# Comparing Biodistance Estimates from Deciduous and Permanent Dental Morphology in the Pre-Spanish US Southwest

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*ABSTRACT*
Biodistance analysis using dental nonmetric traits is a key method to examine population structure in the past. Researchers often favor permanent teeth rather than deciduous dentitions when examining biodistance in archaeological assemblages, despite being correlated. We compare the results of biodistance analyses using 79 permanent and 32 deciduous dental morphological traits from the ancestral remains of 351 individuals with permanent teeth and 122 individuals with deciduous teeth from the pre-Spanish Southwest United States. Biodistance was estimated between six regions based on the archaeological sites where individuals were found: Chaco, Gallina, La Plata, Middle Rio Grande, Mogollon, and Northern Rio Grande. Observations were first dichotomized, then traits were compared using tetrachoric correlation. Distance matrices of mean measure of divergence were then compared using a Mantel test. Biodistance estimates were similar between deciduous and permanent dentitions ($r = 0.55$, $p < 0.05$). Deciduous traits are thought to be a better reflection of underlying genetic variation since they are less impacted by environmental stress. Therefore, they may reveal additional trends that are hidden when only studying permanent teeth. We suggest researchers consider both the deciduous and permanent dentitions when using biodistance to more fully understand population structure.

**Introduction**
Biological distance (biodistance) analysis is a key method used by bioarchaeologists to examine population structure in the past. It measures similarity within or between groups separated culturally, temporally, or geographically (Pilloud and Hefner 2016; Pietrusewsky 2014). We can expect that groups who are biologically related to one another, either through recent shared ancestry or gene flow, will have smaller biodistances than unrelated groups (Pilloud and Larsen 2011; Stojanowski and Schillaci 2006). Biodistance analyses can be conducted using ancient DNA (aDNA), cranial traits, and dental traits (Hefner et al. 2016). In bioarchaeological research, aDNA data is often difficult to acquire due to ethical or preservation considerations; cranial datasets can be limited due to preservation and cultural modifications. Conversely, teeth are often the most preserved and copious elements in archaeological assemblages because of their resistance to taphonomic damage, making them ideal for studying relatedness across groups.

Dental nonmetric traits are a phenotypic proxy for genetic variation, and most traits are selectively neutral (Delgado-Burbano 2018; Rathmann and Reyes-Centeno 2020). Additionally, they are evolutionarily conservative with known heritability estimates (K. S. Paul et al. 2020; Irish 2015; Scott et al. 2018). Because teeth are slow to evolve, they undergo few morphological changes over the course of generations (Bailey 2002; Scott et al. 2018). However, they are subject to changing gene frequencies due to genetic drift and gene flow (Irish and Turner 1990; Turner, Nichol, and Scott 1991). Therefore, dental morphology is an ideal tool to examine migrations and population histories across space and time.

Typically, biodistance analyses utilize nonmetric traits of the permanent rather than deciduous dentition when studying population structure. The

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emphasis on permanent rather than deciduous dentition is due to several reasons. First, deciduous teeth are more susceptible to wear because of their comparatively thinner enamel, quickly rendering morphological traits unobservable due to attrition (Lease 2003; Sumikawa et al. 1999; Grine 2005); second, they are shed early and incrementally throughout childhood (Sciulli 1998); third, they are less consistently represented in the archaeological record relative to permanent teeth. Despite these limitations, many archaeological contexts contain large samples of subadult skeletons with preserved dentitions that have observable nonmetric traits, yet deciduous dentitions remain underutilized in bioarchaeological research relative to their permanent counterparts.

While previous studies have demonstrated the close correspondence between levels of expression and biodistance results derived from the two dentitions (H.J.H. Edgar and Lease 2007; K. S. Paul et al. 2020; Pilloud and Larsen 2011), research that specifically examines the relationship between population structure estimates derived using deciduous and permanent dentitions is scarce (but see Paul and Stojanowski 2017; Sutter and Chhatiawala 2016). Here, we compare the results of biodistance analyses using deciduous and permanent dental morphological traits from the skeletal remains of individuals in the pre-Spanish Southwest United States.

*Ethics Statement*

The human skeletal remains included in this paper were studied following consultation with descendant groups. Consultations were done on behalf of the second author by the following agencies where remains are or were located, according to their own policies: the Maxwell Museum of Anthropology's Laboratory of Human Osteology (MMA) in Albuquerque, NM; the Office of Archaeological Studies (OAS) and Center for New Mexico Archaeology (CNMA)/Museum of Indian Arts and Culture (MIAC) in Santa Fe, NM; the Arizona State Museum (ASM) in Tucson, AZ; Arizona State University (ASU) in Tempe, AZ. Author LO wrote letters detailing (1) the aims of her research and analyses she would conduct [the analyses here fall into the category of described research and analyses], (2) the nondestructive nature of the analyses, and (3) the potential for biodistance analyses to aid in cultural affiliation when paired with other information (including evidence deriving from geographic location, kinship, archaeology, anthropology, linguistics, folklore, oral tradition, historical information, and expert opinion; as cited in NAGPRA [e-CFR 1990]). These letters were sent on her behalf by MIAC staff to the cultural preservation programs of all possibly affiliated groups. In addition to permissions granted, LO received requests not to collect data from individuals buried at the site of Nambé; therefore, this site is not included in analyses and data were not collected from them. All methods used here are nondestructive.

*Contextual Background*

This study consists of individuals who inhabited today's New Mexico in the United States during the late AD 1100s to 1400s. This was a time of significant demographic and social change coinciding with the "Great Drought" which occurred between AD 1275 and 1300. During this time, there was a great upheaval in the northern portion of the San Juan region (Lipe 2010), with the Four Corners region being depopulated by the late AD 1200s. Previous studies have shown that while population density in this area was declining, it was increasing in other areas of the Southwest, including the Northern Rio Grande region and the Mogollon rim (Crown, Orcutt, and Kohler 1996; Ortman 2010; Wright 2010). Some researchers have argued that the population increase throughout the Southwest during this period was due to internal growth of the populations who occupied the areas (Boyer et al. 2010). Other researchers cite migration as the cause for at least some of the observed growth (Crown, Orcutt, and Kohler 1996; Ortman 2012; Wright 2010). While these ideas are not mutually exclusive, migration is a likely candidate for the demographic changes we see in the archaeological record because it can be implemented as a coping mechanism used in response to adverse circumstances, such as climatic downturns, violence, disease, or impoverished conditions (Bylander 2015; Clark 1994; Kulisheck 2003; Meze-Hausken 2000; M. C. Nelson and Schachner 2002; Turner, Turner, and Green 1993). We can track migration using multiple lines of evidence, including oral traditions, archaeological findings, and biological connections. Here, we use biodistance of dental nonmetric traits to study migration patterns and the relationships between groups.

The individuals in this study were originally chosen for dissertation research that examined if and how migration impacted the health of people in the pre-Spanish contact Southwest. Therefore, the sites where these individuals were interred were chosen because of their location or their population history. Sites were chosen following three criteria: 1) they were potentially in the path of people moving (Borck 2012; L. O'Donnell and Schillaci 2021; A. O'Donnell and Ragsdale 2017); 2) they likely had migrants residing at them or are thought to have been founded by migrants (Dutton 1963; Habicht-Mauche 2006; Mathien 2004; K. Nelson and Habicht-Mauche 2006; L. O'Donnell, Meyer, and Ragsdale 2020; L. O'Donnell and Schillaci 2021); or 3) they had experienced population decrease because the inhabitants had likely migrated elsewhere (A. O'Donnell and Ragsdale 2017; A. O'Donnell 2019).

Many studies have examined the relationships between populations in the Southwest using biological, archaeological, and cultural lines of evidence (e.g., O'Donnell and Schillaci 2021), but because previous biodistance analyses used data derived from *permanent* teeth, our goal is to investigate if these same relationships are evident when using nonmetric traits of *deciduous* teeth. Paul and colleagues (2020) have shown that crown morphology of deciduous dentition is equally capable as permanent dentition of estimating underlying genetic variability. Additionally, such estimates are not significantly different from each other. Therefore, we predict that data derived from deciduous and permanent dentitions will result in similar biodistance estimates and similar interpretations of population history.

**Materials and Methods**

To test our hypothesis, our study includes skeletal remains from 17 archaeological sites consisting of 122 individuals with deciduous teeth and 320 individuals with permanent teeth (Figure 1, Table 1). Most individuals lived between AD 1100 and 1400 and are from present-day New Mexico (A. O'Donnell 2019). The skeletal assemblages included in this study are (or were) housed in the Maxwell Museum of Anthropology's Laboratory of Human Osteology, the Office of Archaeological Studies, and the Museum of Indian Arts and Culture, all located in New Mexico.

We observed 32 dental morphological traits in the deciduous dentition and 79 traits in the perma-

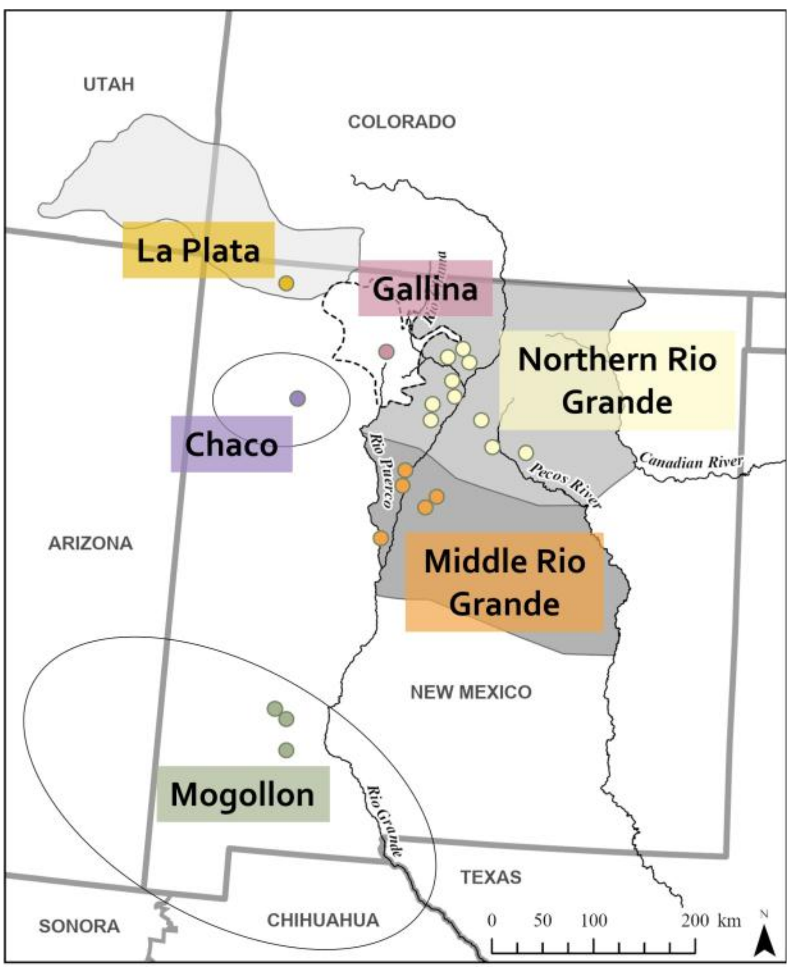


*Figure 1.* Regions and site locations for the individuals included in this assemblage. Figure adapted from O'Donnell (2019).

*Table 1.* Assemblage size description for the number of individuals with deciduous and permanent teeth from each region.

| Region | Deciduous ($n$ = 122) | Permanent ($n$ = 351) | Number of Sites |
|---|---|---|---|
| Chaco | 10 | 21 | 1 |
| Gallina | 6 | 40 | 1 |
| La Plata | 11 | 28 | 1 |
| Middle Rio Grande | 46 | 124 | 5 |
| Mogollon | 15 | 31 | 3 |
| Northern Rio Grande | 29 | 107 | 9 |

nent dentition (Table 2). Permanent teeth were scored by LO following Edgar (2017). As part of her original dissertation data collection, LO photographed all individuals with deciduous teeth. From these photos, EM scored deciduous traits following Hanihara's (1961) and Sciulli's (1998) descriptions. Traits were recorded as unobservable if teeth were broken, affected by large caries, or worn such that morphology was obscured. All traits were then dichotomized using breakpoints following Scott and Irish (2017) for permanent teeth, and Sciulli (1998) for deciduous teeth. Both antimeres were scored, but in cases of asymmetry, the highest expression of a trait was used.

Each author individually assessed intra-observer error for the dichotomized permanent and deciduous traits, respectively. As described in O'Donnell et al., (2020), LO scored 44 individuals, at least one week and up to three months apart. Cohen's Kappa coefficient of agreement (Cohen 1960) was calculated, showing a percent agreement between 0.72 and 1, with an average $k$ of 0.74. EM recorded morphological traits for 30 dental casts of contemporary children observed at least one week apart, after data collection for the present study. These casts are not included in the current assemblage or analyses. All deciduous morphological traits had substantial agreement or higher between observations (Cohen's $k > 0.6$).

We estimated biodistance between regions based on the sites in which individuals were found. Grouping was also based on presumed ethnolinguistic affiliation, archaeological culture designations, and geographic proximity (L. O'Donnell and Schillaci 2021; A. O'Donnell and Ragsdale 2017; L. O'Donnell, Meyer, and Ragsdale 2020). This resulted in six regions: Chaco, Gallina, La Plata, Middle Rio Grande, Mogollon, and Northern Rio Grande (Figure 1). While this is not an exhaustive list of distinct regions in the pre-Spanish arrival Southwest, we are limited by the number of individuals with deciduous teeth from each region.

Prior to data analysis, dental traits with frequencies close to either 0% or 100% were removed, because they do not provide a sense of population variation. Additionally, individuals with greater than 90% missing data were removed.

To compare trait frequencies and counts of observed individuals within each group, we estimated mean measure of divergence (MMD) of the deciduous and permanent traits separately. MMD produces a matrix of biodistance estimates where zero or negative values indicate that groups are not biologically different. MMD is well suited for biodistance estimates of archaeological assemblages because it accounts for groups with small sample sizes, even in the event of missing data (Irish 2010) through the Freeman and Tukey (1950) transformation.

An assumption of MMD is that traits are not correlated; therefore, we first identified inter-correlated traits in the deciduous and permanent dentitions separately, using tetrachoric correlation, using SAS software, university edition. From the resulting correlation matrix, traits with a correlation coefficient of at least 0.75 were removed. In each instance of correlation, the trait representing the least variability (as reflected by trait frequency) was omitted from the data set.

MMD analyses were performed in R (R Core Team 2021) and visualized using principal components analysis. To test if the biodistance matrices using deciduous and permanent morphology data were similar, we applied a Mantel test using 999 iterations, which examines correlation between matrices.

*Table 2.* Morphological traits recorded for the deciduous dentitions, following Hanihara (1961) and Sciulli (1998), and for permanent dentitions following Edgar (2017). Lower case letters denote deciduous teeth. Superscript and subscript numbers indicate a tooth's maxillary or mandibular position respectively. Bolded traits indicate which were used in the final biodistance analyses.

| **Morphological Trait** | **Deciduous Teeth** | **Permanent Teeth** |
|---|---|---|
| Winging | | $\mathbf{I^1}$ |
| Labial Curvature | | $I^1$ |
| Interruption Groove | | $\mathbf{I^1}$, $I^2$ |
| Peg/Reduced | | $I^2$, $\mathbf{M^3}$ |
| Diastema | | $I^1$ |
| Congenital Absence | | $I_1$, $I^2$, $M^3$, $M_3$ |
| Shovel | $\mathbf{i^1}$, $i_1$, $i^2$, $\mathbf{i_2}$, $c^x$, $\mathbf{c_x}$ | $I^1$, $\mathbf{I_1}$, $I^2$, $I_2$, $C^x$ |
| Double Shovel | $i^1$, $i_1$, $i^2$, $i_2$, $c^x$, $c_x$ | $\mathbf{I^1}$, $\mathbf{I^2}$ |
| Tuberculum Dentale | $i^1$, $\mathbf{i^2}$, $\mathbf{c^x}$, $c_x$ | $I^1$, $I^2$, $\mathbf{C^x}$ |
| Mesial Ridge | $c^x$ | $C^x$ |
| Distal Accessory Ridge | $c^x$, $c_x$ | $\mathbf{C^x}$, $\mathbf{C_x}$, $\mathbf{P^3}$, $P^4$ |
| Accessory Cusps | | $\mathbf{P^3}$, $\mathbf{P^4}$ |
| Distosagittal Ridge | | $P^3$ |
| Mesial Accessory Ridge | | $P^3$, $P^4$ |
| Lingual Cusp Complexity | | $\mathbf{P_3}$, $P_4$ |
| Elongated Form | | $P_3$, $P_4$ |
| Metacone | | $M^1$, $\mathbf{M^2}$, $M^3$ |
| Hypocone | $\mathbf{m^1}$, $m^2$ | $\mathbf{M^1}$, $M^2$, $\mathbf{M^3}$ |
| Cusp 5 | $\mathbf{m^2}$ | $\mathbf{M^1}$, $M^2$, $M^3$ |
| Carabelli's Cusp | $\mathbf{m^2}$ | $\mathbf{M^1}$, $M^2$, $M^3$ |
| Parastyle | | $M^1$, $M^2$, $M^3$ |
| Enamel Extension | | $\mathbf{M^1}$, $\mathbf{M^2}$, $M^3$ |
| Anterior Fovea | | $\mathbf{M_1}$ |
| Distal Trigonid Crest | $\mathbf{m_2}$ | $\mathbf{M_1}$, $M_2$, $M_3$ |
| Deflecting Wrinkle | $m_2$ | $M_1$ |
| Groove Pattern | $m_2$ | $\mathbf{M_1}$, $M_2$, $M_3$ |
| Cusp Number | $\mathbf{m_1}$, $\mathbf{m_2}$ | $M_1$, $M_2$, $M_3$ |
| Cusp 5 | $m_2$ | $M_1$, $\mathbf{M_2}$, $M_3$ |
| Cusp 6 | $m_2$ | $\mathbf{M_1}$, $M_2$, $M_3$ |
| Cusp 7 | $\mathbf{m_2}$ | $M_1$, $M_2$, $M_3$ |
| Protostylid | $\mathbf{m_2}$ | $\mathbf{M_1}$, $\mathbf{M_2}$, $\mathbf{M_3}$ |
| Enamel Extension | | $\mathbf{M_1}$, $\mathbf{M_2}$, $M_3$ |

## Results

Following the removal of traits and individuals due 1) high or low trait frequency, 2) large amounts of missing data, and 3) high inter-trait correlation, our final MMD analyses consisted of only 10 deciduous traits among 110 individuals, and 30 permanent traits among 296 individuals (traits bolded in Table 2). The results from MMD analyses are shown in Table 3. A Mantel test comparing the MMD matrices indicates that the biodistance estimates from the permanent and deciduous dentitions are similar (r = 0.55, $p < 0.05$). To further understand these relationships, we visualize the two MMD matrices via principal components analysis, of which the first three components explain 96.2% and 95.9% of the variance respectively for the permanent and deciduous dentitions. Figure 2 displays the loadings of each group on the first three principal components using the two matrices.

In the plot of the permanent dental data in Figure 2, we see that the Mogollon, Middle Rio Grande, and to some extent the Northern Rio Grande regions group together. This pattern is somewhat evident in the plot of the deciduous data, but only for the Middle Rio Grande and Northern Rio Grande groups. The Mogollon are separated by the first and second principal components. La Plata and Chaco cluster closely in PC1 in both plots, which makes sense given their similar occupation times and close geographic locations, but they are distinctly separated by PC3. In both plots, the Gallina appear isolated from the other regions, although the MMD distances between the Gallina and the MRG, NRG, Chaco, and Mogollon are small.

## Discussion

This study assessed whether biodistance analyses using nonmetric traits of deciduous dentitions are comparable to biodistance calculated using permanent dentitions. We tested our hypothesis using an assemblage of human remains from the pre-Spanish US Southwest where groups were previously defined using presumed ethnolinguistic affiliation, archaeological culture designations, and geographic proximity (L. O'Donnell and Schillaci 2021; A. O'Donnell and Ragsdale 2017; L. O'Donnell, Meyer, and Ragsdale 2020). Our results are consistent with Sutter and Chhatiawala (2016) in which the biodistance matrices are correlated between permanent and deciduous teeth (r = 0.55, $p < 0.05$). This supports the use of deciduous dentitions in understanding population relationships. That being said, our results differ slightly from previous research in the strength of the relationship between the two biodistance estimates. Sutter and Chhatiawala (2016) report a correlation of r = 0.997 ($p = 0.001$) via Mantel test, whereas ours is much lower, indicating an imperfect, although positive, correlation. This is likely because they were comparing estimates of genetic diversity and genetic distances across three time periods, rather than across contemporary groups as in the present study. Additionally, our analyses includes unequal numbers of individuals with permanent ($n = 320$) and deciduous ($n = 122$) dentitions and considered many fewer traits in the final analyses (30 permanent traits, 10 deciduous traits), which may have impacted the correlation of biodistance estimates.

Previous work has found that while homologous traits in deciduous and permanent dental morphology are correlated, they are not identical (K. S. Paul

*Table 3.* MMD results based on permanent (below diagonal) and deciduous (above diagonal) morphological traits.

| | **Chaco** | **Gallina** | **La Plata** | **Mogollon** | **MRG** | **NRG** |
|---|---|---|---|---|---|---|
| **Chaco** | 0.00 | 0.06 | 0.26 | -0.01 | 0.13 | 0.18 |
| **Gallina** | -0.01 | 0.00 | 0.13 | 0.09 | -0.02 | -0.14 |
| **La Plata** | -0.05 | 0.11 | 0.00 | 0.13 | 0.15 | 0.21 |
| **Mogollon** | 0.06 | 0.08 | 0.08 | 0.00 | -0.04 | 0.00 |
| **MRG** | 0.06 | 0.06 | 0.05 | 0.01 | 0.00 | 0.01 |
| **NRG** | 0.03 | 0.05 | 0.04 | 0.05 | 0.02 | 0.00 |

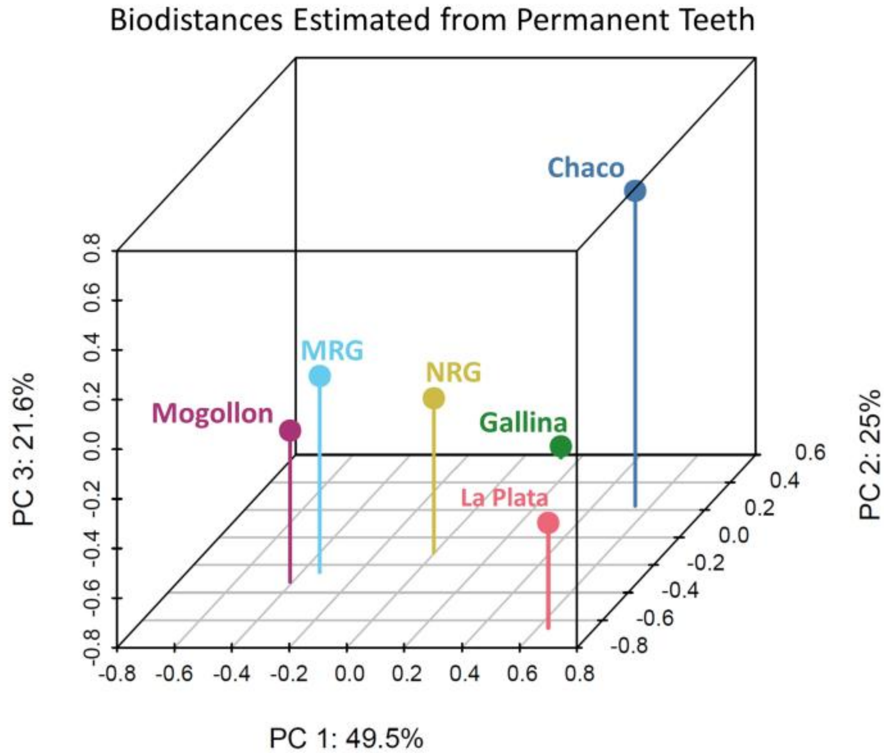


*Figure 2.* 3D PCA depiction of dental biodistances estimated using the mean measure of divergence for the permanent dentitions, explaining 96.2% of the variance. Note: MRG: Middle Rio Grande; NRG: Northern Rio Grande

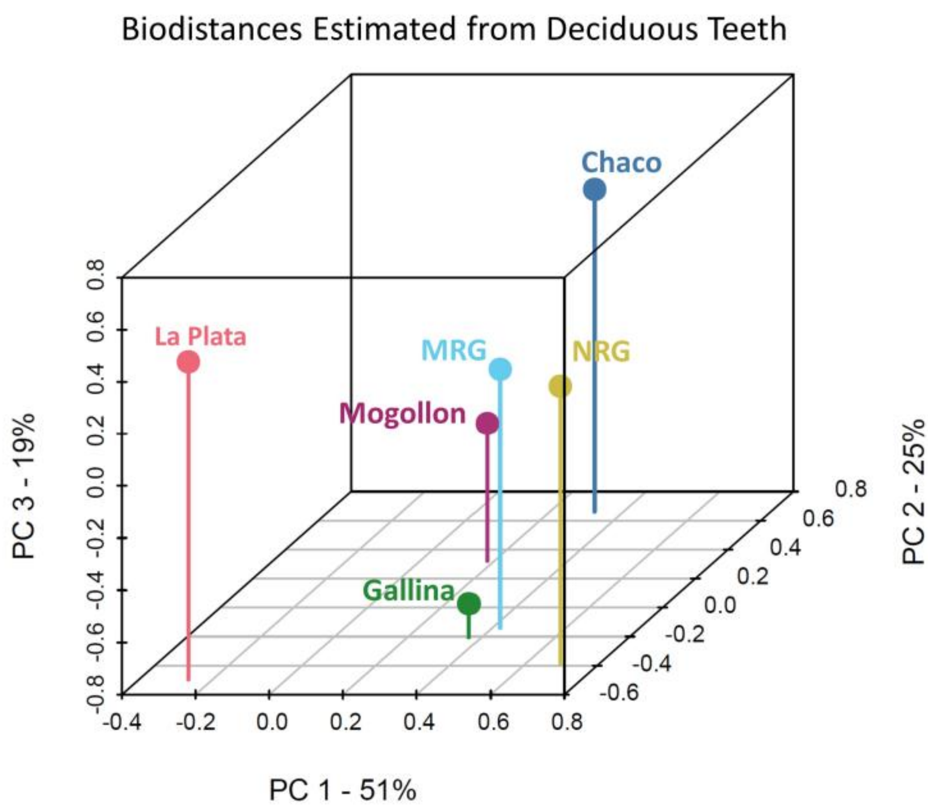


*Figure 3.* 3D PCA depiction of dental biodistances estimated using the mean measure of divergence for the deciduous dentitions, explaining 95.9% of the variance. Note: MRG: Middle Rio Grande; NRG: Northern Rio Grande

and Stojanowski 2017; K. S. Paul et al. 2022; H.J.H. Edgar and Lease 2007). Likely, this is due to deciduous morphology being a more reliable indicator of underlying genetic relationships as compared to permanent teeth (K. S. Paul and Stojanowski 2017) because they largely develop in utero and are relatively buffered against environmental disturbances. Additionally, deciduous morphology is less variable in the recorded ranges of expression as compared to permanent teeth. For example, shovel shape of maxillary central incisors is scored in a range of 0-3 for deciduous teeth (Sciulli 1998) and 0 -6 for permanent teeth (Edgar 2017). Further, many researchers have found that morphological traits with a dentine component are more likely to be observed on deciduous teeth (H.J.H. Edgar and Lease 2007; K. S. Paul and Stojanowski 2017; Saunders and Mayhall 1982; Ocampo et al. 2009). Broadly, traits associated with marginal ridges (ex., shoveling, primary cusp size) are more commonly also observed on the dentine surface as compared to accessory features (ex., accessory ridges, cusp 5) which may uniquely be observed on the enamel surface (Scott et al. 2018). Morphological traits of the permanent teeth without a dentine component may be more susceptible to environmental influences because of their later stages of development. Such was the finding of Blankship-Sefczek et al. (2024) in which maxillary cusp 5 showed lower trait grade expressions in the teeth of nutritionally supplemented children as compared to controls. Furthermore, in the current study, more traits with a dentine component were included in the analysis of deciduous teeth as compared to the permanent teeth (Table 2). Although deciduous dental development is not immune from environmental insult (Moes, Kuzawa, and Edgar 2024; Corrêa-Faria et al. 2013; Ządzińska et al. 2013), it may be that our biodistance estimates from deciduous dentitions compared to the permanent dentitions are more reflective of biological relationships between groups.

Due to their differences in developmental timing, deciduous and permanent homologous traits, especially in the molars which are most prevalent in dental biodistance studies, are unlikely to be reflective of identical genetic variation. To approximate closer ties between permanent teeth and genes, it may be beneficial to preferentially include morphological traits that develop earlier, should the data allow. The preparation for biodistance analysis requires the omission of highly correlated morphological traits. When using permanent teeth, there are often many traits and multiple teeth that must be omitted (such as the high correlation of molar expression grades between molar fields), where the analyst often chooses which trait to retain based on the frequency in the sample as well as the sample size of that trait. However, given the evidence of environmental influence on later forming traits, it may be prudent to retain earlier forming morphological features (such as on the M1 compared to M2) during analysis to maintain closer ties to the underlying genetic diversity.

Here, we advocate for the use of deciduous dental morphology in addition to permanent dental morphology for research aimed at understanding relationships between populations. Work centered on deciduous dentition faces added limitations of often smaller samples sizes and increased dental attrition compared to permanent teeth. Additionally, collecting morphological data is hampered by often ambiguous trait standards that are scattered across the literature (Grine 1986; Hanihara 1960; Sciulli 1998). Nevertheless, our results show that biodistance estimates using deciduous teeth provide comparable information relative to permanent teeth. Young children's teeth, therefore, provide a useful line of evidence that should not be ignored, and may provide additional insight into the past rather than relying exclusively on the permanent dentitions. Children represent a highly vulnerable demographic of society, so their teeth can offer unique insights that may be hidden when only considering adult teeth. For example, new work examines intragroup variation and relatedness in pre-Spanish Tlatelolco, Mexico using a sample of deciduous teeth to understand how biological identity played a role in determining who experienced distinct forms of violence (K. Paul et al. 2025).

Bioarchaeologists have long called for the use of multiple sources of data rather than relying on single strands of information to better characterize migration and genetic relationships between people. In practice, spatial, archaeological, and biological data are often combined to provide a better picture of the past, but data from the youngest members of society should not be ignored in this effort. By omitting young individuals from our studies, and thus overlooking a significant portion of assemblages, we cannot appreciate the full story of human life in the past (Lewis 2007; Gowland and Halcrow 2020).

*Case Study: The Gallina Migrations in the late A.D. 1200s*

The Gallina people lived in northern New Mexico (Figure 1), in an area termed the Gallina district, between the early AD 1100s and the late 1200s. In the late 1200s, the district was depopulated; perhaps indicating that the Gallina left the area. Some researchers suggest that migration from the Four Corners region, which may have been spurred by the 'Great Drought' (AD 1276-1299), may have eventually forced the Gallina to leave their homes.

Historically, the Gallina have been depicted as mysterious and isolated from other groups (Ceram 1971; Gallenkamp 1953; Hibben 1944). The interpretation of isolation is often bolstered by a relative lack of evidence for trade with other groups who lived near the Gallina district (Borck 2012; Constan 2011; Cordell 1979; Riley 1995; Sleeter 1987). Additionally, some human remains from the district exhibit evidence for interpersonal violence resulting in death and there is evidence for burning of several sites. Oral tradition also supports the notion that the Gallina were relatively isolated with fraught relationships with their neighbors (Roberts 1996). Likewise, artifactual evidence provides little support for trade between the Gallina and nearby groups, with roughly 2.3% of sherds found in archaeological contexts being from outside the Gallina district [see Borck 2012, Table 1 for a list of ceramics from outside the Gallina district found at Gallina sites].

Biodistance studies focusing on the Gallina people indicate that they were not as isolated as previously believed. Although work by O'Donnell and Ragsdale (2017) using dental morphology supports oral traditions of isolation from neighbors like the Jemez Pueblo (located in the NRG), it also suggests that they had strong ties to the MRG region (Figure 1), which surrounds today's Albuquerque, New Mexico. Specifically, the authors found that the Gallina are most similar to individuals found at Pottery Mound and Kuaua. Similarly, O'Donnell & Schillaci (2021) find relationships between Gallina and Tijeras individuals using craniometric data, and between Gallina, Southern Tiwa, La Plata, and Pottery Mound using permanent dental morphology.

Interestingly, we see some similarities between studies using the permanent dentition and the results from deciduous dentition presented here. Gallina deciduous dentition is phenotypically similar to that of the MRG (MMD = -0.16). This similarity is present in analyses of permanent dentition (L. O'Donnell and Schillaci 2021; A. O'Donnell and Ragsdale 2017). However, the deciduous biodistance results are not entirely representative of the results using the permanent dentition; this may speak to generational differences between parents and children.

The Gallina provide a story of resilience, they lived somewhere that had become unfavorable, perhaps due to violence or other reasons. They moved southwards and began a new life. The dentition of adults and children provides information linking this group to the MRG, perhaps to an area which was favorable because it was less populated, with good land for farming, and a riparian area for fishing.

**Conclusions**

Dental morphology in both deciduous and permanent teeth has been shown to be a valuable indicator of underlying population structure. Although biodistance estimates can be more accurately examined using genetic analyses, such analyses are not always feasible or permitted, especially when studying archaeological assemblages. Such is the case for our current research in which we examine Native American ancestral remains. Due to this restriction, estimating biodistance via dental morphology is one of the few methods we can use to examine microevolution on a regional scale. Future studies should employ multiple lines of evidence, rather than relying on single strands of data to better characterize migration and genetic relationships in the past. Therefore, by including permanent *and* deciduous dentition in biodistance analyses, researchers can utilize more of an archaeological assemblage in their efforts to study the past. In doing so, we can increase our understanding of the dynamics of the populations we are studying.

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