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Intentional dental modification in Panamá: New support for a late introduction of African origin

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ABSTRACT

Intentional dental modification is a widespread practice in both ancient and modern populations. In Panama, the modern practice is restricted to the Ngäbe indigenous people inhabiting the western provinces. Several researchers have posited that Ngäbe dental modification evidences cultural transfer of African origin due to the absence of post-contact records of this practice in the region, and based on the chipping technique used to create a pointed tooth shape. In this paper, we collate bioarchaeological data from human remains recovered from pre-contact and early colonial period contexts in Panama to evaluate this hypothesis. The results of our study found no evidence for intentional dental modification among the pre-contact sample, but several instances of artificially modified incisor teeth among the early colonial sample. The latter pertained exclusively to individuals of African ancestry, and whose teeth had been chipped to points in the same manner as reported from Ngäbe communities. Isotope data revealed that one individual was a first-generation immigrant who likely originated from the African continent. Based on these results, as well as an exhaustive review of the ethnohistorical and modern ethnographic literature, the original hypothesis of a late introduction of African origin for the practice of dental shaping among the Ngäbe was upheld.

1. Introduction

Body modification has long been the focus of anthropological research into past and present human cultures, as it is linked intrinsically with themes of social identity and cultural affiliation. Bioarchaeologists often consider past instances of body modification through a biocultural lens – viewing human remains as molded by the cultural environments in which they were immersed during life – to gain insight into aspects of sociocultural identity during an individual's lifetime and across generations (Goodman and Leatherman, 1998; Zuckerman et al., 2012; Martin et al., 2013). In this way, the analysis of human remains provides a powerful tool with which to assess the validity of hypothetical origins and longevity of these cultural practices. This paper takes a fresh look at the legacy of one type of body modification – intentional dental modification – in Panama through a re-analysis of ethnohistorical data and the incorporation of data from recent analyses of ancient human dental remains.

1.1. Background

Intentional dental modification, including ablation, filing or notching, the placing of inlays, and tooth dyeing (Burnett and Irish, 2017), allows practitioners to modify their physical form as a unifying embodiment of social group identity, while often adding embellishments that make each modification unique at the individual level. Motivations for these modifications are fluid, often evolving with societal norms while maintaining the practice itself in all other forms and fashions.

The practice of chipping the anterior teeth to points among the indigenous groups and *campesinos* of mixed Spanish and indigenous heritage (i.e., *mestizos*) living in western and central Panama has been noted by several authors beginning in the mid-19th century (Bollaert, 1863, p 151; von Tschudi, 1868, p 402; Pinart, 1892; Verrill, 1927, p 221). This practice has been maintained to the present day, specifically in individuals belonging to the Ngäbe indigenous group of western

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Panama and southern Costa Rica (Marden, 1941; Johnson, 1943, 1948a; Reverte, 1963; Young, 1971; Torres de Araúz, 1980; Brenes and Barrantes, 1983; Villalobos Jiménez, 2018). Nevertheless, the only example of intentional dental modification noted by Spanish chroniclers among the inhabitants of Panama during the years of initial European contact (1502–1509 CE) and the colonial period (1510–1819 CE) is a single reference to dental ablation as a way of branding enslaved people in Darién (Fernández de Oviedo, 1853, pp. 8, 129). There are no records of the practice of chipping or filing the teeth to points among indigenous groups of the Isthmus of Panama in any of the Spanish chronicles, leading several authors to posit that the practice arose from the incorporation of escaped African enslaved people into indigenous communities in the early colonial period (Linné, 1940; Stewart, 1942; Stewart and Groome, 1968).

However, the attribution of the modern practice of dental modification to escaped African enslaved people is problematic because it is based primarily on the absence of evidence rather than evidence of absence. The contact-period historical writings, although often detailed in their description of the indigenous peoples, certainly do not represent unbiased, all-encompassing ethnographic accounts of indigenous ways of life. There are many details about indigenous cultures that were simply not mentioned based on their unimportance to the Spanish conquistadors' main goals of seeking sources of gold and establishing settlements on the Isthmus. Furthermore, the method of dental modification by chipping rather than filing, contrary to the belief of Stewart (1942) and other anthropologists writing in the early 20th century, was indeed practiced among some pre-Columbian populations of the New World (Roksandic et al., 2016).

Prior to initial European contact with indigenous peoples of the Americas, varied forms of intentional dental modification were practiced across broad geographic regions. In the large, well-known civilizations of Mesoamerica and the Andean region, dental modifications formed a large part of the socio-cultural identity of human populations. Specifically, dental filing and inlays appear frequently at sites within the Maya area (Tiesler et al., 2017) and at sites in Ecuador (Saville, 1913; Ubelaker, 1977, 1987).

Panama lies at the center of the ancient Isthmo-Colombian Area – a cultural interaction sphere that spanned from southern Nicaragua to northern Colombia in pre-contact times. Within this area, pre-contact intentional dental modification has been reported only from the Guanacaste Province in northwest Costa Rica (Hoopes, 1980; Solís del Vecchio and Herrera Villalobos, 2011; Aguilar Vega, 2012; Wankmiller, 2016; Valerio-Alfaro and Chavarría-Bolaños, 2017), where the majority fall within Types A1 and A2 of Romero's (1970) classification system (i.e., alterations to the occlusal edge of the incisor teeth). Northwest Costa Rica pertains to a cultural region known as Greater Nicoya, which shared various cultural affinities with Mesoamerica, particularly after approximately 800 CE when a change in ceramic assemblages is thought to coincide with the arrival of the Chorotega group from Mexico (Vásquez, 1983; Hardy, 1992; Obando, 1995; McCafferty and Steinbrenner, 2005). Nevertheless, a recently published analysis of the mitochondrial DNA from one of the individuals with dental filing from the Guanacaste site of Jícaro (800–1250 CE) showed that this individual, along with two other individuals from the site, was likely of local Isthmo-Colombian descent (Morales-Arce et al., 2017). No other reports of intentional dental modification among pre-contact peoples from other regions within the Isthmo-Colombian Area have been reported; however, it is noteworthy that relatively few bioarchaeological studies focused on these populations have been published in general.

In this paper, we collate and analyze data from pre- and post-contact osteological collections from Panama to provide a more comprehensive evaluation of the Linné/Stewart hypothesis of a post-contact African origin for dental modification in Panama. We show that there is no evidence for intentional dental modification whatsoever among the pre-contact human remains included in this study from archaeological sites in Panama. We also report the earliest examples of intentional dental modification on the Isthmus, pertaining to four early colonial period residents of Panama Viejo (i.e., the old city of Panama, a Spanish settlement inhabited from 1519 to 1673 CE). Radiogenic strontium isotope analysis of tooth enamel of one of these individuals was carried out to evaluate a possible non-local origin, whereas stable carbon and nitrogen isotope analyses provided indications of diet.

2. Materials and methods

2.1. Archaeological context of the Cathedral of Panama Viejo

During the dry seasons of 2017 and 2018, archaeological excavations were carried out in the Cathedral of Panama Viejo and in the area south of the main square of the city (i.e., the area occupied by the first Cathedral between 1519 and 1540, which was thereafter relocated to its current position and used until its destruction during the pirate siege on the city led by Morgan in 1671; Hernández Mora et al., 2020). At the culmination of these recent excavations, a total of 159 human burials were recovered from beneath the floor of the Cathedral and 16 more were recovered from the area south of the square.

Like many other colonial period religious spaces, the Cathedral was a sector used to bury those who died in the city. The social status of individuals defined the spatial distribution of burials, as people with money could pay to be buried near the altar, while the price of burial decreased significantly for inhumation closer to the door at the back of the Cathedral. In this way, such spaces are imbued with meaning not only in terms of the ritual and religious nature of the practice, but also aspects associated with family tradition, prestige, social identity, and memory (Martín-Rincón and Díaz Pérez, 2000; Vidal Lorenzo, 2008; Martín-Rincón et al., 2009).

Nevertheless, the osteological analysis of the human remains recovered in these excavations of the Cathedral nave revealed that the population buried there was quite diverse. Not only were individuals of likely European ancestry identified (22.01%; 35/159 individuals), but a good proportion of the sample buried inside the Cathedral corresponded to individuals of African ancestry (24.53%; 39/159 individuals) and, to a lesser extent, there was also an indigenous component (10.06%; 16/159 individuals). The rest of the individuals were of unidentifiable ancestry (43.40%; 69/159). At the site of the first Cathedral south of the square, a similarly diverse population was observed in the five individuals for which ancestry could be estimated (two Europeans, two indigenous, and one of African origin).

Based on city-wide demographic estimates from historical sources, we know that a large portion of the population living at Panama Viejo pertained to individuals of African descent. According to a description dated 1607, about 70% of the population of 5,702 persons living in Panama Viejo was of African origin, followed by 22% of European origin, and only 0.47% defined as indigenous (Mena García, 1984). These data illustrate the high number of city dwellers identified under the category of "Black," but who were not only enslaved people but also free people engaged in different activities in the city, including the formation of confraternities (Mena García, 2000). Whether enslaved or free, all Christians were permitted to be buried inside the churches of the city, and this burial space was organized socially.

Burials in the Cathedral were typically laid in the public inhumation sectors (i.e. the atrium and the main nave of the church), which show evidence of continuous funerary use throughout the colonial period. This pattern of reuse of funerary space has been recorded at many other colonial sites in Latin America (Duque Gómez, 1960; Larsen, 1993; Ubelaker, 1994; Zucchi, 1997; De la Pena, 1998; Martín-Rincón and Díaz Pérez, 2000; Rodríguez Álvarez, 2001; Martín-Rincón, 2002; Rivera-Sandoval, 2006, 2014). Burial plots had thus become areas of high population density, where many people were constantly being buried by disturbing previous burials (Rahtz, 1981). In most cases, the disturbed remains became part of the jumbled fill of the newly laid burials, losing the original body position and funeral context. This

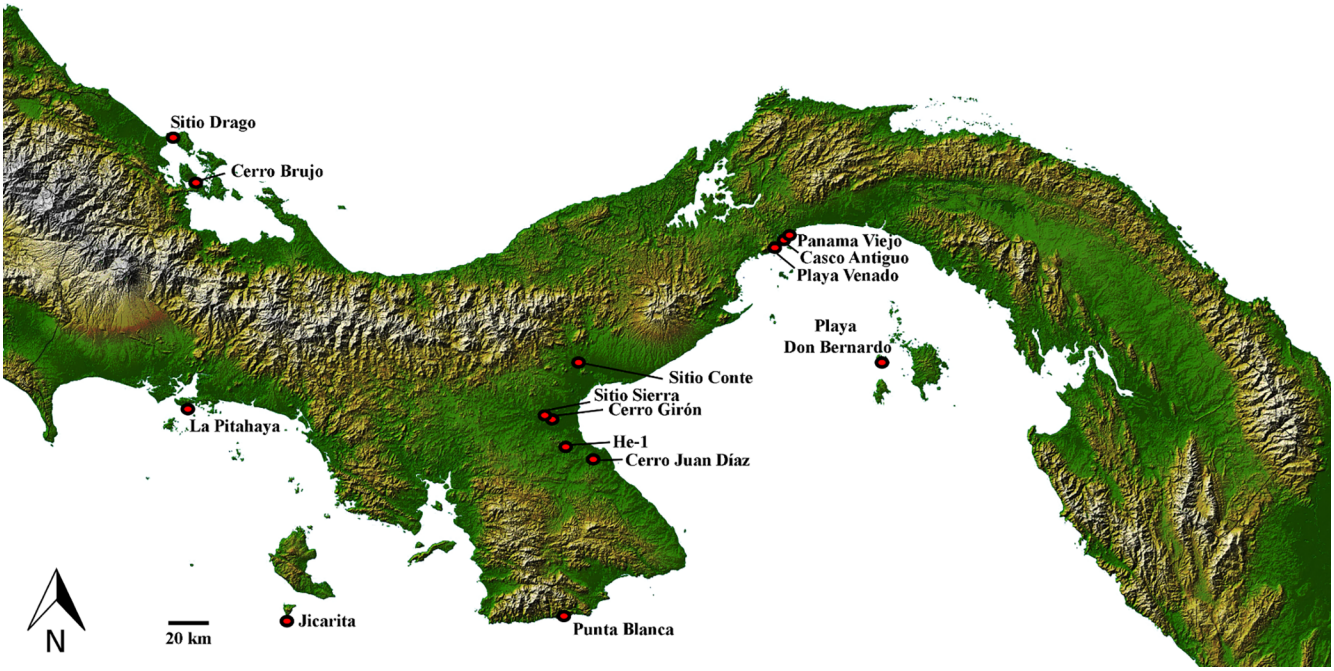

Fig. 1. Topographic map of Panama showing the location of the archaeological sites mentioned in the text.

constant reuse of burial space caused the disturbance, accumulation, fracture, and mixing of the skeletal remains of the original occupants (Larsen, 1993; Martín-Rincón, 2002).

This scenario was exemplified in the burial contexts found beneath the Panama Viejo Cathedral nave: disturbed burials and jumbled remains repurposed as fill for primary burials organized in rows parallel to the side walls of the church (the bodies oriented towards the main altar), with hands placed on the chest or pelvis and legs extended, as is usual in the Catholic rite (Larsen, 1993; Rodríguez Álvarez, 2001; Martín-Rincón, 2002). Clearly, this important burial space was subject to intensive funerary use during the late 16th and early 17th centuries.

2.2. Osteological analysis

The human remains evaluated in this paper pertain to at least 598 individuals that were excavated from a total of 14 archaeological sites across the Isthmus of Panama, from contexts dating from 4220 BCE – 1875 CE (see Fig. 1 and Table 1 for precise location and chronology information). The sites with pre-contact contexts are distinguished by their respective cultural regions: Greater Chiriquí (i.e., the western region), Greater Coclé (i.e., the central region), and Greater Darién (i.e., the eastern region). Four sites within the Greater Chiriquí region yielded samples for this study: the Caribbean coastal sites of Sitio Drago and Cerro Brujo, and the Pacific coastal sites of La Pitahaya and Jicarita. The six Greater Coclé sites include Punta Blanca, Cerro Juan Díaz, Sixto Pinilla (He-1), Cerro Girón, Sitio Sierra, and Sitio Conte. Finally, the three Greater Darién sites include Playa Venado, Playa Don Bernardo, and the pre-contact component of Panama Viejo. The two sites that provided samples from post-contact contexts are both located within the metropolitan area of Panama City. These are Casco Antiguo and the post-contact component of Panama Viejo.

Analysis of the anterior teeth from each individual in the observable sample was performed at a macroscopic scale, following the proposed criteria for identifying artificial dental modifications, particularly those relating to intentional dental modification (Milner and Larsen, 1991; Alt and Pichler, 1998; Mower, 1999). The first author analyzed the pre-contact sample and only the post-contact sample from Casco Antiguo, while the second author analyzed the post-contact sample from Panama Viejo. Demographic data collected for pre-contact individuals included age and sex, while those for post-contact individuals also included ancestry estimation when possible. For adults, age estimation was based primarily on changes to the pubic symphysis and auricular surface of the pelvis (Lovejoy et al., 1985; Brooks and Suchey, 1990), and secondarily on cranial suture closure (Acsádi and Nemeskéri, 1970; Meindl and Lovejoy, 1985). Sex estimation was based on the sexually dimorphic features of the pelvis and cranium. For non-adults, the dental development stage was the preferred method of age estimation, followed by the epiphyseal union stage. For the post-contact sample, ancestry estimation was based on craniometric assessments and the presence of specific non-metric cranial and dental traits (Hefner, 2009; Navega et al., 2015; Scott et al., 2018).

Table 1
Chronological dates for the human skeletal samples by site.

Site	Date*
Playa Don Bernardo	4220 – 3797 BCE
Sitio Sierra	39 BCE – 1158 CE
Cerro Girón	[200 BCE – 500 CE]
Cerro Juan Díaz (early)	33 – 648 CE
Playa Venado	223 – 565 CE
Sixto Pinilla (He-1)	[500 – 800 CE]
Jicarita	668 – 874 CE
La Pitahaya	893 – 1026 CE
Sitio Conte	[800 – 1200 CE]
Sitio Drago	892 – 1262 CE
Punta Blanca	1047 – 1261 CE
Cerro Brujo	1267 – 1388 CE
Panama Viejo (pre-contact)	545 – 1479 CE
Panama Viejo (post-contact)	1519 – 1673 CE
Casco Antiguo	1673 – 1875 CE

* Date ranges listed between brackets are approximations based on relative ceramic chronology. All other pre-contact dates are total 2σ ranges of radiocarbon dates from human collagen samples, calibrated with IntCal20. Post-contact dates are based on historical records.

2.3. Isotope analyses

Strontium isotope compositions ($^{87}Sr/^{86}Sr$) of tooth enamel relate to the geological conditions in the homelands from which humans derived

Table 2
Individuals and teeth surveyed for intentional dental modification from pre-contact sites.

Site	Total individuals	Total anterior teeth	Individuals with anterior teeth	Individuals with intentional dental modification
Playa Don Bernardo	1	2	1	0
Sitio Sierra	36	227	33	0
Cerro Girón	3	12	2	0
Cerro Juan Díaz (early)	52	213	42	0
Playa Venado	65	342	53	0
Sixto Pinilla (He-1)	4	7	3	0
Jicarita	1	2	1	0
La Pitahaya	9	22	7	0
Sitio Conte	3	14	3	0
Sitio Drago	2	6	1	0
Punta Blanca	3	16	2	0
Cerro Brujo	1	9	1	0
Panama Viejo (pre-contact)	52	215	38	0
Total	**232**	**1087**	**187**	**0**

their food and drink during childhood (Bentley, 2006; Szostek et al., 2015). Weathering of bedrock releases strontium into soils and groundwater and makes this trace element biologically available. As a substitute for calcium, strontium is taken up by plants and transported through food chains. Because isotope fractionation is negligible and corrected during data processing, $^{87}Sr/^{86}Sr$ ratios of foodstuffs reflect the geological conditions at the localities of their origin (Capo et al., 1998). The inorganic fraction (hydroxyapatite) of teeth and bones contains most of the strontium in the human body. Enamel of the permanent teeth starts forming in early childhood, remains afterwards unchanged, and is very resistant against alteration during burial (Hillson, 2005; AlQahtani et al., 2010). Thus, it reflects the geological conditions at the place of residency during enamel formation and may identify people as non-local if they moved between childhood and adulthood, especially among places with well-distinguishable biologically available strontium (Price et al., 2002; Evans and Tatham, 2004; Maurer et al., 2012).

Strontium isotope analysis is a very promising method for the identification of individuals of African origin at colonial sites in Panama. Old continental crust dominates the African continent and leads to some of the most radiogenic biologically available strontium on earth. In contrast, geologically young volcanic rocks and sediments form the Isthmus of Panama with accordingly low $^{87}Sr/^{86}Sr$ values. Thus, African immigrants of the first generation should be clearly distinguishable from locally-born individuals.

Ancient diet reconstruction is the main purpose of carbon and nitrogen isotope analysis on bone collagen (Ambrose, 1993; Katzenberg, 2000). The stable isotope compositions of both elements ($\delta^{13}C$ and $\delta^{15}N$) reflect the protein fraction of the human diet. Carbon isotope values are higher in C_4 plants (e.g. millet, sorghum, and maize) and foodstuffs of marine origin than they are in C_3 plants (the majority of plants in temperate and tropical climates; Cerling et al., 1997; Kohn, 2010) and most freshwater and terrestrial diets. Nitrogen isotope values are also higher in marine organisms than they are in terrestrial ones (Bocherens and Drucker, 2003; Hedges and Reynard, 2007). Moreover, they increase with trophic level and reflect fertilization with animal manure as well as aridity (Bogaard et al., 2007).

The skeletal remains recovered from the Cathedral of the colonial town of Panama Viejo were studied isotopically as part of the ArtEmpire project funded by the European Research Council (ERC). Sample preparation and analyses were carried out by the third author at the Curt Engelhorn Center for Archaeometry gGmbH, Mannheim, Germany. This study included one individual (UE 1082) with intentionally modified teeth. We sampled enamel from the maxillary left first molar and the maxillary left third molar teeth of this individual, which represent strontium that was incorporated between birth and the third year of life, and between about seven years and adolescence, respectively. Strontium isotope analysis followed previously described methods (Knipper et al., 2012, 2014, 2017a). Enamel was cut from the crowns, mechanically cleaned, ground, pre-treated with 0.1 M acetic acid buffered with Li-acetate (pH 4.5) in an ultrasonic bath, rinsed, and ashed. Sr separation with Eichrome Sr-Spec resin was carried out under clean-lab conditions. Sr concentrations were determined by Quadrupole-Inductively Coupled Plasma-Mass Spectrometry (Q-ICP-MS), and the isotope ratios by High-Resolution Multi Collector-ICP-MS (Neptune). Raw data were corrected according to the exponential mass fractionation law to $^{88}Sr/^{86}Sr = 8.375209$. Blank values were lower than 10 pg Sr during the whole clean lab procedure. The NBS 987 standard run along with the human samples yielded $^{87}Sr/^{86}Sr$ ratios of 0.71028 ± 0.00003, 2 σ; n = 3 and 0.71031 ± 0.00001, 2 σ, n = 1 (after Sr separation) and the Eimer & Amend (E & A) standard yielded $^{87}Sr/^{86}Sr = 0.70806 \pm 0.00001$, 2 σ; n = 2.

Carbon and nitrogen isotope analyses were carried out on a rib of the same individual (UE 1082). Collagen extraction followed the method laid out by Longin (1971) with modifications as described by Knipper et al. (2017b). Mechanically cleaned bone samples were demineralized in 0.5 N HCl, rinsed, reacted with 0.1 M NaOH, rinsed again, gelatinized, filtered with EZEE filter separators, frozen, and lyophilized. C and N contents and the stable isotopic compositions were determined in triplicates using a vario PYRO cube CNSOH elemental analyzer (Elementar) and a precisION isotope ratios mass spectrometer (Isoprime). The raw data were calibrated against the international Standards USGS 40 and USGS 41 using the IonOS software for stable isotope analysis. Interspersed quality control standards gave the following stable isotope values: IAEA CH6: $\delta^{13}C$: -10.36 ± 0.01‰, IAEA CH7: $\delta^{13}C$: -32.21 ± 0.06‰, IAEA N1: $\delta^{15}N$: 0.38 ± 0.04‰, IAEA N2: $\delta^{15}N$: 20.38 ± 0.11‰, USGS 43: $\delta^{13}C$: -21.24 ± 0.03‰, $\delta^{15}N$: 8.34 ± 0.03‰ (all standards n = 3).

3. Results

A total sample of 232 individuals from pre-contact and 366 from post-contact period contexts were surveyed. Within the pre-contact period sample, a total of 1087 anterior teeth were observable, pertaining to 187 individuals, from which to evaluate the presence or absence of intentional modifications (see Table 2). These included 10 individuals from Greater Chiriquí sites, 85 from Greater Coclé sites, and 92 from Greater Darién sites. None of the anterior teeth from these individuals showed signs of intentional modification.

The post-contact sample from non-commingled contexts contained 361 anterior teeth, pertaining to 71 individuals (see Table 3). These included four individuals from Casco Antiguo and 67 individuals from Panama Viejo. It is noteworthy that the sample from Panama Viejo was more diverse, and included 40 individuals (22.7% of the total) of estimated African ancestry. In contrast, the small sample from Casco Antiguo contained only individuals of European and admixed (European

Table 3
Individuals and teeth surveyed for intentional dental modification from post-contact sites.

Site	Total individuals	Total individuals of African ancestry n(%)	Total anterior teeth	Individuals with anterior teeth	Individuals with intentional dental modification
Panama Viejo (post-contact)	176	40(*22.7*)	347	67	4
Casco Antiguo	17	0(*0*)	14	4	0
Total	**193**	**40(*20.7*)**	**361**	**71**	**4**
Commingled sample at Panama Viejo (post-contact)	349*	–	2402	344*	15*
Total including commingled	**366***	**40(*10.9*)**	**2763**	**348***	**15***

* Minimum number of individuals.

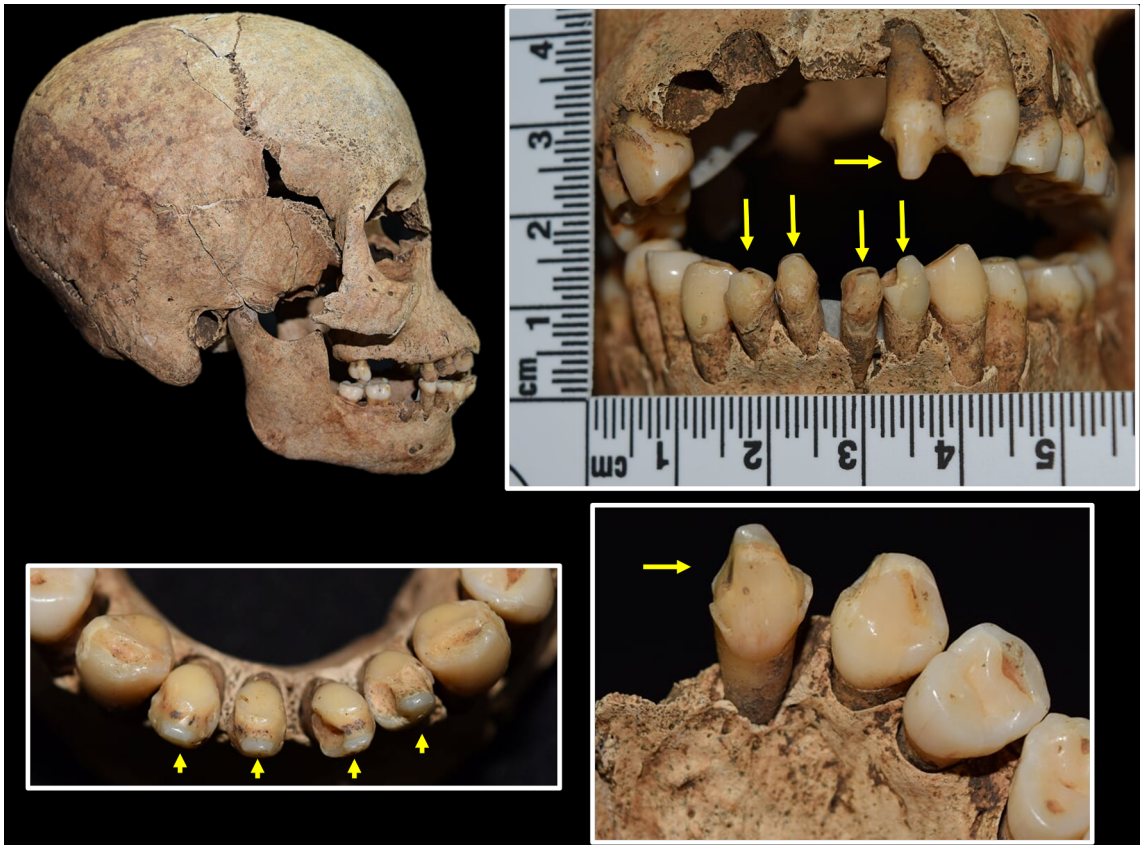

Fig. 2. Photographs of the cranium and dentition of Individual UE 1082, recovered from beneath the Cathedral at Panama Viejo (site code PVCA1). Note visible prognathism (a trait common in individuals of African origin) in the right lateral view of the cranium (top left). Yellow arrows highlight incisor teeth with the enamel chipped to points in an anterior view of the mouth (top right), superior view of the anterior mandible (bottom left), and lingual view of the left maxilla (bottom right). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

and indigenous) ancestry. Four individuals, all from beneath the floor of the Cathedral at Panama Viejo, showed evidence of intentional dental modifications in the form of the maxillary and mandibular incisor teeth chipped to points (see Figs. 2 and 3). All four of these individuals were of estimated African descent. From the same archaeological context (i.e., beneath the colonial Cathedral floor at Panama Viejo), a commingled sample of 2402 anterior permanent teeth were analyzed for the presence of intentional modification. This commingled anterior tooth sample represents a minimum number of individuals (MNI) of 344. Of these, 47 teeth showed evidence of the same type of tooth pointing, indicating that at least 11 and at most 15 additional individuals at Panama Viejo had the same dental decoration. Ancestry estimation was not possible for these isolated dental remains.

One of the intact individuals from Panama Viejo with modified teeth, UE 1082 (pictured in Fig. 2), was sampled for stable isotope analysis. Osteological analysis revealed that this individual pertains to a 20–25 year old female of African ancestry. Like the other individuals buried beneath the floor of the Cathedral, UE 1082 was positioned extended, with her hands placed over her pelvis, and lacked any associated cultural items. The changes to her bones and teeth noted during osteological analysis were also to be expected for her age and predicted lifestyle: slight arthritic lipping of the articular facets of her rib tubercles, slight osteophytosis of the second lumbar vertebra, and entheseal changes to the deltoid attachment sites of the left humerus. Her teeth showed a few cervical carious lesions with associated alveolar retraction, mild to moderate dental calculus, and mild occlusal wear.

The teeth of UE 1082 yielded very similar $^{87}Sr/^{86}Sr$ ratios of 0.71582 ± 0.00002 in the first molar relative to 0.71482 ± 0.00003 in the third molar. The sample of the rib bone contained 3.5% collagen with 14.8% N, 41.9% C, and an atomic C/N ratio of 3.3. These values match the quality criteria for well-preserved collagen (van Klinken, 1999). The stable isotope composition of the sample was

Fig. 3. Incisor chipping visible on the teeth of three additional individuals from the Panama Viejo Cathedral context. Yellow arrows indicate the modified teeth from Individual UE 1162 (top left photo; lingual view of left maxilla), Individual UE 1066 (top left photo; anterior oblique view of maxillae), and Individual UE 1123 (bottom photo; labial and lingual views of the maxillary left lateral incisor). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

$-15.24 \pm 0.08‰$ for $\delta^{13}C$ and $9.87 \pm 0.04‰$ for $\delta^{15}N$.

4. Discussion

4.1. Intentional dental modification and the African diaspora

Recent research into the history of European expansion into the Atlantic world, slavery, and the African diaspora has focused on the processes of change and cultural continuity of groups of people subjected to human trafficking. This focus has allowed the identification of aspects of ethnic and social identity, along with the resistance strategies of these men and women who were forced to adapt to new spaces. Specialists in archaeology, bioarchaeology, and ethnoarchaeology have attempted to answer questions regarding the African diaspora in the New World through evidence for intentional modification of the body, including the incredibly resilient dental tissues which have yielded critical information on the living conditions of past communities (Mower, 1999; Aseffa et al., 2016).

On the continent of Africa, the practice of intentional dental modification has a long history, with the earliest evidence of dental ablation in Morocco dating from 13,800 to 16,100 BP (De Groote and Humphrey, 2017, p 20). Dental filing dates back to more than 6,000 years ago in the lower Tilemsi Valley of eastern Mali in sub-Saharan Africa as evidenced by four female individuals with incisors and canines filed to a point (Finucane et al., 2008). The practice likely expanded out from West Africa with the Bantu groups, who carried it towards the east and south of the continent (Irish, 2017).

Tooth filing is one of the most common types of intentional dental modifications among African cultures, and several explanations have been proposed regarding the motivations for this practice. Irish (2017) suggests the following six reasons in explanation for the preponderance of this custom among both sexes: aesthetic purposes, ethnic affiliation marker, initiation rituals to adulthood, punishment, pain endurance, and tradition. Additionally, some researchers posit that this type of dental modification is linked to some kind of totemic association, mimicking the sharp, pointed teeth of carnivores, including lizards and felines (Baudouin, 1924). Usually, dental filing is understood as a symbol of beauty or ethnic affiliation. This is exemplified by the account of a 17th century a Jesuit priest who observed that the Zape people of West Africa apparently did not show their face in public if their teeth had not been modified.[1] Similar beliefs were held by populations from Angola and other African regions such as Mozambique (Sandoval, 1956 [1627]). In fact, travelers to Mozambique in the 19th-century reveal aesthetic motivations for the local cultural practice of modifying the teeth "in a manner that gives the whole set the appearance of a coarse saw, and this operation, does not injure either their whiteness or durability" (Alpers, 2001, p 6).

Dental modifications have also been observed in contemporary groups such as the Karrayyu Oromo of central Ethiopia, where both men and women undergo a procedure to enlarge the diastema, or gap, between the two front teeth as a marker of cultural identity (Aseffa et al., 2016). This particular procedure is reportedly accomplished by using a hand-axe tapped by a wooden hammer to cut off the mesial corners of the two teeth, thus producing an inverted V-shaped midline diastema. In the Makonde people of Southeast Tanzania, chipping the anterior teeth to points and extraction of tooth buds (i.e., ablation) is generally practiced as part of initiation rituals to adulthood (Fabian and Mumghamba, 2007). Finally, in the suburbs of Cape Town, South Africa, a high proportion of the population practice ablation of the

[1] The original text: "*Finalmente estas castas y todas las que hemos referido, generalmente se labran los dientes, más por pulicia y gala, que no por limpieza, pues no se les da nada se quede la comida entre las muelas cuando comen, porque no se echa de ver, y sienten mucho si se queda entre los dientes; y entre ellos es caso de menos valer no tener los dientes labrados, ni salen en público, ni tratan con gentes hasta que se los labre.*" (Sandoval, 1956 [1627], p 93).

incisors, which is more prevalent in the males and associated with gangsterism, peer pressure, aesthetics, medical, or accidental reasons (Friedling and Morris, 2007).

Due to the ubiquity of intentional dental modification among West African groups in particular, Europeans involved in the slave trade beginning in the 15th century began to build a symbolic perception of these bodily changes. For some slave traders, physical appearance and body modifications became a benchmark for categorizing not only the origin of these populations, but also the character and disposition they had, which in turn generated stereotypes for the appearance of African enslaved people (Alpers, 2001). That many of the groups that were enslaved beginning in the 15th century filed their teeth is visible in bioarchaeological evidence from different historical contexts associated with human trafficking (Stewart, 1939; Ortner, 1966; Handler et al., 1982; Handler and Corruccini, 1983; Handler, 1994; Cox and Sealy, 1997; Tiesler, 2002; Price et al., 2006; Tiesler and Arias, 2010; Pearson et al., 2011; Jaeger et al., 2013; Schroeder et al., 2015, 2014; Wasterlain et al., 2016; Kootker et al., 2016; Rufino et al., 2017). In fact, the Campeche excavations in Mexico were able to collect strontium isotope data suggesting that individuals with dental sharpening likely originated from West Africa (Price et al., 2006). A similar situation was revealed with strontium isotope analysis of individuals with modified teeth from San José de los Naturales Royal Hospital in Mexico (Barquera et al., 2020), the New York African Burial Ground (Goodman et al., 2009), the Newton plantation in Barbados (Laffoon et al., 2013) and from Saint Martin (Schroeder et al., 2014).

The cases of intentional dental modification recorded from the Panama Viejo Cathedral context affect mainly the maxillary and mandibular incisors, although occasionally appearing in some canines as well. The type of modification and its presence exclusively in individuals of African ancestry is consistent with biocultural practices known to have prevailed in Sub-Saharan Africa. Within these populations, chipping and filing the anterior teeth are frequently linked with aesthetic aspects and ethnic differentiation and, to a lesser extent, rites of passage to adulthood, punishment, resistance to pain, and other cultural traditions (Irish, 2017).

The technique used for this dental modification has been recorded ethnographically for the Aka people of the Central African Republic, where the procedure is described as follows. Patients rest their heads on the lap of the person performing the intervention, then bite a wooden stick with the molars so as to leave the incisors in the air. With the help of a knife or chisel and a stone hammer, the teeth are cut into the desired shape, and finally smoothed out to correct possible imperfections (Irish, 2017). Some complications can be generated with this intervention, such as cavities, death or loss of the tooth, abscesses, and trauma caused by exposure of the pulp (Rufino et al., 2017). Surprisingly, none of these pathological dental lesions were recorded in the modified teeth from the Panama Viejo Cathedral sample.

In comparing cases of intentional dental modification from Panama Viejo with those from other post-contact archaeological sites (see Table 4), all individuals showing evidence of enamel chipping modifications were of estimated African ancestry based on the osteological assessment. The isotope data of one of the respective individuals from Panama Viejo (UE 1082) support this finding.

The Isthmus of Panama is geologically highly complex. It is shaped by volcanic activity resulting from the collision of several continental plates between the Late Cretaceous and the Pliocene (Kirby et al., 2008). River water collected across the Panamanian Isthmus yielded $^{87}Sr/^{86}Sr$ ratios of between 0.703420 and 0.705274 (Harmon et al., 2016). These data reflect that the biologically available strontium is mainly derived from geologically young igneous rocks, such as volcanic arc lavas, pyroclastic and volcaniclastic sediments, as well as some marine sedimentary rocks (Harmon et al., 2016). Seawater with an $^{87}Sr/^{86}Sr$ ratio of just below 0.7092 forms the upper limit of the biologically available strontium (Howarth and McArthur, 1997; Brand et al., 2003). In human coastal communities, this seawater value likely

Table 4
Published data from historical contexts and osteological series with intentional dental modification.

Chronology	Individuals of African ancestry (n/N)	Individuals with intentional incisor chipping (n/N)	Archaeological site	Reference
15th-17th centuries	158/158	50/81	Valle da Gafaria, Lagos (Portugal)	Wasterlain et al., 2016; Rufino et al., 2017
16th century	20/600	3/20	San José de los Naturales Royal Hospital, Mexico City (Mexico)	Barquera et al., 2020; Lagunas and Karam, 2003; Meza, 2013
16th-17th centuries	40/176	4/67	Colonial Panama Viejo (Panama)	(Present study)
16th-17th centuries	10/180	4/54	Cathedral Campeche (México)	Tiesler, 2002; Price et al., 2006; Tiesler and Arias, 2010
17th century	3/3	3/3	Zoutsteeg area,Philipsburg, (Saint Martin)	Schroeder et al., 2014
17th-19th centuries	101/101	5/80	Newton plantation cemetery (Barbados)	Handler et al., 1982
1712–1794	301/419	26/166	Lower Manhattan, New York City (USA)	Blakey, 2009; Goodman et al. 2009; Mack et al., 2009.
18th-19th centuries	11/14	9/12	Praça XV de Novembro, Rio de Janeiro (Brazil)	Jaeger et al., 2013
1750–1827	63/63	5/35	Cobern Street, Cape Town (South Africa)	Kootker et al., 2016
1818	35/133	5/8	Fort Knokke, Cape Town (South Africa)	Cox and Sealy 1997
1840–1872	325/325	115/303	Rupert's Valley (Saint Helena)	Pearson et al., 2011

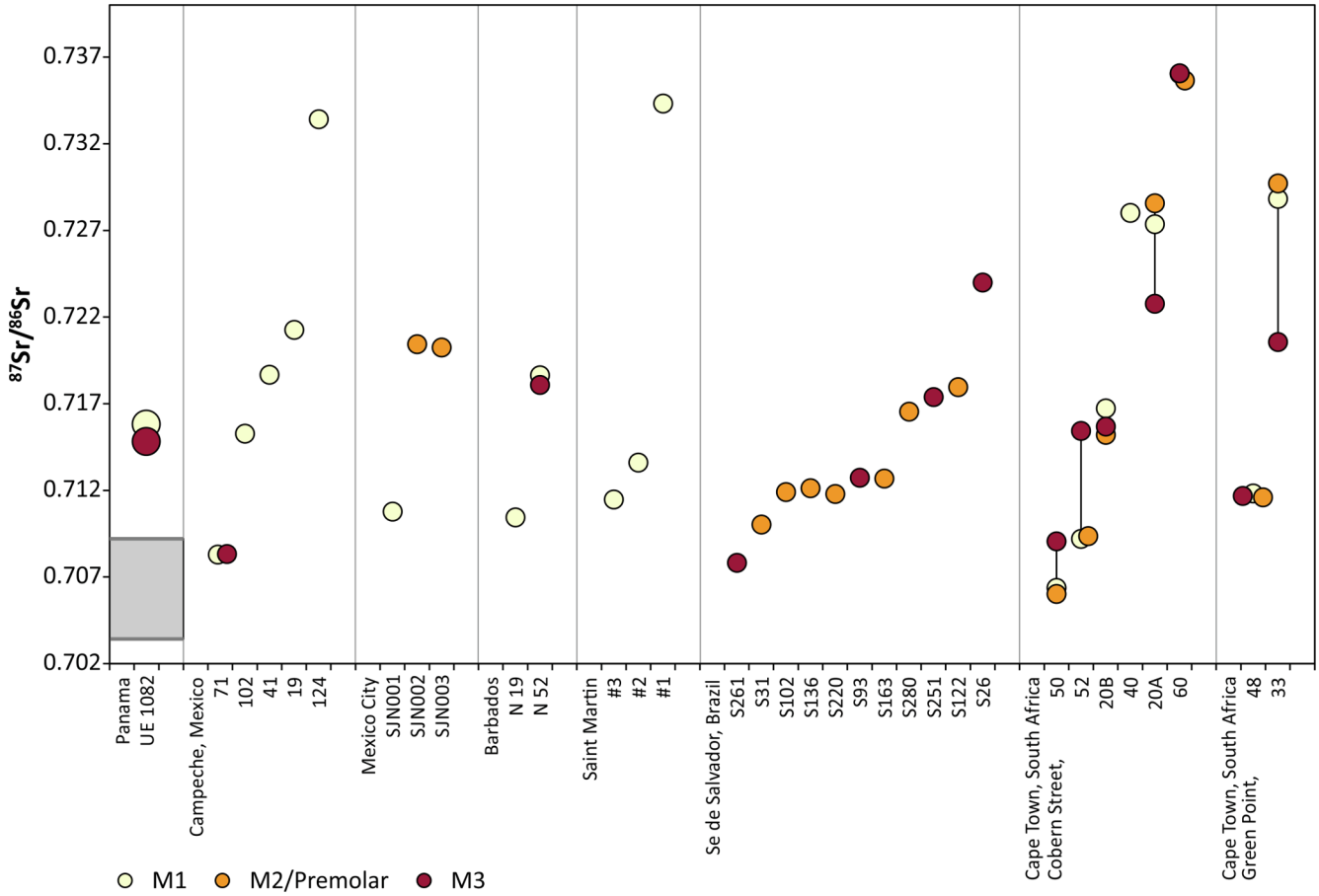

Fig. 4. 87Sr/86Sr ratios of enamel of the female individual UE 1082 from Panama Viejo in comparison to Sr isotope data of individuals with intentionally modified teeth at other colonial sites. The gray box indicates the biologically available strontium within Panama, ranging between local values of river water and that of seawater (Harmon et al. 2016). Comparative site data after Price et al. (2012), Barquera et al. (2020), Schroeder et al. (2009, 2014), Bastos et al. (2016), Kootker et al. (2016), and Mbeki et al. (2017).

contributes to the human strontium budget due to seafood consumption or foodstuffs that grew a very short distance from the coast and were influenced by sea spray effects (Whipkey et al., 2000; Snoeck, 2014). In contrast to Panama, some of the oldest rocks on earth crop out at the surface of the African continent. Accordingly, the biologically available strontium is more radiogenic (i.e., has higher $^{87}Sr/^{86}Sr$ ratios of up to about 0.75; Jørgensen and Banoeng-Yakubo, 2001; Bastos et al., 2016; Blanchet, 2019), whereas seawater forms the lower limit of the Sr isotope spectrum for this region.

With 0.7158 and 0.7148, respectively, the $^{87}Sr/^{86}Sr$ ratios of the enamel samples of UE 1082 are well above the range of the biologically available strontium in Panama and identify this individual as non-local to the Isthmus (Fig. 4). Moreover, the data of both teeth are very similar with only slightly less radiogenic strontium found in the third molar than found in the first molar. This indicates that this individual started to consume foodstuffs with remarkably less radiogenic strontium than typical for Africa in her adolescence at the earliest, when crown formation of the sampled wisdom tooth was nearly or already totally complete. Given that she passed away as a 20–25 year old, she may have resided in Panama for only a few years. UE 1082 was buried under the northwestern quadrant of the Cathedral floor, where she was one of several female individuals, including many of probable African origin. Although it is not possible to estimate the social status of this individual based on the archaeological context or skeletal features, both the overall osteological data as well as the historical documentation indicate that the Cathedral was not a place of burial restricted to individuals of higher social status.

With the $^{87}Sr/^{86}Sr$ ratios well above the local range at Panama, UE 1082 fits well into the spectrum of isotope ratios determined for enamel of individuals with intentionally modified teeth buried in other colonial cemeteries in the New World and in South Africa (also shown in Fig. 4). These data identify most of the individuals as first-generation immigrants originating from different locations on the African continent (Schroeder et al., 2009, 2014; Price et al., 2012; Laffoon et al., 2013; Bastos et al., 2016; Kootker et al., 2016; Mbeki et al., 2017; Barquera et al., 2020). However, the frequencies of these individuals with modified teeth tend to be low in their respective cemetery populations, with the exception of the slave cemetery in Lagos, Portugal (Wasterlain et al., 2016; Rufino et al., 2017), and Rupert's Valley in Saint Helena (Pearson et al., 2011).

Regarding the light stable isotope ratios, individuals with intentionally modified teeth at the different colonial sites in the New World and in South Africa exhibit a remarkably wide range of $\delta^{13}C$ and $\delta^{15}N$ values. Even though local baselines differ, the data indicate dietary compositions ranging from a dominance of C_4 plants (millet and sorghum in Africa and maize in the Americas and Africa), significant contributions of marine or freshwater resources, as well as terrestrial meat or dairy products (Fig. 5; Schroeder et al., 2009; Price et al., 2012; Laffoon et al., 2013; Bastos et al., 2016; Kootker et al., 2016; Mbeki et al., 2017; Barquera et al., 2020). Individual UE 1082 from Panama Viejo revealed both $\delta^{13}C$ and $\delta^{15}N$ in the middle of the data distributions of both isotope ratios of individuals with intentionally modified teeth at colonial sites ($n = 25$). The $\delta^{13}C$ value points to the consumption of C_4 and C_3 plants in probably about equal shares, and may also have been influenced by freshwater or terrestrial meat as well as marine sources. The $\delta^{15}N$ value is also intermediate in comparison to

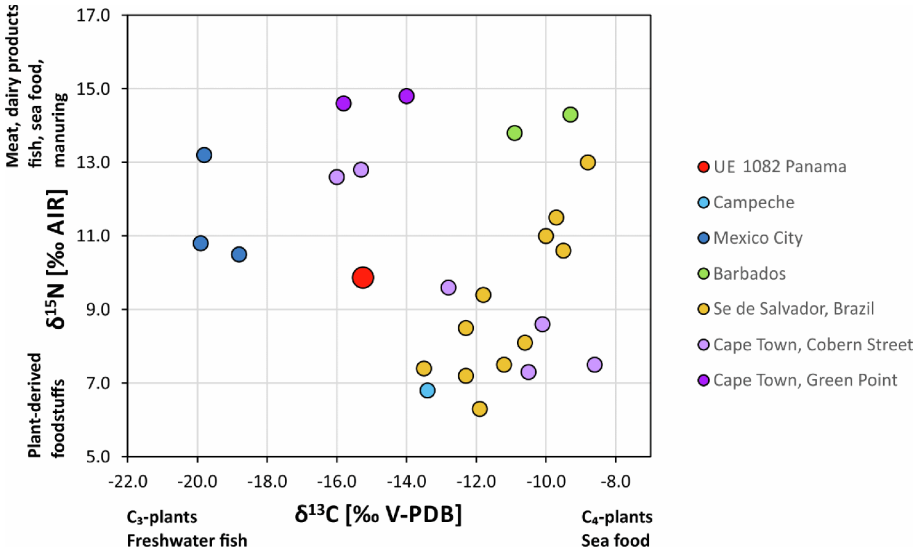

Fig. 5. Carbon and nitrogen isotope data of collagen of the female individual UE 1082 from Panama Viejo in comparison individuals with artificially modified teeth at other colonial sites. Comparative site data after Price et al. (2012), Barquera et al. (2020), Schroeder et al. (2009), Bastos et al. (2016), Kootker et al. (2016), and Mbeki et al. (2017).

the global data spectrum of individuals with modified teeth. These findings argue against a purely vegetarian diet, unless it was based on plants that were intensively fertilized with animal manure (Bogaard et al., 2007). It seems, however, more likely that terrestrial animal-derived foodstuffs and freshwater or marine sources contributed to her diet as well. The data present a long-term average of her diet and may include carbon and nitrogen with different isotope compositions taken up before and after her relocation to Panama. Future research will contextualize the isotope data of her skeletal remains with those of other individuals from colonial and pre-contact contexts at Panama Viejo.

4.2. Evidence from ethnohistorical and ethnographic sources

These data confirming the appearance of modified teeth only in individuals of African ancestry in colonial contexts at Panama Viejo appear to support the hypothesis put forth by Linne and Stewart regarding the introduction of the practice of intentional dental modification to indigenous groups in Panama in post-contact times. Nevertheless, there remains a possibility that the tradition of dental chipping existed in pre-contact times in the interior of the western region of Panama where human remains have not been recovered from archaeological sites. Thus, a closer look at the available ethnohistorical documents is warranted.

Although we cannot be certain of the precise geographic range of the Ngäbere-speaking groups prior to Spanish contact, it is almost certain that these groups inhabited areas of western Panama where they currently live (i.e., within the provinces of Bocas de Toro, Chiriquí, and Veraguas, as well as the Comarca Ngäbe-Buglé). Several Spanish chroniclers refer to "Guaymí" (i.e., Ngäbe) communities living on the island Escudo de Veraguas and the mainland valley which they called "el Valle de Guaymí," located just to the southwest of Escudo de Veraguas (Cooke, 1982, pp 46–49). It is less certain but highly likely that the area inhabited by these groups was more extensive in the past, including some northern parts of the central region of Panama (Johnson, 1948b; Young, 1970).

In our survey of the contact-period literature, we also confirmed Linné and Stewart's assertion that dental modification is not specifically mentioned by any of the early Spanish observations of the indigenous groups they encountered on the Isthmus. However, it is important to note that these historical writings are not without mention of the native isthmians' teeth. Upon first contact, Fernando Colón observed that the peoples inhabiting the Atlantic coast of Veraguas habitually chewed a type of herb – a practice he associated with the state of their "worn and rotten teeth"[2] (Colón, 1892, p 190). Similarly, Oviedo remarks on the "decayed and dirty"[3] state of the teeth among several of the mainland indigenous groups he met with on his travels, which he attributed to the widespread consumption of bread made from corn flour (Fernández de Oviedo, 1851, p 267). Along the Atlantic coast, the Spanish noted the common practice of using human teeth strung on cords as necklaces (Restrepo Tirado, 1892, p 125). Specifically referring to the Guna indigenous group with whom he lived for a time in the eastern area of the Isthmus, Wafer comments on the appearance of their teeth as being "white" and "even" (Wafer, 1934, p 78). Thus, the fact that the Spanish chroniclers and other early colonial texts made mention of the teeth but did not note the existence of dental modification lends further support for the hypothesis that these indigenous groups were not practicing dental modification at the time of contact.

The practice of chipping the teeth to points among the Ngäbe of Western Panama was not noted until the mid-19th century. At this time, thousands of foreigners were moving through Panama on their way to the West Coast of North America during the gold rushes of the 1840 s, 1850 s, and 1860 s (Kemble, 1949). The trans-isthmian transit of these foreigners was expedited by the completion of the railroad from Colón to Panama City in 1855, in turn opening the door for Panama's exploration at a time of heightened awareness and observation of the natural world. The published accounts of diverse physical and cultural aspects of human populations by European travelers in many areas of the world, including Central and South America, would pave the way for the development of the fields of anthropology and ethnography (Hodgen, 1964; Rowe, 1965; Stocking, 1987). To add insult to injury, the discovery of golden artifacts within ancient Chiriquí graves in 1859 was featured in several newspaper articles in the United States, heralding the influx of thousands of foreign tomb raiders to Western Panama (Lothrop, 1919). Thus, perhaps it is not surprising that the practice of dental modification among the indigenous groups of Western Panama was only noted in published form for the first time in 1863

[2] The first author's translation of the original text: "*Las costumbres de estos indios son, comunmente, semejantes a los de la Española é islas vecinas, pero estos de Veragua y del contorno cuando hablan uno con otro, se ponen de espaldas, y cuando comen, mascan siempre cierta yerba, lo cual creemos ser causa de tener* ***los dientes gastados y podridos.***" (Colón, 1892), our emphasis.

[3] The first author's translation of the original text: "*Este pan, coçido ó assado, no se sostiene de dos ó tres días adelante, porque despues se moheçe y se pudre y no se puede comer: ni tampoco es bueno para la dentadura, é assi comunmente esta gente de Indias tienen* ***los dientes dañados é suçios****, y no los he visto peores á ninguna generaçion.*" (Fernández de Oviedo, 1851), our emphasis.

Table 5
Published descriptions of dental modification among the Ngäbe communities.

Year	Author(s)	Location	Technique	Shape	Motivation	Sex bias
1863	Bollaert	Atlantic Coast (Valiente Peninsula)	Chipping the sides of the teeth	Points	Aesthetics; utility; disease protection	[Not noted]
1869	Tschudi	[Interior provinces]	[Not noted]	"Wedge-shaped" points	Aesthetics; utility	[Not noted]
1892	Pinart		[Not noted]	"Sawtooth" canines	[None noted]	[Not noted]
1921	Verrill	Chiriquí and Veraguas Provinces	Teeth chipped by placing a dull knife behind tooth and tapping with stone	"Needle-like points"	Preventing decay	Both sexes
1927	Verrill	Valiente Peninsula, Almirante Bay	Chipped with a stone and rubbed/filed smooth	"Sharpened"	Preventing decay	Both sexes
1941	Marden	Ocú, Herrera Province	Placing dull knife behind tooth and chipping corners with rock	"Pointed"	Preventing decay	Men only
1943	Johnson	Northern and Southern Guaymí	Chipping	"Mutilated"	Rite of passage	Young men only
1948	Johnson	Guaymí	Corners of upper and lower incisors chipped off	"Sharp wedge-shaped" points, or "needle teeth"	[Not noted]	Young men only
1963	Reverte	Río Cricamola Guaymí	Filing ("*limar*")	Points or double-points	Aesthetics	Women only
1971	Young	Southern Guaymí	Chipping the incisors	Points	Aethetics; preventing decay	More women than men
1980	Torres de Araúz	Ocú, Herrera Province	[Not noted]	Sharpened points ("*puntiagudos*")	Aesthetics	Both sexes
1983	Brenes & Barrantes	Southern Costa Rica	[Not noted]	Diverse forms	Aesthetics	[Not noted]
2018	Villalobos	Southern Costa Rica	[Not noted]	[Not noted]	[Not noted]	Both sexes

(Bollaert, 1863).

In considering the published descriptions of the custom of tooth shaping in Panama, the desired shapes seem somewhat uniform, but with a wide range of reported motivations behind the practice (see Table 5). In all cases describing technique, chipping was the mode by which the incisor teeth are shaped into the desired form of pointed occlusal edges (i.e., Romero's Type C-1), but sometimes double points per tooth were observed (i.e., Romero's Type A-1; Verrill, 1921; Verrill 1927; Reverte 1963; Brenes and Barrantes 1983). In modern times, triple points are also common (i.e., Romero's Type A-2; Villalobos 2018). Modifying the teeth for aesthetic purposes was the most common motivation recorded for the practice, but several observers also noted a common belief that shaping the teeth would prevent dental decay. Interestingly, the earliest account of the practice added that practitioners believed shaping their teeth in this way would protect them from smallpox (Bollaert 1863). Although some observers only noted the practice among men or among women in their respective communities, the published accounts taken as a whole clearly demonstrate that both women and men are having their teeth modified.

One detail that remains unclear from the published observations of this practice is exactly at what moment individuals have their teeth chipped. Only Johnson (1943) comments on the incorporation of this practice into male rite of passage rituals; however, the practice is suspiciously absent in descriptions of these rituals by other anthropologists. Further confusion arises from the question of whether the practice of modifying one's teeth among the Ngäbe is a conservative tradition, passed down through the generations, or whether it is a relatively recent development, practiced only among communities and individuals at the outskirts of the cultural area. Johnson (1943, 1948a,b) preferred the latter explanation, which was in line with the Linné/Stewart hypothesis, but Young (1971) was told that the practice was most concentrated in the most uncontacted, conservative communities inhabiting the highland regions.

4.3. Contemporary dental modification practices among the Ngäbe

It was not until 1962 that the Ngäbe started to organize politically as a more cohesive whole. This organization is attributed to the simultaneous rise of *Mamatada*, a new syncretic religious order and spiritual revitalization movement that spawned from messianic underpinnings (Guionneau-Sinclair, 1987). The movement was, however, quickly targeted by the Torrijos administration, which sought to engulf "the people" of the Republic of Panama under a unified national ethos. To this day, these two "imagined" communities (i.e., the Mamatada Ngäbe and Panamanian nationalists, *sensu* Anderson, 1983) continue to build upon elements that make them unique. It follows then, that the question of why or how certain people end up adopting practices such as dental modification is nearly identical to answering another, more nuanced question: why do human groups draw meaning by establishing relative difference from each other? Could the scaffolding of a narrative based on cultural continuity, dispersion, adoption or even coincidence be insufficient? Several field-based conversations and observations by the fourth author support the notion of an individualistic statement or personal vantage point to body modification rather than a cohesive community-wide practice.

The ethnohistorical and archaeological findings indicate two impasses. Firstly, that there is not overwhelming physical evidence to either prove or disprove the adoption of specifically African dental modification practices among indigenous communities. Secondly, that chroniclers would have ideally passed down a more exhaustive survey of all things as apparent as body modification. Indeed, more evidence of dental modification would help understand cultural contiguity or continuity, or that an imagined shared cultural past may be accessed via said practices. In actuality, the degree to which the practice is not ubiquitous among the various other elements that signal Ngäbe authenticity (i.e., language and architecture) point towards a certain

individualism or self-expression. The Mamatada groups are today more heterogeneous than homogeneous, and the practice of modifying the teeth is restricted to those who live in the more secluded mountainous regions of the Ngäbe-Buglé *comarca* (i.e., autonomous tribal lands). The fourth author's observations through extended field work and several interviews with well-connected Mamatada leaders suggest that the main motive for modifying one's teeth could be personal choice rather than collective. Thus, not necessarily out of bravery, rite of passage, or denoting importance in any way. Nonetheless, this observation in itself is nuanced, and a comparison can be drawn in regard to Mamatada.

The Mamatada belief system is in many ways syncretistic with Christianity, but traditional Ngäbe beliefs can have a stronger footing than outsiders may discern. In the writings of Philip Young (1971) and others in the academic literature, and even online in more popular "Wikipedia-type" articles, descriptions abound asserting strong connections between the spiritual Mamatada lore and Christian symbols like the Virgin Mary and Jesus Christ. Nevertheless, through the many years of dissertation work, the fourth author has slowly seen the dismantling of this Christian façade in Mamatada. We can, therefore, draw a direct line between the spiritual logic of syncretism and the hypothetical motivations for dental modification in the pre- and post-contact period of the Americas. The fact that few non-Ngäbe know the full picture, both in terms of the history and motivation for dental modification and in the underpinnings of Mamatada is a strong indication of practitioners' reluctance to divulge certain information to outsiders.

The Ngäbe feel safe withholding information, and will conceal behind familiar symbols, like with the case of Christianity, in order to be undisturbed (Guionneau-Sinclair, 1987; Sánchez Arias 2018). Upon inquiring on the subject of modified teeth in many conversations with Ngäbe individuals, the fourth author noted a similarity in the responses received. These indicate personal and individual aesthetics rather than group identity as a qualifier. In his experience, the fourth author can attest to the Ngäbe culture following this line of thinking. That is, they are very open about others' choices of this kind (i.e., aesthetic). Furthermore, the fluidity between men and women in this regard is also apparent, and comparatively more so than the neighboring Latino culture. The reservations of the Ngäbe make perfect sense when drawn along the central dichotomy of their belief, which is to distrust the colonizer. Modified teeth may be related to themes of identity, but the main inclination seems to be personal choice aesthetics. Thus, the archaeological evidence is the only path forward for anthropologists seeking to identify continuity in dental modification practices among the Ngäbe.

5. Synthesis and conclusions

In this study, we have reported on the earliest known evidence for intentional dental modification in Panama. The results of this study support the theory put forth by Linné (1940) and Stewart (1942) for a post-contact introduction of intentional dental modification of African origin for the continued practice among Ngäbe groups on the Isthmus. There is no evidence for the practice among the pre-contact skeletal remains studied, and the individuals with dental modification in the post-contact sample showed facial and dental traits consistent with individuals of African ancestry. Stable isotope data confirmed this finding for one of the individuals. Nevertheless, a clear limitation of this study is the low sample size ($n = 10$) of pre-contact skeletal samples from archaeological sites in the western (i.e., Greater Chiriquí) region of Panama due in part to the poor preservation of organic remains in the volcanic soils that prevail in this part of the Isthmus.

The question of how the practice was first introduced to the Ngäbe remains unclear. As mentioned in the previous section, the range of this indigenous group is thought to have covered broad parts of Western Panama at the time of contact, with coastal communities pushing further towards the interior highland regions of the Isthmus as a result of Spanish incursions. Early in the colonial period, the Spanish set up mining operations in the western region of Panama, to which they deployed high numbers of African and indigenous enslaved people (see Jopling, 1994 for various primary chroniclers' accounts). One possible scenario for the introduction of intentional dental modification among the Ngäbe is that members of this ethnic group observed African-born enslaved people with pointed teeth and adopted the practice among their own communities. However, it seems more likely that practitioners of African origin must have been adopted into Ngäbe communities for the technique of dental chipping to pass into the knowledge of the indigenous group. No matter how dental chipping came into vogue among the Ngäbe, the practice has been transformed into a cultural tradition unique to this indigenous group. No other indigenous groups in Central America continues to modify the shape of their incisor teeth; thus, the chipping of the teeth to points has become an embodiment of Ngäbe identity among practitioners.

CRediT authorship contribution statement

Nicole E. Smith-Guzmán: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Visualization. **Javier Rivera-Sandoval:** Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Visualization. **Corina Knipper:** Formal analysis, Investigation, Data curation, Writing - review & editing, Visualization. **Ginés Alberto Sánchez Arias:** . **:** Investigation, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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