zygomaxillary breadth)*    | Breadth across maxillae, from left to right zygomaxillare anterior  |

\*Cranial measurements not used in analysis.



**Fig 3 a-c.** Cranial measuring points in (a) frontal, (b) profile, (c) posterior views. (Adapted from Buikstra and Ubelaker 1994)

### 2.1. Statistical Analysis: FORDISC 3.1 Computer Program

FORDISC 3.1 generates an unknown skull's posterior and typicality probabilities (Typ) of membership in each reference group in the database. Posterior probabilities sum to 1 (100%) and are based on the unknown skull's relative similarities (all Mahalanobis distances [ $D^2$ ]) to all groups [13]. A high posterior probability, which in turn creates a small distance, indicates a greater similarity to a particular group. Typ, in contrast, are the unknown skull'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 skull's case—indicates how well groups can be separated using the available variables. The word “typical” 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 Typ 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 [14]. An important result of this 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 among-group variation (eigenvalues) relative to the standardized within-group variation [15].

The variables (or measurements) are combined into a reduced number of functions to maximize the separation among 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 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.

### 3. RESULTS AND DISCUSSION

Osteometric measurements were obtained from the skull and then inputted into the FORDISC 3.1 FDB (Table 4). Based on the measurements, FORDISC 3.1 generated angles (i.e., NAA, PRA, BAA, NBA, BBA, BRA, see Table 4). Because there was no information on ancestry and sex for this cranium, all female (i.e., white, black, Hispanic, American Indian, and Japanese) and all male (i.e., white, black, Hispanic, Guatemalan, American Indian, Japanese, Vietnamese, and Chinese) reference groups were chosen in FORDISC 3.1 FDB for analysis. The term “American Indian” (as opposed to “Native

**Forensic Anthropology and Human Osteological Collections: Skeletal Admixture, Racial Discrimination, and Calls for A NAGPRA-Like Law for the Remains of Other Historically Discriminated Groups in the United States**

American”) was the language used in FORDISC 3.1 FDB. The shape transformation option was

chosen to account for shape variation within and between human groups.

**Table 4.** Craniometric data collected from cranium and inputted in FORDISC 3.1 FDB<sup>∞</sup>

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

\*Craniometrics in millimeters

<sup>α</sup>Additional Measurements/angles automatically calculated and only found in FORDISC 3.1 FDB:

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

<sup>∞</sup>Measurements removed by FORDISC 3.1 FDB: UFBR, FOB, NAA, PRA, BAA

On the initial computing of measurements, FORDISC 3.1 FDB automatically removed measurements UFBR, FOB, NAA, PRA, and BAA from the analysis (Supplement 1). Regardless, the unknown skull was classified into the white female (WF) reference group with a posterior probability of 0.437 (Table 5). But, this skull had posterior probabilities distributed among white, Hispanic (0.334), American Indian (0.157) reference groups. Additionally, the typicality probability-R (i.e., where FORDISC 3.1 ranks an unknown skull within a respective reference group) is higher for the Hispanic (0.267) group than the white (0.153), meaning that the skull falls inside that [Hispanic] range of variation more comfortably than white. This is

often associated with mixed-race groups, such as Hispanics. A graph of the results depicted in 3D canonical space showed this variation depicted in Figure 4.

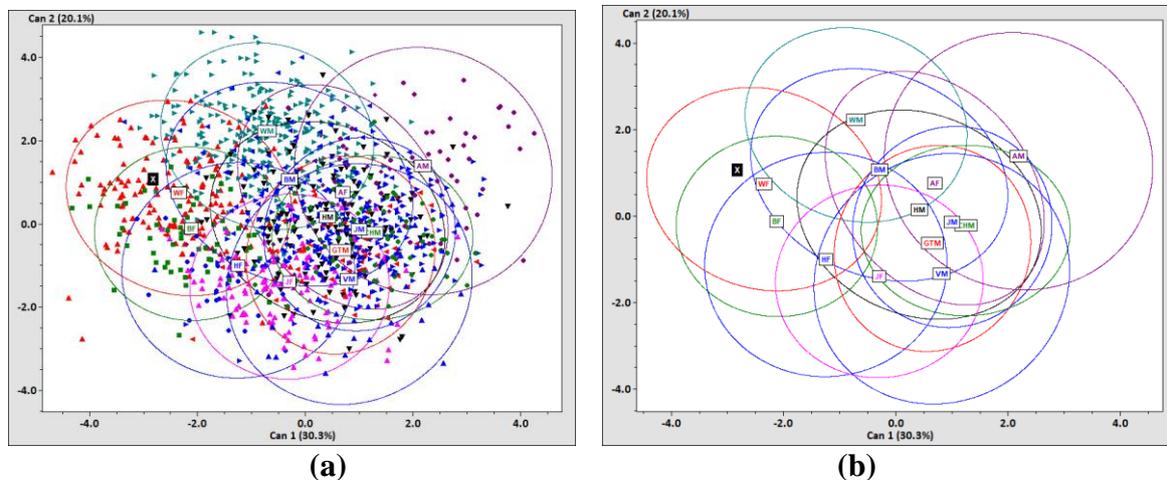
The centroid of the unknown skull (indicated by the bold “X” in the graph) was closest to the white female reference group’s centroid, despite the fact that the ellipses of the white, Hispanic, and black reference groups overlapped. Further, the Hispanic group’s centroid was within the ellipses of the white and black reference groups. See Supplement 1 for additional FORDISC 3.1 descriptive data. In this analysis, 60.3% of the reference groups in FORDISC 3.1 were classified correctly.

**Table 5.** FORDISC 3.1 FDB Multigroup classification of unknown cranium

| Reference group <sup>a</sup> | Classified into | Distance from | Posterior probabilities | Typicality F probabilities | Typicality Chi probabilities | Typicality R probabilities |
|------------------------------|-----------------|---------------|-------------------------|----------------------------|------------------------------|----------------------------|
| WF                           | **WF**          | 32.4          | 0.437                   | 0.139                      | 0.117                        | 0.153 (138/163)            |
| HF                           |                 | 32.9          | 0.334                   | 0.150                      | 0.105                        | 0.267 (22/30)              |
| BF                           |                 | 34.5          | 0.157                   | 0.101                      | 0.077                        | 0.197 (49/61)              |
| AF                           |                 | 36.6          | 0.054                   | 0.077                      | <b>0.048</b>                 | 0.143 (24/28)              |
| WM                           |                 | 39.7          | 0.012                   | <b>0.030</b>               | <b>0.023</b>                 | 0.063 (254/271)            |
| HM                           |                 | 41.8          | 0.004                   | <b>0.019</b>               | <b>0.014</b>                 | 0.127 (137/157)            |
| JF                           |                 | 45.3          | 0.001                   | 0.008                      | 0.005                        | <b>0.009 (113/114)</b>     |
| BM                           |                 | 45.8          | 0.001                   | 0.007                      | 0.005                        | 0.064 (88/94)              |
| GTM                          |                 | 46.3          | 0.000                   | 0.007                      | 0.004                        | <b>0.030 (65/67)</b>       |
| JM                           |                 | 50.1          | 0.000                   | 0.002                      | 0.001                        | <b>0.005 (183/184)</b>     |
| CHM                          |                 | 51.9          | 0.000                   | 0.002                      | 0.001                        | <b>0.014 (73/74)</b>       |
| AM                           |                 | 56.5          | 0.000                   | 0.000                      | 0.000                        | <b>0.078 (47/51)</b>       |
| VM                           |                 | 56.8          | 0.000                   | 0.000                      | 0.000                        | <b>0.020 (48/49)</b>       |

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

**BOLD & red:** unknown cranium not typical for these groups



**Fig. 4a,b.** FORDISC 3.1 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.

When craniometric means generated by FORDISC 3.1 FDB for Hispanic, white, and black reference groups were compared to the unknown cranium's measurements (Table 6), similarities were found with several groups: (1) Basion-Prosthion length was nearly equal to the mean for the FDB Black female reference group; (2) upper facial height (UFHT) was nearly equal to the mean for the FDB Hispanic, White, and Black female reference groups; (3) nasal breadth was nearly equal to the mean for the FDB HF group; (4) orbital breadth (OBB) was nearly equal to the means for all the FDB reference groups; (5) bi-OBB was nearly equal to the means for the FDB Hispanic and White female reference groups; (6) bi-zygomatic breadth was

nearly equal to the mean for the FDB White female reference group; (7) maximum cranial length was nearly equal to the mean for the FDB Black female reference group; (8) frontal chord and parietal chord were nearly equal to the means for the FDB HF reference group; (9) mastoid height was nearly equal to the means for the FDB White and Black female reference groups; and (10) maximum alveolar breadth was nearly equal to the mean for the FDB HF reference group. There were also nearly equal craniometric measurement means for UFHT, nasal height, Basion-bregma height, maximum cranial breadth, foramen magnum length, and cranial base length among the FDB Hispanic, White, and Black reference groups. SPSS statistical software

**Forensic Anthropology and Human Osteological Collections: Skeletal Admixture, Racial Discrimination, and Calls for A NAGPRA-Like Law for the Remains of Other Historically Discriminated Groups in the United States**

was used to generate a line graph showing unknown cranium measurements in relation to the craniometric means of the FDB reference

groups and their relationship with each other (Figure 5).

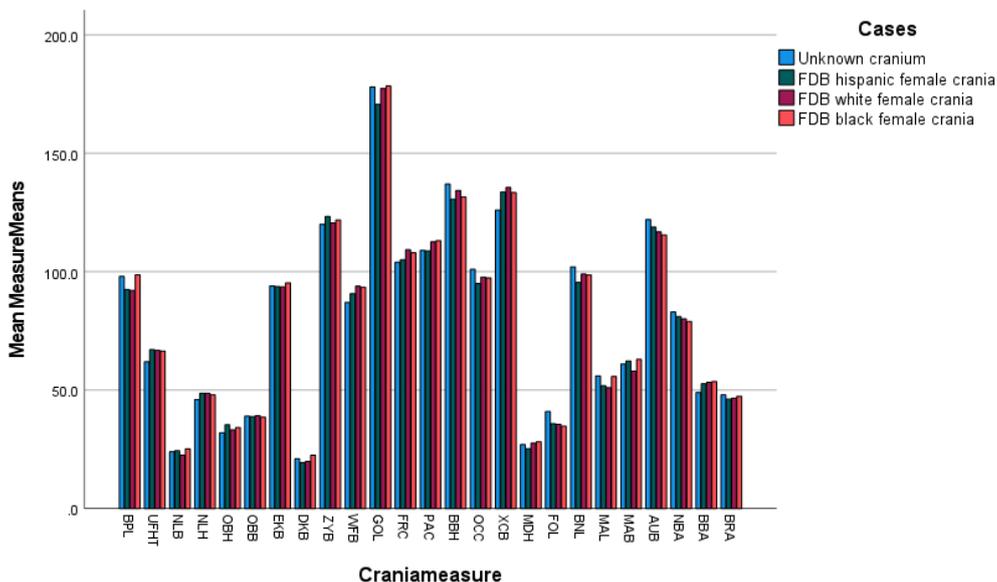
**Table 6.** Comparison of craniometric means of *FORDISC 3.1* FDB females: Hispanics (FDBHF), Whites (FDBWF), and Blacks (FDBBF) reference groups with unknown cranium measurements.<sup>Ω</sup>

| Craniometric landmarks measurements | Unknown cranium | FDBHF (n=29) | FDBWF (n=162) | FDBBF (n=60) |
|-------------------------------------|-----------------|--------------|---------------|--------------|
| <b>BPL</b>                          | <b>98</b>       | 92.5         | 92.1          | <b>98.7</b>  |
| <b>UFHT</b>                         | 62              | <b>67.1</b>  | <b>66.8</b>   | <b>66.5</b>  |
| <b>NLB</b>                          | <b>24</b>       | <b>24.4</b>  | 22.5          | 25.2         |
| <b>NLH</b>                          | 46              | <b>48.7</b>  | <b>48.7</b>   | 48           |
| OBH                                 | 32              | 35.4         | 33.2          | 34.2         |
| <b>OBB</b>                          | <b>39</b>       | <b>38.8</b>  | <b>39.2</b>   | <b>38.6</b>  |
| <b>EKB</b>                          | <b>94</b>       | <b>93.7</b>  | <b>93.6</b>   | 95.3         |
| DKB                                 | 21              | 19.4         | 19.9          | 22.5         |
| <b>ZYB</b>                          | <b>120</b>      | 123.3        | <b>120.6</b>  | 121.8        |
| WFB                                 | 87              | 90.7         | 93.9          | 93.4         |
| <b>GOL</b>                          | <b>178</b>      | 170.7        | 177.4         | <b>178.4</b> |
| <b>FRC</b>                          | <b>104</b>      | <b>105.1</b> | 109.3         | 108          |
| <b>PAC</b>                          | <b>109</b>      | <b>108.8</b> | 112.6         | 113.1        |
| <b>BBH</b>                          | 137             | <b>130.6</b> | 134.3         | <b>131.6</b> |
| OCC                                 | 101             | 95           | <b>97.7</b>   | <b>97.4</b>  |
| <b>XCB</b>                          | 126             | <b>133.7</b> | 135.6         | <b>133.4</b> |
| <b>MDH</b>                          | <b>27</b>       | 25.3         | <b>27.6</b>   | <b>28.2</b>  |
| <b>FOL</b>                          | 41              | <b>35.8</b>  | <b>35.6</b>   | 34.8         |
| <b>BNL</b>                          | 102             | 95.5         | <b>99</b>     | <b>98.6</b>  |
| MAL                                 | 56              | 51.9         | 51            | 55.8         |
| <b>MAB</b>                          | <b>61</b>       | <b>62.3</b>  | 58            | 63           |
| AUB                                 | 122             | 118.8        | 116.8         | 115.5        |
| NBA                                 | 83              | 81.1         | 80.1          | 79           |
| BBA                                 | 49              | 52.7         | 53.3          | 53.6         |
| BRA                                 | 48              | 46.2         | 46.6          | 47.4         |

<sup>Ω</sup>Means in millimeters

**BOLD:** Craniometric measurements with similar means with unknown cranium and respective reference groups

**RED:** Craniometric measurements with similar means among FDB reference groups



# Forensic Anthropology and Human Osteological Collections: Skeletal Admixture, Racial Discrimination, and Calls for A NAGPRA-Like Law for the Remains of Other Historically Discriminated Groups in the United States

## Supplement 1

FORDISC 3.1.321 Analysis of Current Case  
 (Newport township.adt)  
 Using cranial data file version 1.24  
 DFA results using 24 SHAPE variables:  
 AUB BBA BBH BNL BPL BRA DKB EKB FRC GOL  
 MAB MAL MDH NBA NLB NLH OBB OBH OCC PAC  
 UFHT WFB XCB ZYB  
 Measurements removed: UFBR FOB NAA PRA BAA

| Measurement Checks |              | Group Means |        |        |        |        |        |        |        |        |        |        |        |        |        | GS |
|--------------------|--------------|-------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----|
| Imp                | CC Imp       | AF          | AM     | BF     | BM     | CHM    | GTM    | HF     | HM     | JF     | JM     | VM     | WF     | WM     | %      |    |
| %                  | Current Case | 27          | 50     | 60     | 93     | 73     | 66     | 29     | 156    | 113    | 183    | 48     | 162    | 270    |        |    |
|                    | Chk          |             |        |        |        |        |        |        |        |        |        |        |        |        |        |    |
|                    | AUB          | 176.793     | 178.58 | 180.79 | 164.41 | 163.96 | 172.23 | 173.41 | 173.30 | 173.51 | 170.47 | 172.01 | 173.18 | 169.50 | 169.69 |    |
| 7.2                | BBA          | 71.007      | -      | 76.59  | 73.91  | 76.36  | 72.60  | 74.02  | 72.93  | 76.88  | 74.58  | 77.57  | 73.20  | 75.68  | 77.44  |    |
| 3.7                | BBH          | 198.529     | +      | 182.99 | 182.47 | 187.41 | 187.58 | 194.42 | 186.65 | 190.51 | 191.14 | 191.89 | 192.99 | 194.37 | 194.93 |    |
| 4.8                | BNL          | 147.810     | +      | 141.14 | 140.84 | 140.38 | 142.22 | 140.16 | 137.94 | 139.28 | 141.08 | 141.86 | 137.64 | 143.68 | 146.46 |    |
| 4.9                | BPL          | 142.014     |        | 136.46 | 136.97 | 140.49 | 141.92 | 133.84 | 136.98 | 134.88 | 137.67 | 136.09 | 135.97 | 134.64 | 133.70 |    |
| 1.9                | BRA          | 69.558      | +      | 68.94  | 66.94  | 67.54  | 65.45  | 63.32  | 65.55  | 67.39  | 65.22  | 66.20  | 65.01  | 62.83  | 67.61  |    |
| 3.7                | DKB          | 30.432      |        | 31.60  | 30.79  | 32.00  | 32.16  | 30.71  | 30.14  | 28.23  | 29.16  | 29.87  | 29.88  | 29.96  | 28.89  |    |
| 1.8                | EKB          | 136.217     |        | 138.96 | 138.81 | 135.64 | 136.07 | 135.08 | 134.87 | 136.65 | 134.87 | 135.92 | 135.65 | 134.47 | 135.84 |    |
| 1.5                | FRC          | 150.708     |        | 152.50 | 151.63 | 153.70 | 153.47 | 157.23 | 148.95 | 153.28 | 155.45 | 155.95 | 154.79 | 158.10 | 158.67 |    |
| 3.2                | GOL          | 257.943     |        | 250.98 | 246.03 | 254.01 | 253.86 | 250.02 | 242.37 | 249.00 | 249.25 | 249.63 | 250.18 | 243.17 | 257.42 |    |
| 7.0                | MAB          | 88.396      |        | 89.21  | 90.69  | 89.68  | 89.60  | 89.39  | 90.34  | 90.90  | 91.19  | 87.63  | 89.22  | 93.62  | 84.18  |    |
| 5.5                | MAL          | 81.151      | +      | 75.08  | 75.05  | 79.34  | 79.08  | 73.62  | 77.17  | 75.69  | 77.28  | 73.39  | 73.50  | 73.66  | 74.00  |    |
| 2.8                | MDH          | 39.126      |        | 34.78  | 40.25  | 40.12  | 44.32  | 41.10  | 43.66  | 36.95  | 39.47  | 38.16  | 42.00  | 37.30  | 40.09  |    |
| 4.6                | NBA          | 120.277     | +      | 108.93 | 105.78 | 112.56 | 107.23 | 113.63 | 113.60 | 118.45 | 112.16 | 117.76 | 113.22 | 115.53 | 116.42 |    |
| 5.2                | NLB          | 34.779      |        | 36.09  | 35.75  | 35.83  | 35.43  | 36.53  | 35.70  | 35.58  | 34.78  | 36.32  | 35.57  | 36.95  | 32.67  |    |
| 5.7                | NLH          | 66.660      | -      | 73.30  | 73.58  | 68.38  | 71.50  | 73.03  | 72.69  | 71.02  | 72.86  | 70.88  | 71.75  | 74.95  | 70.69  |    |
| 2.6                | OBB          | 56.516      |        | 57.79  | 57.82  | 54.90  | 55.47  | 53.93  | 54.55  | 56.54  | 55.82  | 54.75  | 54.81  | 54.16  | 56.94  |    |
| 3.9                | OBH          | 46.372      | -      | 49.66  | 48.19  | 48.75  | 47.98  | 46.96  | 50.65  | 51.61  | 49.24  | 49.12  | 47.62  | 47.63  | 48.17  |    |
| 3.3                | OCC          | 146.361     | +      | 132.44 | 128.35 | 138.65 | 134.22 | 136.92 | 133.91 | 138.56 | 135.74 | 140.49 | 139.74 | 138.86 | 141.81 |    |
| 3.2                | PAC          | 157.954     |        | 152.39 | 150.52 | 161.01 | 159.63 | 160.66 | 157.12 | 158.70 | 156.50 | 158.50 | 158.23 | 155.77 | 163.46 |    |
| 3.2                | UFHT         | 89.845      | -      | 100.31 | 100.52 | 94.71  | 99.15  | 101.83 | 100.30 | 97.76  | 102.35 | 99.50  | 100.64 | 100.78 | 96.87  |    |
| 2.9                | WFB          | 126.073     | -      | 129.88 | 132.81 | 132.98 | 130.59 | 127.74 | 130.17 | 132.26 | 131.53 | 130.95 | 129.88 | 133.64 | 136.31 |    |
| 3.4                | XCB          | 182.589     | -      | 194.42 | 195.87 | 189.87 | 184.56 | 194.46 | 191.16 | 194.94 | 193.71 | 194.83 | 193.09 | 198.20 | 196.81 |    |
| 2.5                | ZYB          | 173.894     |        | 187.26 | 193.47 | 173.41 | 177.44 | 185.24 | 184.47 | 179.78 | 183.35 | 181.55 | 185.94 | 183.43 | 175.12 |    |
| 11.5               |              | 25.3        |        |        |        |        |        |        |        |        |        |        |        |        |        |    |

+/- measurement deviates higher/lower than all group means; +/- deviates 1 to 2 STDEVs  
 +/+/- deviates two to three STDEVs; +/+/- deviates at least 3 STDEVs

Outliers detected in reference groups: 33

Natural Log of VCVM Determinant = 54.4413

### Classification Table

| From Group | Total Number | Into Group (counts) |    |    |    |     |     |    |    |    |    |    |     |     |        | Correct |
|------------|--------------|---------------------|----|----|----|-----|-----|----|----|----|----|----|-----|-----|--------|---------|
|            |              | AF                  | AM | BF | BM | CHM | GTM | HF | HM | JF | JM | VM | WF  | WM  |        |         |
| AF         | 27           | 15                  | 5  | 1  | 0  | 1   | 1   | 2  | 1  | 1  | 0  | 0  | 0   | 0   | 55.6 % |         |
| AM         | 50           | 4                   | 33 | 0  | 2  | 3   | 2   | 1  | 2  | 2  | 0  | 0  | 0   | 1   | 66.0 % |         |
| BF         | 60           | 1                   | 0  | 40 | 4  | 0   | 0   | 3  | 2  | 2  | 0  | 1  | 5   | 2   | 66.7 % |         |
| BM         | 93           | 1                   | 1  | 6  | 58 | 1   | 3   | 0  | 7  | 2  | 4  | 0  | 1   | 9   | 62.4 % |         |
| CHM        | 73           | 2                   | 1  | 0  | 3  | 34  | 1   | 1  | 5  | 6  | 16 | 4  | 0   | 0   | 46.6 % |         |
| GTM        | 66           | 1                   | 2  | 1  | 3  | 0   | 46  | 3  | 3  | 2  | 3  | 1  | 1   | 0   | 69.7 % |         |
| HF         | 29           | 2                   | 0  | 3  | 0  | 0   | 2   | 13 | 1  | 3  | 0  | 0  | 4   | 1   | 44.8 % |         |
| HM         | 156          | 6                   | 8  | 0  | 12 | 7   | 24  | 9  | 40 | 12 | 10 | 10 | 5   | 13  | 25.6 % |         |
| JF         | 113          | 1                   | 0  | 3  | 1  | 4   | 4   | 11 | 3  | 71 | 10 | 3  | 2   | 0   | 62.8 % |         |
| JM         | 183          | 2                   | 5  | 0  | 6  | 34  | 12  | 1  | 7  | 18 | 91 | 4  | 1   | 2   | 49.7 % |         |
| VM         | 48           | 0                   | 0  | 1  | 0  | 4   | 2   | 2  | 1  | 5  | 0  | 32 | 1   | 0   | 66.7 % |         |
| WF         | 162          | 3                   | 0  | 7  | 0  | 0   | 1   | 5  | 2  | 4  | 0  | 2  | 126 | 12  | 77.8 % |         |
| WM         | 270          | 5                   | 3  | 1  | 17 | 6   | 2   | 1  | 4  | 0  | 7  | 1  | 17  | 206 | 76.3 % |         |

Total Correct: 805 out of 1330 (60.5 %) \*\*\* CROSS-VALIDATED \*\*\*

**Fig 5.** Bar graph showing comparison of craniometric landmark measurement means of FORDISC 3.1 FDB Hispanic females (n = 29), White females (n = 162), and Black females (n = 60) compared to the unknown cranium measurements. The unknown cranium measurements are nearly equal to BPL, UFHT, NLB, OBB, EKB, ZYB, GOL, PAC, MDH, MAB.

#### **4. DISCUSSION**

The FORDISC 3.1 results are not surprising. Human populations have been migrating and admixing (i.e., through warfare and exogamy) for thousands of years so that ancestry is complex despite bureaucratic or state phenotypical assortment or self-identification. The similarities in the craniometric means, where craniofacial measurements dominate, reflect the white, black, and Hispanic reference groups' overlapping ellipses in the graph (Figure 4a,b). Therefore, the FORDISC 3.1 classification results for the unknown cranium indicate that posterior probabilities are distributed largely among Hispanics whites and blacks. This is often the case for mixed-race groups. Hispanics, are culturally and genetically heterogeneous, with European, Native American, and African ancestral populations [16-17].

In admixture genetic analyses research [18-19] using samples of six autosomal DNA markers from nine Hispanic populations from different U.S. regions, geneticists generated the following admixture coefficients: 82.89% European (Pennsylvania), 84.49% European (New Jersey), 65.60% European (San Antonio), 68.30% European (Arizona), 83.40% European (Los Angeles), 17.11% African (Pennsylvania), 6.38% African (New Jersey), 2.50% African (Arizona), 9.14% Native American (New Jersey), 34.40% Native American (San Antonio), and 16.60% Native American (Los Angeles). In essence, the unknown cranium could belong to an individual of mixed race.

Despite DNA analysis by geneticists at the University of North Texas, the unknown skull has not been identified and is 'curated' like museum collections in a police evidence storage locker.

##### **4.1. "Race" and Science: The Historical Obsession with Collecting and Documenting Skeletal Remains of Black and Brown Peoples**

Historically in the United States, it was African American and Native American skeletal remains that were extensively represented in academic or national museums. Included, to some extent, in museum drawers and on shelves were skeletal remains of mixed-race individuals who were, in life, assigned to the lowest ranking racial groups

as hypodescent rule dictated in the previous centuries. These groups consisted of African Americans and Native Americans. Because these groups were discriminated against and marginalized in American society, death due to slavery, American Indian wars, sociocultural violence, health disparities (compared to Whites), and poverty provided 19th- and early 20th-century medical doctors, anatomists, amateur collectors, and museum collectors obsessed with human racial variation with a bounty of skeletal remains for study. There were no laws protecting the remains of the so-called "lower races." For example, in May 1864, a lone Native American man from the Dakota tribe died at the hands of a pair of U.S. soldiers near a dusty outpost in rural Minnesota [20]. Both soldiers and settlers badly mutilated the body, which was then buried. The corpse lay below ground for a short time before being disinterred in the name of science. The medical officer placed the bones in a box and transferred them to the Smithsonian Institution to "advance the medical and anthropological study of race" (p. 3).

In another example, Samuel George Morton—a medical doctor in Philadelphia in the early 19th century—acquired approximately 900 skulls during the 1830s and 1840s. His contemporaries occasionally referred to him as the "American Golgotha" [21-22]. These skulls are part of what is known as the Morton Collection. The collection contained a representative sample of Morton's five races: Caucasian, Mongolian, American, Malay, and Ethiopian. Specifically, the skulls belonged to enslaved individuals, were stolen from Indigenous communities (i.e., removed by military doctors from corpses of individuals killed in battles against the U.S. Army), and taken from "the potter's fields of almshouses and public hospitals, where U.S. and European doctors had long sourced bodies for dissection" [23]. Essentially, "if you were a marginalized or disenfranchised human being, then there's a chance you would end up in Morton's collection" (p. 150).

In 2019, Penn professors and students working on the Penn & Slavery Project definitively learned that the Morton Collection contained 51 skulls of enslaved Africans from Havana in Cuba. Public announcement of this fact generated a flashpoint in 2020. Based on the research by the project members, a Cuban doctor named José

Rodriguez Cisneros dug up the bodies of the 51 “. . . pure rare African . . .” individuals, removed their skulls, and shipped their skulls to Philadelphia in 1840 at Morton’s request (p. 150) [24].

After the May 2020 murder of George Floyd, a black man in police custody, the flashpoint was fully ignited. The history of racial injustice perpetrated by 19th- and early-20th-century scientists reemerged with a vengeance. These scientists focused on scientifically “proving” the superiority of the White race over other races by measuring skull size. In the wake of Floyd’s death, academics and activists turned their attention to the Morton Collection. The protests the murder sparked forced the Penn Museum to put the collection, including the 51 skulls, in permanent storage while a committee of university and community leaders discussed future repatriation plans. The ripple effect of this situation spread to many notable university-affiliated and public natural history museums such as the Smithsonian Institution’s National Museum of Natural History, which “holds the remains of more than 30,000 people, many Indigenous and some likely enslaved” (p. 150) [25] and the American Museum of Natural History in New York City, where curators are scrambling to determine the number of Indigenous and/or enslaved African Americans in their collection.

The ripple effect goes even further because, despite decades of Indigenous activism, the University of California at Berkeley (UC Berkeley) failed to return the remains of thousands of Native American tribes until the Penn Museum-Morton Collection controversy and George Floyd murder sparked protests. In 2020, Tim White, a celebrated paleoanthropologist at UC Berkeley, finally reported and relinquished—after years of legal wrangling—Native American remains for repatriation. He had borrowed the remains from the Phoebe A. Hearst Museum of Anthropology (which, to date, still holds 9,000 Indigenous people on its premises) in the 1990s for teaching purposes [26]. For years, White had used his interpretation of the NAGPRA law, which states that human remains had to have a cultural or biological link to present-day tribes to be considered Native American.

According to White, the collections he worked with needed no reporting under NAGPRA because there was no way to determine the origin of the bones [27]. This was the argument White used when he and two other professors blocked the repatriation of two 9,000-year-old skeletons to the Kumeyaay (12 tribes whose homelands straddle the US-Mexico border with San Diego). This was the implied argument for the Kennewick Man controversy. White used phrases like “we should preserve [the skeletal collections] for study” or “students should not be deprived of the opportunity to learn from them.” A respectable number of human osteologists feel the same way.

The forced reckoning with this long history of viewing human remains as objects for display and research in the United States coupled with chronic racial discrimination, violence, and NAGPRA, has influenced African and Hispanic American communities (and Indigenous and marginalized peoples in other parts of the world) to fight for their ancestral remains’ protection. This may have, to some respects, paved the way for the respectful reburial of more than 400 individuals in 2003 when New York City construction uncovered the largest-known African American burial ground in the United States in 1991.

## **5. CONCLUSION**

Admixture studies using the human skull are not new, but the traditional focus has been on more research-oriented and philosophical questions such as race, ancestry, and craniometrical variation. Practical applications in the forensic context have not been fully considered [28-36]. The current research has the potential to generate standard probability parameters for identifying “Hispanic” skulls, particularly when a skull is discovered and assessed using primarily European and Native American ancestry estimates. On a larger scale, this research can help identify admixture in other population groups. However, one must reflect on whether or not the similar or near identical craniofacial landmark measurements noted between the unknown skull examined in this paper and FDB reference groups are governed solely by genetics and, therefore, can be used to identify an unknown skull as “Hispanic,” or whether these

measurements simply capture limited variation due to a small sample size.

Furthermore, thousands of researchers who have examined documented skeletal collections in museums in the United States and around the world feel both anxiety and shame because they know that, historically, these collections were built with the bodies of black and brown (as well as white—refer to the Terry Skeletal Collection and George Huntington Skeletal Collection) discriminated, impoverished, and marginalized peoples. Nevertheless, the researchers fear that the fervor for repatriation neglects the importance of these skeletons in skeletal anthropological research, education, and training in the United States [37-38].

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