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A Dental Analysis of the South Dakota Arikara Including a Comparative Analysis of C. G. Turner's 1967 *The Dentition of Arctic Peoples*

Michele Grant
University of Tennessee, Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Michele Grant entitled "A Dental Analysis of the South Dakota Arikara Including a Comparative Analysis of C. G. Turner's 1967 *The Dentition of Arctic Peoples*." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

William M. Bass, Major Professor

We have read this thesis and recommend its acceptance:

Richard Jantz, Andrew Kramer

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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A DENTAL ANALYSIS OF THE SOUTH DAKOTA ARIKARA INCLUDING A COMPARATIVE ANALYSIS OF C.G. TURNER'S 1967 THE DENTITION OF ARCTIC PEOPLES

A Thesis Presented for the
Master of Arts Degree
The University of Tennessee, Knoxville

Michele Grant

May, 1995

DEDICATION

This thesis is dedicated to my parents

Captain Lee B. Grant (U.S.A.F. ret.)

and

Mrs. Eleanor D. Grant

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ABSTRACT

A metric and non-metric dental trait analysis was performed on the South Dakota Arikara population housed at the University of Tennessee, Knoxville. Fifty-one male, female, and sex indeterminable individual skeletons from the Larson, Leavenworth, Mobridge, and Sully excavations were examined for standard metric and non-metric dental traits. These data were subjected to standard chi-square analyses in order to test for statistically significant sexual dimorphism. Significant sexual dimorphism was found on the basis of many of the metric dental traits. Several non-metric dental traits also exhibited significant sexual dimorphism. This analysis was then compared to C.G. Turner's Arctic populations data and other analyses based on standard dental traits. The South Dakota Arikara data were similar to data obtained from other Asian-derived populations, but differed significantly from data obtained from African-derived and European-derived populations. Instances of non-metric dental trait sexual dimorphism may be traced to studies linking metric and non-metric dental trait sexual dimorphism to developmental dental genetics.

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INTRODUCTION

The dentition of racial and cultural groups around the world has been a focus of interest for anthropologists for more than a century. As far back as 1840, Bishop I. Veniaminov was reporting his observations of the condition of Aleut teeth. His observations were anecdotal rather than scientific, but did provide a description of a people whose teeth were, "...worn to the roots..." (Turner, 1967). A quotation from Veniaminov cited by Turner (1967; p1) provides a vivid and informative account:

> The teeth are generally white, clean, and narrow, and it should be said, always sound. It is especially noteworthy that the front teeth in the lower jaw and sometimes in both jaws are not sharp and thin and flat, but round. In some cases, they are oval in shape with the longer side perpendicular to the jaw and smooth as if worn down. Such teeth are found only among the pure and adult Aleuts. The teeth of the Creoles and young adult females are much more correctly proportioned--that is, they are not so round, yet not sharp either. These oval teeth, moreover, are sometimes not white but yellowish, and with the approach of old age they become almost completely black (Veniaminov, 1840).

In 1920, Ales Hrdlicka presented one of the first scientific analyses of a non-metric dental trait. He studied the frequency and expression of shovel-shaped incisors in living American whites and blacks, Hawaiians, Chinese, and Japanese. Based on this analysis, Hrdlicka felt that shoveling, especially in its greatest expression, was characteristic of the Asian and Asian-derived populations he studied, but not generally characteristic of either the white or black populations.

In 1925, R.W. Leigh analyzed dental pathologies among four ancient Native American groups. Leigh studied the affect of environment and hunter and gatherer and agriculturist diets on the dentitions of the Kentucky Algonquins, Sioux, Arikara, and Zuni. He found a relatively low frequency of carious lesions among the groups with gritty diets and a much higher frequency of carious lesions among those whose diet consisted primarily of sticky carbohydrates such as maize.

C.T. Nelson (1937) presented an analysis of the mesiodistal, labiolingual, and buccolingual diameters of the teeth of the Pecos Pueblo Indians. He computed the means, standard deviations, and coefficients of variation for each tooth in the dental arcade. He then compared his metric analysis of the Pecos Pueblo Indians to treatises on Australian, Bantu, modern white, and Bushmen teeth by Campbell (1925), Shaw (1931), and Black (1902). Metric analyses of Melanesian, Eskimo, and Native American teeth were also reported by Hrdilcka (1923a, 1923b, 1930, 1935) and compared with Nelson's data as well.

In 1951, A.A. Dahlberg conducted a large-scale examination of the dentitions of American Indians. This study provided standard definitions of several non-metric traits. Dahlberg classified the expression of shoveling, maxillary molar hypoconulid development, mandibular molar cusp number and pattern, and Carabelli's cusp. He then analyzed various Native American groups for frequency of expression of these traits. Dahlberg then compared them to similar analyses by Hrdlicka (1920), Pedersen (1949), Hooton (1930), and Nelson (1937).

Pedersen (1949) and Moorrees (1957) studied East Greenland Eskimo and Aleut dentitions respectively. Comparisons of their data found the Eskimos and Aleuts both to be similar to each other and to other Asian-derived populations around the world. They described a high frequency of shovel-shaped incisors similar to Hrdlicka's 1920 data.

In 1967, C.G. Turner continued the line of research begun by Veniaminov, Pedersen, and Moorrees by examining the dentitions of 427 individuals from nine different Aleut, Eskimo, and Northern Indian populations. Turner stated three objectives for his study:

> (1) to describe and characterize the dental variation in skeletal populations of Aleuts, Eskimos, and Northern Indians;
> (2) to provide an interpretation of the dental variation between Aleutian groups;
> (3) to make estimates, where possible, for the modes of inheritance of non-metric dental features and compute the gene frequencies of same (Turner, 1967).

Turner felt there were two sources of dental variation of importance to his study, genetic and non-genetic variation. Genetic variation is classified as traits; crown size, cusp number, shoveling, Carabelli's cusp, which are not affected by environment (Moorrees, 1957). Characteristics, such as enamel chipping, wear, and caries, which are affected by environment, are non-genetic sources of variation.

D.H. Ubelaker (1971) studied 283 Arikara skulls from the 1965-66 Leavenworth site excavations (W.M. Bass, director N.S.F. Grant # GS-837) and two Arikara skulls from the United States National Museum in Washington, D.C. Ubelaker examined the dentitions of those Arikara skulls for several metric and non-metric dental traits. Ubelaker concluded data from the Arikara he examined exhibited traits he expected to find among an Asian-derived population, including high frequencies of shovel-shaped incisors. Ubelaker also remarked on the extreme attrition among the Arikara and the calculus deposits concentrated in the molar regions of both the maxillilary and mandibular dental arcades (Ubelaker, 1971).

For this study, the dentitions of the South Dakota Arikara population housed at the University of Tennessee were analyzed for several of the genetic and non-genetic variants Turner (1967) used in his study. Teeth were chosen for analysis because they are durable and survive in the archaeological record long after other material had deteriorated. Turner's (1967) study was chosen because many of the traits he used are now considered the standard for dental analysis. Traits such as shoveling, winging, Carabelli's cusp, and molar cusp number and pattern have been found to indicate population affinity (Hrdlicka, 1920; Hooton, 1930; Pedersen, 1949; Dahlberg, 1951; Moorrees, 1957; Turner, 1967; Turner et al., 1991). Further, metric measures of the dentition can provide information on sexual dimorphism as well as population affinity (Black, 1902; Hrdlicka, 1923a, 1923b, 1930, 1935; Campbell, 1925; Shaw, 1931; Nelson, 1937; Dahlberg, 1951; Turner, 1967). Moreover, teeth have a high genetic component (Moorrees, 1957; Turner, 1967). Development, eruption, and wear proceed along predictable paths with observable variations among groups.

For these reasons, dental analyses provide valuable data on populations, both living and dead. Through dental analysis, a population such as the Arikara can be compared to other populations in order to learn a people's history and genetic affinity. Even when genetic affinity is known, dental analyses can provide other valuable information. Dental analyses can provide information on diet type and quality, disease, famine, and damage or wear related to occupational stresses.

CHAPTER ONE: THE ARIKARA

The Arikara were a Northern Plains Native American population. They were located in South Dakota and the sites excavated to date have been located along the Missouri River (Jantz, 1972, 1977). The Arikara ancestors were Central Plains Caddoan speakers and through them, the Arikara are related to the historic Pawnee (Bass et al., 1971; Key, 1983).

The Proto-Arikara date from the periods referred to as the Initial and Extended Coalescent Variants. The Initial and Extended Coalescent Variants span approximately A.D. 1200-1400. It is during this period that the Northern and Great Plains tribes are established. These tribes include the Sioux, Pawnee, Mandan, Hidatsa, and the Arikara (Wedel, 1961; Bass, 1964; Jantz, 1972, 1977; Key, 1983).

The first generally recognized true Arikara are found beginning about A.D. 1600. In the Post-Contact Coalescent period, A.D. 1675 to 1780, the Arikara reached their cultural apex (Jantz, 1977; Key, 1983). During this time, the horse was introduced to the central plains area and the Arikara developed extensive trade networks, both with surrounding plains tribes and with European explorers. The Mandan, Hidatsa, and Arikara were village tribes who hunted, fished, and cultivated crops. They were self-sufficient and politically autonomous (Wood, 1974). The village tribes all actively traded with the neighboring nomadic Siouan tribes. This led to a far reaching exchange network which resulted in a relatively homogeneous culture complex throughout the plains sustained by trade, warfare, visitation, marriage, slavery, and both formal and ritual adoption. All of the plains tribes had direct and indirect contact with Europeans. By the time of European contact, trade networks had made the Arikara the most prosperous and powerful tribe on the plains (Bruner, 1961; Wood, 1974; Kehoe, 1981; Zimmerman, 1985).

These trade networks, however, would eventually be the downfall of the Arikara. They had no immunity to the many European introduced diseases that rapidly descimated their population. As their numbers dwindled, the Arikara faced more and more aggressive attacks by neighboring nomadic tribes. They began consolidating settlements with other village tribes also descimated by disease. By the late 20th century the few remaining Arikara were living on or near Fort Berthold Reservation, North Dakota (Bass et al., 1971; Jantz, 1972, 1977; Key, 1983).

Crainiometric analyses suggest the Arikara may have been interbreeding with the various neighboring Siouan tribes throughout their history (Jantz, 1972, 1977). The Arikara began approximately A.D. 1600 as round-headed and high-vaulted, unlike the surrounding tribes who were long-headed and low-vaulted (Jantz, 1972, 1977). Over the next two hundred years, the Arikara became longer-headed and lower-vaulted, though not to the degree of the surrounding peoples. There is no evidence of new groups moving into Arikara territory. Rather, the evidence points to an in situ change over time through interbreeding (Jantz, 1977).

The Arikara were semi-sedentary, inhabiting riverside villages. They cultivated maize, beans, and squash, hunted and traded buffalo, and trapped fish. Their mixed diet was nutritious and the Arikara enjoyed relatively good health before European contact. There was a high amount of grit in the Arikara diet due to their use of stone implements for processing food. Because of this, Arikara teeth wore quickly and the attrition generally removed carious lesions before they became problematic (Leigh, 1925; Wedel, 1961; Wood, 1974; Perzigian, 1975; Key, 1983).

Turner (1967) noted no examples of carious lesions in any of the arctic populations he examined. Among the Arikara, the frequency of carious lesions was low, but not uncommon. Leigh (1925) stated 28% of the Arikara in his sample population exhibited carious lesions. The Arikara in this study exhibited several examples of carious lesions as well. Twenty percent of the sample population in this study had carious lesions. One female had seven carious teeth, while another female had four.

CHAPTER TWO: METHODS AND MATERIALS

Criteria for inclusion in this study required each individual examined to have at least one tooth of each position and/or type in relatively good condition. It, further, required the teeth be undamaged and unworn enough that crown features could be examined. Both damage and attrition can obliterate dental crown features. Therefore, a minimal amount of either wear or damage can greatly affect the evaluation of surface non-metric traits. The Arikara dentitions were heavily worn due to the high amount of grit in their diet (Leigh, 1925; Wedel, 1961; Wood, 1974; Perzigian, 1975; Key, 1983). The high degree of attrition encountered eliminated any individual older than the 18-30 year age range from analysis. The dentitions of individuals aged 30+ were worn to the point of dentine exposure. Total crown obliteration occurred in old age individuals. Further, many individuals were excluded as post-mortem damage to the dentition removed either individual traits or the entire tooth, and made them impossible to analyze.

Population sample composition. Individuals recovered from excavations at the Larson, Leavenworth, Mobridge, and Sully sites in South Dakota were examined for this study. The sample was restricted to individuals aged younger than thirty years and in reasonably good condition.

There were fourteen males, twenty-three females, and fourteen individuals of indeterminable sex. Thirty-six individuals were from the Larson site, three were from the Leavenworth site, nine were from the Mobridge excavation, and three were from the Sully site. Two males were aged from thirteen to seventeen, twelve were aged eighteen to thirty. Six females were aged thirteen to seventeen and seventeen were aged eighteen to thirty. Of the fourteen individuals of indeterminable sex, five were pre-pubescent aged six to twelve. The other nine were aged eleven to seventeen (see Table 1).

Table 1: Sample Population Composition

	female	male	sex ?
Larson	18	9	9
18-30yr	14	7	0
13-17yr	4	2	3
11-14yr	0	0	1
6-12yr	0	0	5
Leav.	2	0	1
18-30yr	1	0	0
13-17yr	1	0	1
Mobr.	3	3	3
18-30yr	2	3	0
11-17yr	1	0	2
6-12yr	0	0	1
Sully	0	2	1
18-30yr	0	2	0
11-17yr	0	0	1

Age and sex determinations for the Larson and Leavenworth site individuals were made by Bass and his crews during excavations (Bass et al., 1971). Age determinations are generally based on tooth development and eruption, epiphysis ossification, and the pubic symphysis (Todd, 1920; Kronfeld, 1935; McKern and Stewart, 1957; Garn et al., 1959; Greulich and Pyle, 1959; Krogman, 1962; Stewart, 1963; Ubelaker, 1978; Bass, 1987). Excavation crews also provided age determinations for the Mobridge and Sully individuals.

The author made sex determinations for individuals based on standard sexing criteria of the skull and pelvis. Sexing criteria of the skull include supraorbital ridges which are more pronounced in males, the upper edges of the eye orbit which is sharp in females and blunt in males, and the mastoid processes which are larger in males. Sexing criteria of the pelvis are based on the ventral arc which is found on females, but not on males, the subpubic concavity also found on females, but rare in males, and the medial aspect of the ischiopubic ramus which is narrow in females and broad in males. Females also generally have a wide sciatic notch and often a preauricular sulculs between the sciatic notch and the sacroiliac articulation (Washburn, 1948; Krogman, 1962; Bass, 1987). The standards for these characteristics described by Bass (1987) were used in this study. Sub-adults who could not be sexed were included in this study as sex indeterminable individuals, but adults who could not be sexed were excluded from analysis.

Sites. The Larson site (39WW2) is located on the left bank of the Missouri River approximately one mile south of Mobridge, South Dakota. It dates approximately A.D. 1679-1733 (Key, 1983). The Larson cemetery was originally excavated by A.W. Bowers in 1964

(Bowers, 1966) and was further excavated by W.M. Bass and a crew in 1966 and 1967 under National Science Foundation Funding (N.S.F. Grant #GS-837). During these excavations, seven hundred six burials were recovered (Bass et al., 1971).

The Leavenworth site (39CO9) is located along the right bank of the Missouri river and sits approximately seven miles north of Mobridge, South Dakota. Leavenworth dates approximately A.D. 1803-1830 (Jantz, 1972, 1977). The Leavenworth cemetery was first excavated by Over in 1915 and 1917. Later it was excavated by M.W. Stirling in 1923 when he recovered thirty-three burials (Jantz, 1972). In 1965 and 1967, W.M. Bass and a crew supported by the National Science Foundation (N.S.F. Grant #GS-837) renewed excavations at Leavenworth which yielded another two hundred eighty-five burials (Bass et al., 1971).

The Mobridge site (39WW1) is located along the left bank of the Missouri River and is less than a mile northwest of Mobridge, South Dakota. The Mobridge site dates approximately A.D. 1600-1650 and may have lasted as late as A.D. 1700 (Jantz, 1972, 1977). The site was originally excavated by M.W. Stirling, who recovered forty individuals from the site cemetery (Wedel, 1955; Jantz, 1972, 1977). W.M. Bass further excavated Mobridge in 1968 and 1969 (N.S.F. Grant #GS-837) and recovered another six hundred fifty burials (Jantz, 1972, 1977).

The Sully site (39SL4) is located along the left bank of the Missouri River some twenty miles north of Pierre, South Dakota. Sully is a large unfortified earth lodge village. By 1972, it had yielded five hundred sixty-six burials. Sully dates approximately A.D. 1700-1750 (Jantz, 1972, 1977). Bowers first recovered skeletons from Sully in 1930 and W.M. Bass continued the excavations in 1957, 1958, and 1961 with the aid of Smithsonian Institution River Basin Survey crews. Bass returned to Sully in 1962 with a University of Kansas crew under National Science Foundation (N.S.F. Grant #GS-837) funding (Jantz, 1972, 1977).

CHAPTER THREE: OBJECTIVES AND APPROACH

Objectives. There were three main objectives to this study. First was to present a general description of the permanent dentition of the South Dakota Arikara. The dentitions were chosen for study because teeth are an excellent source of information. Teeth have a high genetic component which provides information about affinity to other populations. Teeth are variable and possess many features. Therefore, one individual can provide data on many different traits and characteristics at once. Further, after eruption phenotypes are fixed. Traits can be obliterated, but not modified. Thus, children can provide data as well as adults. Finally, teeth are durable. They survive in the archaeological record long after other materials have deteriorated.

Second, the data gathered from this analysis was examined for evidence of sexual dimorphism. The non-metric dental traits examined in this study were subjected to standard chi-square and Fisher's Exact tests of statistical significance. The metric traits were analyzed by independent two-sample T-tests, Wilcoxon Rank Sum Analyses, and Kruskai-Wallis Chi-square Approximations. Each of these tests was designed to compare male trait frequencies to female trait frequencies in order to find statistically significant frequency differences between the sexes. The final objective was to compare the dental trait data found in the Arikara to other populations. These data will show how the Arikara compare to Turner's Aleut, Eskimo, and Northern Indian populations in terms of trait frequency and pathology. Further, the comparison was extended to other groups by comparing the data on traits and frequencies found in the Arikara to other studies using the same traits on populations around the world.

Approach. The Arikara dentitions studied were examined for both metric and non-metric traits. Non-metric crown trait variants for the teeth are based on standards described by Dahlberg (1951), Turner (1967), and Turner et al. (1991). The metric dental analyses were based on Hrdlicka (1923a, 1924a, 1930, 1935) and Owsley (1981). The individual traits used in this study are discussed in full in chapters four through ten.

Each trait on each tooth examined for this study was analyzed twice in order to remove doubt due to intra-observer error. The author first graded the trait in question by gross observation and recorded the score. The trait was then carefully compared to the trait standards to ensure the observation best fit the trait grade criteria (Dahlberg, 1951; Turner, 1967; Turner et al., 1991).

Turner (1967) handled the problem of trait asymmetry by using "individual count". In the "individual count" system, symmetrical individuals are counted once, asymmetrical individuals twice. An individual is considered asymmetrical if the expression of the non-metric trait being analyzed on any given tooth differs by more than 5% between sides. The alternative is the "tooth count" method in which each available tooth is counted regardless of degree of expression. There is some debate concerning the use of these and similar scoring methods. Statistical analysis assumes the independence of observations. In "individual count" and "tooth count", trait, or side count methods, more than one observation can be taken from a given individual. This increases sample size and highlights differences in expression, but all the observations in a sample are not necessarily independent of one another. Despite this point of contention, the "individual count" and "tooth count", trait, and side count methods are well established, generally accepted, and routinely used in analyses (Hrdlicka, 1920, 1921; Nelson, 1938; Koski and Hatula, 1952; Berry and Berry, 1967; Turner, 1967, 1979; Jantz, 1970; Kellock and Parsons, 1970; Ubelaker, 1971; Rightmire, 1972; Birkby, 1973; Berry, 1974; Corruccini, 1974; Harris, 1980; Sciulli and Schneider, 1985; Richtsmeier and McGrath, 1986; Sciulli, 1990).

For this study, the "tooth count" method was used so the data would fit the parameters of the chi-square analysis as best as possible. The categorical nature of the non-metric data required the use of chi-square analysis to test for statistical significance. In several cases, however, the data did not fit the criteria of the standard chi-square analysis. For that reason, the Fisher's exact analysis was performed as well because it is a better indicator of statistical significance when the data do not met the standard chi-square analysis criteria (Spence et al., 1976). All data were calculated to the 0.05 level of statistical significance (Schlotzhauer and Littell, 1987).

CHAPTER FOUR: INCISOR CROWN TRAITS

Shovel-shaped Incisors. Shovel-shaped incisors are one of the most common incisor crown traits. Hrdlicka is responsible for the wide-spread use of the term "shovel-shaped incisors" which he used in his landmark 1920 paper describing shoveling among Asian-derived populations. He found shoveling was characteristic of the Asian-derived populations he examined. Shoveling has also been documented among Europeans, Bantu, and Polynesians (Pedersen, 1949; Carbonell, 1963; Dahlberg, 1963; Suzuki and Sakai, 1964). European and European-derived populations have the lowest frequency of shoveling of any group (Hrdlicka, 1920; Pedersen, 1949; Turner, 1967). Bantu and other African-derived populations have low shoveling frequencies similar to European-derived populations (Carbonell, 1963; Turner, 1967). Polynesians have much higher frequencies of shoveling and are similar to the Asian-derived populations (Hrdilcka, 1920; Dahlberg, 1963; Suzuki and Sakai, 1964; Turner, 1967).

Shoveling is defined as lingual ridging along the mesial and distal borders of the central and lateral incisors (Turner, 1967). It is most common on the maxillary incisors, but may be found on the mandibular incisors as well. Dahlberg (1963) was the first to develop plaster casts of Hrdlicka's (1920) original four-fold classification for shoveling:

1) Absence of shoveling.
2) Trace shoveling.

3) Semi-shoveling.
4) Marked shoveling.

Turner et al. (1991) added to that; faint shoveling between absence and trace, another grade of semi-shoveling and another grade of marked shoveling. They also first developed a classification for barrel shoveling, which is found only on upper lateral incisors. Incisors can also exhibit mesial and distal edge thickening on the labial tooth surface. This is termed double-shoveling. Shoveling is independent of double-shoveling, but double-shoveling cannot occur without a corresponding degree of shoveling (Turner et al., 1991).

Using the "tooth count" method defined above, a total of seventy-eight upper central incisors were examined for shoveling. (see Table 2).

Table 2: Maxillary Central Incisor Shoveling

	female	male	sex ?
absent	0	0	0
trace	14	6	6
semi	5	3	2
marked	16	11	17

This high percentage of the highest grades of shoveling was expected as the Arikara are an Asian-derived population.

This study found no evidence of sexual dimorphism on the basis of upper central incisor shoveling frequencies. Analysis of the frequencies of shoveling between the male and female Arikara revealed a chi-square P-value equal to 0.458. The Fisher's exact P-value equaled 0.565. Turner (1967) did not find any statistically significant sexual dimorphism on the basis of upper central incisor shoveling either. In his analysis, the chi-square P-value equaled 0.5, similar to the value found for the Arikara.

Other studies, however, have found evidence of significant sexual dimorphism on the basis of shoveling. Harris (1980) found in many of the modern populations he examined, except American blacks, shoveling is significantly more common in females than in males.

Shoveling expression in the upper lateral incisors was similar to that observed in the upper central incisors. A total of seventy upper lateral incisors were examined for shoveling. This study included nine examples of teeth exhibiting barrel shaping, the highest known grade of shoveling (see Table 3).

Table 3: Maxillary Lateral Incisor Shoveling

	female	male	sex ?
absent	0	0	0
trace	2	1	1
semi	12	3	8
marked	17	11	6
barrel	1	5	3

Evidence of sexual dimorphism was found for the Arikara. The chi-square P-value equaled 0.028. The Fisher's exact P-value equaled 0.026. Both of these values are statistically significant. Females among the Arikara had a higher frequency (14%) of absent, trace, or semi-shoveling than did males (4%). However, Turner (1967) did not find any sexual dimorphism among the Arctic populations in his study. In his analysis, the chi-square P-value equaled 0.2, and was not statistically significant.

Though there was sexual dimorphism on the basis of upper lateral incisor shoveling found in this study, it was not the expected finding. As stated above, Harris (1980) found shoveling to be more common in females than in males. However, in this analysis, the sexual dimorphism came from the finding that shoveling was more common among the males than females.

Maxillary incisor winging. The terms incisor winging or bilateral mesial rotation were used by Enoki and Dahlberg (1958) and Dahlberg (1963) to describe the axial rotation of the central maxillary incisors. There are generally five recognized grades of winging:

1) Straight - no axial rotation.
2) Bilateral winging - the distal boarders of both central incisors have greater anterior prominence.
3) Unilateral winging - the distal boarders of one central incisor has greater anterior prominence.
4) Bilateral counterwinging - the mesial boarders of both central incisors have greater anterior prominence.
5) Unilateral counterwinging - the mesial boarder of one central incisor has greater anterior prominence.
(Enoki and Dahlberg, 1958; Turner, 1967; Turner et al., 1991).

Forty-nine dentitions were examined for winging. Two dentitions, both from males, were not scored due to post-mortem loss of the upper central incisors. No examples of unilateral winging or unilateralcounterwinging were found in this sample (see Table 4).

Table 4: Maxillary Incisor Winging

	female	male	sex ?
absent	35	19	19
ridged	0	0	0
cuspule	0	0	5
sm c	0	2	0
full c	0	0	0

There was no statistically significant sexual dimorphism between the male and female Arikara on the basis of winging. In an analysis of the males and females from this sample, the chi-square P-value equaled 0.957. The Fisher's exact P-value equaled 1.00. Neither of these values is statistically significant at the five percent level.

Turner (1967) stated to have found no statistically significant sexual dimorphism on the basis of winging among the Arctic populations in his study, but does not provide a P-value to support his statement. Turner does state, though, this may not prove the absence of sexual dimorphism. Enoki and Dahlberg (1958) found females among their Yuman, Hopi, Navajo, Sioux, and Tama Indian populations to have twice the frequency of bilateral winging as males. However, Enoki and Dahlberg only noted frequency differences and did not perform a chi-square analysis on their sample population. Without a chi-square analysis, there is no definitive evidence of sexual dimorphism.

Tuberculum Dentale. *Tuberculum dentale* is the most commonly used term to describe a cusp or cuspule arising from the cingulum region of the maxillary incisors and canines. *Tuberculum dentale* is scored as:

1) Absent.
2) Faint or trace ridging.
3) Strong or pronounced ridging.
4) Weak cuspule, attached apex.
5) Weak cuspule, free apex.
6) Full cusp, free apex.

In some cases, the full cusp, free apex grade can approach the form of a bicuspid (Hrdlicka, 1921; Turner et al., 1991). Turner (1967) noted neither he nor any other researcher to his knowledge has found evidence that the occurrence of *tuberculum dentale* is characteristic of any geographic group.

The Arikara had a low frequency of *tuberculum dentale*. The trait was absent in a total of seventy-two of seventy-nine upper central incisors examined (see Table 5).

Table 5: *Tuberculum Dentale*; Maxillary Central Incisor

	female	male	sex ?
absent	35	19	19
ridged	0	0	0
cuspule	0	0	5
sm c	0	2	0
full c	0	0	0

There was no evidence of sexual dimorphism on the basis of upper central incisor *tuberculum dental* between the male and female Arikara. In an analysis, the chi-square P-value equaled 0.063. The Fisher's exact P-value equaled 0.136. Turner (1967) found no evidence of sexual dimorphism in the frequency of upper central incisor tubercles either. In his analysis, the chi-square P-value equaled 0.3 for a pooled sample of his Arctic populations

There was a slightly higher frequency of *tuberculum dentale* on the upper lateral incisors. A total of seventy-eight upper lateral incisors were examined for tuberculum dentale (see Table 6).

Table 6: *Tuberculum Dentale*; Maxillary Lateral Incisor

	female	male	sex ?
absent	15	16	10
ridged	7	2	4
cuspule	7	2	4
sm c	4	3	2
full c	2	0	0

There was evidence of sexual dimorphism among the Arikara on the basis of upper lateral incisor *tuberculum dentale*. The female frequency of any expression of *tuberculum dentale* was 20% while the male frequency was 7% In an analysis of the male and female frequencies, the chi-square P-value equaled 0.046. However, the Fisher's exact P-value equaled 0.062, which is not statistically significant. This minor difference presents an interesting puzzle, but does not negate the evidence of sexual dimorphism.

Turner (1967) found no evidence of sexual dimorphism on the basis of upper lateral incisor *tuberculum dentale* in his arctic sample. In his analysis, the chi-square P-value equaled 0.6, and was much higher than the upper central incisor P-value of 0.3. Neither of these values is statistically significant at the five percent level.

Medial lingual ridges. Medial lingual ridges are described as accessory enamel ridges originating from the cingulum and running towards the occlusal edge of the incisor. They are differentiated from shoveling by the fact they are located medially on the lingual surface rather than at the mesial and distal edges. Medial lingual ridges are scored as:

1) Absent.
2) Present - 1 to 2 ridges.
(Hrdlicka, 1921; Turner, 1967; Turner et al., 1991).

There was a low frequency of medial lingual ridges in the Arikara population. Eighty-two teeth were examined for medial lingual ridges (see Table 7).

Table 7: Medial Lingual Ridges; Maxillary Central Incisors

	female	male	sex ?
zero	24	15	17
one	4	3	2
two	8	3	6

There was no evidence of sexual dimorphism on the basis of upper central incisor medial lingual ridges between the male and female Arikara. In an analysis, the chi-square P-value equaled 0.709. The Fisher's exact P-value equaled 0.775.

Turner (1967) noted females among his Arctic populations did have slightly more incisor medial lingual ridges than did males. However, there was no statistical significance. In his analysis, the chi-square P-value equaled 0.60.

There was even less evidence of medial lingual ridges on the upper lateral incisors. Seventy-eight maxillary lateral incisors were examined for medial lingual ridges (see Table 8).

Table 8: Medial Lingual Ridges; Maxillary Lateral Incisors

	female	male	sex ?
zero	26	20	18
one	7	3	2
two	2	0	0

Again, there was no evidence of sexual dimorphism. In an analysis of the male and female frequencies, the chi-square P-value equaled 0.244. The Fisher's exact P-value equaled 0.329. Both of these values are far above the statistically significant five percent level. Turner (1967) found no evidence of maxillary lateral incisor medial lingual ridge number sexual dimorphism either. In his analysis, the chi-square P-value equaled 0.10.

CHAPTER FIVE: MANDIBULAR PREMOLARS

In 1953, Kraus and Furr described seventeen characteristics of the first and second mandibular premolars. Three of those characteristics were used for this study. The traits of the first mandibular premolars examined for this analysis are:

1) Position (medial, mesial, distal) of the main lingual cusp.
2) Number (1-4) of lingual cusps.

On the second mandibular premolar, only the total number of cusps (2-4) was scored.

Eighty-six first mandibular premolars were examined for the position of the main lingual cusp (see Table 9). Seventy-eight first mandibular premolars were examined for lingual cusp number (see Table 10).

Table 9: P3 Main Lingual Cusp Position

	female	male	sex ?
distal	8	4	2
medial	6	2	4
mesial	28	20	12

Table 10: P3 Lingual Cusp Number

	female	male	sex ?
one	28	24	18
two	7	1	0

There was no evidence of sexual dimorphism on the basis of first mandibular premolar lingual cusp position or lingual cusp number among the Arikara. In an analysis of the male and female frequencies for cusp position, the chi-square P-value equaled

0.620. The Fisher's exact P-value equaled 0.683. In an analysis for cusp number, the chi-square P-value equaled 0.072 and the Fisher's exact P-value equaled 0.123.

Turner (1967) did not find any sexual dimorphism on the basis of first mandibular main lingual cusp number among the Arctic populations he examined. In his analysis, the chi-square P-value equaled 0.60. Turner did not find any statistical significance on the basis of first mandibular premolar lingual cusp number either. In his analysis, the chi-square P-value equaled 0.06.

Eighty-six second mandibular premolars were examined for total cusp number (see Table 11).

Table 11: P4 Total Cusp Number

	female	male	sex ?
two	37	24	13
three	6	1	2
four	2	1	0

Analysis of the total number of seconds premolar cusps found no evidence of sexual dimorphism. The chi-square P-value equaled 0.239 and the Fisher's exact P-value equaled 0.307. Turner (1967) stated he found no evidence of sexual dimorphism. He did not provide a chi-square P-value.

CHAPTER SIX: MAXILLARY MOLARS

Cusp number. The maxillary molars generally have four cusps. The distolingual cusp, called the hypocone, is the most variable. According to Dahlberg (1951), there are four maxillary molar cusp patterns based on the size of the hypocone:

1) Grade 4; four well-developed cusps.
2) Grade 4-; the hypocone is reduced in size.
3) Grade 3+; the hypocone is reduced to a cuspule.
4) Grade 3; the hypocone is absent.

One hundred first maxillary molars were graded on the basis of cusp number. Ninety-six had four well-developed cusps. Only four teeth, all from females, exhibited grades 4-, 3+, or 3 (see Table 12).

Table 12: Maxillary Cusp Number; M1

	female	male	sex ?
4...	42	28	26
4-	3	0	0
3+	1	0	0
3...	0	0	0

Again, an analysis of the male and female frequencies of first maxillary molar cusp number showed no evidence of sexual dimorphism among the Arikara. The chi-square P-value equaled 0.109 and the Fisher's exact P-value equaled 0.291.

Turner (1967), on the other hand, did find evidence of sexual dimorphism for this trait among a pooled pan-Arctic population sample. His analysis of the pooled male and female frequencies showed a much higher ratio of grade 4- first maxillary molars among males (10:1) than females (20:1). His analysis found the chi-square P-value equaled 0.03, and was statistically significant.

More variation was found on the second maxillary molar among the Arikara. Ninety-eight second maxillary molars were examined for cusp number (see Table 13).

Table 13: Maxillary Cusp Number; M2

	female	male	sex ?
4...	9	13	11
4-	18	11	9
3+	16	1	4
3...	3	3	0

Analysis of the male and female frequencies for this trait found a high degree of sexual dimorphism. The female frequency of grades 3 and 3+ was 19%, the male frequency was 4%. On the other hand, the male frequency of grade 4 was 13%, the female frequency was 9%. In this analysis, the chi-square P-value equaled 0.016 and the Fisher's exact P-value equaled 0.018.

Turner (1967) found no evidence of sexual dimorphism for second maxillary molar cusp number among the Arctic populations he sampled. In his analysis, the chi-square P-value equaled 0.20, and was well above the statistically significant five percent level.

Carabelli's cusp. This trait was first termed *tuberculus anomalous* by Carabelli c. 1850 (Campbell, 1925). It is an accessory cusp located on the mesiolingual cusp (protocone) of both the deciduous and permanent maxillary molars, usually the first. Carabelli's cusp is classified:

1) Absent or smooth.
2) Line.
3) Pit.
4) Cusp outline.
5) Y-shaped partial cusp.
6) Small cusp, no apex.
7) Small cusp, free apex.
8) Large cusp, free apex.
(Dahlberg, 1956; Turner, 1967; Turner et al., 1991).

A total of ninety-four first maxillary molars from the Arikara were examined for expression of Carabelli's cusp. No teeth in this sample exhibited the four highest grades of Carabelli's cusp. Sex indeterminable individuals exhibited a higher frequency of low grade Carabelli's cusp than did males or females (see Table 14).

Table 14: Carabelli's Cusp

	female	male	sex ?
absent	25	20	5
line	8	2	4
pit	9	1	8
outline	2	2	9

An analysis of the male and female frequencies did not show conclusive evidence of sexual dimorphism at the five percent level. The chi-square P-value equaled 0.052 and the Fisher's exact P-value equaled 0.068.

Turner (1967) found no evidence of sexual dimorphism among the Arctic populations he examined in frequency of Carabelli's cusp. In his statistical analysis, the chi-square P-value equaled 0.6. However, his and Pedersen's (1949) data suggest Eskimos have the lowest frequency of Carabelli's cusp in its highest grades. Dahlberg's (1963) data suggest Europeans and European-derived populations have the highest frequency of high grade expression of Carabelli's cusp.

CHAPTER SEVEN: MANDIBULAR MOLARS

Cusp number. Mandibular molars generally have five cusps and often a sixth. Gregory (1916) named the first five cusps the protoconid, metaconid, hypoconid, entoconid, and hypoconulid (1-5 respectively). According to Turner (1967), a four-cusp molar has cusps 1-4 present, but lacks cusps 5 and 6. A five-cusp molar lacks cusp 6. A distal cusp is automatically cusp 5 regardless of its position. There cannot be a cusp 6 without a cusp 5.

Groove pattern. In any mandibular molar, cusps 2 and 3 touching is a "Y-pattern". This is apparently the oldest groove pattern and is characteristic of great apes as well as humans (Turner, 1967). Gregory (1916) named it the "Dryopithecus pattern" because of its occurrence in the Miocene ape group. Hellman (1928) dubbed cusps 1, 2, 3, and 4 all touching the "+-pattern". Jorgensen (1955) named the contact of cusps 1 and 4 the "X-pattern". For example, a mandibular molar with cusps with cusps 1-5 present and cusps 2 and 3 touching would be denoted a "5Y" molar.

A total of eighty-five first mandibular molars from the Arikara sample population were analyzed for cusp number and groove pattern. The "Y" pattern was most common among the Arikara. There were only twelve teeth in the entire sample which exhibited either the "+" or "X" patterns. The majority of the first mandibular molars examined exhibited five cusps. All of the "+" and "X" pattern teeth had five cusps. Only one first mandibular molar from a female had four cusps (see Table 15).

Table 15: Mandibular Molar Cusp Number and Groove Pattern; M1

	female	male	sex ?
4Y	1	0	0
5Y	22	22	16
6Y	6	2	9
4X	0	0	0
5X	2	1	0
6X	0	0	0
4+	0	1	0
5+	3	0	2
6+	0	3	0

There was no evidence of sexual dimorphism on the basis of first mandibular molar cusp number and groove pattern. For the male and female frequencies, the chi-square P-value equaled 0.543. The Fisher's exact P-value equaled 0.726.

Turner's (1967) analysis found no evidence of sexual dimorphism either. In his analysis for cusp number, the chi-square P-value equaled >0.3. In his analysis for groove pattern, the chi-square P-value equaled 0.13-0.8.

There was more variation in the second mandibular molars. A total of eighty-five second mandibular molars were examined for cusp number and groove pattern (see Table 16).

There was significant evidence of sexual dimorphism on the basis of second mandibular molar cusp number and groove pattern among the Arikara. The female frequency of 4Y, 5Y, and 6Y lower second mandibular molars was 16% , while the male frequency was

Table 16: Mandibular Molar Cusp Number and Groove Pattern; M2

	female	male	sex ?
4Y	3	1	2
5Y	11	1	4
6Y	1	0	0
4X	0	1	0
5X	3	4	4
6X	2	0	0
4+	6	11	4
5+	10	7	6
6+	2	0	0

2%. In an analysis of the male and female frequencies, the chi-square P- value equaled 0.016 and the Fisher's exact P-value equaled 0.012.

Turner (1967) did not find evidence of sexual dimorphism among the Arctic populations he examined. In his analysis of cusp number, the chi-square P-value equaled >0.6. In his analysis of the groove pattern frequencies, the chi-square P-value equaled >0.5.

Protostylid. Dahlberg (1945, 1950) applied the term "protostylid" to the continuum of paramolar features occasionally found on the buccal surface of the protoconid. It is most common on the first mandibular molar (Turner et al., 1991). The protostylid is scored:

1) Absent.
2) Buccal groove pit.
3) Curved buccal groove.
4) Partial cusp, no apex.
5) Slight cusp, free apex.
6) Moderate cusp, free apex.
7) Strong cusp, free apex.

(Dahlberg, 1963; Turner, 1967; Turner et al., 1991).

Ninety-nine first mandibular molars were examined for the protostylid. There was no evidence of any of the four highest grades of protostylid (see Table 17).

Table 17: Protostylid; M1

	female	male	sex ?
absent	22	11	10
pit	22	14	14
groove	0	3	3

Among the Arikara, there was no evidence of sexual dimorphism on the basis of the protostylid on the first mandibular molar. The chi-square P-value equaled 0.374 and the Fisher's exact P-value equaled 0.469.

Turner (1967) stated there were no demonstrable differences in the frequencies of protostylid variants on the first mandibular molar among the Arctic populations he examined. In his analysis, the chi-square P-value equaled 0.08-0.05.

Frequencies of the variants of the protostylid on the second mandibular molar were similar to those seen on the first mandibular molar. Eighty-seven second mandibular molars were examined (see Table 18).

Table 18: Protostylid; M2

	female	male	sex ?
absent	25	11	5
pit	18	12	13
line	0	2	1

Again, there was no evidence of sexual dimorphism. In an analysis of the male and female frequencies, the chi-square P-value equaled 0.260. The Fisher's exact P-value equaled 0.318.

Turner (1967) found no evidence of sexual dimorphism on the basis of protostylid expression of the second mandibular molar among the Arctic populations he examined. The chi-square P-value equaled >0.3.

CHAPTER EIGHT: FEATURES SHARED BY MAXILLARY AND MANDIBULAR MOLARS

Supernumerary cusps. Mandibular molars regularly have cusps 1-6 while maxillary molars generally have cusps 1-4. In addition, both can have up to four supernumerary cusps. These are designated by number only (5-8 for the maxillary, 7-9 for the mandibular molars) except for mandibular molar cusp 10, which is the protostylid discussed above (Turner, 1967).

One female exhibited cusp seven on the right second maxillary molar. One female exhibited cusp seven on both the right and left first mandibular molars. One male exhibited cusp eight on both the right and left second mandibular molars. One sex indeterminable individual exhibited cusp five on both the right and lift first mandibular molars.

There was an insufficient number of supernumerary cusps among the Arikara to make any meaningful comparisons of sexual dimorphism. Turner (1967), also, had too few instances of supernumerary mandibular or maxillary molar cusps to make meaningful comparisons. He did run an analysis for the maxillary molars. In his analysis, the chi-square P-value equaled >0.4 for the first molars. The chi-square P-value for the second molars equaled >0.2. Neither of these values is statistically significant.

Molar enamel extensions and nodules. Leigh (1937) termed the drip-like form of enamel at the crown-root junction on the buccal surface of the molars and enamel extension. He found the feature to be highly variable and characteristic of American Indians, Eskimos, and some Polynesians. Both Pedersen (1949) and Lasker (1950) agreed enamel extensions are a semi-continuous condition with finite classes. Enamel extensions are graded:

1) Straight (no extension).
2) Slight extension.
3) Moderate extension.
4) Marked extension.
5) Reverse extension.

Further, there can be a nodule or enamel pearl either as part of an extension or independent (Turner, 1967).

Frequencies of variants of enamel extension were similar for first and second maxillary and mandibular molars. Ninety-four first maxillary molars were examined for enamel extensions. Sixty-seven exhibited no evidence of enamel extensions. Nine exhibited slight extensions. Eighteen exhibited marked extensions. No first maxillary molars in this sample exhibited moderate extensions (see Table 19).

Table 19: Enamel Extensions; Maxillary M1

	female	male	sex ?
straight	24	21	22
slight	5	1	3
mod.	0	0	0
marked	11	6	1

Ninety-three second maxillary molars were examined. Fifty-five had no enamel extensions. Ten exhibited slight extensions.

Five exhibited moderate extensions. Twenty-seven had marked enamel extensions (see Table 20).

Table 20: Enamel Extensions; Maxillary M2

	female	male	sex ?
straight	25	23	16
slight	4	5	4
mod.	0	3	0
marked	16	11	1

Ninety-six first mandibular molars were analyzed. Sixty-one had no enamel extensions. Ten exhibited slight extensions. Four exhibited moderate extensions. Twenty-one had marked enamel extensions (see Table 21).

Table 21: Enamel Extensions; Mandibular M1

	female	male	sex ?
straight	24	20	17
slight	5	2	3
mod.	1	1	2
marked	12	5	4

Ninety-four second mandibular molars were examined. Fifty-four exhibited no enamel extensions. Fourteen exhibited slight extensions. Six exhibited moderate extensions. Twenty had marked enamel extensions (see Table 22). There were no examples of reversed enamel extensions in this sample population.

Table 22: Enamel Extensions; Mandibular M2

	female	male	sex?
straight	23	13	13
slight	5	7	2
mod.	3	0	3
marked	11	5	4

There was no evidence of sexual dimorphism on the basis of enamel extensions evident in this study. In an analysis for the first and second maxillary and first and second mandibular molars, the chi-square P-values equaled 0.318, 0.260, 0.471, and 0.621 respectively. The Fisher's exact P-values equaled 0.342, 0.286, 0.525, and 0.650 respectively. None of these values are statistically significant at the five percent level. Turner (1967) found no evidence of sexual dimorphism either. In his analysis, the chi-square P-values

equaled 0.11-0.17, >0.80, 0.57-0.80, and 0.57-0.80 respectively.

Only one individual with an enamel pearl was noted. The individual was a female and the nodule was located on a second maxillary molar. The enamel pearl was independent of any other enamel extensions.

CHAPTER NINE: MISSING, SUPERNUMARY, AND DIMINUTIVE TEETH

Hypodontia. The phenomena of congenitally missing teeth, either singly or in groups, is generally considered highly hereditary in origin (Dahlberg, 1937; Brothwell, Carbonell, and Goose, 1963; Turner, 1967). Turner (1967) considered a tooth congenitally missing, that is not absent because of extraction or exfoliation, when:

> 1) There is no indication that socket resorption has occurred and the alveolar boarder at the missing tooth site is the same level, texture, density, and configuration as that of the adjacent extent teeth.
> 2) Normally adjacent teeth show no sign of drifting into the present position following exfoliation of a given tooth.

Congenitally missing third molars are the most common expression of hypodontia.

Two females exhibited congenitally missing third molars. Both met Turner's (1967) criteria that there was neither evidence of socket resorption nor drifting of adjacent teeth. One female was missing the lower left permanent lateral incisor and had retained the lower left deciduous lateral incisor. One female was missing the upper right premolar and had retained the upper right deciduous first molar.

Hyperdontia. Supernumerary teeth are, at best, a rare occurrence in humans (Bolk, 1914). Supernumerary teeth are generally cone-shaped and are most common in the anterior region, although occurrence in every section of the dentition has been documented (Diamond, 1952; Turner, 1967).

Two sex indeterminable individuals exhibited supernumerary upper right permanent lateral incisors. One female exhibited a supernumerary upper incisor protruding through the palate.

Diminutive teeth. Excessively small teeth are generally peg-shaped and have a single cusp, although they can have two cusps. Turner (1967) documented diminutive third molars in the prehistoric Aleut population he examined.

The same female who exhibited a supernumerary incisor protruding through the palate also exhibited a peg-shaped right third maxillary molar. Another female had a diminutive peg-shaped left lateral mandibular incisor. One male exhibited diminutive, peg-shaped right and left maxillary third molars. One female exhibited a peg-shaped right maxillary third molar and another female exhibited a peg-shaped left third mandibular molar.

There were not enough examples of these dental traits to reliably test for sexual dimorphism. Turner (1967) did not have enough examples of supernumerary or diminutive teeth to reliably test for sexual dimorphism either. He did find a sufficient number of congenitally missing third maxillary and mandibular molars to analyze. In that analysis, the chi-square P-values equaled >0.30 for the maxillary molars and 0.15-0.80 for the mandibular molars.

CHAPTER TEN: CROWN SIZE

In this study, only the maxillary canines and first and second maxillary and mandibular molars of the Arikara sample population were measured. This was done because canines and molars were the most numerous teeth available for systematic measurements. All measurements were taken with vernier calipers with pointed tips to 0.1 millimeters.

Mesiodistal dimensions. Mesiodistal measurements are generally only reliable on relatively unworn teeth. For this reason, mesiodistal measurements were limited to the maxillary canines as they were often the least worn. Also, the maxillary canine crown is a reasonably good indicator of genetic affinity and sexual dimorphism (Turner, 1967). Mesiodistal diameter is defined as, "...taken along the plane bisecting the occlusal surface of the canines with end points located at the mesial and distal crests of curvature..." (Owsley, 1981 p. 166).

Only a relatively small number of maxillary canines were available to measure. However, this did not seem to affect any of the statistical procedures performed of the male and female maxillary canines. It was not possible to calculate an average maxillary canine mesiodistal diameter for the sex indeterminable individuals. There were too few sex indeterminable individuals with permanent canines to provide a reliable sample size. The average mesiodistal diameter of maxillary canines was 7.8mm for the males and females of the Arikara sample population. The female mesiodistal average was 7.4mm. The male mesiodistal average was 8.4mm.

Maxillary canine crown dimensions have been found to be highly dimorphic (Black, 1902; Hrdlicka, 1923a, 1923b, 1930, 1935; Campbell, 1925; Shaw, 1931; Nelson, 1937; Dahlberg, 1951; Turner, 1967). This was the case among the Arikara. An independent two-sample T-test was performed on the canine measurements. The P-value equaled 0.0013. The Wilcoxon Rank Sum Analysis and the Kruskal-Wallis Chi-Square Approximation were run as well. Respectively, the P-values equaled 0.0031 and 0.0029. These values are all highly significant at the five percent level.

Turner (1967) noted statistically significant levels of sexual dimorphism on the basis of maxillary canine mesiodistal measurements as well. However, he did not provide any of his calculations in his report.

Labiolingual/buccolingual dimensions. Labiolingual/buccolingual dimensions are less affected by normal wear. Therefore, labiolingual/buccolingual measurements were taken on the maxillary canines and the maxillary and mandibular molars unless teeth were worn to the point of cusp obliteration (Turner, 1967). Labiolingual/buccolingual diameter is defined as, "...taken perpendicularly to the plane of the occlusal surface with end points located at the crown midpoint..." (Owsley, 1981 p. 166).

Labiolingual dimensions of the maxillary canines were calculated for the male and female Arikara. The mean for both sexes was 8.3mm. The female mean was 8.1mm and the male mean was 8.6mm. As with the mesiodistal maxillary dimensions of the maxillary canines, the labiolingual dimensions have been found to be highly dimorphic (Black, 1902; Hrdlicka, 1923a, 1923b, 1930, 1935; Campbell, 1925; Shaw, 1931; Nelson, 1937; Dahlberg, 1951; Turner, 1967). Sexual dimorphism was found among the Arikara. In an independent two-sample T-test, the P-value equaled 0.0182. The Wilcoxon Rank Sum Analysis and the Kruskai-Wallis Chi-Square Approximation were run as well. Respectively, the P-values equaled 0.032 and 0.0305. These values are all highly statistically significant at the five percent level.

There was a relatively large sample size of the first and second maxillary and mandibular molars for the Arikara. The mean buccolingual diameters for the sex indeterminable individuals for the first and second maxillary and mandibular molars were 11.6mm, 11.1mm, 10.8mm, and 10.3mm respectively. The mean buccolingual dimensions for the female first and second maxillary and mandibular molars are 11.7mm, 11.3mm, 11.0mm, and 10.5mm respectively. The mean buccolingual dimensions for the male first and second maxillary and mandibular molars are 11.7mm, 11.5mm, 11.1mm, and 10.7mm respectively.

As with the maxillary canine labiolingual dimensions, Moorrees (1957) and Turner (1967) found statistically significant sexual dimorphism on the basis of the first and second maxillary and mandibular molar buccolingual dimensions. There was no evidence of sexual dimorphism on the basis of first maxillary molar buccolingual dimensions among the Arikara. In an independent two-sample T-test, the P-value equaled 0.827. The Wilcoxon Rank Sum Analysis and the Kruskai-Wallis Chi-Square Approximation were run as well. Respectively, the P-values equaled 0.9772 and 0.9725. None of these values are statistically significant. Further, there was no evidence of sexual dimorphism among the Arikara on the basis of the second maxillary molar buccolingual dimensions. In an independent two-sample T-test, the P-value equaled 0.0695. The Wilcoxon Rank Sum Analysis and the Kruskai-Wallis Chi-Square Approximation were run as well. Respectively, the P-values equaled 0.0838 and 0.0828, and were not significant.

There was no evidence of sexual dimorphism among the Arikara on the basis of the first mandibular molar buccolingual dimensions. In an independent two-sample T-test, the P-value equaled 0.4421. The Wilcoxon Rank Sum Analysis and the Kruskai-Wallis Chi-Square Approximation were run as well. Respectively, the P-values equaled 0.3511 and 0.3481.

However, there was evidence of sexual dimorphism for the second mandibular molar buccolingual dimensions. The same three statistical analyses stated above were performed on the second mandibular molars. Respectively, the P-values equaled 0.0479, 0.0385, and 0.0379. These values are all statistically significant.

CHAPTER ELEVEN: INTERPOPULATION COMPARISONS

Some of the most important data gathered from a dental analysis of a given population is how that population compares to similar analyses performed on other populations. The data from the Arikara dental analysis were compared to several other analyses. Much of the data from Turner's (1967) Arctic population analysis have already been presented in the preceding chapters. There have also been many other dental analyses performed on populations worldwide.

Analyses of shoveling have been performed on Asian-derived, African-derived, and European-derived populations. As expected from these other shoveling analyses, the Arikara have shoveling frequencies similar to other Asian-derived populations (see Table 23).

Table 23 demonstrates the Arikara's affinity to other Asian-derived populations. Most of the Asian-derived populations examined have a frequency of shovel-shaped incisors of 50% or higher. The Arikara frequency is very close to those found for several of the Arctic populations Turner (1967) examined.

The Arikara also show an affinity to other Asian-derived populations in frequency of Carabelli's cusp (see Table 24). Again, the Arikara frequency for Carabelli's cusp is similar to other Asian-derived populations, especially the Arctic populations Turner (1967) analyzed. Asian-derived populations have the lowest frequency of high grade expression of Carabelli's cusp in the world.

European-derived populations have the highest frequencies of the trait.

Table 23: Frequency of Marked Shoveling; I1

(tooth count, sexes pooled)

Arikara	0.56
Aleut, living western	0.59
Aleut, living eastern	0.63
Aleut, prehistoric western	0.61
Aleut, prehistoric eastern, central	0.62
Eskimo, Kodiak	0.60
Eskimo, arctic coast	0.38
Eskimo, Hudson Bay	0.36
Eskimo, Greenland	0.57
Indian, arctic interior	0.55
(Turner, 1967)	
Aleut, living western	0.64
Aleut, living eastern	0.60
Aleut, prehistoric western	0.42
Aleut, prehistoric eastern, central	0.13
(Moorrees, 1957)	
Sioux	0.98
(Hrdlicka, 1931)	
Early Indian, Texas	0.95
(Goldstein, 1948)	
Indian, Pecos Pueblo	0.86
(Hooton, 1930)	
Polynesian (pooled island populations)	0.30
New Guinea	0.04
Australia	0.13
(Riesenfeld, 1956)	
Hawaiian	0.30
Chinese	0.58
Japanese (males only)	0.69
American white	0.02
African-American	0.04
(Hrdlicka, 1920)	

Table 24: Frequency of Carabelli's Cusp; Grade 5 or higher

(tooth count, sexes pooled)

Arikara	0.00
Aleut	0.00
Eskimo	0.03
Indian, Alaskan and Canadian	0.02
(Turner, 1967)	
Greenland Eskimo	0.00
(Pedersen, 1949)	
Indian, Blackfoot	0.12
(Dahlberg, 1963)	
Indian, Apache	0.08
(Kraus and Jordan, 1965)	
Indian, Western Pueblo	0.002
(Snyder, 1959)	
Japanese	0.22
Sakhalin Ainu	0.13
(Suzuki and Sakai, 1957)	
Australian	0.33
(Campbell, 1925)	
African-American	0.34
(Kraus and Jordan, 1965)	
American white	0.51
(Dahlberg, 1951, 1963; Kraus and Jordan, 1965)	

CHAPTER TWELVE: SUMMARY AND CONCLUSIONS

This study demonstrates much of what was expected in a dental trait analysis of the South Dakota Arikara. Since Native Americans are Asian-derived populations, one would expect certain traits to be found in certain frequencies during a dental analysis. Asian-derived populations have been shown to have the highest frequencies of shoveling of any group. Hrdlicka (1920) first demonstrated this with his study of living populations. Hrdlicka found Japanese, Chinese, and Hawaiian sample populations to have 95.9%, 86.9%, and 93.2% respectively of the two highest grades of shoveling. Goldstein (1948) found 95.1% semi- and marked shoveling in an early Indian population from Texas. Nelson (1937) found 89.5% in a sample of Pecos Indians. Pedersen (1949) noted 83.6% semi- and marked shoveling in a sample of East Greenland Eskimos. Turner (1967) found 88.6%, 92.4%, and 90.8% semi- and marked shoveling in the Aleut, Eskimo, and Northern Indian populations he studied respectively. In this study, 56% of the sample Arikara population exhibited marked shoveling. These results demonstrate that the Arikara are similar to other Asian-derived populations in frequency of high-degree shovel-shaped incisors.

For many of the traits analyzed in this study, a low frequency of expression was expected and observed. Seventy-eight percent of the Arikara in this study exhibited no evidence of maxillary incisor winging. This is similar to Turner's (1967) findings. In the Arctic populations he examined, an average of 66.3% of the sample exhibited no evidence of maxillary incisor winging.

The low frequency of *tuberculum dentale* exhibited by the Arikara was also expected. Seventy-two percent of the Arikara in this study exhibited no evidence of *tuberculum dentale*. The Arctic populations in Turner's (1967) study averaged 83.2% absence of the trait.

Further, 100% of the Arikara in this study exhibited either no Carabelli's cusp or only one of the three lowest grades of expression. In Turner's (1967) study, 94% of the sample Arctic populations he examined exhibited either no Carabelli's cusp or one of the three lowest grades of the trait. Studies have shown Asian-derived populations to have the lowest average frequency of high-grade Carabelli's cusp. European-derived populations generally average 40-65% high-grade expression of Carabelli's cusp. African-derived populations average around 33% (Campbell, 1925; Pedersen, 1949; Moorrees, 1957; Suzuki and Sakai, 1957; Snyder, 1959; Dahlberg, 1963; Turner, 1967).

Within group analysis for several of the dental traits examined in this study demonstrates evidence of sexual dimorphism in this Arikara sample population. As expected, significant sexual dimorphism was noted in the canine mesiodistal and labiolingual dimensions. There was also sexual dimorphism noted in the buccolingual dimensions of the second mandibular molar. There were also four unexpected examples of sexual dimorphism noted in non-metric traits. There was evidence of sexual dimorphism found among the Arikara in lateral maxillary incisor shoveling, lateral maxillary incisor *tuberculum dentale*, second maxillary molar cusp number, and second mandibular molar cusp number and groove pattern.

It is possible this non-metric trait sexual dimorphism is related to the interbreeding noted by Jantz (1977). There is well-documented evidence that the Arikara were practicing visitation and mate exchange with their trading partners (Bruner, 1961; Wood, 1974) There is also evidence the Arikara and nomadic Siouan tribes were in contact with both French and Spanish explorers and this contact makes white admixture a possibility (Meyer, 1977; Kehoe, 1981; Zimmerman, 1985). The instances of non-metric dental trait sexual dimorphism observed in this population may reflect change over the 200 year span of the sites from interbreeding and possibly white-admixture as well Asian-derived populations have been demonstrated to have the highest frequencies of shoveling while European-derived populations have the lowest frequencies (Hrdlicka, 1920; Turner, 1967). In this study, the Arikara were found to have a high frequency of high grade shoveling (56%), but the Arikara frequency was lower than the 85-100% shoveling observed in other Native North American Indian populations. A possible explanation is that European admixture lowered the frequency of shoveling in the Arikara in general and was especially evident in the Arikara females, though this may also reflect the sample population's female majority. This explanation, however, does not fit the data from the Siouan populations who also had

European contact and should show similar signs of admixture. Also, European admixture should result in higher frequencies of Carabelli's cusp, but there was no evidence of this occurring.

Another explanation lies in studies of dental genetics. Harris (1980) states many researchers believe incisor shoveling to be an X-chromosome linked trait. These researchers felt that because the X-chromosome contains so much information, one X-chromosome in females may be either partially or wholly inactive or both X-chromosomes may function jointly at the same capacity as the single X-chromosome in males. This may explain the higher frequency of shoveling in females by increasing the dosage effect of the jointly operating female X-chromosomes as the active X-chromosome information would automatically be dominant without competing information from the inactive or partially inactive X-chromosomes (Lyon, 1961, 1974; Gruneberg, 1966, 1969).

Harris (1980) favored the idea that shoveling may be linked to sex differences in the timing and formation (amelogenesis) of the teeth themselves. There is a formation and developmental time-lag between male and female dentitions which many researchers believe is responsible for the sexual dimorphism observed in canine crown size. Male embryos begin tooth bud formation first, but female finish first. Researchers hypothesize the extra time males have in formation results in thicker enamel which increases male canine size and higher frequencies of lingual crown ridges on the male canine (Moss and Moss-Salentijn, 1977; Moss, 1978). Research has shown, "... the epigenetic control of amelogenesis has important influences on final trait expression" (Dahlberg, 1967; Harris, 1980; p. 545). Harris (1980) stated the available evidence suggests male frequencies should be higher. In this study, there were observations which could be explained by both of these genetic models. Females had a higher frequency of lateral maxillary incisor *tuberculum dentale*. This is an expected observation under the X-chromosome linked trait theory. Males had a higher frequency of high grade shoveling on the lateral maxillary incisors, exactly as Harris predicted should occur under the amelogenesis theory.

Either or both of these theories may be correct. In that case, if genetics can explain instances of both metric and non-metric dental trait sexual dimorphism, the answer to the other dimorphic non-metric dental traits may lie in genetic analysis as well.

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