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A RE-ANALYSIS OF TIJERAS PUEBLO
ANOTHER LOOK AT DEVELOPMENTAL DEFECTS
IN
THE PREHISPANIC SOUTHWEST

by

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This thesis entitled:
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The final copy of this thesis has been examined by the signatories, and we find that both the content and form meet acceptable presentation standards of scholarly work in the above mentioned discipline

ABSTRACT

Williams, Heather Susan (M.A., Anthropology)

A Re-analysis of Tijeras Pueblo: Another Look at Developmental Defects in the Prehispanic Southwest

Thesis Directed by Professor Darna L. Dufour

The current study is a reanalysis of the skeletal collection from Tijeras Pueblo, an Ancestral Pueblo site in New Mexico, occupied between A.D. 1300 and A.D.1425. The analysis examines the types of developmental defects and the biocultural factors that may have influenced the incidence of these defects at the site. Specifically, this study focuses on the spatial patterning of developmental defects among individuals recovered at the site, and the potential relationship between the incidence of defects and lead glaze-paint production. Barnes' (1994) morphogenetic approach is used to identify and classify developmental defects in the axial skeleton.

The reanalysis of the skeletal materials indicates that defects originally identified as neural tube defects are cases of neural arch clefting. Additionally, several other minor defects in the axial skeleton, not previously described, have been identified in the sample. These new data indicate a pattern of developmental defects different than the one originally reported. The distinction between a cleft neural arch and a neural tube defect in this sample also adds new insight to the incidence of neural tube defects at Tijeras Pueblo, and possibly throughout the Prehispanic Southwest. Ultimately, this type of study may lend to our understanding of the environmental and social factors that influenced population dynamics at Tijeras Pueblo, and other Ancestral Pueblo populations.

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CHAPTER I

INTRODUCTION

Tijeras pueblo is a central Rio Grande Ancestral Pueblo located in the Albuquerque district (Eckert and Cordell, 2004). The pueblo was excavated between 1971 and 1976 (Cordell, 1977), during which time 55 skeletons were excavated and analyzed.

The current study is a reanalysis of the skeletal collection from Tijeras Pueblo. Previous studies (Ferguson, 1980; Cordell and Devor, 1980), had reported a high incidence of neural tube defects, possibly spina bifida occulta, in this population. While there is a genetic predisposition for spina bifida occulta in some populations, it can also be exacerbated by environmental influences (Devor and Cordell, 1980). The 1980 paper by Devor and Cordell used genetic and environmental models to examine the prevalence of spina bifida at Tijeras, and concluded that the high incidence was more likely to be attributed to lead mining activities and production of a lead based glaze pigment at the site. The purpose of this study was to reanalyze the skeletal collection, identify and define the developmental defects in the population, and establish whether or not the presence of developmental defects is related to lead mining and glaze paint production at the site.

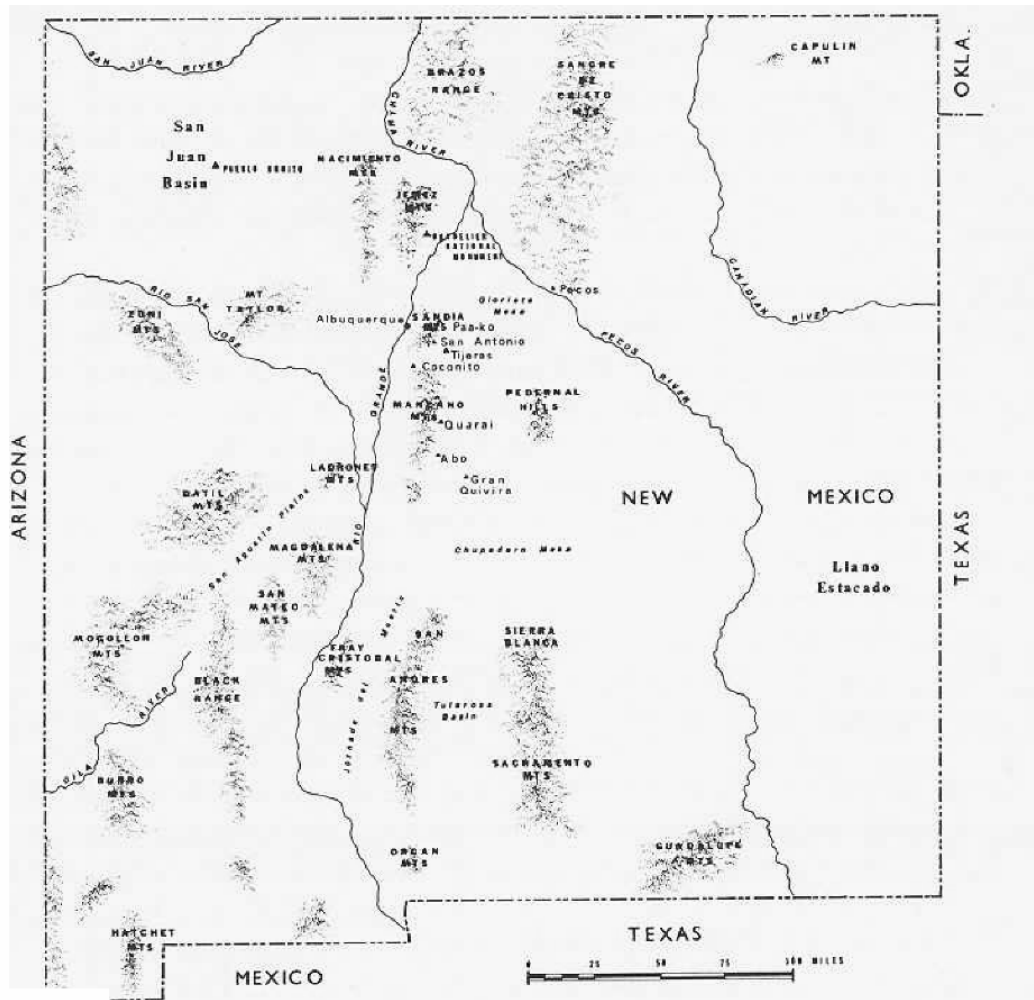
The skeletal analysis consisted of a general inventory of each skeleton in the collection which included: age and sex estimates, pathological conditions not classified as developmental defects, post cranial and facial measurements, and digital photographs of the collection.

CHAPTER II

BACKGROUND

Tijeras Pueblo, also designated site LA-581, is located in Tijeras Canyon on the grounds of the Sandia Ranger station in the Cibola National Forest (Judge, 1974). Tijeras Canyon is approximately 15 miles east of Albuquerque, New Mexico and serves as a major pass through the Sandia and Manzano Mountains; linking the Rio Grande Valley and the Estancia Basin (Cordell, 1977) (Figure 1)

Figure 2.1. Tijeras Pueblo Location



The site itself lies in the canyon bottom; within a mountainous setting at an elevation of 6,200 feet near a number of perennial water sources. The highest elevation in the Sandias to the west is 10, 675 feet and Cedro Peak in the Manzanos to the east is 7, 767 feet (Cordell, 1977). The environmental setting surrounding Tijeras also provides the site access to several different ecological zones. This location would have been favorable for early agriculturalists because it would have provided access to resources in both the Rio Grande Valley and the Estancia Basin, as well as access to a diverse plant and animal resources in the different ecological zones (Cordell, 1977).

History of Excavation and Research

The favorable ecological conditions of Tijeras canyon have attracted humans for seasonal hunting and later, agricultural settlements. These settlements have been of interest to archaeologists, and archaeological research in Tijeras canyon has been conducted since the 1940's. In 1948, Fred Wendorf excavated at two sites: LA-586 (Tijeras Canyon site) and LA-581, originally named Cedro Canyon site (now Tijeras Pueblo). During that season, 22 rooms were excavated at Tijeras Pueblo (Judge, 1974). In 1968, Stewart Peckham began salvage excavations at LA 581, and excavated 14.5 rooms (Judge, 1974). In 1971, James Judge became director of the University of New Mexico Field School and excavations at LA 581 (Tijeras Pueblo) were initiated again. Judge was the director of the field school until the 1973 field season. During this time, Judge was concerned with the physical location of the site and its relationship to resource availability and population dynamics in the canyons (Cordell, 1989).

In 1974, Linda S. Cordell became the director of the University of New Mexico Field School. Excavations continued under her direction until 1976. During this time excavations were carried out with an ecological focus and were concerned with depletion of key resources and population dynamics (Cordell, 1989). Specifically, the research orientation focused on the relationship between resources availability (water, wood, and food resources) and population fluctuation (Cordell, 1977). This relationship was established through investigations of material culture and settlement pattern studies from surveys by Blevens and Joiner (Cordell, 1977). The relationship between resource availability and population dynamics was also established through information obtained from skeletons excavated from the site.

During the 6 period of excavations by the UNM Field School at, 55 burials were excavated from Tijeras Pueblo. During 1974-1976 seasons, the excavation of each burial was supervised by a member of the Osteology Lab from the Maxwell Museum (Cordell, personal communication). Following the excavation of the burials, each skeleton was analyzed and documented by the staff at the UNM osteology lab for each year's site report. The entire skeletal collection was accessioned into Osteology Lab at the Maxwell Museum where it continues to be curated. Following the site reports, an analysis of the collection in its entirety was conducted by Ferguson (1980). This analysis reported a high frequency of spina bifida occulta in the Tijeras population. This finding led to further investigation into the cause of such a high incidence of this defect, and in 1980, Devor and Cordell published a paper linking the frequency of neural tube defects (spina bifida occulta) to lead glaze paint production at the site.

Data from the excavations at Tijeras not only provided information about the skeletal collection, but also placed Tijeras into a cultural context for the Southwest. Although people occupied the canyon seasonally prior to the 12th century, the Pueblo itself was occupied between A.D.1300 and 1425 (Cordell 1977). Construction and the initial occupation at Tijeras Pueblo began in A.D.1300 during what has been termed the Late Coalition Period (A.D.1200-1325) (Wendorf and Reed, 1955). This period has been characterized by increased population and the production of Galisteo Black-on-White ceramics. Occupation of the site continued into the Rio Grande Classic Period (A.D.1325-1600) (Wendorf and Reed, 1955), which is characterized by the production of red slipped glaze paint wear (but not the discontinuation of black on white), and population fluctuation at Classic sites. This period can also be characterized by a reduction in the number of sites, and population aggregation at a few concentrated sites (Cordell, 1977).

The late Coalition Period and the Rio Grande Classic period are periods used to refer to sites within the Rio Grande. These two periods are contemporaneous with the Pueblo IV period of the Pecos classification system developed by Kidder (1927). This system is used as a scheme for the entire Ancestral Pueblo area, and the Pueblo IV period spans from A.D. 1275 –1600 (Adams and Duff, 2004). Because occupation at Tijeras falls in this span, it is referred to as a Pueblo IV site. Tijeras as a Pueblo IV site has made it a favorable site to address past and current research questions concerning the Pueblo IV period.

In the 1970's, when Tijeras was being excavated, one of the major issues in research was the relationship between population fluctuation and resource

availability. At Tijeras, this relationship was addressed by monitoring the types of resources used at the site and the population dynamics at the site. Changes in fauna were monitored to determine if there were changes in game strategies at the site. For example, faunal remains were examined to determine if there was a change from the use of larger game animals to small game animals (Cordell, 1977). Changes in architecture, room function, ceramic frequencies were also thought to reflect changes in population and changes in resource availability and were also the focus of the original excavation and analysis. For example, if resource depletion had not been a problem at Tijeras, then it was expected that this would be reflected architecturally through the gradual addition of rooms. On the other hand, if there had been resource depletion and stress, then this would be reflected by site abandonment (Cordell, 1977). Also, it was expected that if resources were becoming depleted there would have been increased stress and possibly intergroup hostility. This would have been reflected by a shift to defensible locations and evidence of violent destruction of a site (Cordell, 1977).

The excavation methods at Tijeras reflected interest in resource availability and population fluctuation by monitoring architectural change, room function, and the contents of trash deposits at the site (Cordell, 1977). Issues of resource availability were also addressed by examining evidence of nutritional stress in the skeletal collection (Cordell, 1977). The research at Tijeras at this time emphasized the relationship between environmental stress and population fluctuation. Therefore, an environmental approach was used in the research orientation at Tijeras (Cordell, 1989).

Research questions and interest in the Pueblo IV period have shifted since Tijeras was excavated in the 1970's. Since the initial excavation and analysis of the Tijeras materials, research from other sites and archival collections has resulted in new data. From these new data, new research themes and research questions have emerged (Adams and Duff, 2004). One of the contemporary issues questions concerning the Pueblo IV period is the question of social organization of settlement clusters and how this organization influenced social interaction on a local and regional level (Adams and Duff, 2004).

Current research is focusing on the social mechanisms that may have influenced population aggregation at Pueblo IV sites. Some of these mechanisms include the spread of religious societies and cooperative agricultural or hunting. These mechanisms would have allowed residents of each village in a settlement cluster to enter into a regional network. This process may have allowed for movement between villages as well as interaction with other regions. Eventually these social networks may have served as a means for formal trade networks to develop (Eckert and Cordell, 2004). Additionally, some villages may have had access to resources needed by other villages, and would have specialized in some sort of production for trade (Eckert and Cordell, 2004). Therefore, craft specialization, religious and social exchange may have provided a context for the development of local and regional trade (Eckert and Cordell, 2004).

One way to trace these networks is by examining material culture. The distribution of kiva shapes, ceramic styles and iconography may reflect social networks. Current research in the central Rio Grande has found a broadly

homogenous pattern material culture, but has also found that specific settlements are heterogeneous. These data suggest that there was continuous local and regional interaction in the central Rio Grande (Eckert and Cordell, 2004).

Tijeras Pueblo is no exception to the current research in the central Rio Grande. Tijeras may have entered into a formal social network through craft specialization. Specifically, through the production and distribution of a lead based glaze paint for ceramics. Through craft specialization, Tijeras would have participated in local social networks and perhaps regional networks.

In addition to glaze paint production and distribution from Tijeras, other aspects of the site are significant to the current research context. The skeletal collection may also reflect patterns of social interaction and population aggregation in the central Rio Grande. The original analysis reported a high frequency of neural tube defects in the Tijeras collection (Ferguson, 1980). These defects were linked to lead glaze-paint production at the site (Devor and Cordell, 1980). Therefore, the pattern of developmental defects at Tijeras may reflect social groups or family groups that engaged in craft specialization at Tijeras. Such a specialization would have allowed Tijeras to enter into and participate in local or regional trade network. It is likely in addition to trade items, ideas, social knowledge, and people moved between villages in trade networks.

The Tijeras skeletal collection is significant for tracing social developments because like material culture, skeletal patterns may also reflect a broad homogeneous pattern in the central Rio Grande. However, as mentioned, the patterns of developmental defects in the Tijeras collection may also represent a pattern unique to

the site. If these patterns are indeed related to lead glaze paint production, then they may reflect craft specialization at the site. Furthermore, the presence of these patterns at other sites may reflect migration from Tijeras or marriage exchange between Tijeras and other sites. Thus, glaze paint production and redistribution may be one mechanism for population aggregation in the central Rio Grande settlements.

Also, in addition to the patterns in developmental defects, other skeletal patterns may reflect social networks in the central Rio Grande. For example, patterns in cranial deformation may reflect a preference for a particular aesthetic change in skull shape produced by a cradleboard. These patterns may also reflect deformation resulting from changed in child-care practices and how cradleboards were used (Piper, 2002) Ideas about aesthetic choice and child care may have been exchanged between settlements, and the skeletal evidence may reflect this process.

Understanding mechanisms of social interaction and population aggregation are among the current research foci in the Pueblo IV period (Adams and Duff, 2004). Material culture such as ceramic design, kiva shapes and iconography may reflect the pattern of social developments during this time (Eckert and Cordell, 2004). However, patterns in skeletal remains, such as developmental defects, pathological conditions, and cranial deformation patterns may reflect environmental conditions, disease processes, and developmental processes that occurred in particular social groups. Therefore, they may also serve as a tool to trace social networks in the Southwest. Tijeras Pueblo is one settlement that may be significant to this research because it was not only engaged in glaze production and redistribution (Eckert and Cordell, 2004), it also has a skeletal collection available for research. The patterns observed in the

skeletal collection may further reflect Tijeras' participation in local and regional social and trade networks. Additionally, new methods for skeletal analysis have been developed. By using these new methods, perhaps new information, not previously documented can be gained from the Tijeras skeletal collection. This new information may add to our understanding of life at Tijeras Pueblo as well as how Tijeras fits into the current research context.

CHAPTER III

METHODS

The Sample

The sample used for this study was the collection of 55 skeletons excavated by the University of New Mexico Field School between 1971 and 1976. The skeletal collection is housed in the osteology laboratory repository at the Maxwell Museum, located on the University of New Mexico campus in Albuquerque, New Mexico. The skeletal analysis was conducted between June 2004 and July 2004.

Skeletal Inventory

The first step in the analysis was a full inventory of the skeletal collection. The museum accession number, excavation number, and a written description of the physical condition of each skeleton were recorded on the first page of the inventory sheet and included descriptions of the general completeness, post-mortem damage, and weathering of each skeleton. The methods outlined by Buikstra and Ublelaker (1994) were followed to record and score completeness, damage and weathering for each skeleton.

An inventory of each skeletal component was conducted for each individual burial in the collection. The inventory was conducted and recorded in the following order: cranium, teeth, vertebral column, ribs, appendicular skeleton, and unidentifiable bone fragments. The completeness and the condition of the cranium

were described in writing, and when it was present and observable, cranial deformation was recorded. For this collection, minimal, intermediate, and definite were used to describe the degree of cranial deformation present in an individual. These definitions were adapted from the criteria outlined by Buikstra and Ubelaker (1994) for describing cranial deformation

The first section of the skeletal inventory also included a dental inventory. Teeth in place in the mandible and maxillae were recorded on a dental diagram (Appendix 1) included in this section. Any post-mortem tooth loss was also noted, and if they were present, loose teeth associated with an individual were identified and recorded in a section designated for loose teeth.

An inventory of the vertebral column followed the cranial and dental inventory. The vertebral column was separated into cervical, thoracic, lumbar, and sacral sections. Each vertebra was listed as present or absent in the appropriate section by its number. For example, if all of the cervical vertebrae were present, then they were listed as: present, C-1 – C-7 (1st cervical vertebra through 7th cervical vertebra). Descriptions of the vertebrae (vertebral osteophytes, damage etc.) were also included in this section.

The bones of the appendicular skeleton were recorded on the second page of the inventory. Each bone was identified, sided (left or right), recorded as present (check mark) or absent (X), and recorded as complete, incomplete, or fragmented (following standards in Buikstra and Ubelaker, 1994) (Table 3.1). Also, a numerical score was added to the incomplete bones to indicate which part of the bone was present (Table 3.2)

Table 3.1. Scores for Bone Descriptions

Score	Description
C	Complete: More than 2/3 of the bone and both articular surfaces are present
I	Incomplete: less than 2/3, but at least 1/3 of the bone is present
F	Fragmented: less than 1/3 and one or more joint surface is missing

Table 3.2. Scores for Long Bones

Score	Description
2	Proximal 1/3 missing only
3	Middle 1/3 missing only
4	Distal 1/3 missing only
5	Proximal 1/3 present only
6	Middle 1/3 present only
7	Distal 1/3 present only

Some boxes contained small bags of unidentified fragments and non-human bones. When possible, the fragments were identified and recorded. However, in many instances the fragments were unidentifiable. In these cases, the unidentified fragments were classified as indeterminate, and recorded in the indeterminate section of the inventory. Non-human bones were described and recorded in the additional notes section of the inventory.

Aging and Sexing

Each skeleton was assigned an age and sex. Standard methods outlined in Buikstra and Ubelaker (1994) were used to report ages for adults and immature individuals. In addition to using standard methods, Dr. Ann Palkovich was consulted to confirm age and sex assignment of the skeletons.

For adults, developmental stages (reported in phases) based on age-related changes in the pubic symphysis, the auricular surface of the os coxae and the cranial sutures were used to determine an age range for each adult individual. When only one element was present for aging (e.g. one pubic symphysis, or only the auricular surface), only the method appropriate for that element was used. For example, in some cases, only the left or right auricular surface was present, therefore, only the method for reporting changes in the auricular surface was used. However, many individuals had very complete os coxae and crania. In these cases, all four methods for aging were used. Meindl and Lovejoy's phases for age-related changes in the auricular surface, the Todd and Suchey and Brooks phases for changes in the pubic symphysis, and Meindl and Lovejoy's criteria for changes in cranial suture closure (1989;1921;1990; and 1985, in Buikstra and Ubelaker, 1994), are the standard methods used to report ages in archaeological populations, therefore, they were the four methods used for this analysis.

There is some variation in the age ranges for each method (Table 3.3). To account for these differences, five year ranges based on a comparison of all of the methods used on each individual were used to report age for each individual. The five-year age ranges assigned to each individual reflect the minimum, maximum and mean ages of each method used, as well as overlap of age ranges between each aging method.

Table 3.3. Methods Used for Determining Age

Skeletal Element	Age Range for Each Phase	Reference
Auricular Surface (os coxae)	4 years	Mendl and Lovejoy, 1989
Pubic Symphysis (os coxae)	2-4 years	Todd, 1921
Pubic Symphysis (os coxae)	10-40 years with mean age	Suchey and Brooks, 1990
Cranial Suture Closure	15-20 years	Mendl and Lovejoy, 1985

While all four methods were used when appropriate, the auricular surface was the most useful because it has age ranges most consistent with ranges in other aging methods, and the auricular surface tends to be better preserved than the pubic symphysis. As a result, age ranges for more individuals were reported using the auricular surface method. On the other hand, because there is a considerable amount of variation in the timing of suture closure, this method is the least useful, and was only used to obtain a broad age range (i.e. young adult, middle adult, and old adult) of an individual. This method was only used for comparison with age ranges reported from the other methods, and if the os coxae were not present or too incomplete for aging. In cases where the pubic symphyses, auricular surfaces, and cranial sutures were incomplete, missing, or damaged, epiphyseal closures of the sternal end of the clavicle and epiphyseal rings of the vertebrae were used to obtain a broad age range (over 25, under 25) (Buikstra and Ubelaker, 1994).

Changes in the pubic symphysis are not observable until adulthood; therefore, other methods were used to report ages in adolescents, children, and infants. For adolescents, dental development and degree of epiphyseal closure would have been used to report age. However, there were no skeletons representing this age group in the sample.

Children and infants were present in the sample, and ages are reported for these groups. Crown and root formation stages, as well as eruption sequence described by Ubelaker (1979; in Buikstra and Ubelaker, 1994) were used to determine age at death for each child and infant skeleton. The stage of development for each tooth, if observable, was recorded on an age estimate page (Appendix 1). A tooth was considered observable if the crown and root could be observed. Teeth that had not erupted and were not fully visible without the use of a radiograph were not scored. The pattern of development was then compared to a dental chart with various stages of development and related ages (Buikstra and Ubelaker, 1994). The age range that most closely corresponded to the observed pattern in the individual was used for the approximate age at death.

Also, for immature individuals, maximum lengths of diaphyses of the long bones, as well as the scapula and os coxae were recorded and used to determine an age range for each individual. Age estimates based on diaphyseal length were taken from data in Scheuer and Black (2000).

Adult skeletons were assigned a sex of male or female. Morphology of the cranium and the os coxae were used to make this assignment. Each sexually dimorphic feature was scored on a five-point scale (Table 3.4) based on standard criteria in Buikstra and Ubelaker (1994), and were used for an overall assessment of sex. In some cases, when measurements were possible, the vertical diameters of the humeral and femoral heads (Bass, 1995) were also used to distinguish males from females (Appendix 1).

Table 3.4. Scores for Sexually Dimorphic Traits

1	Female
2	Probable female
3	Ambiguous sex
4	Probable male
5	Male

Skeletal Measurements

If an element was present and complete, then skeletal measurements for that element were taken and recorded. Skeletal landmarks used for these measurements were based on the criteria recommended for measurements in Buikstra and Ubelaker (1994). A field osteometric board (Paleo-Tech Concepts) was used to take maximum lengths of the long bones. Spreading calipers (Paleo-Tech Concepts) were used to take maximum breadth measurements and measurements over 200 millimeters. Sliding calipers (Minytoto, Paleo-Tech concepts) were used for measurements under 200 millimeters. Finally, a measuring tape (Paleo-Tech Concepts) was used to measure distal and mid-shaft circumferences of long bones. All measurements were taken in millimeters and were recorded on a data sheet for post-cranial measurements (Appendix 2).

The maximum number of post-cranial measurements taken from a skeleton was 58; however, measurements were only taken if the bone had not suffered post-mortem damage that can affect the measurement. Unless it was damaged or missing, all measurements were taken from the left side (Buikstra and Ubelaker, 1994). In these cases, when damage had occurred to the left side, the right side was used and

noted on the data sheet. All measurements were compiled into a spreadsheet and entered into SPSS (version 12) for later data analysis. Additionally, measurements of the femora were used in Genoves (1967) formulae for calculating stature in Mesoamericans.

Pathological Conditions

If pathologies were present in an individual, they were identified, classified and described using the following categories: porotic hyperostosis, cribra orbitalia, osteoarthritis (as described in Buikstra and Ubelaker, 1994), dental disease (as described in Buikstra and Ubelaker, 1994), trauma (as described in Buikstra and Ubelaker, 1994; Ortner, 2003), and undefined pathological conditions (i.e., porous lesions, lytic lesions) (as described in Ortner, 2003). Each pathological condition present in an individual was photographed using a digital camera, and described in writing by indicating the affected bone, the location of the pathology on the bone's surface, the type of pathological condition, and the severity of the condition. Some pathological conditions, such as cribra orbitalia and porotic hyperostosis, were also assigned scores based on their severity. In cases of cribra orbitalia and porotic hyperostosis, a scoring system adapted from Buikstra and Ubelaker (1994) was used to describe the severity of porosity on the outer cranial surface and orbits (Table 3.5).

Table 3.5. Scores for Porotic Hyperostosis and Cribra Orbitalia

Score	Description
1	Porosity is barely discernable and lesion is healed
2	Moderate porosity with an inactive or healing lesion
3	Coalesced porosity with an active lesion
4	Coalesced porosity over more than 2/3 of the surface and active at the time of death

A similar system, also adapted from Buikstra and Ublelaker (1994), was used to describe osteoarthritis. Osteoarthritis was scored on a five point scale and was based on the amount of lipping around the joint margins and porosity on the joint surface (Table 3.6).

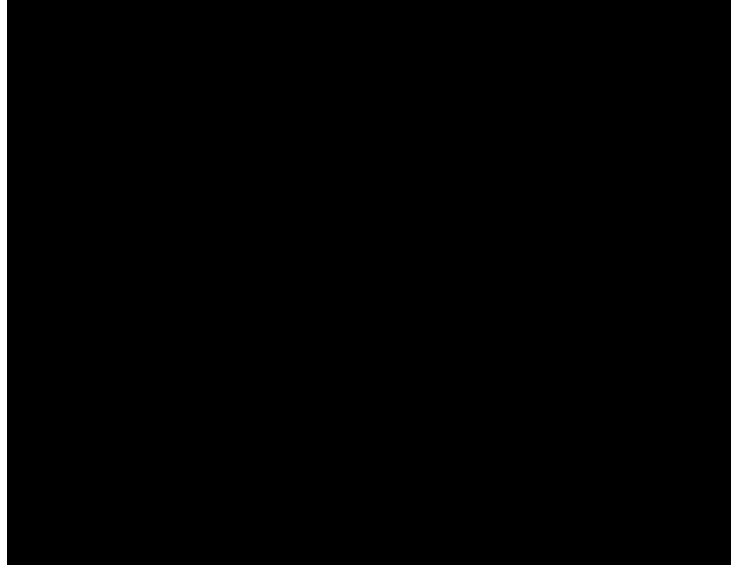
Table 3.6. Scores for Osteoarthritis

Score	Description
1	Barely discernable pinpoint porosity and slight lipping around the joint surface
2	Coalesced porosity and sharp ridges around the joint margin
3	Both pinpoint and coalesced porosity on the surface and extensive spicules around the joint margin
4	Severe with ankylosis

The criteria for scoring vertebral osteoarthritis were slightly different, but were also adapted from criteria from Buikstra and Ubelaker (1994). Osteophytes on the vertebral body, and Schmorl's nodes (Figure 3.1) were used to describe and score the severity of the arthritis and were scored on a five-point scale (Table 3.7).

Figure 3.1. Osteophytes and Schmorl's Nodes

a. Schmorl's Node on Superior Vertebral Body



b. Vertebral Osteophytes



Table 3.7. Scores for Vertebral Osteoarthritis

Score	Description
1	Osteophytes are present, but barely discernable. Schmorl's nodes are absent or barely discernable.
2	Osteophytes are present and forming an elevated ring around the joint margin. Schmorl's nodes are present and moderate.
3	Osteophytes are forming curved spicules and Schmorl's Nodes are marked.
4	Osteophytes are fused to adjacent vertebrae (ankylosis)

If dental disease such as caries or abscesses was present, the type of dental disease was classified and recorded as a written description in the dental section of the inventory. The tooth and the surface affected were recorded. Abscesses were also sketched on a cranial chart. Pre-mortem tooth loss and edentulous conditions were also recorded.

In cases of trauma, the type of trauma was classified and recorded as a written description attached to the inventory under additional notes. For example, if a fracture was observed, then the type of fracture, the location of the fracture, and the condition (healed, not healed) were described in the notes section. If there was any type of infection associated with the trauma, it was also noted and described.

Other lytic lesions or pathologies were classified following Ortner (2003) and recorded in the inventory. As with the other pathological conditions, the severity of the lesion was described and included in the additional notes section of the inventory.

Developmental Defects

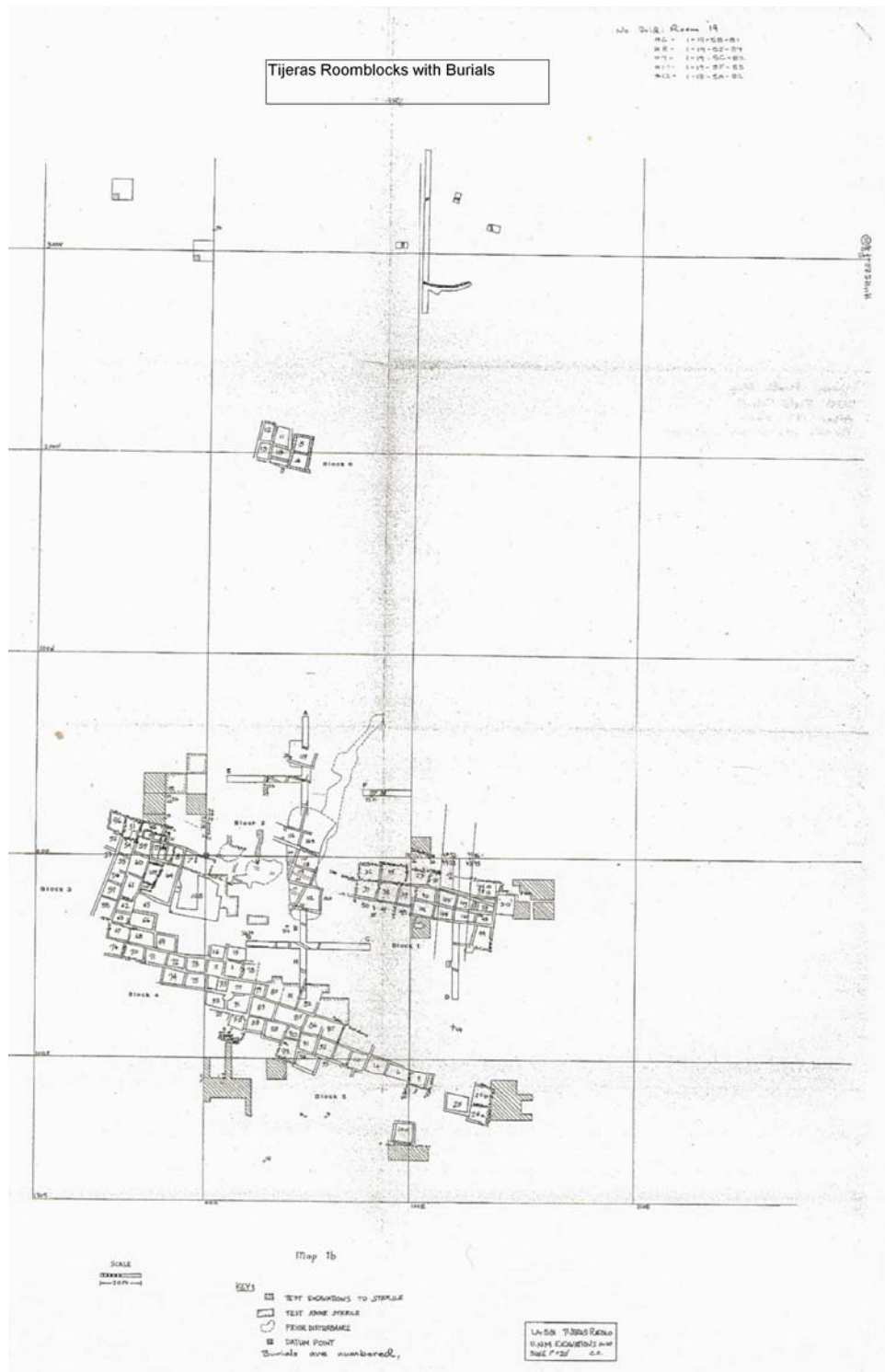
The focus of this study is on developmental defects; therefore, each skeleton was surveyed for any type of observable developmental defect. Defects were separated into two broad categories: developmental defects in the axial skeleton and developmental defects in the appendicular skeleton. Developmental defects in the axial skeleton were classified based on descriptions by Barnes (1994), Scheuer and Black (2000), and Ortner (2003). Developmental defects in the appendicular skeleton were classified based on descriptions by Ortner (2003), Buikstra and Ubelaker (1994), and Scheuer and Black (2000). The severity and the classification of each observed defect were recorded in the skeletal inventory. A citation for the criteria used to define the defect was also included in the inventory. Finally, all observed developmental defects were photographed.

Excavation Records

In addition to the gross skeletal analysis, this study included a survey of the excavation records related to Tijeras Pueblo. Site maps, burial forms, and field notes from the excavation were surveyed. Also, Dr. Linda Cordell was consulted for information about the site and the excavation.

A map of the site showing burial locations (Figure 3.2), burial forms, and information provided by Dr. Cordell were used to determine the burial location of each skeleton. This information was also used to determine each burial's age relative to the site. Two categories were used for relative age: early (AD 1300 –AD1360) and late (AD1390 – AD1425).

Figure 3.2. Map of Site with Burial Locations



Data Analysis

The data collected from the skeletal inventory and the excavation records were entered into SPSS for Windows (Version 12), and compiled into tables to report the sex distribution (males vs. females), age groups, cranial deformation patterns, specific pathological conditions, and specific developmental defects. These data are included in the results chapter of this report

All data were analyzed using SPSS for windows (version 12) at the alpha level of 0.05. The following tests were used to analyze the data: t-test, chi square, Fisher's exact test. The stature of this population was analyzed using a t-test. However, most of the data were categorical, and as a result, Chi square and Fisher's exact were the most appropriate tests for the sample. Sex (male vs. female) occupational phase (early vs. late), pathological conditions (present or absent), developmental defects (present or absent), and burial location were entered into SPSS for Windows (Version 12), and all used as categories to compare the data. Chi square and Fisher's exact tests were used to compare the categorical data to determine if there are any significant relationships or differences between the categories. The results of these comparisons are reported in the Results section.

CHAPTER IV

RESULTS

Introduction: Condition and Preservation of the Sample

Overall, the general preservation of the skeletal collection was good. In the sample of 55 individuals, only 2 adults had suffered enough post-mortem damage to prevent sex determination, 3 individuals were missing crania, and 9 were missing pubic symphyses and auricular surfaces for aging. Because of the quality of preservation, a reasonable assessment of the age and sex distribution was possible. Also, because of the good preservation of the sample, a reasonable assessment of the patterns developmental defects and pathology were possible. The results with an emphasis on the patterns of developmental defects and burial location are presented below. A discussion of the significance of these patterns follows in the next chapter.

Developmental Defects

A number of localized developmental defects were observed in 45 (81.9%) individuals. Most of the defects occurred in the axial skeleton; however, none could be classified as neural tube defects. Many of the defects in the axial skeleton were paraxial mesoderm defects resulting from segmentation errors (block vertebrae, Figure 4.1) or developmental delays (bifurcated spinous process Figure 4.2, cleft neural arch Figure 4.3) during embryonic development (Table 4.1). Other types of developmental defects include: blastemal desmocranium field defects (extra suture ossicles, Figure 4.4), sternal plate defects (sternal aperture, Figure 4.5), and patellar defects (bipartite patella, Figure 4.6) (Table 4.1).

Figure 4.1. Segmentation Error: Block Vertebrae (C-1 and C-2 are fused)

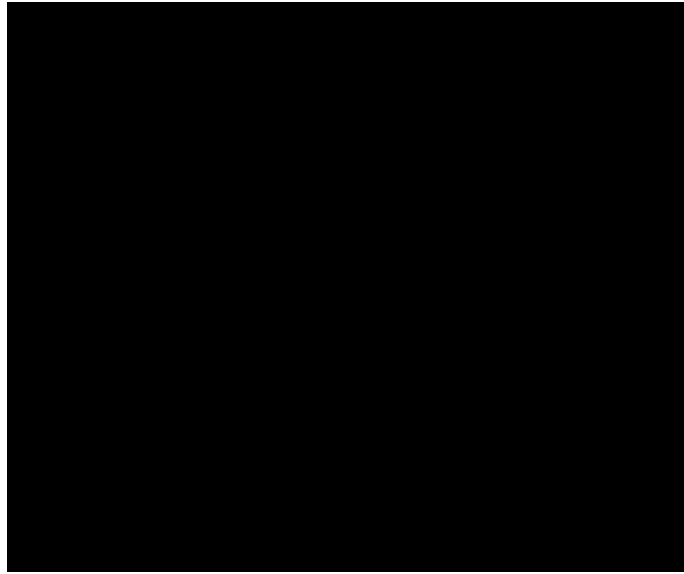


Figure 4.2. Developmental Delays: Bifurcated Spinous Processes

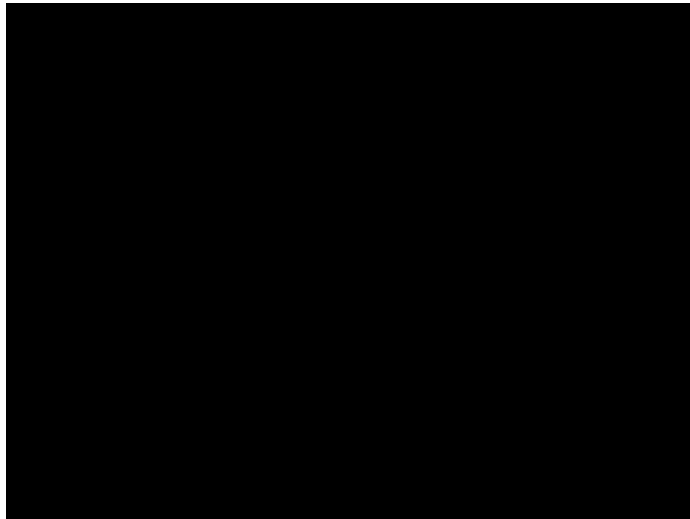


Figure 4.3. Developmental Delay: Cleft Neural Arch

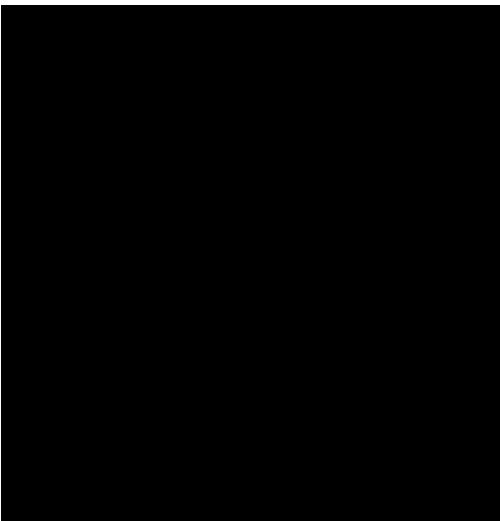


Figure 4.4. Blastemal Desmocranium Defect: Extra Suture Ossicles

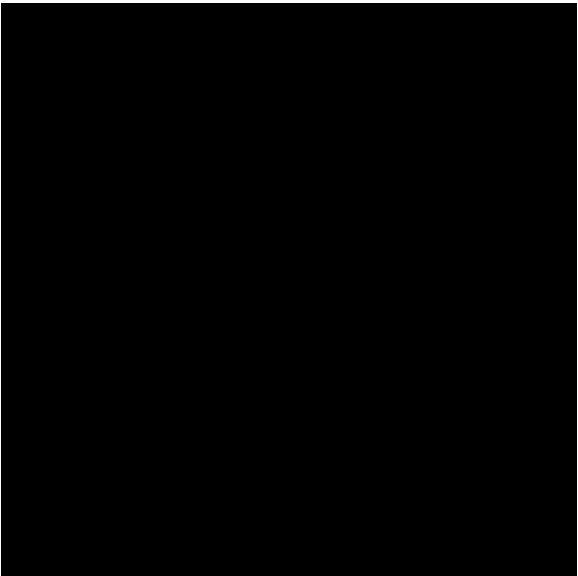


Figure 4.5. Sternal Aperture

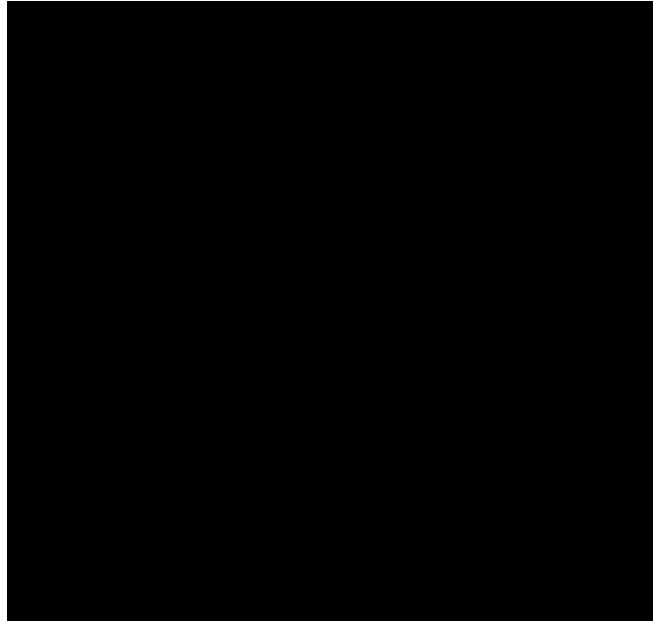


Figure 4.6. Bipartite Patella

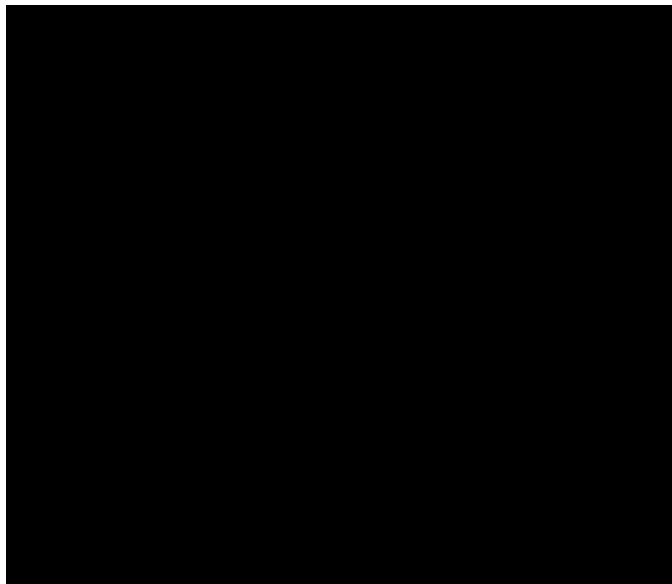


Table 4.1. Developmental Defects in the Tijeras Population

Defect by Classification	Males	Females	Subadults	TOTAL
Neural Tube Defects				
Spinal meningocele with spina bifida cystica or occulta	0	0	0	0
Paraxial Mesoderm Defects				
Bifurcated spinous process (mild delay)	3	5	6	14
Type II Block Vertebra (failure of segmentation)	5	2	0	7
Cleft Neural Arch (developmental delay)	2	1	1	4
Other Vertebral Defects				
Spondylolysis	1	0	0	1
Blastemal Desmocranium Field Defects				
Extra primary suture ossicles (failure to coalesce)	4	7	1	12
Developmental Delay in the Sternum				
Sternal aperture (incomplete caudal cohesion)	3	1	0	4
Defects in the appendicular skeleton				
Bipartite Patella	3	0	0	3
TOTAL	18	16	8	45

Bifurcated spinous processes (cervical vertebrae only), block vertebrae and extra primary suture ossicles (Table 4.1) were the most common developmental defect. Neural arch clefting, sternal aperture, and bipartite patella, although less frequent, were also present.

Developmental defects were present in both males and females. However, defects tended to occur more often in males than in females, but the difference was not significant (Table 4.2).

Table 4.2. Sex Differences in Developmental Defects Evaluated by Fisher's Exact

Defect	Males	Females	<i>p</i>
Extra Primary Sutures	4	7	0.458
Bifurcated Spinous Processes	3	5	0.685
Type II Block Vertebrae	5	2	0.394
Neural Arch Clefting	2	1	1.000
Sternal Aperture	3	1	0.600
Bipartite Patella	3	0	0.226
TOTAL	20	16	

Developmental defects are present in individuals from both the early and late occupational phases (Table 4.3). With the exception of neural arch clefting which is statistically significant (Fisher's Exact, $p=0.014$), the relationship between the presence of developmental defects and occupational phase is not statistically significant (Table 4. 3).

Table 4.3. Developmental Defects by Occupation Phase Evaluated by Fisher's Exact

Developmental Defect	N	Present	Absent	<i>p</i>
Bifurcated Spinous Processes				
Early	35	6	29	
Late	20	8	12	
TOTAL	55	14	41	0.106
Type II Block Vertebrae				
Early	35	4	31	
Late	20	3	17	
TOTAL	55	7	48	0.696
Neural Arch Clefting				
Early	35	0	35	
Late	20	4	16	
TOTAL	55	4	51	0.014*
Extra Suture Ossicles				
Early	35	6	29	
Late	20	6	14	
TOTAL	55	12	43	0.319
Sternal Aperture				
Early	35	3	32	
Late	20	1	19	
Bipartite Patella				
Early	35	2	33	
TOTAL	55	4	51	1.000

**p*<0.05

Burial Location

Male, female, and infant burials were excavated from all roomblocks (Figure 7), and there is no statistically significant relationship between burial location and age or sex (Table 4). There was, however, a significant relationship between the presence of neural arch clefting and burial location, as well as the relationship between burial location and occupation phase. All of the individuals with neural arch clefting were late burials ($\chi^2= 10.7$, $p = 0.005$), and were clustered in the southeast corner of the site (Figure 4.7).

Figure 4.7. Site map (arrows note concentration of burials with clefting)

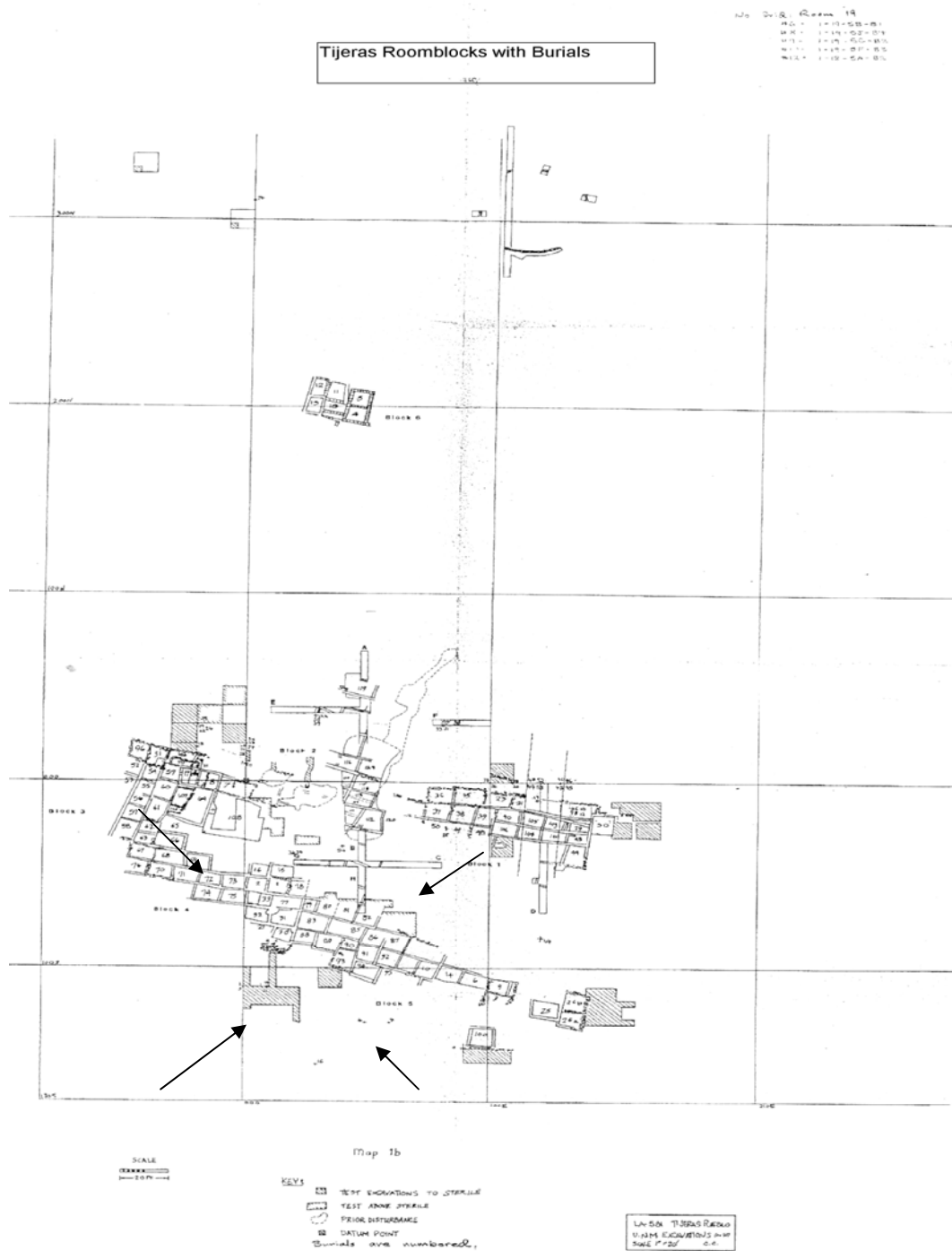


Table 4.4. Distribution of Burials by Occupation Phase

Burial Location*	Early	Late	Total
NW	13	3	16
NE	16	5	21
SE	6	12	18
TOTAL	35	20	55

$\chi^2 = 10.7, p = 0.005$

*Burial location is based on excavation number which lists provenience

Sex and Age Distribution

There were 16 males, 16 females, and 23 undetermined individuals (infants or individuals without sexually dimorphic features) in the collection. This distribution fell into two separate occupations of the site: early (AD1300 – AD1360) and late (AD1390- AD1425). A total of 35 individuals, (12 males, 9 females 14 undetermined sex), represent the early occupation. A total of 20 individuals represent the late occupation (4 males, 7 females, 9 undetermined sex). (Table 4.5)

Table 4.5 Sex and Age Category Distribution in the Early and Late Occupation of the Site

Sex	Early	Late	Total
Male	12	4	16
Female	9	7	16
Undetermined	1	1	2
Juvenile	1	1	2
Infant	12	7	19
Total	35	20	55

Fisher's Exact p= 0.4

The total number of identifiable males and females (both occupational phases) was the same. Of the 16 males in the sample, 12 came from the early occupational phase and 4 came from the late phase. Of the 16 females in the sample, 9 came from the early occupational phase and 7 came from the late occupational phase. The

difference between male and female skeletons in the early and late occupational phase was not statistically significant (Fisher's Exact, $p= 0.4$).

The age distribution of the sample falls into three broad age categories: infant (fetal – 3.5 years), juvenile (6-11 years) and adult (over 18 years). Interestingly, there were no individuals in that collection that fell into the adolescent age range (12-17 years). There were 20 infants in the sample, which made up 34.5% of the total sample. Of these infants, 16 fell into the 1-3.5 year category, and the remainder of the infant skeletons was 9 months or less. There were also 2 juveniles that I aged between 6 and 8 years at death. The remainder of the sample was adults, ranging between 18 and 50 years of age, with the largest percentage of the adult skeletons coming from the 30-35 year category (Table 4.6).

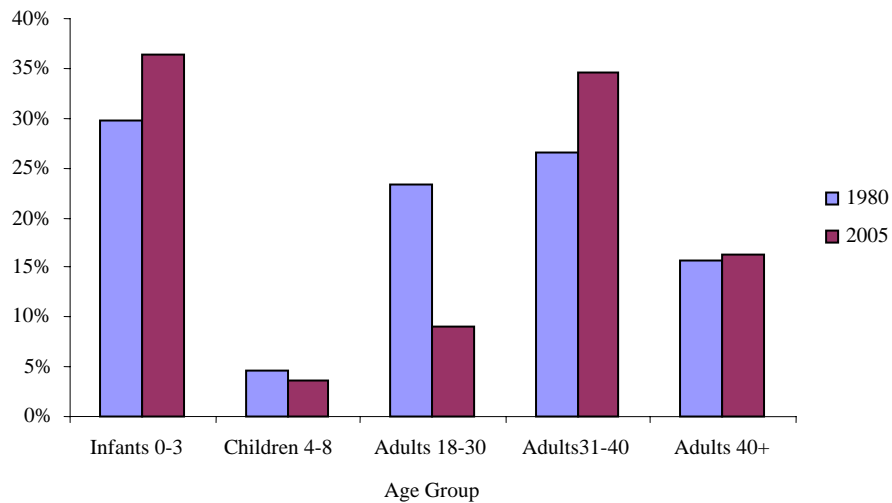
Table 4.6. Age Distribution of Tijeras

Age Category	N	%
Fetal –under 1yr	4	7.3
1-3.5yrs	16	29.1
6-10yrs	2	3.6
12-18 yrs	0	0
19-25 yrs	2	3.6
25-30 yrs	3	5.5
30-35 yrs	2	3.6
35- 40 yrs	8	14.5
40-45 yrs	1	1.8
45-50 yrs	4	7.3
50+	3	5.5
Older Adult (>30)	10	18.2
TOTAL	55	100

Although the additional aging methods used in this study (auricular surface of the ilium) differ slightly than the method used in the original analysis (Ferguson, 1980; pubic symphysis), there tended to be some agreement in the age ranges, especially with regard to Mendl and Lovejoy's and Todd's method (see method

chapter). Additionally, there was a slight difference between age at death reported in the original analysis and the current analysis. When the current data were recoded into the same age groups as the original analysis, there tended to be differences in the percentages (Figure 4.8). The greatest difference was between the percentages reported for adults between 18-30 (14.3% difference). The percentage reported for adults over 40 showed the least difference between the two analyses (Table 4.7).

Figure 4.8. Percentage of Age at Death
(1980 data compared with 2005 Data)



*there are no individuals between the ages of 9-17 in this collection

Table 4.7. Comparison of Percentage of Death by Age Group*

Age	% (Ferguson, 1980)	% (Williams, 2005)	% difference
Infants 0-3	29.7	36.4	6.7
Children 4-8	4.7	3.6	1.1
Children 9-11	0	0	0
Adolescents 12-17	0	0	0
Adults 18-30	23.4	9.1	14.3
Adults 31-40	26.6	34.5	7.9
Adults over 40	15.6	16.3	0.7

*Adult and infant age groups are based on age groups used by Ferguson, 1980

In addition to the differences between the two analyses, there are also some similarities. In both analyses, Infants between 0 and 3 years and Adults between the ages of 31 and 40 make up the largest percentage of individuals in the sample (Table 8). In both analyses, children between the ages 4 and 8 make up the smallest percentage of the sample, and there are no individuals between the age of 10 and 17 in either sample.

Stature

Stature estimates from the femur (Genoves, 1967) were calculated for 22 adult skeletons. The mean stature for the 22 skeletons was 156cm. The mean stature of all males was 160.4cm and significantly taller than that of all females (150cm) ($t = 5.53$, $p=0.0000$) (Table 9) in the sample. These results are within 0.5cm of the original stature estimates reported in 1980 (Ferguson, 1980). However, the original report did not compare stature by occupational phase, so a comparison between the analyses is not reported here.

Although there was a significant difference in stature between males and females when both occupational phases were combined, there was only a significant difference in stature within the early occupation phase ($t = 5.4$, $p = 0.00$). When stature was compared across occupational phases, late males tended to be shorter than early males, whereas, late females tended to be taller than early females (Table 9), however, there were no significant changes in stature between males and females from the early to late occupation phases (males: $t = .496$, $p=0.64$; females: $t = 1.9$, $p = 0.21$). When only compared by occupational phases (males and females combined), stature tended to be slightly larger (157.4cm) in the early occupational phase than the

late occupational phase (153.6cm), however, this was not a significant difference ($t = 1.2, p = 0.23$).

Table 4.8. Mean Stature of Males and Females by Occupational Phase

Group	N	Mean Stature	<i>P</i>
Early Occupation			
Males	9	162	
Females	5	149	
Total	14	157.4	0.00*
Late Occupation			
Males	4	157	
Females	4	150.4	
Total	8	153.6	0.15
Both Occupations Combined			
Males	13	160.4	
Females	9	150	
Total	22	156	0.00*

*(t -test, $p < 0.05$)

Cranial Deformation

Three different patterns of cranial deformation were observed, and were classified as follows: Definite vertical flattening, intermediate flattening (some deformation and asymmetry), intermediate flattening with an “occipital bun”, and minimal flattening or no flattening (i.e. very little evidence of cranial deformation) (Table 4.9). Some of the crania had rodent damage, were weathered, or broken prior to excavation and were not included in this part of the analysis. However, 26 individuals (47.2%) had crania available for classification. Of these 26 crania (Table 4.9), 12 had definite flattening (8 males, 3 females, and 1 juvenile); 8 had intermediate flattening (2 males, 3 females, 3 infants) and 5 had intermediate flattening with an “occipital bun” (5 females). The remaining 29 (52%) individuals fell into one of two categories: missing cranium or fragmented cranium. Most of the

individuals with missing or very fragmented crania were subadults (16 individuals).

The remaining 8 individuals with fragmented or missing crania were adults.

Table 4.9. Distribution of Cranial Deformation Patterns

Sex	Definite flattening	Intermediate Flattening	Intermediate with “bun”	Minimal, or No flattening	Fragmented or missing
Adult Male	8	2	0	1	5
Adult Female	3	3	5	0	5
Adult	0	0	0	0	2
Subadult	1	3	0	0	17
TOTAL	12	8	5	1	29

I compared the patterns of cranial deformation between the early and late occupational phase. Patterns in cranial deformation between the early and late phases were not significantly different (Table 4.10)

Table 4.10. Cranial Deformation Patterns in Early and Late Occupations Compared by Fisher’s Exact

Cranial Deformation	Early Occupation	Late Occupation	Total	<i>p</i>
Definite Flattening	7	5	12	0.713
Intermediate Flattening	5	3	8	0.683
Intermediate Flattening (with occipital bun)	1	4	5	0.148
Minimal Deformation	1	0	1	
Total	14	12	26	

Pathological Conditions

Several pathologies were observed and classified into six categories: osteoarthritis, porosity, cribra orbitalia, endocranial lesions, trauma, and vertebral pathologies. These pathologies were observed in skeletons from both the early and the late phase occupations, but the differences between occupations were not statistically significant ($\chi^2=0.74, p=0.86$). For both occupations combined, 39

(70.9%) of the skeletons had at least one of these pathologies, 4 (7.2%) had multiple pathologies, and 9 (16.4%) had no observable skeletal pathologies (Table 12).

Table 4.11: General Prevalence of Pathologies

General Prevalence	Early	Late	Total	%
No pathologies	5	4	9	16.4%
1-2 pathologies	26	13	39	70.9%
Multiple pathologies (>2)	2	2	4	7.2%
Indeterminate	2	1	3	5.5%

$\chi^2=0.74, p=0.86$

Osteoarthritis

Osteoarthritis was a commonly observed pathology in the adult skeletons. Of the 32 adults in the sample, 14 (43.8%) had some degree of osteoarthritis, with all of the lesions being the same severity in any given individual (Table 4.12). Most (85.7%) of these individuals had lesions classified as slight (pinpoint porosity on less than 1/3 of the joint surface) to moderate. In only two cases (14.3%) were they classified as severe (coalesced porosity on 2/3 or more of the joint surface, lipping around the joint margin, and ankylosis).

Table 4.12. Prevalence of Osteoarthritis in Adults

Osteoarthritis	Early Occupation	Late Occupation	Total	% Total	<i>p</i>
Absent	12	6	18	56.3	
Present (Slight)	1	4	5	15.6	
Present (Moderate)	6	1	7	21.9	
Present (Severe)	1	1	2	6.3	
TOTAL	20	12	32	100	0.58*

* $\chi^2=0.31$

Individuals with osteoarthritis came from both the early occupation phase and the late occupation phase. Differences in the number of individuals with osteoarthritis in the early and late occupational phases were not statistically significant ($\chi^2=0.31, p=0.58$).

There were sex differences in the presence of osteoarthritis. While the general distribution of males and female adults was fairly even (51.6% and 48.4% respectively) a higher percentage of male skeletons had osteoarthritis (Table 4.13). More of the male skeletons than the females showed some degree of osteoarthritis (56.3% for males versus 33.3% for females). These sex differences, however, were not statistically significant (Fisher's Exact, $p=0.285$).

Table 4.13. Differences in Osteoarthritis (all lesion types) between all Males and Females

	Males	Females
Absent	7 43.8%	10 66.7%
Present	9 56.3%	5 33.3%
Total ^b	16 51.6%	15 48.4%

^b Excludes one individual for whom sex was indeterminable

Porotic Hyperostosis and Cribra Orbitalia

Porotic hyperostosis (porous lesions) was observed in the cranial vaults of both the adult and infant skeletons. The severity of the lesions was classified from slight (healed and barely discernable) to moderate (active or in the process of healing, but not coalesced), with most of the individuals with lesions (18) classified as slight. There was one moderate case of porous lesions, but there were no cases of severe porosity in the sample (Table 4.14).

Table 4.14. Prevalence of Porotic Hyperostosis in Entire Collection

Porosity	Age Category			Total
	Adult	Juvenile	Infant	
Absent	21	2	13	36
Present (slight)	11	0	7	18
Present (moderate)	0	0	1	1
Present (severe)	0	0	0	0
Total	32	2	21	55

* Includes individuals for whom porosity was not identifiable

Cribriform orbitalia was also present in 13 individuals from both occupational phases (8 early and 5 late), and was classified from slight to severe, with most of the individuals being classified as slight (Table 4.15). However, 11 skeletons had poorly preserved crania (fragmented) and could not be classified.

Table 4.15. Distribution of Cribriform Orbitalia by Age Category

	Adult	Juvenile	Infant	Total
Absent	27	2	13	42
Present (slight)	5	0	8	13
Present (moderate)	0	0	0	0
Present (severe)	0	0	0	0
Total	32	2	21	55

* Includes individuals for whom porosity was not identifiable

Endocranial Porous Lesions

Endocranial lesions characterized by slight channeling in slight cases and deep channels with “plaque-like” bone deposition in more severe cases were present in 5 individuals. The lesions occur on the inner table of the parietals and occipital bone, and are concentrated around the meningeal grooves and the transverse sulci of the occipital bone (Figure 4.9). Individuals in both the early and late occupational phases (4 and 7 respectively) had endocranial lesions, but the difference between the two phases was not significant ($\chi^2 = 0.276$ $p = 0.964$) (Table 4.16)

Figure 4.9. Endocranial Lesions

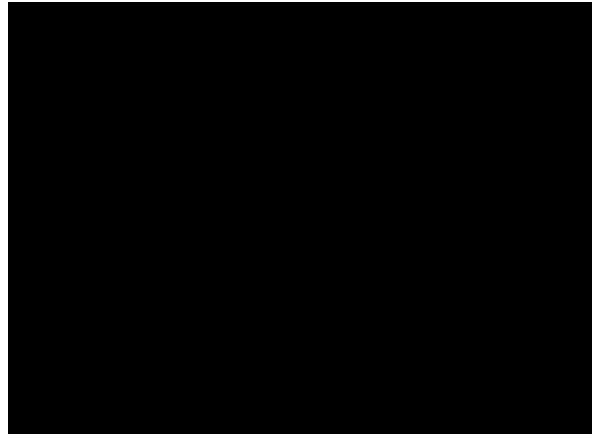


Table 4.16. Distribution of Endocranial Lesions by Occupational Phase

Endocranial Lesions	Early Occupation	Late Occupation	Total
Absent	30	14	44
Present (Slight)	2	2	4
Moderate	3	4	7

$\chi^2 = 0.276$ $p = 0.964$

There was, however, a significant relationship between the presence of endocranial lesions and age category ($Z = -2.683$ $p = .007$) (Table 12). The lesions occurred in infants between 9 months and 3.5 years, but not in the juvenile or adult skeletons.

Table 4.17: Distribution of Cranial Lesions by Age Category

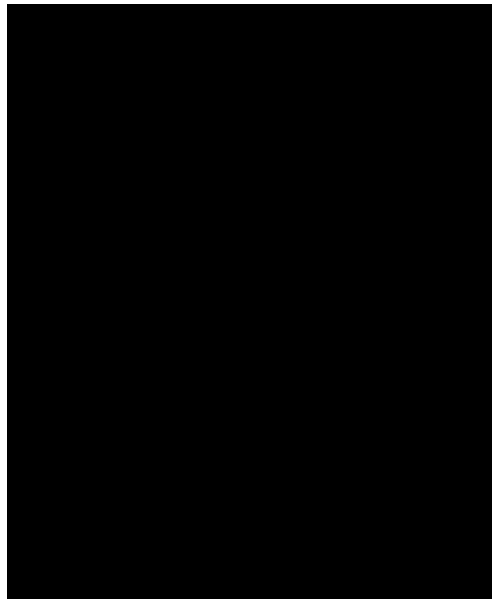
Endocranial Lesions	Infant	Juvenile	Adult	Total
Absent	7	2	28	37
Present (slight)	4	0	0	4
Present (moderate)	7	0	0	7
Indeterminate	3	0	4	7
Total	21	2	32	55

$Z = -2.683$ $p = .007$

Vertebral Pathologies

There were 5 individuals with vertebral pathologies. One of these individuals, 1 had spondylolysis in the 4th lumbar vertebra. Three individuals had collapsed vertebrae with moderate to severe osteophytes around the vertebral body. One individual had severe ankylosis in which three lumbar vertebrae were completely fused together. (Figure 9).

Figure 4.10. Severe Ankylosis (L-3,L-4, L-5)



CHAPTER V

DISCUSSION

Since the original analysis of the Tijeras collection, new methods, standards, and classification systems (pathologies, developmental defects) for skeletal analysis have been developed. Furthermore, archaeologists and biological anthropologists are asking new questions about population aggregation, social interaction, and health in the Prehispanic Southwest (Adams and Duff, 2004; Kamp 2002, Barnes, 1994). As a result, many previously reported sites such as Arroyo Hondo (Palkovich, personal communication), Puye, and those on the Central Pajarito Plateau (Barnes, 1994) have been, or are currently the focus of new studies. Tijeras Pueblo is no exception to this trend because like many of the other skeletal collections that have not been re-buried and are being re-analyzed, it has many data available for re-analysis and reinterpretation.

In the current study, the Tijeras skeletal collection provided a valuable opportunity for reanalysis and reinterpretation, which have resulted in several new observations that may redefine many of the characteristics of the Tijeras population. In many cases, new observations were the result of changes in how the collection was analyzed (i.e. sample size, occupational phases, aging methods etc.). These types of observations resulted in slight changes in the demographic profile, and are listed in Table 5.1.

Table 5.1. Differences in Methodology between Original and New Analysis

Change in Analysis/Methods	Ferguson, 1980	Williams, 2005
Sample size*	64	55
Settlement phases	None used	Early and Late phases distinguished
Auricular surface for aging	Not used: fewer adults aged	Used: more adults aged
Cranial deformation Patterns	Not described	3 patterns described
Barnes' method for identifying developmental defects used	Only 1 type of defect described	All observable developmental delays described Neural tube defects and neural arch clefting differentiated

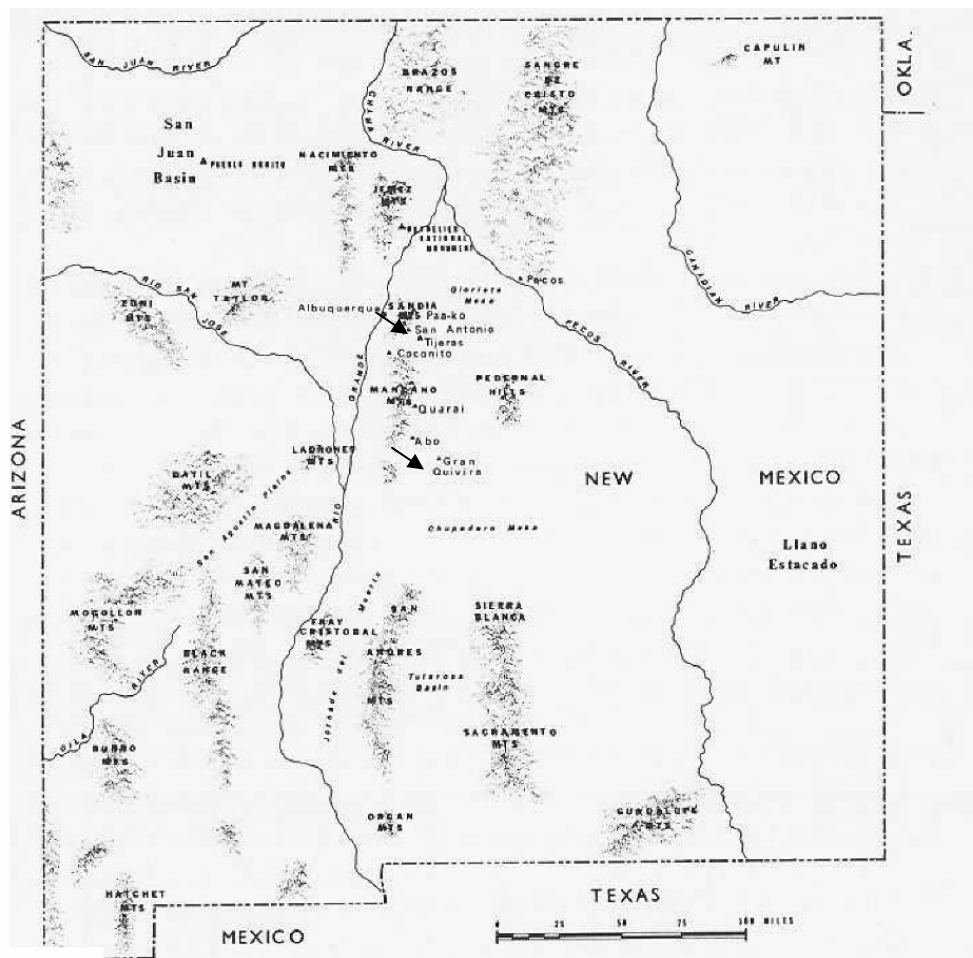
* 9 skeletons that were not part of the UNM excavation of Tijeras Pueblo were excluded from the current analysis, but were used in the original analysis.

These changes have resulted in new data that have contributed to our understanding of the conditions that influenced life at Tijeras Pueblo within a local site specific context. These new data have also contributed to our understanding of the role of Tijeras within the context of the Prehispanic Southwest by providing additional information about Tijeras that can be used for comparison with data from other central Rio Grande settlements. Furthermore, these new data add to the current research interest in the mechanisms of social interaction and population aggregation during the Pueblo IV period by providing additional information about social networks through skeletal patterns.

To place Tijeras within the context of the central Rio Grande, data from other central Rio Grande sites were used for comparison. Paa-ko, San Antonio, and Arroyo Hondo (Figure 5.1) have skeletal data and were contemporaneous with Tijeras Pueblo. Arroyo Hondo also had two phases of occupation, similar to the phases at Tijeras.

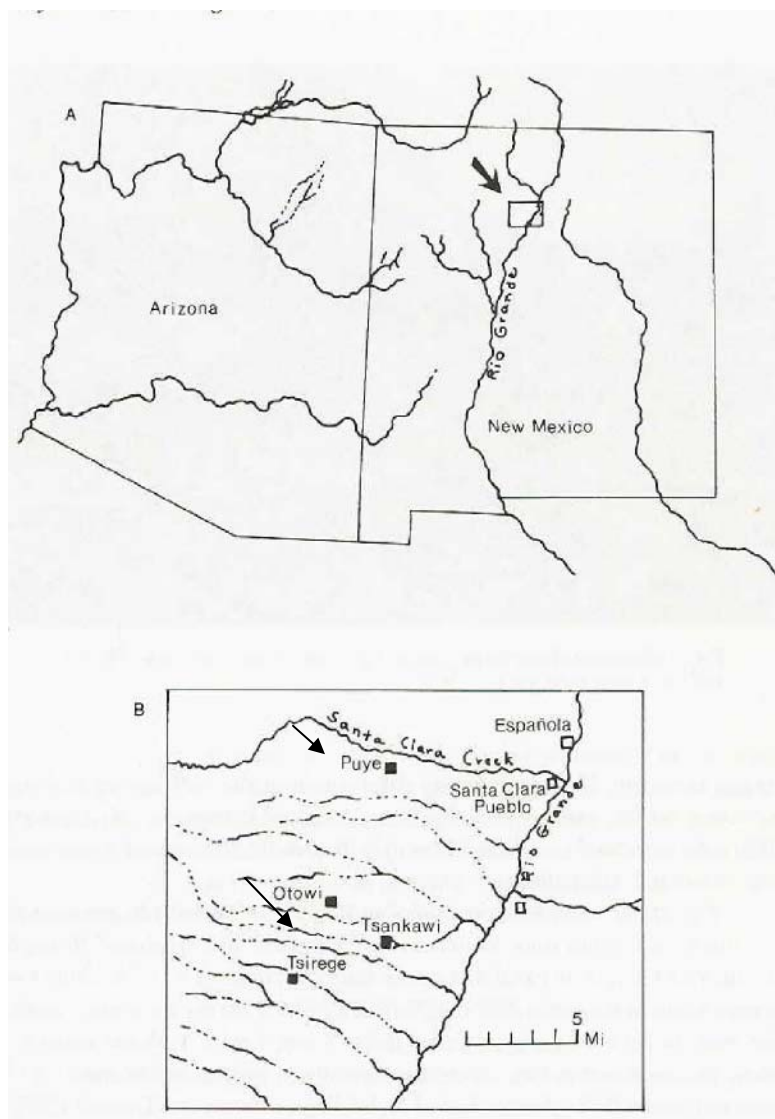
Other settlements not in the central Rio Grande were also used to place the Tijeras study within the context of the larger southwest. These sites include, Gran Quivira, Puye, and sites in the Pajarito Plateau (Figure 5.2). A more detailed discussion of the Tijeras skeletal collection, with an emphasis on developmental defects follows.

Figure 5.1. Central Rio Grande Settlements
(Including Tijeras, Paa-ko, San Antonio, and Gran Quivira)



Reprinted from Cordell, 1980:2

Figure 5.2. Settlements in the Pajarito Plateau



Reprinted from Barnes, 1994:299

Developmental Defects

The focus of this analysis was on the patterns of developmental defects in the Tijeras collection. This interest stemmed from the earlier sources that report a high frequency of neural tube defects and the potential link between these defects and lead glaze production at Tijeras (Ferguson, 1980; Devor and Cordell, 1980). Also, the potential relationship between neural tube defects and lead glaze paint production may reflect craft specialization and therefore, reflect a mechanism of social interaction through trade between Pueblo IV period settlements.

During the analysis, a number of developmental defects were observed in the Tijeras collection. Some of these defects were also observed in the original analysis; however, they were classified differently. The original analysis identified these defects as neural tube defects (Ferguson, 1980), and suggested that the incidence may be in part related to lead glaze paint production at the site (Devor and Cordell, 1980). The current study re-analyzed these patterns of developmental defects and their significance to lead production at the site. The analysis made a distinction between neural tube defects and other similar looking defects (paraxial mesoderm defects) in the Tijeras population, which changed how defects were classified in the Tijeras collection. In addition to this distinction, other developmental defects, not previously reported were described. The distinction between neural tube defects and other defects, as well as the description of other defects in the collection has important implications for Tijeras with regard to other Ancestral Pueblo sites. These differences and how they impacted the Tijeras analysis are discussed below.

The original Tijeras analysis identified neural tube defects in the population. Because neural defects occur when the paraxial mesoderm is developing, they can interfere with the developing vertebrae and sacrum. As a result, a bony defect is usually associated with a neural tube defect. In some of the more severe forms where several vertebrae are involved, the cleft is wide and large portions of the vertebrae fail to develop. The bony defect in these cases is referred to as spina bifida cystica. There are some defects where fewer vertebrae are involved, and in these cases the bony defect is referred to as spina bifida occulta (Barnes, 1994). The bony defects associated with neural tube defects have been used to identify neural tube defects in prehistoric populations (Ferguson, 1980). However, recent work by Barnes (1994) suggests that the neural tube defects originally identified in these collections are not neural tube defects, but rather minor developmental delays in the paraxial mesoderm not associated with the neural tube. Distinction between neural tube defects and paraxial mesoderm defects is significant because they have a different etiology. This difference has significance because it has implications for population movement in the Southwest. Therefore, it is important to distinguish the differences between neural tube defects and paraxial mesoderm defects. The differences between the two defects and the significance of this difference in the Southwest are discussed below.

Neural tube defects are often multifactorial disorders. There tends to be a familial tendency for neural tube defects. However, these defects are also strongly linked to an epigenetic disturbance to the embryo during a critical developmental stage (Barnes, 1994). Epigenetic disturbances that may cause neural tube defects have been associated with poor maternal health. For example, a neural tube defect can

result from inadequate selenium, zinc or folic acid intake (Barnes, 1994). Also, recent research (Felkner et. al., 2003) suggests a relationship between maternal diarrhea and neural tube defects. In this case, the diarrhea contributes to poor nutrient absorption, which in turn contributes to a disturbance to the embryo. Other environmental factors, such as lead or mercury may also act as teratogenic agents, and result in a developmental defect. For example, in the original Tijeras analysis, because the high incidence relative to the sample size, lead glaze paint production, rather than genetic influence was cited as a link to the neural tube defects in the collection (Devor and Cordell, 1980).

When an epigenetic disturbance occurs during in the first twenty days of embryonic development, it interferes with the developing neural tube as it is closing. As a result, open lesions occur in the neural tube. This disruption also interferes with proper development of the cranial and vertebral structures (Barnes, 1994). In some cases, a disturbance results in failure of the neural folds to fuse (cranial portion of the neural tube) causing a spinal cord and brain fissure. This disruption also inhibits the developing paraxial mesoderm (cranial and vertebral structures) from developing normally. This defect is commonly known as craniorachischisis (Barnes, 1994), which results in death in the early embryonic or fetal stage (Barnes, 1994). In some cases the fetus continues to develop postcranially, but the cranium or brain do not develop. This type of neural tube defect is known as craniorachischisis with anencephaly. This is of course also lethal, but sometimes the fetus is carried to full term and dies shortly before birth. Anencephaly is rare in skeletal collections, and to date, only one case in a prehistoric collection has been identified (Ortner, 2003).

However, one individual with anencephaly was recently observed in the Arroyo Hondo collection (Palkovich, personal communication). The data concerning this individual are still in the process of being analyzed and have not been published.

Anencephaly is the most frequent fatal defect in the skull (Ortner, 2003), and is associated with a neural tube defect. However, neural tube defects can also be non-fatal and occur in other parts of the axial skeleton. A meningomyelocele can also occur if the neural tube fails to close posteriorly. In this disturbance, the spinal cord and nerve roots (meningomyelocele) become displaced outside of the vertebral canal. Like anencephaly, a meningomyelocele interferes with the developing paraxial mesoderm, and are commonly observed the lumbrosacral region. A meningomyelocele is usually associated with unfused neural arches, thin pedicles, deformed laminae, and raised edges on the bony defect. The more severe forms of this defect are referred to as spina bifida cystica, and are always associated with a neurologic disability. In the most severe cases, infants die shortly after birth. If the defect occurs above the third lumbar vertebrae, then paraplegia occurs. If the defect occurs in the lower lumbrosacral region, then the hip flexors or knee flexors can either be paralyzed or weak. Neural tube defects occurring in the lower lumbrosacral region can also affect motor control of the feet and the plantar flexors can be paralyzed, and gait would also be affected (Barnes, 1994). Incontinence is also common with a meningomyelocele. In many cases, a meningomyelocele lesion results in a buildup of cerebrospinal fluid. The buildup of fluid results in hydrocephalus, which is often associated with babies born with a meningomyelocele (Ortner, 2003).

Another neural tube defect is also associated with spina bifida cystica or spina bifida occulta because like a meningomyelocele, it interferes with the proper development of the paraxial mesoderm. This defect is referred to as a meningocele and involves improper development of the meninges. In this defect the neural tube has closed properly, but the meninges become herniated through the vertebral column. This results in a cyst or in less severe forms a skin covered lipoma (Barnes, 1994), and also a bony defect known as spina bifida cystica or spina bifida occulta. The symptoms associated with a meningocele are less severe than a meningomyelocele, but still involve some problems with motor control of the sphincter as well as gait. In some cases, foot deformities are associated with meningocele (Barnes, 1994).

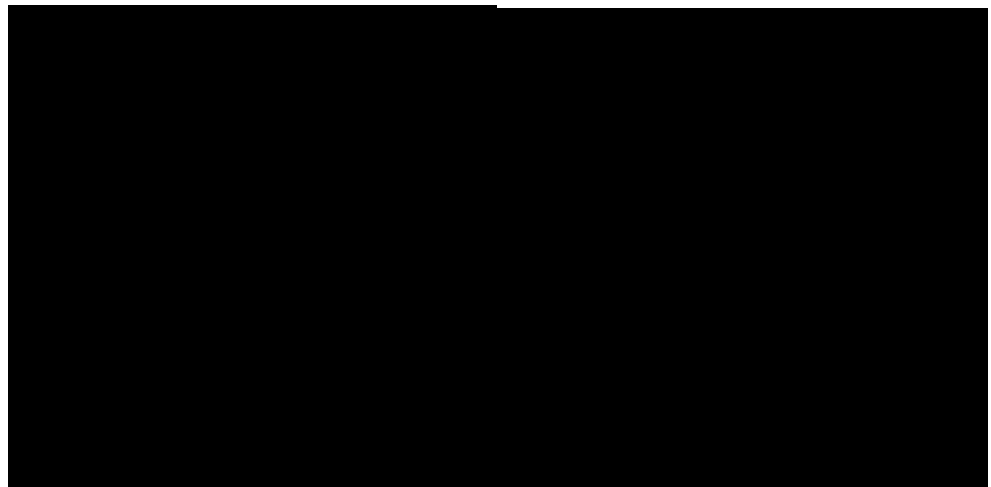
Paraxial mesoderm defects sometimes resemble the bony defect associated with neural tube defects. However, unlike neural tube defects, paraxial mesoderm defects are not considered to be epigenetic; meaning that the defect is not influenced by environmental factors. Rather, they are the result of an underlying genetic template (Barnes, 1994). Therefore, these defects have not been associated with maternal health or teratogenic factors such as lead or other toxins (Barnes, 1994). Also, paraxial mesoderm defects simply result in a minor delay in the development of a bony structure. These delays are mild, and unlike neural tube defects, they do not influence the health of the individual (Barnes, 1994). Finally, because paraxial mesoderm defects are not epigenetic, they are more likely to represent family patterns of inheritance (Barnes, 1994). Furthermore, recent research by Barnes (1994), as well as recent comparisons between Tijeras and Arroyo Hondo, suggest that patterns in

these defects vary between different populations, but are homogenous at each settlement. These data further suggest that the patterns in developmental defects observed in the southwest reflect family patterns of inheritance.

The difference between paraxial mesoderm defects and neural tube defects is significant in the Tijeras population because it changes the way we look at Tijeras in regard to ceramic glaze-paint production. As mentioned, the original analysis reported neural tube defects in the population (Ferguson, 1980). A subsequent paper linked these defects to lead glaze-paint production at the site (Devor and Cordell, 1980). Additionally, part of the site (room block 8) had a burial with potter's tools, clay, and ceramics. One of the original goals of the current analysis was to establish a relationship between individuals with neural tube defects and their burial location within the site. If there was a relationship between the two, or in other words, if individuals with neural tube defects were buried together in a specific location with potter's tools, then it might reflect a family group or occupational group of glaze-paint and ceramic producers. Such a relationship could indicate an occupational guild or division of labor at the site that would have had significant implications for social interaction at the site, as well as for social interaction among Rio Grande settlements. It may have been possible that a group of people engaged in a particular occupation would have had a different social status than other groups at the site, and they may have had differential access to resources at the site. Also, they may have been considered lower status, and would have had limited access to resources. If this had been the case, then the difference in social status may have also been reflected by other skeletal markers (such as porotic hyperostosis).

However, a relationship between neural tube defects, and burial location could not be identified at Tijeras. A closer examination of the defects originally identified as neural tube defects found that these defects were actually the result of a paraxial mesoderm defect. What had been previously identified as spina bifida occulta was identified as neural arch clefting (Figure 5.3).

Figure 5.3. Comparison between Neural Arch Cleft and Neural Tube Defect



Right: neural tube defect; Left neural arch clefting in the Tijeras collection. Note the cleft that occurs with the neural tube defect. It is wide and the edges are pushed upward. This is not the case with a developmental delay, where the neural arch cleft is incomplete and narrow.

As previously mentioned, spina bifida occulta is a bony defect caused by a herniated meninge. The defect is a skeletal response to accommodate the herniated meninge. The result is a neural arch cleft with the edges of the bony defect pushed outward, an absence of spinous processes, and thin and poorly developed laminae and pedicles. In a paraxial mesoderm defect, there is a cleft, however, the cleft is not as wide, and the edges are not pushed outward. Also, in spina bifida the cleft that occurs is complete, whereas in a paraxial mesoderm defect, the cleft may only include 1 or 2

vertebrae (Barnes, 1994). In addition to the differences between the bony defects themselves, neural tube defects would also be accompanied by other skeletal defects. For example, decreased motor control of the hip and knee flexors as well as foot deformities can occur with neural tube defects (Barnes, 1994). The deformities would leave markers on the skeletons, either through a lack of muscular development, or increased muscular development in other areas to accommodate for the awkward gait caused by the defect. This was not the case in the Tijeras collection. The individuals with defects had only localized defects. The appendicular skeletons of these individuals had normal muscular development. The tarsal bones of these individuals were also normal in these individuals, indicating that there were not secondary bony defects associated with a neural tube defect. Furthermore, the defect was a cleft in the sacrum. These data indicate that the defects observed in the Tijeras collection are paraxial mesoderm defects, specifically, neural arch clefting (Barnes, 1994). These incidence of these defects is not likely directly influenced by lead exposure, but rather the result of minor developmental delays influenced by intrinsic (genetic) factors.

Therefore, lead glaze paint production at Tijeras had no observable impact on the skeletons of the Tijeras population. This is not to say that the health of those engaged in lead glaze paint production at the site was not compromised. It is likely that there were some negative health consequences for those engaged in lead mining and glaze paint production. However, these consequences affect the soft tissue and did not impact the skeleton. For example, recent research (Mendola et.al., 2002) has linked impaired cognitive development to lead absorption, which would not have any

impact on an individual's skeleton. However, this type of impairment might have impacted general quality of life of an individual with lead toxicity.

In addition to neural arch clefting, two other paraxial mesoderm defects were observed in the Tijeras collection. The first type was bifurcated a spinous process. Bifurcated spinous processes are the result of a delay in the paraxial mesoderm commonly observed in the cervical vertebrae and are the most commonly observed paraxial mesoderm defect (Barnes, 1994). They were also the most commonly observed defect in the Tijeras collection (14 individuals). The second type of paraxial mesoderm defects observed was a segmentation error. In segmentation errors, the sclerotome fails to separate resulting in block vertebrae. This defect was also observed in 7 individuals in the Tijeras collection. Not only were these defects common in the Tijeras collection, but they have also been commonly observed in the Arroyo Hondo collection (Palkovich, unpublished data).

This similarity between the two sites (Tijeras and Arroyo Hondo) demonstrates the lack of a direct relationship between the incidence of paraxial mesoderm defects and lead glaze paint production. Arroyo Hondo was never a lead glaze paint producing site, yet paraxial mesoderm defects are present. This lends further support that the incidence of defects observed in the Tijeras collection was not directly caused by lead glaze-paint production at the site. Additionally, the patterns of the defects observed in both Tijeras and Arroyo Hondo are different. For example, at Arroyo Hondo, individuals with neural arch clefting in the sacra have clefts in the beginning at the top of the sacrum (S-1, S-2) (Palkovich, unpublished data). This

pattern differs from individuals at Tijeras, who have clefting in the lower half (S-4, S-5) of the sacrum.

In addition to neural arch clefting, there are other paraxial mesoderm defects present in the Arroyo Hondo collection that are not present in the Tijeras population. For example, defects resulting from a cervicothoracic border shift, lumbrosacral border shifts. Also, there are some individuals with multiple defects (Palkovich, unpublished data)

There is also a neural tube defect in the Arroyo Hondo collection. One individual with anencephaly was identified in the collection. This is significant because Arroyo Hondo was never a lead glaze-paint producing site (Cordell, personal communication), yet there is an individual with a neural tube defect. Tijeras, on the other hand, was a lead glaze-paint producing site, but there were no cases of neural tube defects identified in the collection. Again, these data suggest that the frequency of developmental defects at Tijeras is more likely the result of underlying genetic factors in homogenous populations.

The presence of paraxial mesoderm defects at both Arroyo Hondo and Tijeras, and the variation in these patterns between the sites further supports the idea that the developmental defects at Tijeras represent a familial pattern of inheritance. Also, the difference between the patterns of developmental defects suggests that although they are contemporaneous Ancestral Pueblo settlements (both occupied between A.D.1300 and 1425) and only 40-50 miles apart from each other, the Arroyo Hondo population and the Tijeras population were two different populations (different gene pools).

In addition to paraxial mesoderm defects, other developmental defects were observed in the Tijeras collection. These defects included blastemal desmocranium field defects (extra primary sutures), sternal plate defects (sternal aperture) and bipartite patella. Like paraxial mesoderm defects, these defects are localized and are linked to an underlying genetic template, and are not linked to epigenetic disturbances (Barnes, 1994). Also, like paraxial mesoderm defects, these defects are minor and do not influence the health of an individual.

In previous texts (Bass, 1995), some of these defects have been referred to as non-metric traits and have been documented as such in other reports. For example, sternal aperture and extra sutures were documented as non-metric traits by Reed (1977) in the Gran Quivira collection. However, recent research at other settlements in the central Rio Grande (Palkovich, personal communication) and the Pajarito Plateau (Barnes, 1994) has identified these traits and described them as developmental defects. For example, defects in the blastemal desmocranium have been observed at Arroyo Hondo (Palkovich, unpublished data).

Variation in developmental defects has also been observed in other Ancestral Pueblo populations outside of the central Rio Grande, and like Tijeras and Arroyo Hondo, the patterns in the defects vary between settlements (Barnes, 1994). The presence of these defects at other settlements is not only significant because these defects are not neural tube defects and cannot be linked to lead glaze paint production at Tijeras; it is also significant because these defects may also represent family patterns of inheritance (Barnes, 1994). As mentioned, these defects are considered to be variations in genetic control over critical periods of development. In some cases,

these periods are delayed, and a minor developmental defect occurs. Further support for the idea that these defects may reflect familial patterns comes from the variation in patterns of these defects. The paraxial mesoderm defects, blastemal desmocranium defects, and sternal plate defects that have been observed at Tijeras as well as in other non-lead glaze paint producing sites vary in how they are expressed.

A comparison of developmental defects between specific Ancestral Pueblo sites demonstrates the variation in how these patterns have been expressed in the Southwest. For example, Puye is one site where neural arch defects occur in the sacrum (Barnes, 1994), and these defects differ from those at Tijeras and Arroyo Hondo, but are similar to Otowi (Barnes, 1994). At Arroyo Hondo, individuals with neural arch clefting in the sacra have a regular pattern of clefting in the cranial portion of the sacrum (Palkovich, unpublished data). This pattern differs from the individuals at Tijeras, where the pattern of clefting in the sacra is regular and occurs in 3rd, 4th and 5th segments of the sacrum. On the other hand, neural arch clefting in the Puye collection tended to be irregular (Barnes, 1994). Also, at Puye, several of the individuals had a mixture of cleft neural arch in some segments, and bifurcation in other segments of the sacrum (Barnes, 1994). The Otowi collection, another population from the Pajarito plateau, also had sacral cleft neural arch. Unlike Puye, the pattern of clefting only affected the first and second sacral segments (Barnes, 1994). However, although the number in sacral segments involved varied between Puye and Otowi, the shape of the clefting is similar. Barnes (1994) attributes this similarity between Puye and Otowi to both populations being from the same gene

pool. In the case of the clefting in the Arroyo Hondo and Tijeras collections, the patterns of sacral segments involved, as well as the shape of the cleft differs.

The paraxial mesoderm defects are not the not the only defects that vary among these sites. Another example is with sternal plate defects. No sternal plate defects were observed in the Arroyo Hondo collection. However, there were 4 individuals with a sternal aperture in the Tijeras collection. Again, the differences in these patterns suggest that the two populations were different populations. Also, there were differences between blastemal desmocranium defects occurred between Arroyo Hondo and Tijeras. Only blastemal desmocranium field defects in the form of extra primary sutures occurred in the Tijeras collection. However, there were cases of extra primary sutures as well as sutural agenesis in the Arroyo Hondo collection (Palkovich, unpublished data).

The variation in the patterns of developmental defects has implications for migration and marriage patterns between sites in the Southwest. For example, the presence of the same pattern at two different sites may reflect a familial kinship between two sites, or marriage between individuals from two different sites. Similarities in patterns may also reflect migration between sites (Barnes, 1994).

The patterns in developmental defects not only have implications for social ties between Ancestral Pueblo settlements, these patterns also have important implications for the patterns of settlement at Tijeras. Changes in these patterns may indicate changes in the gene pool at the site, which may reflect a new population moving into Tijeras. Also, significant differences between males and females may represent marriage patterns at the site. There were no significant differences in the

presence of developmental defects between males and females. However, there was a significant pattern in the presence of neural arch clefting in the early and late occupational phases. While the frequency of the other defects was not significantly different between early and late occupational phases, there was a significant difference in the presence of neural arch clefting between the early and late occupational phases ($p=0.01$). All of the individuals with neural arch clefting occurred in the late occupation. These data in addition to evidence that developmental defects have strong familial ties, suggest that individuals from a gene pool different than the original founding population settled at Tijeras during the later occupational phase. This change may reflect the general trend for population aggregation at a few settlements in the Pueblo IV period.

Other Observations in the Collection and Site Comparisons

While the focus of this analysis was on the patterns of developmental defects at Tijeras, it is also important to note that several other observations were made. These observations concern the general characteristics of the Tijeras population. Most of the observations are similar to patterns observed at other contemporaneous settlements; therefore, they indicate that Tijeras follows the general trend for Ancestral Pueblo settlements. However, there are some patterns that differ from the other sites used for comparison. These differences may simply reflect differences in data collection or reporting for other sites. However, these differences may also reflect specific practices that occurred at Tijeras, but not at other settlements, and may be relevant to our understanding of Tijeras within the current research context. The

observations made in the current analysis, their significance, and a comparison to other settlements follows in the discussion below.

Sex and Age Distribution

There were a total of 55 individuals in the collection. When this sample size is compared to other contemporaneous Ancestral Pueblo sites that have skeletal data in the central Rio Grande, it falls into the range of skeletal samples from other sites. Some sites are very large, and have larger samples, whereas other sites are smaller and have smaller skeletal collections. Therefore, the Tijeras sample size falls into a comparable range of other Ancestral Pueblo sites, and the data from Tijeras can be compared to other sites. Skeletal samples from some of these sites have sample sizes below 30 individuals, whereas some are well over 100 individuals. For example, data from San Antonio Pueblo was collected from 28 individuals (Ferguson, 1980) and data for Paa-ko Pueblo was collected from 57 individuals (Ferguson, 1980).. On the other hand, Arroyo Hondo was a very large site (over 1000 rooms) the skeletal sample consisted of 120 individuals (Palkovich, 1980).

The sample size, age and sex distribution at Tijeras is similar to other contemporaneous sites. These data indicate that Tijeras Pueblo had similar trends in population size, age and sex distribution as other contemporaneous sites in the central Rio Grande. When the data are compared to sites within the same district (Paa-ko, San Antonio) and time period (Arroyo Hondo) the demographic pattern at Tijeras is similar.

Stature

Stature was calculated for 22 adults in the sample, and mean stature was calculated for both occupations combined and for early and late occupation phases. Overall, males in this population were significantly taller than the females (160.4cm and 150cm respectively). Furthermore, there were no significant changes in stature between the early and late occupation phases. These data are similar to other data collected from Ancestral Pueblo sites throughout the entire Southwest. According to Sobolik (2002), the mean stature for all Ancestral Pueblo populations ranges between 147.7cm and 169.3. The mean stature for all individuals measured from Tijeras is 156cm, which falls into the broad stature range for the Southwest. Furthermore, the general pattern is that males tend to be taller than females. For example; the stature range for small and large ancestral pueblo sites is 158.75cm – 169.3cm for males and 147.7cm – 162.0cm for females. (Sobolik, 2002). The mean stature for Tijeras was 160.4cm and 150cm (males and females respectively), which follows a similar pattern for the Southwest.

However, when mean stature for Tijeras males and females is compared to contemporaneous sites within the Albuquerque district of the central Rio Grande, a different pattern emerges. While Tijeras males tend to be taller than Tijeras females, Tijeras males and females tend to be shorter than males and females from other contemporaneous sites in the same district. For example, the mean stature for Paa-ko is 164.44 and 151.61 (males and females respectively) (Ferguson, 1980), whereas the mean stature for Tijeras Pueblo is 160.4cm and 150cm (males and females

respectively). There is a similar difference in stature at San Antonio Pueblo. The mean stature for San Antonio is 162.63cm and 153cm (males and females respectively) (Ferguson, 1980), which is also larger than the mean stature for Tijeras.

Finally, the mean stature for Arroyo Hondo was also larger than Tijeras. Arroyo Hondo is contemporaneous to Tijeras, and also had two occupation phases. When the mean stature for both of these phases was compared to mean stature from both occupational phases at Tijeras, the mean stature for the first occupation at Arroyo Hondo (A.D.1300-1370) is 163.9cm and 156.2cm (males and females respectively). The mean stature from the second occupation (A.D.1370-1425) is 165.6cm and 153.5cm (Palkovich, 1980). At Tijeras, the mean stature for the early occupation (A.D.1300-1360) was 162cm and 149cm (males and females respectively), and 157cm and 150.4cm for the late occupational phase (A.D.1390-1425). Again, these stature estimates indicate that Arroyo Hondo inhabitants in both occupations were taller than their Tijeras counterparts.

Previous studies of Ancestral Pueblo populations link smaller stature to cumulative stresses during childhood. For example, nutritional stress, parasitic infections, and other diseases are all stresses that influence stature (Sobolik, 2002). According to Sobolik (2002), stature is similar throughout the Southwest, and attributes some of the general trends in stature to dietary stress as a result of an increased dependence on maize.

The overall mean stature for Tijeras Pueblo falls into the general range for Ancestral Pueblo populations indicating that Tijeras follows the same trends in general quality of life as other Pueblo sites. When compared to other neighboring

sites, Tijeras inhabitants are shorter. However, this difference in stature may simply be the result of differences in sample size. Only 22 adults from Tijeras were used for stature estimates, which is less than the number at Arroyo Hondo. The differences in sample size make it difficult to determine if there are significant differences in stature between Tijeras and other Rio Grande Pueblos.

In sum, stature estimates from Tijeras follow a general trend for the Prehispanic Southwest (Sobolik, 2002) indicating that the quality of life at Tijeras was similar to other Ancestral Pueblos. Any more interpretation of the significance of stature at Tijeras is limited by differences in sample size between Rio Grande Pueblos.

Cranial Deformation

One of the new observations made in the current analysis was more than one pattern in cranial deformation at Tijeras. Three different patterns of cranial deformation were observed in the Tijeras collection. These patterns include vertical flattening (occipitally deformed), intermediate flattening (lambdoidally deformed) with an “occipital bun”, and undeformed. Vertical flattening and lambdoidal flattening are patterns associated with the use of cradleboards in the Southwest, and have been associated with Ancestral Pueblo populations (Piper, 2002). According to Piper (2002), the flattening that occurs with cradleboards used by Pueblo populations was not the result of the design of the cradleboard; rather, it was the result of how the cradleboard was used. As agriculture became more important, infants were placed in cradleboards, which allowed the mother to lay the infant down while she worked.

Also, recent research by Piper (2002) suggests that cranial deformation in the Southwest was not simply an accidental result of cradleboarding, but may have also produced a preferred head shape associated with the local cultural norms. Some of the patterns, then, may have been achieved by “pillowing” the infant. If this is the case, the odd pattern observed in the Tijeras collection may have represented an intentional deformation from a pillow, which may have been an aesthetic choice for individuals at Tijeras. This may be further supported by the pattern of individuals with this type of cranial deformation. First, only females have this particular pattern, and all but one of these females are from the late occupational phase. These data suggest a possible matrilineal maternal lineage at the site. Because these individuals occur mostly in the late occupation phase, they may represent a family lineage that migrated to the site during the later occupational phase.

The implications for the patterns of cranial deformation need to be researched further in order to determine their significance in the context of the Prehispanic southwest. Comparison of the Tijeras patterns with other settlements may indeed show a pattern that reflects one family group (a maternal lineage). Perhaps this development was related to changes in aesthetic choice driven by participation in a common religion or social network, or it was related to changes in childcare practices. Future comparisons may be able to trace this development with greater detail.

Pathological Conditions

Six categories of skeletal pathologies were observed in the Tijeras collection: osteoarthritis, porotic hyperostosis, cribra orbitalia, endocranial lesions, trauma and

vertebral pathologies. These same pathologies have been observed in other Ancestral Puebloan populations. For example, osteoarthritis, porotic hyperostosis, cribra orbitalia and endocranial lesions have been observed in the Paa-ko (Ferguson, 1980), San Antonio (Ferguson, 1980), and Arroyo Hondo populations (Palkovich, 1980).

These conditions are often skeletal responses to physical, disease, and nutritional stress, and have been used to interpret the general health and quality of life in skeletal populations (Sobolik, 2002). However, not all diseases result in changes in the skeleton; therefore, these conditions may not directly indicate an individual's cause of death and may only reflect underlying nutritional and disease processes present in the population (Palkovich, 1980). Because these conditions can reflect underlying disease processes they are still useful for identifying possible underlying nutritional or disease stress at Tijeras. Furthermore, because these patterns manifest themselves in the skeleton, they leave a partial record of the some of these environmental factors that may have influenced the quality of life at Tijeras. Because these patterns occur at other sites they can also be used for comparison between Tijeras and other contemporaneous sites for differences and similarities in qualities of life. Similarities in pathologies may represent a general trend for ancestral pueblo populations, whereas, significant differences may represent unique conditions at Tijeras or the other sites used for comparison. The pathological conditions observed in the Tijeras skeletons, as well as how they compare to other sites are discussed below.

Osteoarthritis

Osteoarthritis is the result of degenerative changes in the bone as a result of chronic physical stress or the aging process (Ortner, 2003). Degenerative changes occur in the joint surfaces and the around the vertebral bodies of the vertebrae. These changes can range very slight and unnoticeable to severe and occur in adults. Severe vertebral osteoarthritis may be a secondary condition following injury or other disease process. In some severe cases of vertebral arthritis, ankylosing (fusion) of the vertebrae is present. In such cases, the individual's mobility would be affected (Ortner, 2003). There was one case of osteoarthritis with ankylosing in the Tijeras collection. It is likely that this individual suffered a back injury that resulted in degenerative changes in the lower spine. This was an isolated case, and is not a commonly observed pathology in the Tijeras collection.

However, other degenerative changes in the vertebral column and joint surfaces were commonly observed in the Tijeras collection and have also been reported in other skeletal analyses. For Ancestral Pueblo populations, the general trend is that osteoarthritis has been commonly observed. This trend has been attributed to the physical demands of agriculture. Previous comparisons between hunter-gatherer populations and early agriculture populations suggest that the physical demands of agriculture were resulted in an increase in the prevalence of osteoarthritis (Goodman et. al., 1984).

Previous skeletal analyses of Rio Grande Pueblos report fairly high incidences of osteoarthritis. For example, Ferguson (1980) reported a high incidence of

osteoarthritis in the Paa-ko population; 71% of the adults in the sample suffered from vertebral arthritis and 61% of the adults suffered from arthritis in other joints.

Osteoarthritis was also common in the Tijeras sample (present in 43.7% of the adults) and ranged from slight to severe. However, there were only two individuals with severe osteoarthritis, and most of the individuals with arthritis had slight to moderate lesions. Furthermore, there were no significant differences in osteoarthritis between males and females or early and late occupation phases. These data suggest that Tijeras follows the general trend for arthritis in early agricultural populations, although the prevalence is slightly lower than Paa-ko. This difference may be the result of more difficult farming conditions and Paa-ko (Ferguson, 1980). However, the difference may also be the result of the differences in methodology. The Tijeras percentage is the prevalence of all arthritic lesions, whereas the Paa-ko data are separated based on where the lesions occurred. This difference may have resulted in higher percentages due to differences in sample size.

There were no dramatic changes in the prevalence of osteoarthritis between the early and late occupations at Tijeras, suggesting that it is likely that there were no major changes in daily activities at the site. Also, males and females were not significantly different with regard to osteoarthritis, suggesting that all adults were engaged in some sort of physical activity, and one sex was not under more physical stress than the other.

Porotic Hyperostosis and Cribra Orbitalia

Two other pathological conditions observed in the Tijeras collection were cribra orbitalia and porotic hyperostosis. These two conditions are the result of metabolic disturbances and often reflect iron deficiency anemia (Ortner, 2003). Cribra orbitalia is considered an early expression of anemia and porotic hyperostosis is a more severe expression. Both are characterized by porous osteolytic lesions in the orbit and on the outer table of the cranium. In more severe cases, there is a thickening of the diploe (between the inner and outer table of the cranium).

Both porotic hyperostosis and cribra orbitalia have been observed in Ancestral Pueblo populations and have been linked to the increased dependence on maize agriculture and decreased use of other food resources, as well as decreases in food supply due to fluctuating climatic conditions and drought (Sobolik, 2002). These conditions would have reduced dietary diversity, and increased dietary intake of iron poor foods (maize).

In addition to dietary stress, iron deficiency anemia has also been linked to parasitic infections, which would have also been likely in some pueblo populations living in under relatively crowded conditions. High parasite loads have the potential to prevent absorption of some nutrients such as iron, and lead to anemia. Additionally, a parasite infection may lead to diarrheal disease, which would also result in decreased nutrient absorption (Reinhard, 1992). Therefore, parasite infestation may also be responsible for the prevalence of cribra orbitalia and porotic hyperostosis at some large densely populated sites.

Like other Ancestral Pueblo sites, Tijeras relied on a maize based diet. Previous analyses (Garber, 1980 and Young, 1980) also indicate that Tijeras inhabitants also supplemented their diet with a number of local plant resources, wild game (rabbits, pocket gophers, artiodactyls), and turkeys. However, with the exception of rabbits (over 30% of the faunal remains) (Table 5.2), the relative percentage of these animals in the faunal assemblage is fairly low.

Table 5.2. Distribution of Faunal Resources at Tijeras

Animal	Early Occupation		Late Occupation	
	Relative %	MNI	Relative %	MNI
<i>Sylvilagus sp.</i> (cottontails)	31.1	42.5	30.9	26
<i>Lepus californicus</i> (jackrabbits)	5.9	8.0	5.9	5.0
<i>Thomomys bottae</i> (pocket gophers)	15.4	21.0	23.2	19.5
<i>Antilocarpa Americana</i> (pronghorn antelope)	4.4	6.0	3.0	2.5
<i>Odocoileus sp.</i> (deer)	3.7	5.0	3.6	3.0
<i>Meleagris gallopavo</i> (turkey)	8.0	5.9	6.5	7.7

(Data from Young, 1980:100)

The changes in the fauna from the early to late occupations also suggest that use of some animals may have decreased (by over-hunting), so other, more abundant small animals became more important resources (Young, 1980). Also, some of the burrowing animals such as pocket gophers may have disturbed the site after it had been abandoned and the increased percentage may not represent fauna used at the site (Young, 1980). Nevertheless, the presence of faunal remains, and the changes in the types of animal remains suggest that the Tijeras inhabitants used a variety of available resources to supplement their diet. However, these resources it may not have been sufficient provide adequate amounts of protein and dietary iron in the diet for all inhabitants at the site. Furthermore, the reduction in some of the animals in the faunal assemblage also suggests that animal resource availability may have

decreased, which would have also contributed to decreased animal protein intake. The low percentage of animal protein in the diet, coupled with a high intake of maize would have led to a diet chronically low in iron. As a result, metabolic disturbances such as iron deficiency anemia would have occurred in the Tijeras population (Ortner, 2003; Ferguson, 1980).

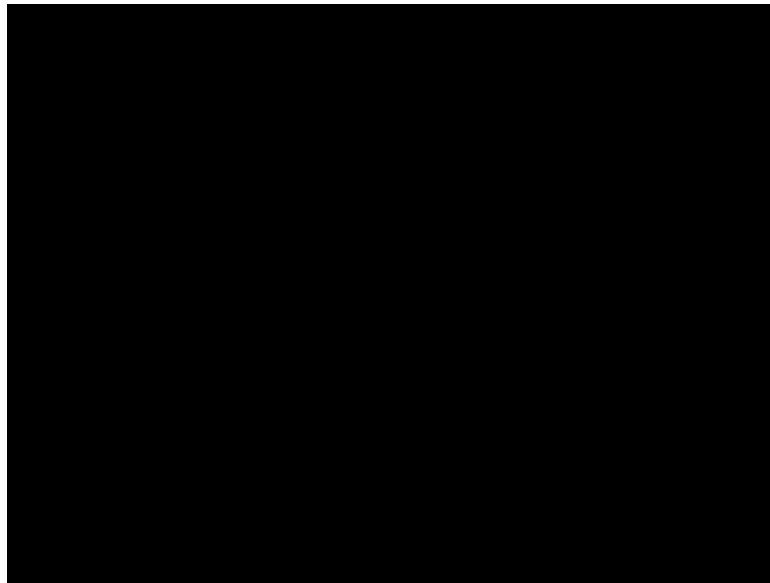
Indeed, the cases of porotic hyperostosis and cribra orbitalia in the Tijeras skeletons suggest that some of the individuals had suffered a metabolic disruption during life, which was likely in part related to the low animal protein, maize based diet (Wetterstrom, 1986). However, the severity of porotic hyperostosis and cribra orbitalia ranges from slight to moderate, with most cases falling into the slight category. Also, many of these cases were healed lesions, suggesting that the stress had occurred early on, but did not continue throughout the person's life. These data suggest that some individuals did suffer from metabolic disturbances, either from disease or nutritional stress. However, because the lesions are slight to moderate, and some are healed, it is possible that the stress that occurred at Tijeras was marginal, and for the most part, the Tijeras population had an adequate diet.

Endocranial Lesions

In addition to porotic hyperostosis and cribra orbitalia, lesions on the inner table of the cranium were observed in several of the infant skeletons. These lesions were characterized by slight to deep channeling with "plaque like" bone deposition on the inner table of the parietals and occipital bone. In many cases the lesions were

concentrated around the meningeal grooves and transverse sulci of the occipital bone (Figure 5.4)

Figure 5.4. Endocranial Lesions on the Inner Table of the occipital Region



These lesions were observed exclusively on skeletons in the 1-3 year age category, and were present in 11 (52%) total. Similar lesions were observed in the Arroyo Hondo collection, and like Tijeras these lesions were observed only in 3 (3/20) individuals in the 1-4.9 year old category (Palkovich, 1980). These data suggest that the underlying cause of these lesions affected children more than adults. This is not surprising because infants and children tend to be more susceptible to insults from disease and nutritional stress because their bones are not completely mineralized (Sobolik, 2002). Also, in older infants (6 months to 1 year), increased use of protein and calorie deficient weaning foods such as diluted cornmeal gruels would have also increased nutritional stress and made these children more susceptible to disease (Wetterstrom, 1986).

The underlying cause of these lesions, however, has not been specifically defined in the literature. However, like cribra orbitalia and porotic hyperostosis, the endocranial lesions may be a response to a bacterial infection or dietary insufficiency. The number of individuals with this type of lesion is higher than those at Arroyo Hondo (lesions of this nature were not reported for San Antonio or Paa-ko). This may reflect a dietary stress or infection that was present at Tijeras, but not at Arroyo Hondo.

CHAPTER VI

CONCLUSION

The current analysis of the Tijeras skeletal collection has important implications for future research in the Prehispanic Southwest. Developmental defects that were previously identified as neural tube defects (Ferguson, 1980) were not neural tube defects; rather they were the result of an underlying genetic predisposition for minor developmental delays (Barnes, 1994). This distinction changes previous ideas about the relationship between lead production at Tijeras and neural tube defects.

Furthermore, the distinction between neural tube defects and other developmental defects (paraxial mesoderm defects) has identified similar defects in other non-lead glaze paint producing sites. A closer look at these defects has also identified variation between the patterns and general shapes of these defects between sites. Because these patterns have been genetically linked, they may represent familial groups. This has important implications because the variation in these patterns may be a means to follow marriage patterns or migration patterns throughout the southwest. By identifying these patterns, it may be possible to identify social networks. Furthermore, changes in these patterns may also represent new migrations into sites, as well as changes in social networks.

Finally, the new data obtained from the Tijeras collection underscores the importance of reanalysis and reinterpretation in the Prehispanic southwest, as well as in other skeletal collections. Recent work by Barnes (1994) provided a new method for distinguishing differences between various developmental defects, as well as

some specific data for comparison. Recent data from Arroyo Hondo (Palkovich, personal communication), and Tijeras provide additional data that demonstrate the variation in paraxial mesoderm defects, and reify the importance of comparing these patterns with other sites to determine the true incidence of neural tube defects, as how the patterns occur throughout the southwest.

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APPENDIX 1

Skeletal Inventory Forms: Inventory, page 1

SKELETAL INVENTORY

<u>Site</u> _____	<u>Date</u> _____
<u>Burial No.</u> _____	<u>Recorder</u> _____
<u>Sex (criteria used)</u> _____ _____	
<u>Age (criteria used)</u> _____ _____	
<u>Condition of Skeleton</u> _____ _____	
<u>Cranium</u> _____	

<u>Mandible</u> _____	

<u>Hyoid</u> _____	<u>Loose Teeth</u> _____
_____	_____
<u>Vertebrae</u>	
<u>Cervical</u> _____	
<u>Thoracic</u> _____	
<u>Lumbar</u> _____	
<u>Sacrum</u> _____	

KEY C= complete (2/3 of bone with articulating surfaces)
 I= incomplete (less than 2/3 of bone but more than 1/3 of bone with 1 art. surface)
 F= fragmentary (less than 1/3 of bone)

Appendix 1. Skeletal Inventory Forms: Inventory, page 2

Ribs No. present		No. complete	
L	R	L	R
Sternum		Innominate	
Clavicle		(Immature individual)	Pubis
Scapula			Ilium
Humerus			Ischium
Radius			L R
Ulna			Femur
Carpals			Patella
Navicular			Tibia
Lunate			Fibula
Triquetral			Tarsals
Pisiform			Talus
Gr. Mult.			Calcaneus
Lsr. Mult.			Navicular
Capitate			Cuboid
Hamate			1st Cuneiform
Metacarpals			2nd Cuneiform
MC 1			3rd Cuneiform
MC 2			Metatarsals
MC 3			MT 1
MC 4			MT 2
MC 5			MT 3
			MT 4
			MT 5
Phalanges(hand)		Phalanges(foot)	
Indeterminate			
Additional notes			

Key (cont.) ✓ = Present, X = absent, if epiphyses present on child's long bones, indicate this.

Appendix 1. Skeletal Inventory Forms: Adult Aging and Sexing, page 3

4) Pubic Symphysis and Auricular Surface Age _____

	Left		Right		Score
Todd pubic scoring	phase	_____	phase	_____	_____
Suchey-Brooks pubic scoring	phase	_____	phase	_____	_____
Auricular surface scoring	group	_____	group	_____	_____

5) Cranial suture closure

(Ectocranial)				(Endocranial)			
		L	R			L	R
Midlambdoid	_____	_____	_____	_____	_____	Sagittal	_____
Lambda	_____	_____	_____	_____	_____	Coronal	_____
Obelion	_____	_____	_____	_____	_____	Lambdoid	_____
Ant. Sagittal	_____	_____	_____	_____	_____	_____	_____
Bregma	_____	_____	_____	_____	_____	_____	_____
Midcoronal	_____	_____	_____	_____	_____	_____	_____
Pterion	_____	_____	_____	_____	_____	Age	_____
Sphenofrontal	_____	_____	_____	_____	_____	_____	_____

Range _____ Prob. Age _____
Min/Max _____ Code _____

SKELETAL SEXING Sex designation _____
Code _____

Ventral arc _____	Nuchal crest _____
Subpubic concavity _____	Mastoid process _____
Subpubic angle _____	Supra-orbital sharpness _____
Ischio-pubic ramus ridge _____	Supra-orbital ridge size _____
Greater sciatic notch width _____	Mental eminence size _____
Preauricular sulcus _____	Mental shape _____
Auricular surface elevation _____	Femur head diam (F<42.5,47.5>M) _____
Curvature of the sacrum _____	Humerus head diam (F<43,47>M) _____

Notes:

Appendix 1. Skeletal Inventory Forms: Subadult Aging Forms, page 4

AGE AND SEX DETERMINATION

Catalog no. _____ Recorder _____ Date _____

SKELETAL AGING

1) *Dental development* Age _____

Deciduous

canine _____ m1 _____ m2 _____

Permanent

Maxillary I1 _____	Mandibular Pm1 _____
Maxillary I2 _____	Mandibular Pm2 _____
Mandibular I1 _____	Mandibular M1 _____
Mandibular I2 _____	Mandibular M2 _____
Mandibular C _____	Mandibular M3 _____

2) *Epiphyseal union* Age _____

Metopic suture _____	Distal humerus _____
Mental symphysis _____	Humerus epicondyle _____
Lateral to basilar _____	Proximal radius _____
Lateral to squamous _____	Distal radius _____
Basilar suture _____	Proximal ulna _____
C halves of arch _____	Distal ulna _____
C arch to centrum _____	Ilium to pubis _____
C vert superior rim _____	Ischium to pubis _____
C vert inferior rim _____	Ischium to ilium _____
T halves of arch _____	Ischial tuberosity _____
T arch to centrum _____	Iliac crest _____
T vert superior rim _____	Proximal femur _____
T vert inferior rim _____	Greater trochanter _____
L halves of arch _____	Lesser trochanter _____
L arch to centrum _____	Distal femur _____
L vert superior rim _____	Proximal tibia _____
L vert inferior rim _____	Distal tibia _____
Scapula coracoid _____	Proximal fibula _____
Scap. glenoid cavity _____	Distal fibula _____
Scap. acromium _____	S1-S2 _____
Scap. inferior angle _____	S2-S3 _____
Scap. medial border _____	S3-S4 _____
Clav. sternal end _____	S4-S5 _____
Proximal humerus _____	

3) *Subadult Bone Measurements* Age _____

C vert max length _____	Radius max length _____
T vert max length _____	Ulna max length _____
L vert max length _____	Os pubis max length _____
Scapula max length _____	Femur max length _____
Clavicle max length _____	Tibia max length _____
Humerus max length _____	Fibula max length _____

APPENDIX 2

Post-Cranial Measurement Recording Form

POST-CRANIAL MEASUREMENTS									
Catalog no			Recorder		Date				
			R						R
1.	Clavicle maximum length	(CML)	_____	_____					
2.	Clav ant/post diam midshaft	(CSD)	_____	_____					
3.	Clav sup/inf diam midshaft	(CVD)	_____	_____					
4.	Scapula maximum height	(SML)	_____	_____					
5.	Scapula maximum breath	(SMB)	_____	_____					
6.	Scapula spine length	(SLS)	_____	_____					
7.	Scapula supraspinous length	(SSL)	_____	_____					
8.	Scapula infraspinous length	(ISL)	_____	_____					
9.	Scap glenoid cavity breath	(GCB)	_____	_____					
10.	Scap glenoid cavity height	(GCH)	_____	_____					
11.	Scap glenoid to inf angle	(GIL)	_____	_____					
12.	Manubrium length	(MML)	_____	_____					
13.	Mesosternum length	(MSL)	_____	_____					
14.	Stenebra 1 width	(S1W)	_____	_____					
15.	Stenebra 3 width	(S3W)	_____	_____					
16.	Humerus maximum length	(HML)	_____	_____					
17.	Humerus prox epiph breath	(BUE)	_____	_____					
18.	Hum maximum diam midshaft	(MDS)	_____	_____					
19.	Hum minimum diam midshaft	(MDM)	_____	_____					
20.	Hum max vert diam of head	(MDH)	_____	_____					
21.	Humerus epicondylar breath	(EBR)	_____	_____					
22.	Hum least circumf of shaft	(LCS)	_____	_____					
23.	Radius maximum length	(RML)	_____	_____					
24.	Radius maximum diam of head	(RDH)	_____	_____					
25.	Radius ant/post diam of shaft	(RSD)	_____	_____					
26.	Rad med/lateral diam of shaft	(RTD)	_____	_____					
27.	Rad neck shaft circumference	(MCS)	_____	_____					
28.	Ulna maximum length	(UML)	_____	_____					
29.	Ulna physiological length	(UPL)	_____	_____					
30.	Ulna max breath olecranon	(BOP)	_____	_____					
31.	Ulna min breath olecranon	(MBO)	_____	_____					
32.	Ulna max width olecranon	(WOP)	_____	_____					
33.	Ulna olec-radial notch	(ORL)	_____	_____					
34.	Ulna olec-coronoid length	(OCL)	_____	_____					
35.	Ulna ant/post diam of shaft	(UAD)	_____	_____					
36.	Ulna med/lateral diam of shaft	(UMD)	_____	_____					
37.	Ulna least circumf of shaft	(ULC)	_____	_____					
38.	Sacrum anterior length	(SAL)	_____	_____					
39.	Sacrum ant/superior breath	(SAB)	_____	_____					
40.	Sacrum maximum breath S1	(SMB)	_____	_____					
41.	Innominate height	(INH)	_____	_____					
42.	Iliac breath	(ILB)	_____	_____					
43.	Pubis length	(PUL)	_____	_____					
44.	Ischium length	(ISL)	_____	_____					
45.	Femur maximum length	(FML)	_____	_____					
46.	Femur bicondylar length	(FOL)	_____	_____					
47.	Femur trochanteric length	(FTL)	_____	_____					
48.	Fem subtroch ant/post diam	(APD)	_____	_____					
49.	Fem subtroch med/lateral diam	(MLD)	_____	_____					
50.	Fem ant/post diam midshaft	(APS)	_____	_____					
51.	Fem med/lateral diam midshaft	(MLS)	_____	_____					
52.	Femur max vert diam of head	(VHD)	_____	_____					
53.	Femur max horiz diam of head	(HHD)	_____	_____					
54.	Fem ant/post diam lat condyle	(APL)	_____	_____					
55.	Fem ant/post diam med condyle	(APM)	_____	_____					
56.	Femur epicondylar breath	(FEB)	_____	_____					
57.	Femur bicondylar breath	(FCB)	_____	_____					
58.	Femur min vert diam of neck	(VDN)	_____	_____					
59.	Femur circumference midshaft	(FCS)	_____	_____					
60.	Tibia condylo-malleolar length	(TML)	_____	_____					
61.	Tibia max breath prox epiph	(BPE)	_____	_____					
62.	Tibia max breath dist epiph	(BDE)	_____	_____					
63.	Tibia ant/post diam nut for	(APN)	_____	_____					
64.	Tibia med/lateral diam nut for	(MLM)	_____	_____					
65.	Tibia position of nutr foramen	(CPL)	_____	_____					
66.	Tibia circum.at nutr foramen	(FCN)	_____	_____					
67.	Fibula maximum length	(BML)	_____	_____					
68.	Fibula maximum diam midshaft	(FMD)	_____	_____					
69.	Calcaneus maximum length	(CLL)	_____	_____					
70.	Calcaneus middle breath	(CMB)	_____	_____					