CLEVELAND HEALTH SCIENCES LIBRARY
School of Dentistry Library

ANALYSIS OF THE DENTITIONS OF AN OHIO PRECOLUMBIAN INDIAN POPULATION

by

JAMES TIMOTHY FANNO

Submitted in partial fulfillment of the requirements
for the Degree of Master of Science

Department of Orthodontics
CASE WESTERN RESERVE UNIVERSITY
June 1968

RULES COVERING USE OF MANUSCRIPT THESES IN THE
CASE WESTERN RESERVE UNIVERSITY LIBRARIES

Unpublished theses submitted for the doctor's degrees and deposited in the Case Western Reserve University Libraries are open for inspection, but are to be used only with due regard to the rights of the authors. If the thesis is borrowed by another Library, the same rules should be observed by it. Bibliographical references may be noted, but passages may be copied only with the permission of the authors, and proper credit must be given in subsequent written or published work. Extensive copying or publications of the thesis in whole or in part must have the consent of the author as well as of the Dean of Graduate Studies.

This thesis has been used by the following persons, whose signatures attest their acceptance of the above restrictions.

A Library which borrows this thesis for use by its readers is expected to secure the signature of each user.

NAME AND ADDRESS	DATE
Kayburgh du Hyatt Glen Ellyn Illinois	9/25/68
Stuart B Kay DDS Cleveland, Ohio	6/18/70
Gary D. Richard Dept of Anthro, Washington Univ., St. Louis	6/16/75

CASE WESTERN RESERVE UNIVERSITY

GRADUATE STUDIES

We hereby approve the thesis of

JAMES TIMOTHY FANNO

candidate for the Master of Science

degree.

Signed: David B. Scott, DDS
(Chairman)

Richard C. Beatty D.D.S

Paul E. Boyle D.M.D.

Date 5-7-68

ACKNOWLEDGEMENTS

The author would like to extend his most sincere appreciation to the following individuals:

Dr. David B. Scott, Thomas J. Hill Distinguished Professor of Physical Oral Biology, School of Dentistry, Case Western Reserve University, for his guidance, time, and assistance.

Dr. Richard C. Beatty, Professor and Chairman of the Graduate Department of Orthodontics, School of Dentistry, Case Western Reserve University, for his interest and encouragement.

Dr. Albert A. Dahlberg, Director of the Zoller Memorial Dental Clinic and member of the Department of Anthropology, University of Chicago, for his instruction and consultation.

Dr. P. O. Pedersen, Professor and President of the Royal Dental College, University of Copenhagen, Denmark, for his interest and consultation.

Dr. Olaf H. Prufer, Professor and Chairman of the Department of Anthropology, University of Massachusetts, for his cooperation and consultation.

Dr. Thomas J. Smith, Post-doctoral trainee in Physical Oral Biology, School of Dentistry, Case Western Reserve University, for his invaluable aid and cooperation.

The author wishes to express his gratitude to several other individuals who aided in the preparation of this thesis. They are: Mr. Stuart Katz for his help in the laboratory aspects of this analysis; Mrs. Carol Williams for her adept typing ability; Mrs. Mary Horrigan and Mrs. Jacqueline Toth for their assistance; and my wife, Maria, for her patience and understanding in so many ways.

The analysis of the dentition was supported by Public Health Service Training Grant DE 00180-02.

The material on which this study was based was obtained from a project supported by the National Science Foundation Grant GS-1700.

DEDICATION

To my parents

TABLE OF CONTENTS

Chapter

I. INTRODUCTION 1

II. STATEMENT OF THE PROBLEM 6

III. METHODS AND MATERIALS 7

- Tooth Material 10
- Tooth Morphology 14
- Dental Attrition 19
- Dental And Osseous Pathology 23
- Periodontal Conditions 27
- Cephalometry And Occlusion 31
- Physical Laboratory Methods 40

IV. TOOTH MATERIAL 46

- Review Of Literature 46
- Findings And Discussion 50

V. TOOTH MORPHOLOGY 62

- Review Of Literature 62
- Findings And Discussion 75

VI. DENTAL ATTRITION 96

- Review Of Literature 96
- Findings And Discussion 103

VII. DENTAL PATHOLOGY AND ANOMALIES 119

- Review Of Literature 119
- Findings And Discussion 126

VIII. PERIODONTAL CONDITIONS 154

- Review Of Literature 154
- Findings And Discussion 159

IX. CEPHALOMETRY AND OCCLUSION 172

- Review Of Literature 172
- Findings And Discussion 177

Chapter
X. SUMMARY AND CONCLUSION 192

APPENDIX 198

BIBLIOGRAPHY 241

LIST OF TABLES

Table		Page
1.	Criteria for Classification of Skulls	11
2.	Scoring of Carabelli's Cusp and the Protostylid	18
3.	Occlusal Attrition Index	20
4.	Proximal Attritional Index	24
5.	Breakdown of the Osseous and Dental Pathology and Abnormalities Surveyed	26
6.	Recording Code for Caries Survey	28
7.	Ramfjörd's Scoring of Calcareous Deposits . . .	32
8.	Tooth Presence within the Sample	51
9.	Premortem and Postmortem Tooth Loss	53
10.	Percentage of Individuals with Premortem and Postmortem Tooth Loss	54
11.	The Distribution of Teeth Present and the Premortem and Postmortem Tooth Loss	56
12.	Distribution of Teeth as Related to Tooth Type and Maxilla or Mandible	59
13.	Distribution of Tooth Loss by Sex	60
14.	Shovel-Shaped Incisors	77
15.	Double-Shovel Incisors	78
16.	Percentage Distribution of Shovel-Shaped Incisors Among Various Populations and Races	80
17.	Lower Molar Cusp Pattern	82
18.	Upper Molar Cusp Pattern	84
19.	Percentage Distribution of Molar Cusp Patterns Among Various Populations (First Molar) . . .	85

Table		Page
19.	Percentage Distribution of Molar Cusp Patterns Among Various Populations (Second Molar) . .	86
19.	Percentage Distribution of Molar Cusp Patterns Among Various Populations (Third Molar) . . .	87
20.	Scoring of Carabelli's Cusp in the Libben Indians	89
21.	Scoring of the Protostylid in the Libben Indians	91
22.	Occurrence of Various Other Morphological Traits in the Libben Sample	93
23.	Infants (7) Deciduous Dentition	104
24 A	Children (8) Deciduous Dentition	107
24 B	Children (8) Permanent Dentition	107
25.	Young Adults (10) Permanent Dentition	108
26.	Adults (59) Permanent Dentition	109
27.	Seniles (19) Permanent Dentition	110
28.	Attrition by Tooth Type (Adults - 88)	113
29.	Attritional Score vs. Age Group	114
30.	Percentage Distribution of Occlusal Attrition .	116
31.	Proximal Attrition	117
32.	Caries Location and Frequency vs. Age Group . .	128
33.	Percentage of Carious Surfaces vs. Age Group .	130
34.	Distribution of Carious Teeth by Tooth Type . .	131
35.	Distribution of Carious Surfaces by Tooth Type	133
36.	Summary of Caries Aspect of the Libben Indians	135 and 136
37.	Population Comparison of the Frequency of Caries and Abscesses	138
38.	Percentage Distribution of Missing Third Molars	142

Table		Page
39.	Percentage Distribution of Missing and Anomalous Lateral Incisors	143
40.	Percentage Distribution of Supernumerary Teeth	145
41.	Percentage Distribution of Palatal and Mandibular Tori	147
42.	Percentage Distribution of Missing, Reduced, and Impacted Teeth	148
43.	Distribution of Dental and Osseous Pathologies and Anomalies	151
44.	Summary of Infrequent Pathologies and Anomalies	153
45.	Percentage Distribution of Calculus Among the Various Age Groups	161
46.	Frequency of Occurrence of Alveolar Bone Pathology by Age Group	164
47.	Frequency of Occurrence of Alveolar Bone Pathologies	166
48.	Frequency of Occurrence of Contributory Osseous Pathologies	168
49.	Percentage Distribution of Alveoloclasia Among Various Populations	170
50.	Cephalometric Analysis	179
51.	Comparison of the Cranial Index and Palatal Shape Among Various Amerindians	183
52.	Interpopulation Comparison of Mesiodistal Tooth Diameters	185
53.	Distribution of Rotations by Tooth Type	187
54.	Distribution of Types of Occlusion Among Various Amerindians	190
55.	Carious Surfaces vs. Tooth Types for the Infant Group	199

Table		Page
56.	Carious Surfaces vs. Tooth Types for the Children's Group	200
57.	Carious Surfaces vs. Tooth Types for the Young Adult Group	201
58.	Carious Surfaces vs. Tooth Types for the Adult Group	202
59.	Carious Surfaces vs. Tooth Types for the Senile Group	203

LIST OF ILLUSTRATIONS

Illustration		Page
1.	Measuring Proximal Attrition	22
2.	Anatomical Landmarks and Cephalometric Points	36
3.	Bilateral Winging	38
4.	Dryopithecus Pattern	67
5.	Progressive Changes in Occlusal Wear	106

LIST OF PLATES

Plate		Page
I.	Shovel-Shaped Incisors	204
II.	Shovel-Shaped Incisors Affected by Attrition	205
III.	Carabelli's Cusp on Upper Permanent First Molar	206
IV.	Protostylid on Lower Permanent Second Molar	207
V.	Protostylid on Lower Permanent Third Molar	208
VI.	Barrel Lateral Incisor	209
VII.	Paramolar Cusp on Upper Permanent Second Molar	210
VIII.	Enamel Extension into the Furcation	211
IX.	Lower Anteriors with no Attrition	212
X.	Attrition of Lower Anteriors Involving the Dentin	213
XI.	Attrition of Lower Anteriors Totally Exposing the Dentin	214
XII.	Attrition of Lower Anteriors Sufficient to Expose the Pulp	215
XIII.	Advanced Attrition of Lower Anteriors	216
XIV.	Periapical Abscess as a Sequel to Advanced Attrition	217
XV.	Lower Arch Showing Different Stages of Attrition	218
XVI.	Lower Arch Showing Occlusal Caries	219
XVII.	Lower Arch Showing Both Occlusal and Buccal Pit Caries	220
XVIII.	Extensive Buccal Pit Caries of a Lower Permanent Molar	221

Plate		Page
XIX.	Beginning of Proximocervical Caries of Upper Permanent Cuspid	222
XX.	Progressive Stage of Proximocervical Caries	223
XXI.	Progressive Stage of Proximocervical Caries	224
XXII.	Pulp Exposure Via Proximocervical Caries	225
XXIII.	Buccal Root Caries of Lower Permanent Molars	226
XXIV.	Periapical Abscess as a Sequel to Proximocervical Caries	227
XXV.	Microradiograph of a Ground Section Through a Carious Lesion	228
XXVI.	Microradiograph of a Ground Section Through a Carious Lesion	229
XXVII.	Supernumerary Tooth	230
XXVIII.	Reduction of Upper Third Molar	231
XXIX.	Enamel Hypoplasia (Structural Calcification Defects)	232
XXX.	Pathologically Perforated Palate	233
XXXI.	Fenestration and Dehiscence of Roots	234
XXXII.	Extensive Loss of Supporting Alveolar Bone	235
XXXIII.	Three-Walled Infrabony Pocket	236
XXXIV.	X-Ray Powder Diffraction Patterns of Calcareous Deposits	237
XXXV.	Bilateral Winging	238
XXXVI.	Lateral View of the Occlusion	239
XXXVII.	Frontal View of the Occlusion	240

CHAPTER I

INTRODUCTION

For many centuries, man has been aware that significant knowledge could be obtained by studying himself. Out of this desire for knowledge came development of the science of anthropology. Because the study of man is overwhelming in scope, many concentrated their efforts in specific areas. Subsciences of ethnology, cultural anthropology, and paleodontology were evolved. Paleodontology, the study of the dentition of ancient man, accurately defines the extent of this treatise. The dentition of the North American Indian of 850 A.D., who occupied the southern shores of Lake Erie, is the specific subject of this thesis.

The Libben site on the Portage River, Ottawa County, Ohio, was discovered in 1966 by the members of the Archeological Survey of Ohio. Although the area was known locally as an "Indian Burial Ground," its true potential did not become apparent until that time. The site itself is part of the Libben farm and is located on a sandy knoll which is surrounded by a swamp except to the south where it is gradually being eroded by the Portage River. This pure sand deposit is three feet

deep and represents an ancient beach of one of the predecessor lakes of Lake Erie. Due to the neutral pH of the soil and the exceptional water drainage it provided, the majority of the skeletal remains proved to be in an excellent state of preservation. Occasional damage to the skeletons was observed. This damage was caused most often by changes in ground pressure, burrowing of animals, the weight and action of the farmer's plow, and poor field technique in the removal of the skeletons.

The surrounding topography of the site made it a geographical isolate and its inhabitants an effectively homogeneous inbreeding population. Laboratory examination of the cultural remains verified the geographical impression and indicated that the site was a single unit. According to Prufer (102), the remarkable uniformity of these cultural finds (ceramics, etc.) strongly suggested the existence of a people at this site for not more than three generations which is approximately seventy-five years.

Because of the site's unique characteristics of good preservation, easy availability, and discrete three-generation time span, test excavations were undertaken in August of 1966 under the direction of Olaf H. Prufer, Professor of Anthropology, Case Institute of Technology. These test trenches revealed densely packed skeletal remains which displayed numerous evidence of disease,

trauma, and genetic anomalies. On this evidence, Dr. Prufer approached members of the medical and dental professions in order to elicit an opinion on the possible desirability of obtaining a massive sample of the Libben population for study. The professions agreed to participate. Both the School of Medicine and the School of Dentistry of Western Reserve University would collaborate with the Department of Humanities of Case Institute of Technology on this project. This idea was truly unique for very few discrete prehistoric North American Indian populations have been adequately analyzed either in anthropologic, medical, dental, genetic, or demographic terms; and none have been studied from all aspects simultaneously. The integration of the results of these separate areas of study would reveal a complete health, social, and cultural picture of the Libben population.

Full-scale excavation of the site began in the spring of 1967 and ended in early fall of the same year. During this time, half the site was exposed. Three hundred burials containing cranial remains were exhumed. Fifty-nine complete skulls and 44 partial skulls containing complete dentitions were reconstructed for dental investigation. This sample of 103 dentitions comprised the basis of the presently described findings.

Many anthropologists, Funkhouser (41,42), Hooton (59, 60, 61), McPherron (84), Neumann (95), Newman (96),

Snow (118, 119), and Webb (125, 126, 127, 129), have studied the ancient populations in North America. In their works, the dentition has been largely neglected even though the importance of teeth in the study of early man is unquestionable. Teeth are not only the hardest part of the skeleton, but they are often the sole remains. Because their number, patterns, and structure are governed by rigid morphological laws that are genetically determined, they provide the most reliable information available to us about the health, race, and culture of primitive societies.

It is on this basis that the author combed the literature in search of well-documented, accurately executed analyses of other Amerindian dentitions. Both the physical anthropology and the dental literatures were comprehensively reviewed. In addition, the complete series of Yale University Publications in Anthropology (1936-1966), the Peabody Museum of American Archaelogy and Ethnology Papers (1868-), The Anthropological Papers of the American Museum of Natural History (1907-1965), and the Smithsonian Institution Bureau of American Ethnology Bulletins (1879-1967) were examined for useful information.

To take full advantage of the opportunity to study the dental structures in this unique precolumbian American Indian population with evidence of racial unity,

UTHSCSA HEALTH SCIENCES LIBRARY
School of Dentistry Library

geographic isolation, and limited diet, the present survey of the dentition was divided into six broad categories. They are: (1) Tooth Material, (2) Tooth Morphology, (3) Dental Attrition, (4) Dental and Osseous Pathology, (5) Periodontal Conditions, and (6) Cephalometry and Occlusion. In this way, it was felt that the investigation of the dentitions would be thorough and the results systematically revealed. Once the results are integrated, the complete dental health of this prehistoric community will be understood. In the discussion of each of the above categories, comparisons with other ancient Amerindian populations will be made. Unfortunately, comparisons of total dental health of the various Amerindian tribes cannot be made because this is, to the author's knowledge, the first time such a comprehensive analysis of one skeletal group has been attempted.

CLEVELAND HEALTH SCIENCES LIBRARY
School of Dentistry Library

CHAPTER II

STATEMENT OF THE PROBLEM

The purpose of this investigation was to describe accurately the complete dental health of the Libben people of 850 A.D. and compare their dental health with that of other ancient Mongoloid populations. Pertinent points were also made by comparisons with contemporary populations. In assessing the complete dental health, consideration was given to the entire dental-facial complex and the relationships of the associated structures. The data have been collected by means of visual observation, measurement, roentgenographs, microradiography, x-ray diffraction, and other physical methods used in the laboratory. Every effort was made to be as comprehensive as possible in the present analysis.

CHAPTER III

METHODS AND MATERIALS

The specimens used in this analysis are from a precolumbian, early Woodland Amerindian population of northwestern Ohio exhumed in the summer of 1967. The site is extensive and is estimated to have at least 1,000 individuals placed in shallow graves of sand. The land was formerly an orchard and until recently had not been plowed for farming. Generally, Woodland sites are small and shallow and have been largely obliterated by American farming. The Woodland pattern as described by Kroeber (76), was derived from preceramic cultures and extended to the start of pottery making and farming.

A sample of 103 skulls and dentitions was used in this survey. They were chosen at random according to age, sex, and state of preservation. An attempt was made to obtain a representative cross-section of the population to be studied.

A junior dental student was hired part-time to help the author reconstruct the skulls that had been flattened or crushed by the farmer's plow or by changes in ground pressure. As soon as the skulls were uncovered by the field workers, they were removed as a unit. The

surrounding moist dirt, artifacts, skull, mandible, and cervical vertebrae were immediately wrapped in wide sheets of Reynolds' heavy duty aluminum foil, and then this package was placed in a plastic bag and labeled according to burial position within the site. The bags containing cranial material were then placed in cardboard boxes, packed with newspaper as a buffering material, and delivered to the reconstruction laboratory. The skulls were carefully unwrapped, and the bones were separated and cleaned with a soft-bristled brush. The adhering sand was removed from regions where access was limited by the use of a fine-tipped dental explorer and compressed air. Two examples of such areas most frequently encountered were the internal nasal bones and the interproximal spaces of the dentition. After the bones had thoroughly dried, they were glued together as accurately as possible with Duco cement (DuPont). A preservative was not used on the skeletal material to provide an uncontaminated source for additional laboratory investigation.

The sand that had accompanied the cranial remains was saved. After being sifted through a screen-type strainer that removed the small bone chips and isolated teeth, the sand was returned to the plastic bag that had originally contained the skull. In this way, the sand would be available for future research for blood typing,

element content, etc. After the skulls were reconstructed, they were labeled with their Libben site number. Undamaged skulls were cleaned externally with a brush. A dental cement spatula was used to remove the intracranial sand via the foramen magnum. Any intracranial sand that remained was dissolved and floated away by filling the skull with tap water and rinsing out the sand with a gentle shaking motion. Loose soil was removed from the teeth with a Py-co-Pay medium, natural-bristled toothbrush and water. Care was taken not to dislodge the calcareous deposits.

If a skull was inordinately comminuted or if the maxilla and/or mandible was missing, no attempt was made to reconstruct it for this present study. There were 25 cases of skulls with no mandible and 5 isolated mandibles were rejected for study.

In order to reconstruct a skull properly, at least five hours were needed. After 59 skulls were completed, it became apparent that remaining time would not permit continuation of this procedure. It was then decided to reconstruct only the maxilla and mandible of an additional 44 individuals. This made the sample exceed 10 per cent of the estimated number of burials; and therefore, this sample can be considered a representation of the entire population. After reconstruction and labeling, the skulls and dentitions were placed on shelves for easy

access. They were then renumbered consecutively from 1 to 103 with water-soluble Sanford's marker. The site numbering system used by the anthropologist to identify burial location was too cumbersome for use in this analysis.

The skulls distributed themselves into three main groups. Eighty-eight had a permanent dentition, 8 had a mixed dentition, and 7 had a deciduous dentition. Further classification of the material according to age was based on two criteria. They were the dentition and the closure of the vault sutures. Closure times of the sagittal, coronal, and lambdoidal sutures plus the eruption pattern of the teeth yielded a rough assessment of age. Montagu (90) stated that the vault sutures taken together usually can come within six years of the exact age of an adult over 35. This is not as accurate as it could be, but is more than adequate for the present age grouping requirements. See Table 1 on page 11.

Tooth Material

Visual examination with the aid of good artificial light and a new, fine-tipped Cleve-Dent explorer (Number 3) comprised the main method of obtaining information about the teeth of the Libben people. The first step was to count accurately the number of teeth present per skull and record exactly which teeth they were. Also

TABLE 1

CRITERIA FOR CLASSIFICATION OF SKULLS

Number of Skulls	Classification	Age Range	Criterion (Dentition-Sutures)
7	Infant	Birth-2 yrs.	Second deciduous molars not in function
8	Child	2-12 yrs.	Complete deciduous dentition through mixed dentition
10	Young Adult	12-18 yrs.	Permanent dentition with second molars in function
59	Adult	18-35 yrs.	Permanent dentition with third molars in function
19	Senile	35-(?) yrs.	Closure of the sagittal and coronal sutures with partial closure of the lambdoidal Dentin exposed due to attrition

determined was the number and identity of those teeth that were lost premortem and of those that were lost postmortem. To avoid possible confusion, the teeth were numbered consecutively starting with the upper right third molar as number 1 and proceeding around the arch to the upper left third molar as number 16. Then dropping down to the lower arch, the lower left third molar was numbered as 17, and proceeding around the arch, the lower right third molar was numbered as 32. The deciduous dentition was handled in the same way except that Roman numerals were used. The upper right deciduous second molar was recorded as Roman numeral I, and proceeding around the arch, the upper left deciduous second molar was recorded as Roman numeral X, and so on. In this way, each tooth had a different number.

As the observations were made, they were recorded in appropriately designated columns drawn on legal-size paper. At times the student assistant would be available to record the results which increased the efficiency of the process. Tooth presence was indicated even if only the root or root tips of a tooth were remaining. The loss of a tooth was considered to be premortem only when the tooth was absent and the socket completely or partially obliterated by the healing process. Congenitally missing teeth, although very infrequent, were recorded under premortem loss. When the tooth was absent and the

CLEVELAND HEALTH SCIENCES LIBRARY
School of Dentistry Library

socket remained intact, the loss was considered to be postmortem. In the majority of cases, the sockets were filled with sand indicating that the teeth were dislodged and lost during the burial process or as the result of natural causes while the individual was interred.

Other possible causes of postmortem loss were poor field technique during skeletal excavation, improper packaging, shipping, and handling. Some teeth may have been lost due to damage caused by worms, gophers, or other burrowing animals. The postmortem loss in just 5 skulls accounted for approximately 25 per cent of the total postmortem loss experienced in the sample.

An omnipresent factor to be accounted for in this analysis is error in observation. Precautions were constantly taken to keep mistakes to a minimum. The caries and cephalometric aspects of the analysis were repeated to provide a check of accuracy. Blind checks were also incorporated into the survey technique. For example, as previously described, the author counted the missing teeth and categorized their loss as either premortem or postmortem. When the attritional aspect of the project was studied, missing teeth were again recorded, and type of loss determined. The results of both tabulations were then compared, and when necessary, corrections made. In the morphological, attritional, and periodontal sections, repeated observations were made on every fifth

CLEVELAND HEALTH SCIENCES LIBRARY
School of Dentistry

skull, and the results checked. Positive correlation was the rule, not the exception, when observations were compared. Multiple opinion technique was used also to determine if the author's judgment of the degree of expression of dental traits and diagnosis of pathology was competent over a wide range of specimens. Computations and observations were often repeated by the student assistant as a countercheck on the author's experimental accuracy.

Tooth Morphology

Cusp presence, number, and pattern of the molars were recorded along with the degree of shovel-shaping of the incisors. Several additional aids were employed at this point. Having spent a week in August, 1967, with Dr. A. A. Dahlberg, Director of the Zoller Memorial Dental Clinic and member of the Department of Anthropology, University of Chicago, the author was most familiar with his methods of recording and classifying tooth characters. In an attempt to standardize the classification of these genetically determined morphological traits, he developed a series of stone plaques, each containing a number of models illustrating particular tooth characters, their sequences, gradations of intensity, and range of expression. Dahlberg's (26) three-dimensional models of Carabelli's cusp, shovel-shaped incisors, and

molar-cusp patterns were an irreplaceable adjunct in scoring and classifying the morphological traits of the dentitions of the Libben people.

Throughout the literature on tooth morphology, shovel-shaping is usually reported as marked, semi-shovel, trace, or none. This has obviously been a very subjective method of analysis. On the other hand, Dr. A. A. Dahlberg (22, 23) in two studies has made an attempt to actually measure the depth of the lingual fossa from the highest parts of the rim to the deepest point of the fossa of upper incisors, using an adapted Boley gauge. This indeed was the first attempt to use a metrical system of evaluating the shovel character. After obtaining hundreds of measurements, he found that he had to use a certain figure as a cut-off point so that he could classify the shovel-shaping and compare his results with the works of previous authors. That cut-off point was a depth of three fourths of a millimeter. Accordingly, in the present study, two jigs were made out of stainless steel with a projection point of exactly three fourths of a millimeter. One jig was designed for the upper central incisors, and the other was adapted for the upper lateral incisors. The jig was placed firmly on the lingual surface of the tooth. If the projection point did not contact the lingual fossa while the jig rested on the prominent lateral borders, the tooth was classified as

markedly shovel-shaped. If the projection point prevented the jig from resting on the lateral borders, the tooth was classified as semi-shovel. Trace and none categories were resolved subjectively by clinical judgment. Wear of the lateral borders of the lingual fossa would have a tendency to lower the gradation of intensity of the shovel-shape character; yet no accurate method could be devised to compensate for this attritional factor.

In some instances, the markedly shovel-shaped incisor was accompanied by a concavity on the labial surface which produced what has been termed a double-shovel. There was also a malformation principally of upper lateral incisors which was associated with the cingulum and lingual surface. In most instances, the anomaly caused the tooth to have the appearance of a malformed bicuspid or a "barrel" shape. The occurrence of double-shovel and barrel laterals was recorded, but the degree was not scored.

By means of observation and comparison with the morphological standards, the cusp patterns of upper and lower permanent molars were identified. As described by Dahlberg (23), the 5 cusped lower molars are of two types. First, there are those in which the proportionate sizes of the cusps are such that when viewed from the lingual the grooves form a figure "Y." In these

instances, the protoconid (mesiobuccal cusp) is not in contact with the entoconid (distolingual cusp). Second, there are those in which the grooves form a "+" instead of the "Y" and the protoconid contacts the entoconid. The numeral 5 is joined to the "+" or "Y" to designate the particular combination. Likewise with a 4 cusped tooth, the proportionate sizes of the cusp designate a "+" or "Y" groove pattern and the teeth are labeled "+4" or "Y4."

The upper molar has 4 occlusal cusps; however, there is a trend in modern populations to lose the hypocone (distolingual cusp). If an upper molar has 4 well-developed cusps, it is classified 4. If the hypocone is reduced in size, the tooth is designated as 4-. Total absence of the hypocone is indicated by a 3 and, if the 3 type has a cuspule on the distal border, it is called a 3+ tooth.

Attrition, fractured teeth, and missing teeth were major factors in limiting the number of observations made; however, a general impression of cusp pattern for each molar was obtained.

Carabelli's cusp and the protostylid were classified according to the simplified system proposed in 1966 by A. Dahlberg, T. Dahlberg, Snow, and Snyder (33). The system scored these traits as to their degree of expressivity. See Table 2 on page 18.

CLEVELAND HEALTH SCIENCES LIBRARY
School of Dentistry Library

TABLE 2

SCORING OF CARABELLI'S CUSP AND THE PROTOSTYLID

Carabelli's Cusp	Score	Protostylid	Score
Smooth surface	1	Smooth surface	1
Furrow	2	Wrinkle or disruption of surface continuity	2
Pit	3		
"Y"	4	Buccal groove deviation and/or small elevation from the buccal pit antero-occlusally	3
Double furrow	5		
Small delineated cusp	6	Small definite cusp	4
Large cusp	7	Large cusp	5

Dental Attrition

Attrition was another characteristic of the dentition of the Libben people investigated by visual examination. Attrition is defined as the gradual wearing away of the hard parts of the teeth through physical and physiological agencies of mastication. The occlusal and incisal aspect of every tooth in the sample was examined, and its classification tabulated so that a total, comparative view of the attritional status of the population could be obtained. Many methods of classification of occlusal attrition have been published. The most frequently used and accepted standard for scoring occlusal attrition is the oldest; it was established in 1879 by Broca (14). His four degrees were as follows: first, attrition of only the enamel; second, partial exposure of dentin; third, total exposure of the dentin; and fourth, total loss of the crown. The above classification was extended to include certain intermediate stages. See Table 3 on page 20 for the standard stages of occlusal attrition and their corresponding scores used in this study. These scores were then analyzed according to age group, tooth type, and sex. As previously stated, the methods for studying occlusal attrition were subjective and were based on a series of criteria which were compared to the investigator's visual interpretation of the occlusal surface of the tooth. Mehta (87) very recently

TABLE 3

OCCLUSAL ATTRITION INDEX

Order	Description	Score
A	No evidence of attrition	0
B	Attrition of enamel only Wear facets on cuspal planes with no dentin exposed	1
C	Attrition extends through the enamel into the dentin in cuspal and incisal areas Cusp pattern maintained	2
D	Total exposure of dentin Occlusal surfaces are worn flat Inverted cusp pattern present	3
E	Attrition is sufficient to expose the pulp Rate is greater than secondary dentin formation	4
F	Attrition responsible for the total loss of the crown	5

tried to obtain an actual calculation of the amount of attrition by measuring the crown heights of an Amerindian population and comparing these figures with crown heights of modern man. This method obviously contained many inherent sources of error and unacceptable assumptions. It is the opinion of this author that such attempts to use an objective method of measuring attrition are steps in the right direction even though a satisfactory method has not been developed.

Another type of attrition was present. It was the wearing of the contact areas of neighboring teeth, which resulted in changes in their proximal contours. Begg (10) maintained that proximal attrition was quite normal and a vitally necessary physiologic process which was related to and part of the process of continual tooth migration. As revealed by the literature, proximal attrition has not been sufficiently studied especially from an objective approach. This is true because of the many innate variables that can be present at the contact area of neighboring teeth. The size of the teeth, contour of the proximal surfaces, number and size of roots, and time of eruption are a few of the factors that have a direct influence on the wear of the proximal surface of each tooth within the arch. This is true regardless of the race, age, or diet of the population being examined.

With the use of a modified Boley gauge, an attempt was made to measure proximal wear. Trying to minimize the effect of the previously mentioned factors, contact areas of teeth of nearly equal size were chosen. These areas were between the first and second bicuspids and between the first and second molars. The proximal contour and root surface area of these teeth are relatively equal. Differences in eruption times of these teeth could not be compensated for. With a Boley gauge, the buccolingual widths of the neighboring teeth were measured and then averaged. Reverse bevels were placed on the measuring arms of another Boley gauge to facilitate entering the embrasures of the contacting teeth. See Illustration 1 shown below.



Illustration 1.--Diagram of the measuring arms of a Boley gauge entering proximal embrasures.

Then the buccolingual length of the contact area was measured and divided by the average buccolingual width of the teeth to obtain the percentage of the total buccolingual dimension that is contact area; the greater the percentage, the greater the proximal attrition. See Table 4 on page 24.

Dental And Osseous Pathology

According to Ramfjörd (105), the initial approach in epidemiological investigations of disease was to study the prevalence and incidence. Prevalence refers to the number of events or defects observed in an individual or population at a specified time. Incidence refers to the number of defects that may accumulate in an individual or population during a given period of time. When the extent and distribution of the disease has been investigated, the available information is utilized in a search for etiological factors and studies of the nature of the disease.

The Libben population was scanned for manifestations of both dental and osseous pathology. Those abnormalities that would affect the individual tooth, such as hypoplastic enamel, were recorded in the appropriate column designated for each tooth so that prevalence per skull could be derived. In addition, the distribution of a particular abnormality in the entire population could

CLEVELAND HEALTH SCIENCES LIBRARY
School of Dentistry Library

TABLE 4

PROXIMAL ATTRITIONAL INDEX

Order	Description	Percentage	Score	Remarks
A	No attrition, normal contact	0-10%	0	Considered normal range and variation
B	Broadened into contact area	10-30%	1	
C	Wearing of proximal contours of neighboring teeth	30-50%	2	Range of most primitive populations reported
D	Attrition involving the marginal ridges of the teeth	50-70%	3	
E	Attrition of proximal beyond the marginal ridge thereby reducing the occlusal table	70-90%	4	Found infrequently
F	Maximum proximal wear	> 90%	5	

CLEVELAND HEALTH SCIENCES LIBRARY
School of Dentistry Library

be ascertained from the tabulations. Those abnormalities that had a general effect on the entire oral cavity, such as cleft palate, were also recorded on an individual skull basis. The incidence of pathology could be calculated and related to the entire sample. A complete breakdown of the osseous and dental pathology and abnormalities observed is presented in Table 5 on page 26.

Often it was necessary to remove the calculus from the buccal and labial surfaces of the teeth so that enamel hypoplasia and structural defects could be detected. These calcareous deposits were placed in vials and labeled as to origin. By enamel hypoplasia, it is meant that there was an incomplete calcification of the enamel demonstrating itself in the form of white spots, dark coffee-colored areas, and opaque flecks but without evident loss of form in the outer surface. The structural defect category is self-explanatory. It represents incomplete development of the enamel surface, resulting in grooves, pits, and ridges.

Under high-intensity artificial light, every surface of every tooth was visually examined and tactually probed with a fine-tipped Cleve-Dent explorer (Number 3). It was necessary to remove every other tooth from the alveolus in order to provide a clear view of the opposing proximal surfaces. A record was kept of each skull noting which teeth had caries and which surfaces of the tooth

PETERSON ORAL PATHOLOGY COLLECTION LIBRARY
School of Dentistry Library

TABLE 5

BREAKDOWN OF THE DENTAL AND OSSEOUS PATHOLOGY AND ANOMALIES SURVEYED

Dental Pathology and Anomalies		Osseous Pathology and Anomalies	
Observation	Method	Observation	Method
Abscesses	Visual and x-ray	Tori, Palatal	Visual
Enamel Hypoplasia	Every surface--visual	Tori, Mandibular	Visual
Structural Defects	Every surface--visual	Congenital Syphilis	Visual
Erosion	Every surface--visual	Exostoses	Visual
Abrasion	Every surface--visual	Cleft Palate	Visual
Impaction	X-ray	Arthritis of TMJ	Visual
Congenitally Missing	X-ray	Amelogenesis Imperfecta	Visual
Supernumerary	X-ray	Paget's Disease	X-ray
Microdontia	Every tooth--visual		
Macrodontia	Every tooth--visual		
Fusion	Every tooth--visual		

CLEVELAND HEALTH SCIENCES LIBRARY

were involved. This was then divided according to age groups and analyzed to determine possible relationship of caries incidence, as well as distribution by tooth and surface type, with advancing age. Table 6 on page 28 is the key to the code that was utilized in surveying the dentitions for caries. The code simplified the recording procedure without sacrificing either accuracy or completeness.

If a lesion on a tooth was questionable concerning the diagnosis of caries, the classification EC was used. These explorer catching areas were either enamel structural defects, such as grooves and pits, or they were the initial stages of the caries process; and therefore, did not demonstrate the classical properties of frank decay. Carious lesions of deciduous teeth were considered separately and received a red check over the appropriate code. (Red check was standard notation to indicate a deciduous tooth in the recording of the data of all aspects of the analysis.)

Periodontal Conditions

As revealed by their skeletal remains, this Amerindian population had been afflicted with periodontal disease. With the exception of the works by Hirschfeld (57, 58) in the mid 1920's; approaches to analyzing periodontal disease of skeletal material have been vague,

TABLE 6

RECORDING CODE FOR CARIES SURVEY

Code	Description
Blank	Tooth missing
F	Free of caries
O	Occlusal caries
B	Buccal caries (labial)
M	Mesial caries
D	Distal caries
L	Lingual caries
R	Root caries
P	Pulp exposure
P_1	Pulp exposure with only roots remaining
EC	Explorer catches
~	Tooth fractured postmortem

inadequate, and generalized. To overcome this trend, periodontal lesions and associated bone deformities were studied from several aspects in this investigation. Lesions that were the result of bone destruction, such as pockets, interproximal craters, and furcation involvements, were recorded. A brief description of their location and extent was included. Thickened bony margins and blunting resorption of the interdental lamina dura along with the bony abnormalities of dehiscences and fenestrations were also cataloged according to occurrence and location. By reviewing the data collected, bone condition could be evaluated and related to attrition, age, and diet. In this way, an accurate understanding of periodontal conditions could be obtained.

Decisions on the diagnosis of the lesions were sometimes difficult and required subjective judgments. Hirschfeld (57) warned of such a possibility. "In a study of dry specimens, it is essential to guard against confusion of post-mortem damage with destruction resulting from disease during life." He continued by stating that one should be aware of anatomical variation which is difficult to explain but not necessarily pathological. With these comments in mind, only unmistakable occurrences of periodontal disease were noted.

Perhaps the most apparent clue of periodontal health of any population is the presence, location, and

CLEVELAND HEALTH SCIENCES LIBRARY
School of Dentistry Library

amount of calculus. Unlike clinical situations both supragingival and subgingival deposits can be examined with equal ease. It is still possible, however, that the amount of calculus observed may represent an underestimation since postmortem events from burial to disinterment and laboratory examination can dislodge, fracture, and otherwise reduce the amount of calculus originally present. On the assumption that this would be a constant factor throughout the sample, ratings of calcareous deposits were made without regard to the above-mentioned possibilities.

Goldman (44), Grant (48), Ramfjord (105), and Schour (110) have created periodontal indexes to indicate accurately the severity of the disease and to provide a means of making the information suitable for statistical evaluation. Most of these indexes involve the soft tissue pathology and ignore or touch lightly upon the bone destruction phases of the disease. Only one index at present relates pocket depth to a fixed point on the tooth, but adaptations could not be made to accurately convert its use to skeletal material. The periodontists consulted were in agreement that a true picture of pocket depth and periodontal destruction could not be obtained from skulls unless gingival level was known. One could relate the free gingival margin to the cemento-enamel junction, which could be either above or

UT HEALTH SCIENCE CENTER LIBRARY
School of Dentistry Library

below the base of the pocket, but could not relate the cemento-enamel junction to the pocket depth. Soft tissue pocket depth and resulting bone level are not the same, and the relationship between the two is not a constant factor. Therefore, an objective-measurement method could not be used.

There is a positive correlation between the presence, amount, and location of calculus and the periodontal health of the individual. Using this classical approach and Ramfjörd's (105) method of scoring calculus shown in Table 7 on page 32, the dentitions were surveyed.

Cephalometry And Occlusion

The word cephalometry means the scientific measurement of the dimensions of the head. In the present analysis, these measurements were taken from cephalometric roentgenograms. Utilization of cephalometric roentgenograms is found in comparative studies, in growth studies of the skull and dental apparatus, in the study of the characteristics and relationships of individuals and populations, and in genetic studies of the skull. Comparison of these cephalometric measurements with those of other Amerindian populations of the same time period (Woodland) would be desirable in order to establish the cranial characteristics and relationships of these people. Such a comparison, however, is

CLEVELAND HEALTH-QUINCY LIBRARY
School of Dentistry Library

TABLE 7

RAMFJÖRD'S SCORING OF CALCAREOUS DEPOSITS

Order	Description	Score
A	Absence of calculus	0
B	Supragingival calculus extending slightly below the cemento-enamel junction	1
C	Moderate amount of supra and subgingival calculus or subgingival calculus only	2
D	An abundance of heavy supra and subgingival calculus	3

CLEVELAND HEALTH SCIENCES LIBRARY
School of Dentistry Library

impossible because this is one of the few attempts to study the skulls of an Amerindian population using a cephalometric approach.

It is known that these skulls are subjected to change by the environment, intragroup variability, and intergroup similarity. Nevertheless, the importance of cephalometry in the description and analysis of the remains of fossil man cannot be overstressed. Study of the dento-facial complex as a whole and the inter-relationships of the associated structures can add meaningful information to the understanding of the total dental health of these prehistoric Amerindian people.

Availability of the Bolton Study facilities in the School of Medicine, Case Western Reserve University, made the cephalometric aspect of the project possible. A complementary set of lateral and frontal cephalometric roentgenograms were taken of each of a group of 33 skulls which were exhumed with the cranial base intact. The occipital, sphenoid, and ethmoid bones make up the cranial base of a skull. The mandibles of these skulls were firmly fixed in full occlusion to the crania with masking tape, and then the skulls were placed in the Broadbent-Bolton roetgenographic cephalometer for proper orientation and for the production of the standardized roentgenograms.

CLEVELAND HEALTH SCIENCES LIBRARY
School of Dentistry Library

Kodak no screen x-ray film was used because it produces greater contrast and detail from skeletal material. The Bolton Study's cephalometric setup features two perpendicular stationary General Electric x-ray tubes which, in conjuction with the adjustable cephalometer, maintain a constant target to film distance of five feet for both frontal and lateral views. Exposure times, kilovoltage, and milliamperage settings varied according to the size of the skull and thickness of the bone. A guide chart, which was provided by the Bolton Study, gave settings that were a satisfactory starting point. By trial and error, the proper exposure was obtained. The final setting for each skull was recorded on mimeographed forms. The skull number was formed out of lead numerals and placed on the outside of the cassette prior to exposure of the film. In this way, the skull number appeared on the developed film. These records and standardized roentgenograms will make future investigation of measuring the development and growth of the dentition, face, and head of this population possible.

After processing the film, a thin, clear piece of acetate paper was placed over the lateral roentgenogram and attached with transparent Scotch tape. With the aid of a General Electric illuminator, certain anatomical landmarks of each skull were identified and traced with a red pencil. The important landmarks were: sella

CLEVELAND HEALTH SCIENCES LIBRARY
School of Dentistry Library

turcica and neighboring clinoids, ear hole, mandible, maxilla, upper and lower central incisors, nasal bone, frontal bone, and the orbital margins. From these nine structures, various cephalometric points were located. Angles were formed when lines were drawn between these points. The relation of one line to another was expressed by the angles which gave the information necessary for a skeletal analysis.

Illustration 2 on page 36 demonstrates the positions of the anatomical landmarks, cephalometric points, and resulting lines and angles.

The major purpose for making a skeletal analysis was to gain an appreciation of facial type and an appraisal of anteroposterior apical base relationship particularly in Class II and Class III malocclusions. Skeletal dysplasias become apparent when there is a malrelationship of the maxillary and mandibular bases. The teeth reflect this malrelation even though they can be in fairly good position when compared to their basal bone alone. There are many ways to measure apical base relationship which is the relation of the maxilla to the mandible and of both to the cranial base. Downs's (35) method was one of the simplest. His method was to make angular measurements of point A on the maxilla and point B on the mandible, to reference cranial base line (S-Na-A and S-Na-B). The difference between the two angles determined the

CLEVELAND CLINIC EDUCATION FOUNDATION
School of Dentistry Library

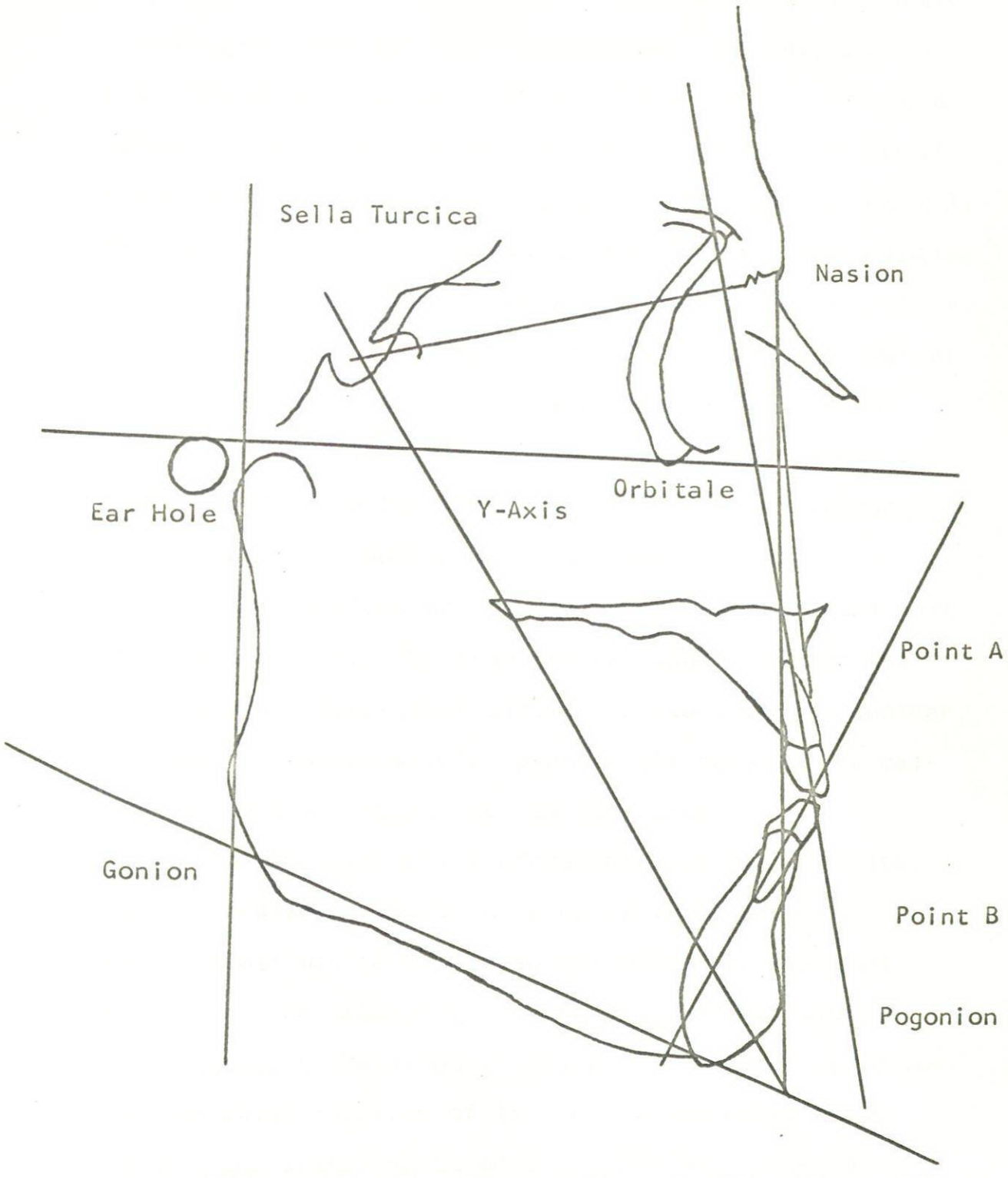


Illustration 2.--Diagram demonstrating the positions of the anatomical landmarks, cephalometric points, and resulting lines and angles.

maxillo-mandibular difference. Measurement of the angle A-Na-B gave much the same information. To help assess the anteroposterior position of the mandible, the angle formed by the facial plane and the Frankfort horizontal plane and the angle formed by connecting nasion, point A, and pogonion (angle Na-A-Po) were measured. These angles related the convexity or concavity of the facial profile. The inclination of the mandibular plane with the cranial base plane could influence the profile. The Y axis, which indicated the chin point, direction of growth of the mandible, and the relative retraction or protraction of the mandible could also affect the profile.

The positions of the teeth were an important part of this analysis. The interincisal angle related the maxillary and mandibular central incisors to one another, and the incisor-mandibular plane angle related the mandibular central incisor to its bony base.

In addition to the aforementioned measurements, the mesio-distal dimension of every newly erupted, unworn tooth was taken. Also the angle was measured between a line extending the median palatine suture forward beyond the alveolus and a line created by following the axial rotation of the central incisors which brought the distal parts of the teeth into anterior prominence. See Illustration 3 on page 38.

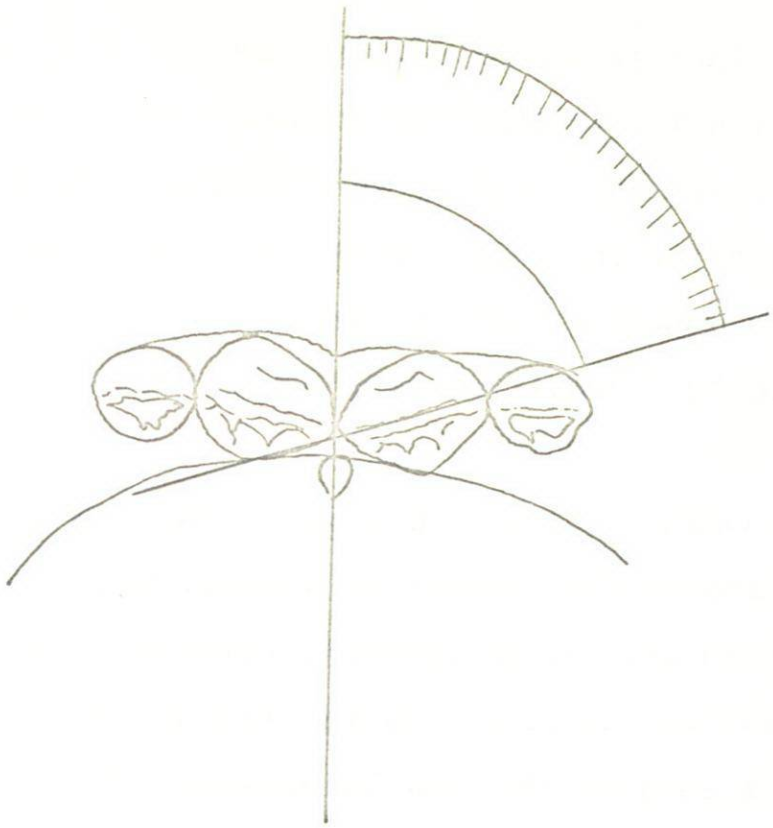


Illustration 3.--Diagram of bilateral winging.

Occlusion represents the functional relationship between the teeth of the maxilla and mandible. The absence of opposing teeth, of pericementum, of the interarticular cartilage, and of the ligaments of the temporomandibular joint often made it difficult to establish the approximate relations between the teeth and the alveoli and between the mandible and maxilla. Moreover, warpage of the mandible and/or skull added to the difficulties. If a dentition could not be occluded with reasonable accuracy, it was not utilized in the present study.

UNIVERSITY OF MARYLAND HEALTH SCIENCES LIBRARY
School of Dentistry Library

The jaws were occluded using the attritional patterns of the molars, temporomandibular joint articulation, and maximum intercuspation as guides. Several alternate positions would be tried. That position, which satisfied the most criteria, was chosen to be the proper occlusion for the individual. Angle's classification of occlusion was used.

There were only brief, generalized comments on the occlusion of other Amerindian populations in the publications of both physical anthropologists and dental investigators. Few analytical or objective studies have been done thus far because of the difficulties experienced in occluding the two jaws as they were prior to the death of the individual.

Observations were made on overjet, overbite, openbite, anterior crowding, rotations, arch form, spacing, crossbite, arch symmetry, and midline discrepancies. Arch forms were classified as either ovoid, square, or tapering. The presence of each rotation and the tooth affected were recorded so that the frequency of rotation of any given tooth could be determined for the entire population. The location of crossbite was designated. Attempts to measure the amount of overjet and overbite with a Boley gauge were unsuccessful because a consistent degree of accuracy could not be achieved. Nevertheless, the relationship of overjet and overbite could still be described in a general way and related to other populations.

OREGON HEALTH SCIENCES UNIVERSITY
School of Dentistry Library

Physical Laboratory Methods

The major laboratory methods used in this analysis were microradiography of the dental caries, x-ray diffraction of the calcareous deposits, and various photographic techniques. The use of these sophisticated methods of laboratory investigation would answer many of the pertinent questions resulting from the examination of these 1,100 year old dentitions.

A detailed histological picture demonstrating dental caries was desirable as a proof of the clinical diagnosis. Although the lesions appeared to have all the characteristics of caries, more scientific proof was needed to rule out other possibilities, such as erosion or postmortem effects of interment. A change in the morphology of the dentinal tubules under the carious lesion, the presence of reparative or secondary dentin as a pulpal response, and the presence of zones of calcification and decalcification in the affected dentin were the microscopic signs of proof sought after to confirm the clinical impression.

Because both structural details and mineralization status could be studied, microradiography, which is also known as x-ray microscopy, was the method of choice. Microradiography is a process by which an x-ray shadow image of a very thin ground section of tooth is produced on a slide coated with a fine-grained photographic

PORTLAND HEALTH SCIENCES UNIVERSITY
School of Dentistry Library

emulsion. The resulting radiograph can subsequently be examined microscopically or enlarged several hundred times or until the resolution approaches the resolving power of the photographic emulsion (about one micron resolution). In this particular project, contact microradiography was employed using the equipment in the Physical Oral Biology Laboratories of Case Western Reserve University. The distinction is that in contact microradiography the specimen is held firmly against the slide with the photographic emulsion.

The initial procedure was to pick an intact tooth with a carious lesion involving the dentin. The tooth was embedded in an epoxy resin (Epon) and cured overnight. The embedding medium was then shaped with a band saw so that it could be mounted in a brass ring with fast setting plaster-of-paris. Thin sectioning was accomplished on a special cutting machine equipped with a rotary jeweler's slotting saw. This produced sections approximately 0.005 inch in thickness. One side of the section was then lapped to a high finish with diminishing grades (0 to 4/0) of abrasive paper, and glued to a brass cylinder with Waterglas (sodium silicate). The exposed side of the section was lapped with the abrasive papers as previously described until a final thickness of 0.002 inch (50 microns) was attained. This was then placed in water for 30 minutes to dissolve the glue. The freed section was then ready to be exposed.

CLEVELAND HEALTH SCIENCES LIBRARY
School of Dentistry Library

The equipment used for microradiography was a custom-made apparatus, consisting of a variable anode x-ray tube and a helium path camera equipped with a vacuum specimen holder. The x-ray tube and its power supply were built according to a design by Dr. R. W. G. Wyckoff, University of Arizona, and the remaining components were developed in the present laboratory. The radiation of choice for calcified tissue is the characteristic K alpha of titanium which has a wave length of 2.75 angstrom units. This produced maximum contrast between mineral and non-mineral components and still was absorbed sufficiently in the non-mineral portion to provide structure detail. The radiation was generated at 14 kilovolts and 6 milliamperes, and passed through a 0.002 inch Mylar window equipped with a titanium filter (0.0025 inch foil). The camera was positioned so that the anode to film distance was approximately 8 inches. The specimen was held in close contact to the Kodak 649-0 emulsion by means of a Mylar film drawn down tightly by vacuum and was exposed to the radiation for 30 minutes. To reduce absorption of the soft radiation, the path between the x-ray window and the specimen holder was continuously flushed with helium. After being exposed, the slide was removed from the apparatus and developed in Kodak D-19 developer for 6 minutes, rinsed, and then fixed in Kodak Rapid-Fix for an additional 6 minutes. When the slide had thoroughly

School of Dentistry Library

dried, it was examined under a Lietz Ortholux microscope equipped with a Xenon light attachment. Polaroid photographs were taken of the magnified microradiographs.

X-ray diffraction is a commonly used physical method for identification and characterization of crystalline compounds. In this study, the Debye-Scherrer 114 millimeter camera was used for obtaining powdered diffraction patterns of the calcareous deposits on the teeth of the Libben Indians. After their collection, these deposits were finely ground in a agate mortar and pestle and placed in a special thin-walled glass capillary. The specimen within the capillary was then inserted in the camera which was loaded with no screen x-ray diffraction film. Exposures were made with nickel filtered copper K alpha radiation generated at 40 kilovolts and 20 milliamperes. The specimen and the film were exposed to this radiation for 4 hours. Following development of the film in Kodak D-19 developer, the resulting patterns were measured for identification. Direct comparisons were also made with standard patterns for hydroxyapatite, whitlockite, and brushite as well as patterns that were made from the sand which often adhered to the original specimen. The spacing and intensity of the lines were the basis for comparisons between standard and experimental patterns.

School of Dentistry Library

With the exception of Polaroid, the photographs in this thesis were produced with an Exa II single-lens reflex camera equipped with a Zeiss 2.8/80 Biometar lens and loaded with Kodak Pan X (ASA-32) film. A Honeywell Prox-o-lite provided the illumination with an exposure time of 1/30 of a second, and f stop of 11, and a distance of approximately 7 inches. Clay was used as a mounting medium and black art paper served as a background. The negatives were developed and corresponding photographs printed using standardized darkroom procedures.

School of Dentistry Library

ANALYSIS

School of Dentistry Library

CHAPTER IV

TOOTH MATERIAL

Review Of Literature

Although the dentitions of many Amerindian sites have been studied in the past, they have not exceeded the dentitions of the Libben site in number or state of preservation. As the following review of past studies will show, the dentition has been described in general terms, and an accurate comparison among the various populations has thus been precluded.

In 1916, Hrdlicka (65) examined a group of skulls from a Delaware Indian site. Although the number of specimens was not given, it was reported that 13 per cent of the teeth in males and 21 per cent of the teeth in females were lost during the individual's lifetime. In order for this information to be of value for comparative purposes, the total number of teeth in the sample and the postmortem loss would have had to be provided.

Earnest Hooten (59) in 1920 examined the skeletal remains from the Madisonville, Ohio, site and reported, "So many of the teeth have been lost post-mortem in the present group that observations of the dentitions are very unsatisfactory." He continued by stating that, of

School of Dentistry Library

the 61 skulls exhumed, 29 per cent had premortem tooth loss. Again comparison was impossible because the number of postmortem loss and the total number of teeth in the sample were not given. Two years later, Hooten (60) aided in the excavation of the Turner site in Hamilton County, Ohio. Of the 28 skulls collected, 8 (27.5%) had premortem tooth loss. As before, other needed information was not included in his report.

A dentist named Raymond Bentzen (11) in 1929 analyzed the teeth and jaws from a series of Mimbres skeletons unearthed by the Jenks Expedition. The sample consisted of 26 complete maxillae, 29 complete mandibles, 9 maxillary fragments, and 145 miscellaneous teeth. His results indicated that 159 teeth were lost postmortem, and 78 teeth were lost premortem. Although he described the sample, further details about the dentitions were not provided; and therefore, it was not known whether the 145 miscellaneous teeth were included in the postmortem loss figure.

Rihan (106) in 1932 published the results of a study of 289 adult skulls of the Pecos Indians in New Mexico. There were 47.5 per cent of these skulls that had a loss of teeth. The total number of teeth or a breakdown of loss as to before or after death was not included in either the tables or text.

School of Dentistry Library

Ten years later Newman and Snow (96) published their findings on the skeletons from the Pickwick Basin in Alabama. Out of the 65 skulls examined, 52 per cent had premortem tooth loss. This information was further clarified by a table, which indicated within a range the number of teeth lost per skull; however, the total number of teeth and the number of premortem loss were deleted, making any valid comparison impossible.

Rabkin (104) worked on a group of less than 300 Kentucky Indian crania in 1943. He discussed tooth presence and loss as follows:

> Nevertheless, in this instance as is the case with most prehistoric remains, not all of the skulls are in a state of preservation permitting satisfactory examination. Some do not possess a complete complement of teeth (due to either ante or post mortem loss).

In 1948, Goldstein (46) studied Indian crania from five different regions of Texas and stated that the antemortem loss of teeth as a per cent of the total crania of both sexes was a range of 35.4 per cent to 73.7 per cent depending on the geographical origin of the skulls. Without additional information a comparison could not be made with this extensive study.

Sarnas (108) published a lengthy description of the dentitions of Indian Knoll in 1964. He realized the difficulty of using available data for comparative purposes when he stated:

School of Dentistry Library

> Few investigations have given full documentation as to which teeth have been available for examination and which teeth have been missing. In view of this it appears as if a strict comparison . . . would be more or less unsound.

In his study of the Indian Knoll material, he selected from the 1,200 crania 189 skulls with upper and lower jaws present and the sex determined. They were divided into three categories: primary, mixed, and permanent with the latter comprising 75 per cent of the sample. In this group, 617 deciduous teeth and 4,011 permanent teeth were present. There was a premortem loss of 1 and a postmortem loss of 98 in the deciduous dentition and premortem loss of 11 and a postmortem loss of 196 in the permanent dentition. Comparisons will be drawn with Sarnas' findings in this analysis.

In 1966 Mehta (88) studied 21 postcolumbian Arkansas Indian skulls. Of the 616 teeth he examined, 34 teeth were lost postmortem, and 19 were listed as missing. This represented a total loss of 8 per cent which would be considered very low except for the fact that only those skulls were chosen for the study that "had nearly a full complement of teeth and had normal occlusion."

Just last year McPherron (84) of the University of Michigan reported on the Juntunen Site. There was a diversified table of pathologies and anomalies which had included as an entry 8 skulls with antemortem tooth loss. Neither the text of the report nor the other tables

School of Dentistry Library

contained more information about tooth presence, sample size, or tooth loss. It was hoped that this perpetuating trend of neglect of the dentition in future anthropological endeavors could be reversed.

Findings And Discussion

The present study was based on a sample of 103 skulls which was approximately 10 per cent of the estimated number of burials contained within the site. The skulls were divided into three main groups according to the stage of dental development: 7 deciduous, 8 mixed, and 88 permanent dentitions. There were 2,580 teeth in the entire collection out of a possible 3,163 (ideal). Eighty-two per cent of the teeth were present which verified the fact that these skulls were outstanding in their state of preservation. Accordingly the average number of teeth observed per skull was very high. See Table 8 on page 51. As shown in this table, the average number of teeth per skull in the permanent group was 25.6 and in the deciduous group was 18.9. These figures did not reach the ideal numbers because of the non-eruption of teeth, shedding of deciduous teeth, premortem and postmortem loss of teeth and anodontia. When the figure for the permanent group was computed, including the premortem loss of 368 teeth, the average number of teeth per skull equaled 29.8. This number represented more accurately the condition of the sample being

School of Dentistry Library

TABLE 8

TOOTH PRESENCE WITHIN THE SAMPLE

Dentition	Number of Skulls	Number of Teeth	Average Number of Teeth per Skull	Ideal	Number of Teeth Missing	Per Cent Missing	Average Number of Teeth Missing per Skull
Deciduous	7	132	18.9	20	8	5.7%	1.14
Mixed	8	193	24.1	---	13	6.3%	1.63
Permanent	88	2,255	25.6	32	562	19.9%	6.30

HEALTH SCIENCES LIBRARY
School of Dentistry Library

studied. There were three and one-half times as many teeth missing from the permanent group than from the others. This was again expressed in the per cent missing column which emphasized the fact that one out of every five teeth in the permanent group was absent. By analyzing missing teeth as to the time of their loss (either before or after death), much could be learned about the dental health of the individuals, the excavation technique, and the environment of the grave. Table 9 on page 53 shows the pattern of premortem and postmortem losses in the sample. From the table it can be seen that all loss of teeth in skulls with deciduous dentitions was postmortem, while approximately two thirds of the loss of teeth in skulls with mixed dentitions was premortem. The reverse was true for the permanent dentition group. Only one third of the loss of teeth occurred postmortem indicating the following trends. Premortem loss of teeth increased with the acquisition of the permanent dentition, which could be expected, but the postmortem loss decreased substantially from deciduous to permanent dentition. Table 10 on page 54 simply shows the number and corresponding percentage of skulls of each group having premortem and postmortem loss of teeth. Note that two thirds of the skulls with a permanent dentition have premortem loss, postmortem loss, or both. It would be meaningful to know in the adult population of 88 skulls the number of central incisors, lateral incisors, cuspids, etc.

School of Dentistry Library

TABLE 9

PREMORTEM AND POSTMORTEM TOOTH LOSS

Dentition	Total Number of Teeth Present	Total Tooth Loss	Premortem Loss	Premortem Loss ÷ Total Loss	Premortem Loss ÷ Total Number of Teeth Present	Postmortem Loss	Postmortem Loss ÷ Total Loss	Postmortem Loss ÷ Total Number of Teeth Present
Deciduous	132	8	0	0.0%	0.0%	8	100.0%	5.7%
Mixed	193	13	5	38.5%	2.4%	8	61.5%	3.9%
Permanent	2,255	562	368	65.4%	13.0%	194	34.6%	6.8%

HEALTH SCIENCES LIBRARY
School of Dentistry Library

TABLE 10

PERCENTAGE OF INDIVIDUALS WITH PREMORTEM AND POSTMORTEM TOOTH LOSS

Dentition	Number of Skulls with Premortem Loss	Percentage	Number of Skulls with Postmortem Loss	Percentage
Deciduous	0	0.0%	5	71.0%
Mixed	2	25.0%	5	62.5%
Permanent	55	62.5%	58	66.0%

School of Dentistry Library

that were present and the type of tooth loss that was responsible for those teeth that were missing. Table 11 on page 56 provides the information concerning the number of observations made, and the type of loss experienced for each tooth. As demonstrated in Table 11, cuspids were least likely to be missing, followed closely by both premolars and lateral incisors. The absent toll was greatest for the first molars. The most frequent premortem loss was in the first, second, and third molars in that order, and the most frequent postmortem loss was in the central incisors. The teeth least likely to be lost premortem were the cuspids and lateral incisors, and the teeth least likely to be lost postmortem were the first and second molars. This table clearly shows that for this population, as for others studied in the past, the molars were the first teeth lost during the individual's lifetime. This was especially true for the first molars because they were the first permanent teeth to erupt. They alone received the trauma and the attritional aspects of the diet for six years before another molar erupted to help alleviate the load. The incisors, on the other hand, were seldom lost during life, but as single-rooted teeth, they were most likely to fall out of their sockets during handling, excavation, and transportation of the remains. Therefore, the table shows the postmortem loss of the central incisor to be higher than any other tooth.

School of Dentistry Library

TABLE 11

THE DISTRIBUTION OF TEETH PRESENT AND THE PREMORTEM AND POSTMORTEM TOOTH LOSS

	I^1	I^2	C	P^1	P^2	M^1	M^2	M^3	Total
Number of teeth present	273	307	318	306	305	249	255	245	2,258
Premortem loss	20	13	12	24	35	95	87	82	368
Postmortem loss	62	32	22	23	12	8	10	25	194
Total per cent missing	23.1%	12.8%	9.7%	13.3%	13.3%	29.2%	27.5%	30.4%	19.9%

SCOTTISH HEALTH SCIENCES LIBRARY
School of Dentistry Library

In comparison with Sarnas' (108) distribution of observed permanent dentitions and their premortem and postmortem losses, this study has some striking dissimilarities. The total premortem loss for his sample of 141 adults was 19 as compared to 368 for the 88 Libben adults. This meant that the Libben sample had forty times the premortem loss as the Indian Knollers. This was significant and strongly suggested that dental disease literally plagued the Libbenites when they were compared to their Kentucky counterparts. In agreement with the present study, the central incisors in his sample were the most frequent postmortem loss; however, the agreement ended here. The first molar in the Indian Knoll study was the tooth most often observed, but in the Libben site it was the tooth most often missing. Only 5 molars in Sarnas' sample were lost during the lifetimes of the individuals as compared to 95 first molars lost from this sample. These results appeared to be at opposite ends of a range. Nevertheless, it can be said that tooth loss was uncommon in Kentucky Indian adults but very common in the Libben population. In Sarnas' selected sample, the postmortem loss rate was about two thirds of the rate for the Libben sample. There were 196 teeth lost from 141 permanent dentitions of Indian Knoll compared to 194 teeth lost from 88 permanent dentitions of the present sample.

School of Dentistry Library

Table 12 on page 59 gives more information concerning tooth loss in this adult segment of the population. Arch was a distinguishing factor and was related to tooth type which has been somewhat condensed from Table 11. The premortem loss of lower molars was greater than the upper molars while the postmortem loss was about the same. The opposite was true for the premolars. The premortem loss was greater in the upper arch than the lower, and the postmortem loss was about equal. Unlike the molars and the premolars, the arch factor was not significant in cuspid presence or loss. There was a greater premortem and postmortem loss recorded for the upper incisors, and despite the fact that the observation was a consistent one, the reasons were not known and can only be speculated upon.

How important was the sex factor in influencing the number of teeth lost prior to the death of any given individual? Table 13 on page 60 shows that of the 59 skulls which could be sexed, almost three fourths of them were males. Although the rate of postmortem tooth loss was about the same for both sexes, the premortem loss in males was twice as high as in females. Hereafter the sexes will be pooled in presenting and discussing the data because only one half of the sample could be sexed, and of the 59 skulls which could be, males outnumbered females almost three to one. Significant sex comparisons of disease,

School of Dentistry Library

TABLE 12

DISTRIBUTION OF TEETH AS RELATED TO TOOTH TYPE AND MAXILLA OR MANDIBLE

	Total Ideal	Number Present	Present ÷ Ideal	Number of Premortem Loss	Premortem ÷ Ideal	Number of Postmortem Loss	Postmortem ÷ Ideal
Upper molars	528	396	75.0%	108	20.5%	24	4.5%
Lower molars	528	353	66.9%	156	29.5%	19	3.6%
Total molars	1,056	749	70.9%	264	25.0%	43	4.1%
Upper premolars	352	300	85.2%	37	10.5%	16	4.5%
Lower premolars	352	311	88.4%	22	6.2%	19	5.4%
Total premolars	704	611	86.8%	59	8.4%	35	4.9%
Upper cuspids	176	157	89.2%	8	4.5%	11	6.3%
Lower cuspids	176	161	91.5%	4	2.3%	11	6.2%
Total cuspids	352	318	90.3%	12	3.4%	22	6.3%
Upper incisors	352	281	79.8%	21	5.9%	53	15.0%
Lower incisors	352	299	84.9%	12	3.4%	41	11.6%
Total incisors	704	580	82.4%	33	4.7%	94	13.3%

HEALTH SCIENCES LIBRARY
School of Dentistry Library

TABLE 13

DISTRIBUTION OF TOOTH LOSS BY SEX

Sex	Number	Premortem Loss	Premortem ÷ Number	Postmortem Loss	Postmortem ÷ Number
Males	43	220	5.1	96	2.23
Females	16	42	2.6	30	1.87

School of Dentistry Library

attrition, etc. cannot be based on such a small sample of female skulls.

School of Dentistry Library

CHAPTER V

TOOTH MORPHOLOGY

Review Of Literature

Along with size, the form and structure of the teeth have been studied intensely during the past fifty years to yield knowledge about the evolution of man, to establish a criteria for race, and to relate tooth morphology with other factors of demographic investigation. Measurements and observations of teeth have been subject to misinterpretation because various workers in this field have used different definitions, different techniques, and different populations. Many dental traits have been misconstrued as being racial, but as more studies were published, it was realized that the prevalence of any given trait per specific group of people was significant and not the mere presence of the trait. The genetic component, which controls the frequency of a trait in a population when compared to another, was the reliable information which could be used constructively. The old concept that a skull's origin could be identified if it had a particular dental trait was not acceptable. However, computing the probability that a skull would have a certain group of traits with a particular degree of

School of Dentistry Library

expressivity present within the same dentition could yield semi-reliable information concerning race and perhaps origin. The recent awareness of intragroup variability and intergroup similarity has dimmed the polish in this area of odontology. To quote Lasker and Lee (78):

> The extravagant hopes for the use of dental features as a hallmark of race have not been fulfilled. To speak of a dental trait as racial merely implies that it occurs in higher frequency in one race than in another. It is unlikely that a certain feature will be found exclusively in a given race.

One such trait that was thought to be racial was shovel-shaped incisors. It was found in high frequency and intensity in the Mongoloid racial stock. Hrdlicka (66) in 1920 described the occurrence of a type of incisor which he called a "shovel-shaped incisor." Shoveling occurred as a generalized condition throughout the primate order, and although it was best developed in upper teeth, it was also found in lower incisors and deciduous incisors. Hrdlicka stated:

> The original call for the development of a rim and hollow on the lingual surface of the front teeth was in all probability a call for strengthening. An incisor of this form, all other things being equal, must in mechanical principles be considerably stronger than a flat surfaced tooth.

He recognized three grades of shovel-shaped teeth. The word "shovel" indicated the best developed type; for less well-developed grades, the term "semi-shovel" was used. "Trace shovel" was applied to a slight but definite indication of the shovel-shaped form. He gave the

School of Dentistry Library

frequencies of this character among the various races of the world. They were: White, 6 per cent; Negro, 10 per cent; Hawaiian, 47 per cent; Chinese, 60 per cent; Japanese, 85 per cent; and American Indian, 91 per cent.

In 1921, Hrdlicka (67) published a description of upper incisors which exhibited a marked overdevelopment of the cingulum that extended incisally approximately three fourths of the length of the crown. The labial surface of these teeth was usually convex with the cingulum functioning as a lingual cusp for an incisor. A. A. Dahlberg (23) likened these overdeveloped incisors to the appearance of premolars and labeled them "barrel-shaped incisors."

Hooten (59) in 1920 in his analysis of the skeletal remains of an Indian village near Madisonville, Ohio, observed shovel-shaped incisors in 12 of 13 male crania and in all of the 6 female crania. Two years later in his reports on the Turner site, Hooten (60) stated, "Thirteen crania had shovel-shaped incisors, and one had not. In the remainder of the series, the presence or absence of this feature could not be determined." In 1924, Hooten (61) in a publication on the Indian burial site in Winthrop, Massachusetts, discussed the remains of each burial separately and frequently mentioned the presence of shovel-shaped incisors.

School of Dentistry Library

The following year Leigh (80) studied the dental pathology in four different Indian tribes which were dissimilar in their environment and diet. He found that elevated marginal ridges and deep concave lingual fossae of upper incisors occurred quite constantly in all four tribes which were the Algonquin, Sioux, Arikara, and Zuni. He concluded that this feature must have been a universal physical characteristic of the American Indian.

In a discussion of the anthropology of the Sioux Indians, Hrdlicka (68) in 1931 verified Leigh's findings and emphasized the fact that the characteristic shovel-shaped upper incisors were present in almost 100 per cent of the tribe. Of 56 boys, 54 had well-developed shovels, and 1 was placed in each of the categories of semi-shovel and trace. Of 60 girls, 51 had well-developed shovels, 8 had semi-shovels, and 1 had a trace.

Sedwick (113) examined precolumbian Indian skulls unearthed in New York State in 1936 and mentioned the fact that most of his material had anterior teeth with well-developed marginal ridges between which was a concave lingual fossa--the characteristic of American Indians which Hrdlicka described and termed "shovel-shaped teeth."

Samuel Rabkin (104) studied the Indian Knoll material of Kentucky in 1943 and in general terms discussed his impressions of the dentitions. He considered the raised labial marginal ridges of anterior teeth as being

School of Dentistry Library

a newly developed trait; and therefore, it was not nearly as prominent as the lingual shovel-shaped feature.

Wissler (133) in his book, The American Indian, published in 1938, stated that the most distinctive tooth character in the New World was the shovel-shaped or ventrally concave upper incisor. It is interesting to note at this point that according to Weidenreich (130) this Mongoloid trait which Wissler referred to as "New World" dated back one million years to Sinanthropoid skeletons found in caves near Peiping, China.

Snow (119) in 1948 in his analysis of the Indian Knoll skeletons mentioned the consistent, pronounced shoveling of the center-four teeth of the upper arch.

Carbonell (19) found in a study of variations in the frequency of shovel-shaped incisors that laterals were more affected by the shovel trait than centrals and that, if the centrals were shoveled, usually one would find the laterals shoveled to the same degree.

Dahlberg (28) commented on the frequency of this trait: "A very marked form of shovel-shaped incisor occurs in over 95 per cent of American Indians." The shovel-shaped character was moderate in its expression in ancestral forms. Some populations lost the character (modern Whites), some retained it (certain Asiatics), and others accentuated it (Amerindians). This loss of specialization had taken place with almost all tooth

School of Dentistry Library

characters and has resulted in the many diverse dentitions of today.

Besides shovel-shaped incisors, certain other characters were typical of Mongoloid dentitions and were generally studied in an Indian population. The number and pattern of molar cusps, the presence of Carabelli's cusp in upper molars, and protostylids in lower molars have been the object of much study. In 1926 Gregory (52) presented the fundamental molar cusp and groove pattern of a hominid lower molar and named it the "Dryopithecus Pattern," an ancestral form seen in tooth phylogeny and common to both man and anthropoid apes. This typical Dryopithecus pattern exhibited five main cusps, 3 buccal, and 2 lingual. The groove pattern closely resembled the letter "Y" as seen in Illustration 4 shown below. In the

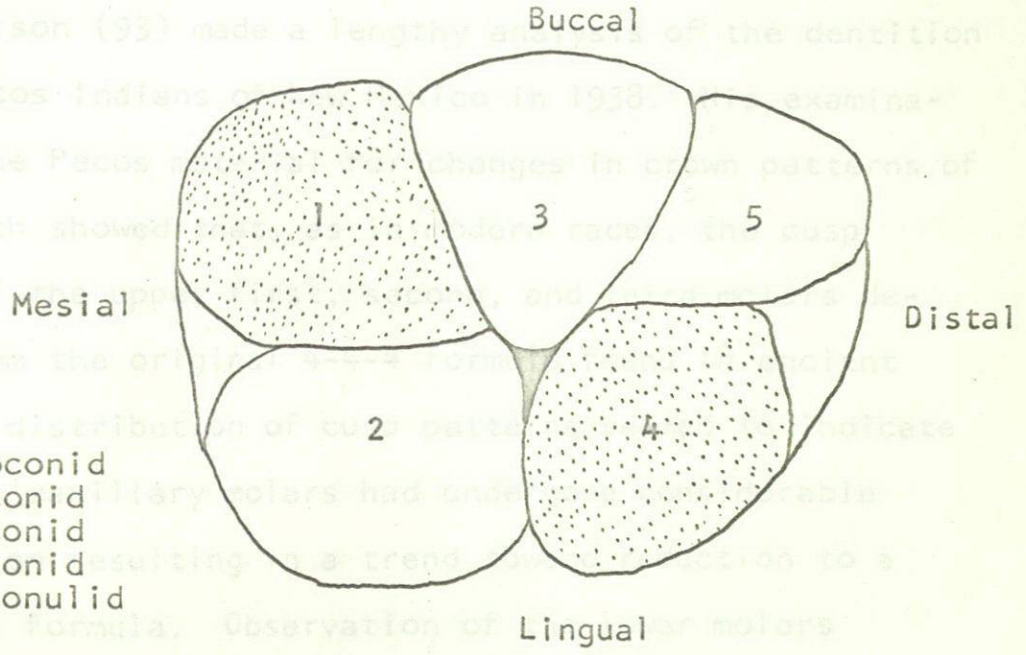


Illustration 4.--Diagram of the Dryopithecus Pattern.

School of Dentistry Library

typical Dryopithecus pattern, the base of the crest of the metaconid came into contact with the base of the hypoconid while the bases of the crests of the protoconid and entoconid remained separated.

Hellman (56) in 1928 contended that, although there was a wide variation in lower molar patterns, they could be traced back to Gregory's Dryopithecus pattern. He introduced the term Y5 pattern for this basic and standard form of Dryopithecus. He also contended that changes appeared which tended to modify the fundamental pattern by a gradual, progressive process of evolution. These changes involved a modification in the system of furrows and reduction in the number of main cusps or both. Hellman even showed molars of the same dentition in different degrees of change.

Nelson (93) made a lengthy analysis of the dentition of the Pecos Indians of New Mexico in 1938. His examination of the Pecos material for changes in crown patterns of molar teeth showed that, as in modern races, the cusp formula of the upper first, second, and third molars deviated from the original 4-4-4 formula found in ancient man. The distribution of cusp patterns seemed to indicate that Pecos maxillary molars had undergone considerable modification resulting in a trend toward reduction to a 4-3-3 cusp formula. Observation of the lower molars indicated that the mandibular first molar was the most

School of Dentistry Library

primitive of the Pecos lower molars since it retained the Dryopithecus pattern in the greatest number of cases while the second and third molars departed from the original. Comparison of the Pecos findings with the present study will be made in the Findings and Discussion section of this chapter.

In 1939, after much confusion about the Y5 pattern of mandibular molars, Allin and Robinson (4) published an article defining the variable cusp patterns. The simplest form of modified pattern in molars was +4 in which the hypoconulid had been lost as well as the distal fossa and fissure. This cruciform (+) pattern, particularly when concurrent with a reduction in the number of cusps, was a progressive stage in lower molar crown evolution. The two intermediate stages were: The +5 which had all the elements of the Y5 pattern except that the Y5 was distorted because the hypoconulid did not have a common border with the entoconid in the central fossa; and the Y4 which had retained the character of Y5 (metaconid-hypoconid contact) except that the hypoconulid was lost along with the fissure and fossa.

In Goldstein's (46) study of dentitions of Indian crania of Texas, 100 per cent of the permanent incisors observed were shovel-shaped, and much like the Pecos Indians, the upper molar cusp formulae had a strong tendency for reduction to 4-3-3. In fact, about 30 per cent

School of Dentistry Library

of the skulls examined had this reduced formula, and an additional 30 per cent had a 4-4-3 formula while only about 20 per cent retained the ancestral formula 4-4-4. Only the lower first molars of this group were predominantly of the Dryopithecus pattern. The second and third molars were most commonly cruciform in pattern. Goldstein brought special attention to the fact that the incidence of lower second molars with four cusps in the Texas Indian groups was very high for American Indians (72.3 per cent). This +4 pattern was considered to be relatively rare. He explained:

> Differences in molar cusp numbers and patterns among various groups of Indians, as well as among peoples of other races, are probably due to inadequate samples or when the samples are adequate, to actual variability in subgroups as a result of secular factors such as greater isolation and inbreeding in one group than another.

The actual effect of isolation and inbreeding on human genetics is an arduous if not impossible area of investigation. Therefore, the amount of variability that can be attributed to the presence of these factors within a subgroup is purely speculation.

In 1953 Dahlberg (25) wrote an article concerned with the evolution of tooth crown form. He stated that in most early men the three lower molars had the five cusps with a Y formation of the intervening grooves, but in second and third lower molars of the White race of today and other populations, the distobuccal cusp was missing. He explained:

School of Dentistry Library

The last parts added to the molars are most variable in form and size and sometimes missing entirely. These parts are the distolingual cusp of upper molars and distobuccal and distolingual cusps of lower molars.

In 1949 Dahlberg (23) presented a paper that summarized much of the previous work on the dentition of the American Indian up to that date. A year later Dahlberg (24) reported on the evolutionary significance of the protostylid. This cusp appeared in many of the Australopithecine (Sinanthropus), rarely in most modern man (only 11 cases reported), but in 30 per cent of the Pima Indians of Arizona. The protostylid can be described as a elevation or ridge of enamel on the anterior part of the buccal surface of the lower molars which ascends from the gingival end of the buccal groove and extends mesio-occlusally. It occurred in varying degrees of prominence. Seemingly residual evidences of the cusp were commonly seen in the form of pits and distal deviations of the gingival end of the buccal groove on modern lower molars.

Tratman (122) in 1950 made a comparison of the teeth of Indo-European racial stock with Mongoloid racial stock. Besides the Mongoloid features of shovel-shaped incisors and Dryopithecus fissure pattern of lower molars, he mentioned the very low incidence of Carabelli's cusp on maxillary first molars and the presence of enamel extensions into the furcations of the molars, particularly the first.

School of Dentistry Library

Pedersen (98, 99) found that Carabelli's tubercle was extremely rare or practically absent in pure Greenland Eskimos; whereas it existed frequently in Eskimos mixed with Whites. Pedersen also quoted the work of other authors who had found a very low incidence of the tubercle in Chinese but a little higher incidence in Japanese. He also pointed to the high incidence of enamel extensions and enamel pearls between the roots of molars.

Juett (71) also spoke of the presence of epithelial pearls and enamel extensions, but as indications of a primitive race such as the early Indians of South Central Kentucky which he studied.

Scott (112) in his text, Dental Anatomy, stated that Mongoloid characteristics of enamel extensions, absence of Carabelli's cusp, enamel pearls, and shovel-shaping of incisors had an unusually high frequency of occurrence in pure Eskimo and Indian populations.

In 1959 Kraus (75) analyzed in detail the occurrence of the Carabelli's trait in Southwest ethnic groups. He presented a four-fold classification of the Carabelli's trait and used it in determining the frequency of its manifestation in the Southwest Indians. All observers concurred that Mongoloids had a low frequency of Carabelli's cusp. Comparisons with the reports of other Indian tribes as well as other races were made. Contrary to what had been implied in the findings of others, Kraus felt that

School of Dentistry Library

Mongoloids may have a higher frequency of the Carabelli's gene than do Whites but that modifying genes appeared to have changed the nature of its expression. Much more definitive population and pedigree studies are needed to confirm his contention.

In 1961 Dahlberg (27) discussed the trend of modern dentitions toward a reduction in size and form of the teeth as well as the retraction of the muzzle. The implication that reduced cusp number was accompanied by reduced size was confirmed; and therefore, changes in morphology affected the dimensions of a tooth, assuming that they were from populations having a common genetic background.

Two years later, Dahlberg (29) published a paper on the analysis of Amerindian dentitions in which he discussed the size of tooth crowns, the frequency of Carabelli's cusp, and the protostylid and the variability of molar cusps and cusp patterns. His findings indicated that only the Australian Aboriginal and the East Greenland Eskimo exceeded the American Indian in tooth size and that Carabelli's cusp played a small part in the function of the Amerindian dentition. He also described the seven gradations of intensity of Carabelli's cusp as well as the five classes for protostylid expressivity. He re-affirmed that the last cusp to be added in the evolution of the maxillary molar was the hypocone which tended toward marked reduction or complete absence. In all

School of Dentistry Library

Amerindian groups the lower first molar was, with few exceptions, a five-cusped tooth.

In the same year, 1963, Dahlberg (28) published another article on dental traits as they applied to identification of disaster victims and of familial relationship problems. He reviewed the dental traits and structures that were common to all men yet emphasized that there were enough different degrees in expression and in frequency of occurrence to distinguish one population from another. These differences permitted strong arguments in statistical probability and thus allowed their use in identification of individuals.

Von Koenigswald (124) in 1964 wrote a fine article on the importance of teeth in the study of early man. He listed ten primitive characteristics of the dentition. They were: (1) presence of wrinkles in the enamel, (2) presence of shovel-shaped incisors, (3) presence of a prominent cingulum, (4) presence of strong canines, (5) long roots, (6) Dryopithecus pattern, (7) taurodontism, (8) presence of a protostylid, (9) predominance of second molar over the third, and (10) predominance of the first bicuspid over the second. He also listed the modern characteristics of the dentition which were: reduction of wrinkles, loss of the Dryopithecus pattern, and presence of Carabelli's cusp.

School of Dentistry Library

Garn (43) in 1966 did a study with monozygotic twins to determine whether the degree of development of Carabelli's trait was independent of crown size, cusp number, groove pattern, and tooth number reduction or whether, like tooth size and cusp number, it was an interacting dental polymorphism. Results of the study showed that Carabelli's trait was genetically independent of the above mentioned factors.

In 1967 Hanihara (54) published his study of the racial characteristics of the dentition in which he introduced the new term, "Mongoloid dental complex." The term referred to a combination of crown characteristics that commonly showed high frequencies in the Mongoloid groups. The following section reveals how the Libben population portrayed this "Mongoloid dental complex."

Findings And Discussion

The Libben Indians were no exception to the rule that Mongoloid populations have a high frequency of shovel-shaped incisors. See Plate I on page 204. Accordingly shovel-shaped incisors had been referred to as the most typical dental character of the American Indian. In the present study over half of the upper incisors had pronounced shovel-shaping, and an additional third was in a semi-pronounced category. No upper incisor in the sample was judged to be negative in the trait. Attrition was definitely a factor in this aspect of the analysis. By

School of Dentistry Library

the wearing of the marginal ridges, the depth of the lingual fossa would be lessened and thereby could result in a less prominent classification of the shovel. See Plate II on page 205. No objective method of compensation could be made to overcome this attritional factor. Table 14 on page 77 shows the results of the present study for both upper and lower incisors. As stated previously, the sample contains 103 skulls, but for the morphology study the 7 infant skulls were not included. The remaining 96 skulls potentially could have 2 upper central and 2 upper lateral incisors, each thereby providing an ideal sample of 192 upper centrals and 192 upper laterals and so on for the lower anteriors. As the table shows, this ideal total for each tooth was accounted for by adding the number of observations and the number of teeth missing, not erupted, etc.

Note that approximately 20 per cent of the anteriors could not be judged for the shovel-shaped trait because of the extreme attrition. Over 60 per cent of the lower centrals and over 50 per cent of the lower laterals demonstrated some degree of shoveling. The double-shovel trait existed when there was a concavity on the labial surface as well as the lingual, and it often accompanied the shovel-shape. Table 15 on page 78 presents the findings of the present survey for this trait.

School of Dentistry Library

TABLE 14

SHOVEL-SHAPED INCISORS

Incisors	Total Observations	Total Positive Observations	Marked	Marked ÷ Total Observations	Semi-Shovel	Semi-Shovel ÷ Total Observations	Trace	Trace ÷ Total Observations	None	None ÷ Total Observations	Attrition And Caries	Missing	Non-erupted	Fractured	Total
Upper Central	96	96	58	60.4%	30	31.3%	8	8.3%	0	0.0%	37	53	6	0	192
Upper Lateral	106	106	58	54.6%	37	35.0%	11	10.4%	0	0.0%	40	34	8	4	192
Lower Central	104	64	16	15.4%	--	--	48	46.2%	40	38.5%	38	41	2	7	192
Lower Lateral	109	56	13	12.0%	--	--	43	39.4%	53	48.6%	51	20	6	6	192

School of Dentistry Library

TABLE 15

DOUBLE-SHOVEL INCISORS

Incisors	Total Observations	Total Positive Observations	Marked	Marked ÷ Total Observations	Trace	Trace ÷ Total Observations	None	None ÷ Total Observations	Attrition And Caries	Missing	Non-erupted	Fractured	Total
Upper Central	111	54	14	12.6%	40	36.0%	57	51.4%	22	53	6	0	192
Upper Lateral	121	35	5	4.1%	30	24.8%	86	71.1%	25	34	8	4	192
Lower Central	111	15	0	0.0%	15	13.5%	96	86.5%	29	41	2	9	192
Lower Lateral	123	11	0	0.0%	11	8.9%	112	91.1%	38	20	6	5	192

School of Dentistry Library

Both upper and lower centrals had a higher frequency of double shoveling than their neighbors, the lateral incisors. Neither the lower centrals nor the lower laterals had the characteristic to a marked degree, and accordingly the vast majority of the lower anteriors did not exhibit the trait at all. Of course, the tendency for these traits was genetically determined and varied from population to population. A comparison of the data of the Libben incisors with other Indian groups, other Mongoloids, and other races provided a complete picture of this shovel-shaped characteristic. As Table 16 on page 80 shows, the Libben results followed the same pattern as Nelson's (93) findings on the Pecos Indians, Goldstein's (46) Texas Indian males, and Hrdlicka's (66) work on United States Indians and Mongolians.

The scoring of the shovel-shaped trait in this analysis was based on consistent, rigid criteria and not subjective judgment. As mentioned before, attrition was also a major factor. The results of many of the studies on other Amerindian populations which are being compared in Table 18 on page 84 were not based on such rigid criteria and were not as affected by attrition. Therefore, their percentage of markedly shoveled incisors was much higher when in essence their sample displayed the trait in the same or lesser degree of expressivity and range of intensity as the Libben sample which is presently being considered.

School of Dentistry Library

TABLE 16

PERCENTAGE DISTRIBUITON OF SHOVEL-SHAPED INCISORS AMONG VARIOUS POPULATIONS AND RACES

Population	Investigator	Central Incisor					Lateral Incisor				
		Number	No Shovel	Trace	Semi	Shovel	Number	No Shovel	Trace	Semi	Shovel
Chinese	Hrdlicka 1920	♂ 208	3.8%	1.0%	12.5%	82.7%	208	3.4%	1.0%	13.5%	68.8%
		♀1,094	7.8%	1.8%	23.5%	66.2%	1,094	9.5%	1.5%	24.0%	56.9%
Mongolian	Hrdlicka 1920	24	--	8.5%	29.0%	62.5%	24	--	--	25.0%	75.0%
Japanese	Hrdlicka 1920	344	4.0%	--	18.0%	77.9%	344	4.0%	--	20.3%	72.7%
Eskimo	Hrdlicka 1920	40	--	15.0%	47.5%	37.5%	37	--	--	43.0%	57.0%
Amer. Negro	Hrdlicka 1920	1,000	56.0%	32.6%	8.0%	3.6%	1,000	47.5%	35.1%	11.1%	3.8%
Amer. White	Hrdlicka 1920	1,000	70.4%	21.8%	5.2%	2.6%	1,000	59.6%	29.9%	7.4%	1.0%
U. S. Indian	Hrdlicka 1920	277	2.0%	9.0%	24.0%	67.0%	300	1.0%	6.0%	17.0%	76.0%
Sioux Indian	Hrdlicka 1931	116	--	1.7%	--	98.3%	--	--	--	--	--
Pecos Indian	Nelson 1938	324	2.2%	8.3%	15.4%	74.1%	338	1.4%	9.2%	17.4%	72.0%
Amer. Chinese	Lasker 1945	269	2.2%	13.0%	66.2%	18.6%	--	--	--	--	--
Texas Indian	Goldstein 1948	♂ 33	--	3.0%	60.6%	36.4%	--	--	--	--	--
		♀ 25	--	4.0%	40.0%	56.0%	--	--	--	--	--
Indian Knoll	Snow 1948	♂ 90	1.1%	4.4%	78.9%	15.6%	--	--	--	--	--
		♀ 124	0.0%	9.7%	70.2%	20.1%	--	--	--	--	--
E. G. Eskimo	Pedersen 1949	116	--	1.7%	14.7%	83.6%	--	--	--	--	--
Pueblos Indian	Dahlberg 1949	21	--	--	19.0%	81.0%	21	--	--	14.0%	81.0%
Indian Knoll	Dahlberg and Snow 1949	30	--	--	16.0%	84.0%	30	--	--	17.0%	80.0%
Pima Indian	Dahlberg 1951	♂ 125	--	1.0%	--	99.0%	119	--	7.0%	--	81.0%
		♀ 101	--	4.0%	--	96.0%	93	1.0%	13.0%	--	81.0%
Aleuts	Moorrees 1957	75	--	2.7%	34.7%	62.6%	70	--	2.9%	31.4%	65.7%
Libben Indians	Fanno 1968	96	--	8.3%	31.3%	60.4%	106	--	10.4%	35.0%	54.6%

School of Dentistry Library

Another subject of intense interest to odontologists had been the occlusal surface patterns of the lower molars. The evolution of a cone through the stages of cusp addition to the Dryopithecoid pattern of a five-cusped tooth with a "Y" formation of the intervening grooves was fascinating. Almost all early man had this arrangement of five cusps on the lower molars. Modern man has a simplification of lower molars both in size and in the cusp-groove architecture. The lower first molars of the Libben Indians retained their ancestral Y5 pattern 92.5 per cent of the time with the conservative +5 pattern receiving the remaining percentage. Table 17 on page 82 shows the statistics for all of the lower molar patterns. The third molar was an extremely variable tooth and could not be trusted too much for pattern. The second molar was relatively conservative but not as stable as the first. The incidence of +5 patterns was much higher than the Y5 in the Amerindian second molar.

Dahlberg (27) felt that the Pimas were the least specialized in the trend toward a reduction in the number of cusps on lower molars because from the available data they seemed to have a higher frequency of +5 patterns in the second (69.0 per cent) and third molars (57.0 per cent) than the other Indian and Eskimo groups available for comparison. As Table 19 on pages 85, 86, and 87 reveals, the Libbenites surpassed the Pimas in frequency of +5 patterns in the second molars (70.6 per cent).

School of Dentistry Library

TABLE 17

LOWER MOLAR CUSP PATTERN

Tooth	Y5	+5	Y4	+4	Total Observations	Attrition And Caries	Missing	Fractured	Non-erupted	Irregular	Total
Lower 1st Molar	37 (92.5%)	3 (7.5%)	0	0	40	86	66	0	0	0	192
Lower 2nd Molar	8 (23.5%)	24 (70.6%)	0	2 (5.9%)	34	80	62	0	16	0	192
Lower 3rd Molar	2 (11.1%)	9 (50.0%)	2 (11.1%)	5 (27.8%)	18	60	62	0	37	15	192

School of Dentistry Library

The occlusal surface pattern of upper molars was also reviewed. The upper molar had 4 occlusal cusps, 1 of which was tending toward reduction or complete loss in some populations. The distolingual cusp or hypocone was the unstable unit; however, this tendency for reduction varied from one population to another. Table 18 on page 84 verifies Dahlberg's contention that the upper first molar was the most stable unit, and the upper third molar was the most variable. Almost 92 per cent of the population had the ancestral cusp pattern of the upper first molar while the remaining 8 per cent had a slight reduction of the hypocone. The upper third molars of these Amerindians did not retain the 4 cusps. Although the sample was small, nearly 90 per cent had 3 cusps or 3 cusps plus a cuspule on the distal border. For comparison with other populations, see Table 19 on pages 85, 86, and 87. It indicates that almost all groups had a high percentage of 4 well-developed cusps on the upper first molars. As Dahlberg (23) stated:

> The East Greenland Eskimo has been reported as having 100 per cent, the Pimas, Pecos, and Texas Indians following closely by 98 per cent or better. In the second molar, however, there is a sharp turn in all groups toward reduction of the hypocone to the 4- and 3 classifications. The 3 and 3- types are much higher in the third molar, and irregular forms are not uncommon.

A relatively recent evolutionary character, the Carabelli's cusp, had been the object of study by this

School of Dentistry Library

TABLE 18

UPPER MOLAR CUSP PATTERN

Tooth	4	4-	3+	3	Total Observations	Attrition And Caries	Missing	Fractured	Non-erupted	Irregular	Total
Upper 1st Molar	64 (91.4%)	6 (8.6%)	0	0	70	76	45	1	0	0	192
Upper 2nd Molar	15 (28.8%)	29 (55.8%)	8 (15.4%)	0	52	83	41	0	16	0	192
Upper 3rd Molar	0	3 (12.6%)	12 (50.0%)	9 (37.4%)	24	64	56	0	36	12	192

School of Dentistry Library

TABLE 19

PERCENTAGE DISTRIBUTION OF MOLAR CUSP PATTERNS
AMONG VARIOUS POPULATIONS

First Molar

Population	Investigator		Lower Molar					Upper Molar				
			Number	Y5	+5	Y4	+4	Number	4	4-	3+	3
Chinese	Hellman	1928	26	100.0%	--	--	--	--	--	--	--	--
Mongol	Hellman	1928	36	100.0%	--	--	--	--	--	--	--	--
Aust. Aborg.	Hellman	1928	18	100.0%	--	--	--	--	--	--	--	--
Afric. Negro	Hellman	1928	97	99.0%	--	1.0%	--	--	--	--	--	--
Pecos Indian	Nelson	1937	332	88.6%	10.8%	--	0.6%	285	98.9%	--	1.1%	--
Texas Indian	Goldstein	1948	160	68.7%	30.6%	0.6%	--	270	99.6%	--	--	--
Alaskan Eskimo	Goldstein	1948	67	89.6%	6.0%	1.5%	3.0%	--	--	--	--	--
E. G. Eskimo	Pedersen	1949	143	95.7%	2.8%	--	1.4%	186	100.0%	--	--	--
Pima Indian	Dahlberg	1949	162	99.4%	0.6%	--	--	322	99.4%	0.6%	--	--
Libben Indian	Fanno	1968	40	92.5%	7.5%	--	--	70	91.4%	8.6%	--	--

School of Dentistry Library

TABLE 19--CONTINUED

PERCENTAGE DISTRIBUTION OF MOLAR CUSP PATTERNS AMONG VARIOUS POPULATIONS

Second Molar

Population	Investigator		Lower Molar					Upper Molar				
			Number	Y5	+5	Y4	+4	Number	4	4-	3+	3
Chinese	Hellman	1928	21	--	19.0%	--	81.0%	--	--	--	--	--
Mongol	Hellman	1928	39	--	31.0%	5.0%	64.0%	--	--	--	--	--
Aust. Aborg.	Hellman	1928	21	5.0%	43.0%	--	52.0%	--	--	--	--	--
Afric. Negro	Hellman	1928	96	17.0%	8.0%	12.0%	63.0%	--	--	--	--	--
Pecos Indian	Nelson	1937	313	8.3%	24.3%	1.3%	66.1%	278	66.1%	--	32.1%	1.4%
Texas Indian	Goldstein	1948	206	1.5%	26.2%	3.4%	68.9%	228	59.3%	--	--	39.4%
Alaskan Eskimo	Goldstein	1948	132	12.8%	63.8%	3.0%	20.5%	--	--	--	--	--
E. G. Eskimo	Pedersen	1949	115	19.0%	42.0%	4.0%	35.5%	181	65.7%	--	--	34.3%
Pima Indian	Dahlberg	1949	89	2.0%	69.0%	1.0%	28.0%	182	11.0%	47.0%	23.0%	19.0%
Libben Indian	Fanno	1968	34	23.5%	70.6%	--	5.9%	52	28.8%	55.8%	15.4%	--

School of Dentistry Library

TABLE 19--CONTINUED

PERCENTAGE DISTRIBUTION OF MOLAR CUSP PATTERNS
AMOND VARIOUS POPULATIONS

Third Molar

Population	Investigator	Lower Molar					Upper Molar				
		Number	Y5	+5	Y4	+4	Number	4	4-	3+	3
Chinese	Hellman 1928	16	--	50.0%	--	50.0%	--	--	--	--	--
Mongol	Hellman 1928	31	--	77.0%	--	23.0%	--	--	--	--	--
Aust. Aborg.	Hellman 1928	23	14.0%	72.0%	--	14.0%	--	--	--	--	--
Afric. Negro	Hellman 1928	88	20.0%	59.0%	3.0%	17.0%	--	--	--	--	--
Pecos Indian	Nelson 1937	249	8.4%	51.0%	4.8%	35.8%	227	33.4%	--	21.2%	40.6%
Texas Indian	Goldstein 1948	91	12.1%	47.3%	6.6%	34.1%	158	36.7%	--	--	53.8%
Alaskan Eskimo	Goldstein 1948	59	20.4%	69.5%	--	10.2%	--	--	--	--	--
E. G. Eskimo	Pedersen 1949	55	15.0%	74.0%	11.0%	--	101	33.3%	--	--	66.6%
Pima Indian	Dahlberg 1949	7	--	57.0%	--	14.0%	25	4.0%	12.0%	8.0%	72.0%
Libben Indian	Fanno 1968	18	11.1%	50.0%	11.1%	27.8%	24	--	12.6%	50.0%	37.4%

School of Dentistry Library

author. It is an accessory cusp found on the lingual surface of upper molars. See Plate III on page 206. Using Dahlberg's (33) method of classification of Carabelli's cusp, the Libben population was surveyed. See Table 20 on page 89. This cusp appeared on the second and third molar, as well as the first, but in lesser frequencies and lesser gradations of intensity. Although it was not indicated in the table, Carabelli's cusp could be unilaterally or bilaterally present. If bilaterally present, it could be in different degrees of expression; for example, a pit on one side and a small delineated cusp on the other. As many other dental characters, Carabelli's cusp was genetically determined and therefore, was subjected to group influences of suppression or aggravation. Dahlberg (23) reported in 1949 that he found 41 per cent occurrence in the first molar and 8 per cent in the second in American Whites. All cusps that he counted were distinct. Pedersen (100) reported that none were found on his East Greenland Eskimo skulls and only 1 on a second molar in 162 living East Greenland Eskimos. Additional data on the occurrence of Carabelli's cusp among various populations was as follows: 0.0 per cent on Labrador Eskimo molars (Dahlberg 23), 8.8 per cent on Pecos Indian molars (Nelson 93), 8.0 per cent on Pima Indian molars (Dahlberg 23), and 24.0 per cent on Indian Knoll molars (Dahlberg 23). The present study revealed that 6.0 per cent of the Libben Indians

School of Dentistry Library

TABLE 20

SCORING OF CARABELLI'S CUSP IN THE LIBBEN INDIANS

Tooth	1 Smooth Surface	2 Furrow	3 Pit	4 "Y"	5 Double Furrow	6 Small Cusp	7 Large Cusp	Total Observations	6 & 7 ÷ Total	Sum 1-7 ÷ Total (Mean Score)	Fracture	Non-erupted	Attrition And Caries	Missing	Total
Upper 1st Molar	33	37	15	3	7	4	2	101	6.0%	2.35	8	0	38	45	192
Upper 2nd Molar	98	9	2	0	0	1	1	111	1.8%	1.22	5	16	19	41	192
Upper 3rd Molar	79	2	2	0	0	0	0	83	0.0%	1.07	2	36	15	56	192

School of Dentistry Library

had distinct Carabelli's cusps on their upper first molars, and 1.8 per cent had prominent cusps on their upper second molars.

Another evolutionally significant character, which occasionally showed up, was an accessory cusp on the anterior portion of the buccal surface of lower molars. According to Dahlberg (23), only 11 isolated instances of protostylids on lower first permanent molars have been reported in the literature other than in his findings on Pima Indians and in 1 skull of Indian Knoll. As Table 21 on page 91 shows, this ancestral trait was present in the Libben population. Although none of the lower first molars examined had a protostylid, it was found in a little over 1 per cent of the lower second molars and in 5.3 per cent of the lower third molars. See Plates IV and V on pages 207 and 208. Various irregularities of the enamel surface anterior to the buccal groove and pit were observed. Some authors believed that such irregularities of the surface at the cusp site were a demonstration that the gene or genes for a protostylid were present but that a suppressor or modifier gene had changed the potential expression of the protostylid gene, resulting in incomplete penetrance of the trait.

Dahlberg (24) examined 80 Pima Indians and found cusps in varying degrees of prominence in 31 per cent. He also reported finding no protostylids in a sample of

School of Dentistry Library

TABLE 21

SCORING OF THE PROTOSTYLID IN THE LIBBEN INDIANS

Tooth	1 Smooth Surface	2 Wrinkle	3 Groove Deviation Or Elevation	4 Small Cusp	5 Large Cusp	Total Observations	4 & 5 ÷ Total	Sum 1-5 ÷ Total (Mean Score)	Fracture	Non-erupted	Attrition And Caries	Missing	Total
Lower 1st Molar	83	11	5	0	0	99	0.0%	1.21	8	0	19	66	192
Lower 2nd Molar	76	10	4	1	0	91	1.1%	1.23	6	16	17	62	192
Lower 3rd Molar	41	22	9	2	2	76	5.3%	1.71	5	37	12	62	192

School of Dentistry Library

129 Indians, and 58 Eskimos in the skeletal material available at the Chicago Natural History Museum. Pedersen (100) found no protostylids on the first molars in 340 East Greenland Eskimos; however, he did find a few on the second and third molars. Moorrees (92) reported no protostylids among the Aleuts. Leigh (81) likewise failed to find any on the lower first molars of 324 modern Eskimo crania; however, an extra buccal cusp was found in four lower third molars. Snow (119) found one protostylid on the lower first molar of an Indian Knoll skull. Dahlberg (24) mentioned as a possible explanation for the high incidence of the protostylid among the Pimas the fact that the population seemed to be a highly inbred group which had occupied a refuge spot of relative isolation for many years.

The frequency of occurrence of other dental morphological characteristics was recorded and summarized in Table 22 on page 93. Five barrel lateral incisors were observed in the collection of 133 teeth. See Plate VI on page 209. Dahlberg (23) found 5 barrel laterals in a sample of 156 laterals from Indian Knoll which was not as frequent as his 8 per cent figure for the Pimas. His examination of 25 living Pecos Indians revealed 4 barrel-shaped lateral incisors. Pedersen (100) in 1949 did not report finding barrel lateral incisors in East Greenland Eskimos.

School of Dentistry Library

TABLE 22

OCCURRENCE OF VARIOUS OTHER MORPHOLOGICAL TRAITS IN THE LIBBEN SAMPLE

Dental Trait	Positive Observations	Negative Observations	Total Observations	Positive ÷ Total	Attrition And Caries	Missing	Non-erupted	Fractured	Irregular	Total
Barrel Lateral	5	128	133	3.8%	16	34	8	1	0	192
Paramolar Cusps	3	367	370	0.8%	3	142	52	9	0	576
Buccal Pits	106	178	284	37.3%	45	190	53	3	1	576
Enamel Extensions Upper	156	214	370	42.2%	2	142	52	8	2	576
Enamel Extensions Lower	135	176	311	43.4%	12	190	53	5	5	576

School of Dentistry Library

Bolk (13) published the original report on the existence of paramolar cusps on the buccal surface of upper molars. He believed that these cusps never occurred in modern populations. In this study, 3 such paramolar cusps on the buccal surface of upper molars were found in 370 observations. One is shown in Plate VII on page 210.

In Nelson's (93) article on Pecos Indians in 1938, he stated that Leigh was one of the first to describe a condition in which a point of enamel extended toward the bifurcation of roots in molars of Mongoloids. Leigh called this "enamel extension" and noted that it was present on approximately 93 per cent of the ancient Polynesian molar teeth. Whites exhibited this feature in only 27 per cent of their molars. Nelson personally examined 1,155 molar teeth of the Pecos Indians and found that 34 per cent exhibited this feature. As presented in Table 22 on page 93, the molars of the Libben Indians had enamel extensions present between 42 and 43 per cent of the time. See Plate VIII on page 211. Upper or lower arch location of the molar made no significant difference in the frequency of occurrence of enamel extensions.

The buccal cusps of lower molars were separated by grooves which terminated on the buccal surface near the cervical third of the crown. This groove, which separated the protoconid from the hypoconid, was very prominent in some populations and frequently terminated in a pit. It

School of Dentistry Library

was rare in White populations, but in Indians and Eskimos, on the other hand, a buccal pit of considerable size was often present and vulnerable to decay. In the Libben people over 37 per cent of the lower molars examined had this defect.

School of Dentistry Library

CHAPTER VI

DENTAL ATTRITION

Review Of Literature

The usual primitive Amerindian population showed a characteristic occlusal attrition of the teeth which existed more times than not to a very marked degree. Such an observation was reported in the dental literature almost a century ago by Sozinskey (120) who examined Indian crania of the Eastern United States. He wrote: "The crown of all the teeth were worn more or less flat, and to such an extent that they were nearly on a line with the gums."

In 1895 Smith (117) reported the disappearance of the cusps from wear in the examination of teeth in 10 Sioux Indians.

Hrdlicka (65) reported wear in the Delaware Indians and classified it as slight, moderate, and advanced.

Hooten (59, 60, 61) in his analysis of the skeletal remains of the Madisonville site, Turner site, and Winthrop site, commented on the presence of wear of the teeth. The number and corresponding percentage were recorded under the headings of pronounced, medium, submedium (slight), and none.

School of Dentistry Library

In 1925 Leigh (80, 81) published a work on the dental pathology of the Eskimo. He defined attrition and established a classification of attrition based on discrete criteria which could be looked for objectively and on which appropriate judgments could be made. He gave the results of his study using his system of classification and summarized by stating that attrition was an accompaniment of senility in which it was fairly generalized. In the same year he reported on the dental pathology of four Indian tribes and related their dental conditions to their diet and environment. Of the four Indian tribes he examined, the Kentucky crania had the severest attrition (diet of maize), followed by the Arikara and Zuni with moderate wear and the Sioux with relatively little wear (diet of meat).

Rihan (106), Bentzen (11), Juett (71), and Fisher (39) described the extreme attrition of precolumbian Indians. A concensus was that this universally present characteristic was caused by sand and gritty material in the food and not necessarily by advanced age. They described the various degrees of wear from enamel facets to pulp exposures and the ensuing pathological consequences.

Sedwick (113) referred to attrition as the most common dental lesion found in the New York Indian crania that he studied. He used Leigh's (80) definition and classification of attrition as a guide.

School of Dentistry Library

Funkhouser (41, 42) in his study of the osteological material from the Norris and Wheeler Basins of the Tennessee River stated that, in general, the teeth were in bad condition and that severe attrition was present in practically all of the teeth of the adults. In some cases the cusps were worn off, and the enamel was lost from the entire surface. He did not classify his results, thereby preventing comparison with the present findings.

Among the Shell Mound Indians of the Pickwick Basin of the Tennessee River, Newman and Snow (96) found tooth wear to be a prominent characteristic in the majority of the crania unearthed. Charles E. Snow contributed the physical anthropology sections to a series of reports by William Webb (125, 126, 127) on various Kentucky mounds. These volumes were published by the University of Kentucky's Department of Anthropology and Archaeology in the early 1940's. Snow analyzed the skeletal remains of the C. and O. mounds, the Riley, Landing, and Crigler mounds, and the Hartman and Grave Creek mounds. All these mounds plus numerous others not listed were part of the Adena Complex within the state of Kentucky and were summarized in one publication, The Adena People by Snow (118).

Without exception the teeth of these various Amerindian populations showed a pronounced degree of wear which occasionally was so deep into the dentin that the

School of Dentistry Library

pulp was exposed. Snow (119) in 1948 reported on the dental phenomena of Indian Knoll and emphasized that most of the teeth present in the jaws of the adults had pronounced wear, particularly of the upper first molars, with pulp exposure and abscess as common sequelae. In none of his many surveys of skeletal remains did Snow make any attempt to classify objectively the degree of attrition, to record the number in the sample, or to record the locations and identities of the teeth which were worn. As a result, comparison with these various Kentucky Indian groups was impossible.

Lewis (83) in 1961 made a study of the Eva site in the Kentucky Basin and stated:

> Shovel-shaped incisor teeth are difficult to observe because of the excessive wear on the teeth of most crania. Tooth wear is excessive in most of the adult Eva crania . . . . Most of the enamel crowns are often worn off, leaving merely the root portions.

Neumann (95) just last year found "pronounced dental attrition" in his study of the paleopathology of the Archaic Modoc Rock Shelter inhabitants of Illinois. Neither Lewis nor Neumann analyzed the attritional factor objectively so that comparative studies with the Libbenites could be made.

Rabkin (103, 104) analyzed the dental conditions among prehistoric Indians of Kentucky (the Indian Knoll collection) and Northern Alabama. In lengthy discussions he refuted the idea that the degree of wear of teeth

School of Dentistry Library

always corresponded to the approximate age of the individual. Variations in diet, tooth structure, genetic makeup, and rate of secondary dentin formation were possible reasons that, among some, wear occurred more rapidly than among others. He contended that excessive and rapid attrition, not caries, lead to the morbid dental picture usually revealed by his cranial material.

In 1947 Pedersen (99) was in East Greenland studying the dentitions of pure Eskimos. He observed severe general attrition of the teeth during maturity of males as well as females. The teeth were often "worn down to the gums"; however, the exposure of the pulp was rare because of the abundant formation of secondary dentin which protected the pulp. The attrition was generalized, even, and slow, but the rate was constant.

In another publication Pedersen (98) compared the degree of attrition of primitive and urbanized Greenland natives. He showed that attrition increased with age but decreased with urbanization. Although the females used the teeth to prepare seal hides for domestic purposes, the male Eskimo displayed a little less wear of his teeth than the female. This refuted a popular explanation of excessive wear of the primitive Eskimo's teeth. Their diets of fresh meat and fat were not particularly abrasive, but diets of dried meat and fish gave an abrasive quality to the food which required strenuous and prolonged chewing.

School of Dentistry Library

Pedersen contended that their heavy attrition was caused in part by such vigorous and prolonged mastication rather than by the abrasive nature of their food.

Mehta (87, 88) in 1966 studied Arkansas Indian skulls and assessed the attrition of 616 teeth in 21 skulls using Broca's classification. A considerable amount of attrition was observed on all teeth. About 75 per cent of the teeth analyzed were either in Stage II or III attrition. Mehta attempted to actually calculate the exact amount of occlusal attrition by measuring the crown heights and comparing them with unabraded teeth of modern man. To determine the amount of proximal wear, he measured the mesiodistal diameters of the teeth and compared them with those of modern man.

To the author's knowledge, this was one of the first attempts to calculate the exact amount of proximal wear and to relate this information to other races, populations, and diets. Largely ignored by previous investigators, proximal attrition could make a meaningful contribution to the total picture of the dentition of the Amerindians. Some workers tried to judge the amount of proximal attrition by measuring the distance of the mesial surface of the crown of the lower first molar to the mental foramen and comparing this distance with that of modern man. Because there were variations in the position of the mental foramen and the comparison involved different

School of Dentistry Library

evolutionary times, the method lacked the accuracy to be of significant value.

In 1954 Begg (9) examined the skulls and mouths of Australian Aborigines and recorded the attrition of their teeth. Begg observed the extreme proximal wear and accordingly developed the theory that, to compensate for this extensive attrition, the teeth in the Stone Age man were greater in mass than the supporting bone. His research revealed that 5.28 millimeters of tooth substance were lost per quadrant prior to third molar eruption. Begg felt that this proximal wear with resulting mesial migration of the teeth was responsible for the low incidence of malocclusion and third molar impaction in Australian Aborigines.

Nelson (93) in his treatise on the Pecos Indians used the four degrees of attrition as a classification and found that the majority of the skulls exhibited Stage II and Stage III of attrition.

Goldstein (45, 46), using his own classification, reported that a major proportion of the Texas Indian crania manifested considerable dental attrition (medium and pronounced). He took note of the fact that there was a lack of extensive secondary dentin formation. The pulp cavity was thus exposed relatively early with a considerable amount of the tooth remaining. This was in contrast with his Eskimo findings in which the teeth were commonly worn to the gum before the pulp cavity was exposed.

School of Dentistry Library

Drennan (36), Sarnas (108), and Jarcho (70) contended that although attrition often caused serious destruction of the teeth it endowed the community with essentially an immunity to dental caries. These men also believed that the smoothing out of the fissures between the cusps may have been a factor in prevention of the disease. As a result, earlier populations exhibited higher degrees of wear but lower incidence of decay. The converse of the situation was true for modern populations. The observation that occlusal caries decreased with age as a direct effect of the attrition increasing with age was made by Sarnas (108). The implications of his observation were contrary to most of the previous work describing the relationship of caries and age.

The following section will demonstrate how the Libben population conformed to the attritional pattern of prehistoric dentitions. Comparisons will be made when possible with the other populations reviewed here.

Findings And Discussion

Occlusal and proximal attrition were prominent characteristics of the teeth of the Libben Indians regardless of age group. Slight to severe degrees were observed from skull to skull and from tooth to tooth within the same dentition. To estimate the actual amount of occlusal attrition, a five point scoring system was used. See legend of Table 23 on page 104 and Plates IX to XIII on

School of Dentistry Library

TABLE 23

INFANTS (7) DECIDUOUS DENTITION

Tooth Type	Total Teeth	Score 0	Score 1	Score 2	Score 3	Score 4	Score 5	Mean Score	S. D.
Incisors	51	18	8	25	0	0	0	1.13	± .91
Cuspids	21	8	3	10	0	0	0	1.09	± .92
Molars	40	2	31	7	0	0	0	1.12	± .45
Total	112	28	42	42	0	0	0	1.12	± .78
Percentage	100.0%	25.0%	37.5%	37.5%	0.0%	0.0%	0.0%		

SCORES:

0 = no attrition

1 = enamel only, wear facets

2 = dentin involved, cusp pattern maintained

3 = total exposure of dentin, inverted cusp pattern

4 = pulp exposed due to attrition

5 = crown worn off, root remaining

School of Dentistry Library

pages 212 to 216. Illustration 5 on page 106 from Hirschfeld (58) shows a diagrammatic cross-section of a lower molar and outlines the progressive changes in occlusal wear.

Table 23 and 24 on pages 104 and 107 show the attritional pattern of the deciduous teeth in infants and children. As could be expected, the primary teeth of the children in the mixed dentition group showed a greater amount of wear than the primary teeth of the infant group. One fourth of the primary teeth in the mixed dentition group had total dentinal exposure with inverted-cusp pattern compared to 0.0 per cent in the infants. Conversely, one fourth of the primary teeth had no evidence of attrition in the infant group compared to 0.0 per cent of no attrition in the children. Pulp exposure and complete crown loss due to attrition were not seen in this deciduous sample. Also noted was the fact that the incisors had a greater rate of wear than the other teeth in these deciduous dentitions. Tables 24 B, 25, 26, and 27 on pages 107, 108, 109, and 110 show the progression of attrition in the permanent dentition of these people. In the mixed dentition, only 2 out of 71 permanent teeth observed were worn sufficiently on the incisal edge to expose the dentin. Over half of the teeth in this group had no signs of wear and therefore, were rated a zero score. In the young adults,

School of Dentistry Library

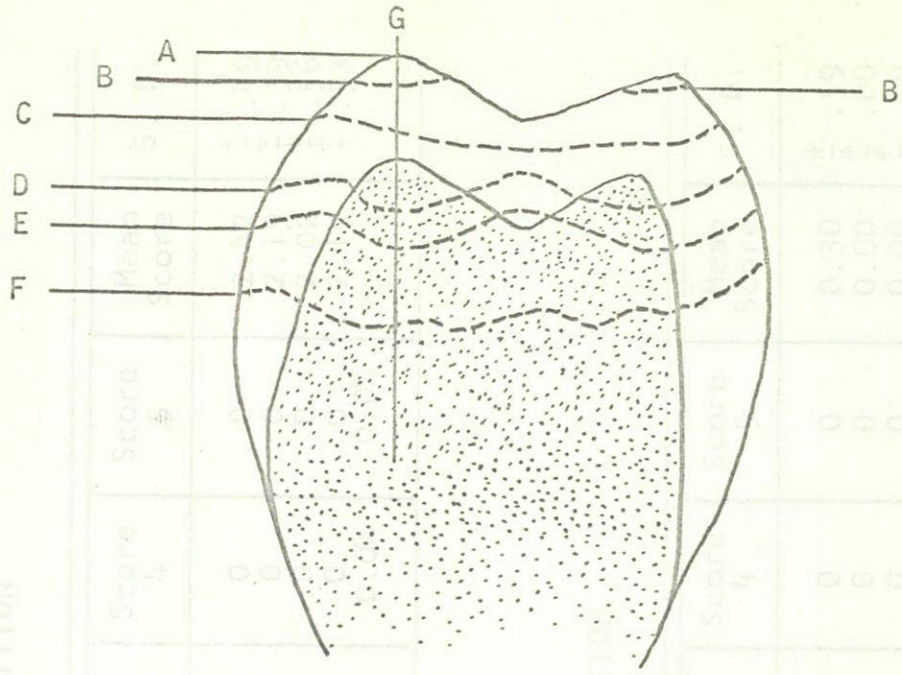


Illustration 5.--A diagram of a diagrammatic cross-section of a lower molar, outlining progressive changes in occlusal wear.

A. Normal convexity of cusp (not worn).

B. (Left) Small facet making its appearance at the beginning of occlusal wear.

B. (Right) Concavity which may appear on the lingual cusp at some stage.

C. Almost complete disappearance of the buccal cusp with a slight exposure of dentin, the lingual cusp being only partly worn away.

D. Buccal cusp completely missing and the concavity now formed in the dentin having its greatest depth opposite the part of the original cusp--line G.

E. Concavity in the dentin of the lingual cusp, the enamel in the center of the occlusal surface being still in evidence.

F. Disappearance of enamel in center of occlusal surface and fusion of the concavities in the dentin.

School of Dentistry Library

TABLE 24 A

CHILDREN (8) DECIDUOUS DENTITION

Tooth Type	Total Teeth	Score 0	Score 1	Score 2	Score 3	Score 4	Score 5	Mean Score	S. D.
Incisors	21	0	0	12	9	0	0	2.42	± .49
Cuspids	26	0	0	21	5	0	0	2.19	± .39
Molars	54	0	8	37	9	0	0	2.02	± .56
Total	101	0	8	70	23	0	0	2.14	± .53
Percentage	100.0%	0.0%	7.9%	69.3%	22.8%	0.0%	0.0%		

TABLE 24 B

CHILDREN (8) PERMANENT DENTITION

Tooth Type	Total Teeth	Score 0	Score 1	Score 2	Score 3	Score 4	Score 5	Mean Score	S. D.
Incisors	30	23	5	2	0	0	0	0.30	± .59
Cuspids	4	4	0	0	0	0	0	0.00	± .00
Premolars	5	5	0	0	0	0	0	0.00	± .00
Molars	32	9	23	0	0	0	0	0.71	± .45
Total	71	41	28	2	0	0	0	0.45	± .55
Percentage	100.0%	57.7%	39.4%	2.8%	0.0%	0.0%	0.0%		

School of Dentistry Library

TABLE 25

YOUNG ADULTS (10) PERMANENT DENTITION

Tooth Type	Total Teeth	Score 0	Score 1	Score 2	Score 3	Score 4	Score 5	Mean Score	S. D.
Incisors	63	1	23	39	0	0	0	1.60	± .51
Cuspids	38	1	17	20	0	0	0	1.50	± .55
Premolars	76	5	60	11	0	0	0	1.07	± .45
Molars	81	9	51	21	0	0	0	1.14	± .59
Total	258	16	151	91	0	0	0	1.29	± .41
Percentage	100.0%	6.2%	58.5%	35.3%	0.0%	0.0%	0.0%		

School of Dentistry Library

TABLE 26

ADULTS (59) PERMANENT DENTITION

Tooth Type	Total Teeth	Score 0	Score 1	Score 2	Score 3	Score 4	Score 5	Mean Score	S. D.
Incisors	410	0	16	164	217	6	7	2.57	± .67
Cuspids	216	2	3	157	49	3	2	2.25	± .59
Premolars	415	0	105	263	44	0	3	1.87	± .71
Molars	499	6	220	201	72	0	0	1.67	± .73
Total	1,540	8	344	785	383	9	12	2.05	± .62
Percentage	100.0%	0.5%	22.3%	51.0%	24.9%	0.6%	0.8%		

School of Dentistry Library

TABLE 27

SENILES (19) PERMANENT DENTITION

Tooth Type	Total Teeth	Score 0	Score 1	Score 2	Score 3	Score 4	Score 5	Mean Score	S. D.
Incisors	89	0	0	6	60	8	15	3.36	± .83
Cuspids	53	0	0	8	41	1	3	2.98	± .62
Premolars	92	0	4	45	39	1	3	2.50	± .75
Molars	82	0	25	24	30	2	1	2.14	± .91
Total	316	0	29	83	170	12	22	2.73	± .93
Percentage	100.0%	0.0%	9.2%	26.3%	53.8%	3.8%	7.0%		

School of Dentistry Library

however, the destructive tendency could be perceived. Fifty per cent of the 258 teeth in the group had wear facets in the enamel, and an additional 35 per cent had dentinal involvement in the cuspal and incisal areas although the cusp pattern was maintained. As in the deciduous dentition, there was a marked tendency for the rate of wear of the incisors to be higher than that of the molars. Over half of the incisors and only a fourth of the molars in the young adult group had exposed dentin. Eruption time, tooth form, occlusion (end-to-end bite), and enamel thickness were important factors and were potential explanations for the higher rate of incisor wear. The trend for heavy anterior function was definitely present and could be meaningful. Table 26 on page 109 of the adult group continues this story of attritional destruction. Note that about 25 per cent of the teeth had total dentinal exposure with a corresponding inverted-cusp pattern in posteriors. Accordingly, over 75 per cent of all teeth in the adults had sufficient wear to result in exposure of dentin. The tendency for heavy anterior function was even more obvious, with over 50 per cent of the incisors having total dentinal exposure compared to 26 per cent of the molars. The cuspid rate of wear was similar to that of the molars (25 per cent with third degree wear) while the premolar rate was much less (10.5 per cent with third degree wear). This was

School of Dentistry Library

understandable considering the normal eruption pattern. Table 27 on page 110 shows the final phase of the destructive process. The senile group had almost 11 per cent of their teeth lacking the crown or having an exposed pulp due to attrition. Periapical abscesses were frequent sequelae of such severe attrition. See Plate XIV on page 217. Complete loss of the occlusal enamel resulting in total dentinal exposure had risen from 25 per cent of the teeth observed in the adults to 54 per cent in the seniles. See Plate XV on page 218. These findings on the permanent teeth are summarized in Table 28 on page 113.

A classic frequency distribution could be computed from the totaled data. The heavy anterior attritional component was especially evident when compared to the other tooth types. Fourth degree and fifth degree attrition were the exposure of the pulp and the complete wearing away of the tooth respectively. The incisors had the greatest percentage in these two categories than all the other tooth types combined. The attritional scores are compared with the various age groups in Table 29 on page 114.

It could be determined from the mean scores that in the Libben population as in others reported in the literature the degree of attrition of any given tooth was directly proportional to the length of time the

School of Dentistry Library

TABLE 28

ATTRITION BY TOOTH TYPE (ADULTS - 88)

Tooth Type	Total Teeth	Score 0	Score 1	Score 2	Score 3	Score 4	Score 5	Mean Score	S. D.
Incisors	562	1	39	209	277	14	22	2.58	± .80
%		0.2%	6.9%	37.1%	49.2%	2.5%	3.9%		
Cuspids	307	3	20	185	90	4	5	2.28	± .72
%		1.0%	6.5%	60.2%	29.3%	1.3%	1.6%		
Premolars	583	5	169	319	83	1	6	1.86	± .74
%		0.8%	29.0%	54.8%	14.4%	0.1%	1.0%		
Molars	662	15	296	246	102	2	1	1.67	± .78
%		2.2%	44.7%	37.1%	15.4%	0.3%	0.1%		
Total	2,114	24	524	959	552	21	34	2.05	± .86
%		1.1%	24.7%	45.3%	26.1%	1.0%	1.6%		

School of Dentistry Library

TABLE 29

ATTRITIONAL SCORE vs. AGE GROUP

Age Group	Total Number Of Skulls	Mean Number Teeth/Skull	Attritional Mean Score	S. D.
Infants	7	16.0	1.12	± .78
Children - Deciduous	8	12.6	2.14	± .53
Children - Permanent	8	9.0	.45	± .55
Young Adults	10	25.8	1.29	± .41
Adults	59	26.1	2.05	± .62
Seniles	19	17.0	2.73	± .93
Total Adults	88	23.0	2.05	± .64

School of Dentistry Library

tooth had been in function. This usually was directly related to the age of the individual. Diet, vigor of mastication, and culture could affect this otherwise obvious correlation. The proportionality was true for both deciduous and permanent dentitions. Although objective studies in occlusal attrition were limited and varied in criteria for classification, technique of obtaining data, and size and type of sample, comparison was made with other populations. See Table 30 on page 116. The Libben Indians followed the trend of most of the other groups compared. Stage II and III (Medium and Pronounced) wear was the classification appropriate for the majority of teeth in the majority of the populations listed in Table 30 on page 116. The Delaware, Pecos, and Texas Indians had a greater percentage of their teeth in Stage III and IV than the other groups compared including the Libbenites.

Proximal attrition was also considered in the present analysis. Table 31 on page 117 reveals the results of this investigator's objective method of determining the amount of proximal attrition. A general scan of the data would yield the impression that the proximal attrition was fairly uniform in the posterior segments between teeth of similar size. Trends for upper proximal wear to be greater in amount than for lower contact areas and for premolars to have slightly more wear than molars

School of Dentistry Library

TABLE 30

PERCENTAGE DISTRIBUTION OF OCCLUSAL ATTRITION

Population	Author		Total Skulls	None	Stage			
					I	II	III	IV
					Slight	Medium	Pro-nounced	Very Pro-nounced
Delaware Indians	Hrdlicka	1916	22	--	22.7%	26.3%		41.0%
Madisonville Indians	Hooten	1920	65	6.1%	60.0%	23.0%	10.9%	--
Turner Indians	Hooten	1922	30	3.3%	16.6%	36.6%	43.3%	--
Greenland Eskimos	Leigh	1925	324	8.3%	30.8%	27.7%	25.0%	8.2%
Pecos Indians	Rihan	1932	289	2.0%	--	--	97.2%	--
Alabama Indians	Newman & Snow	1942	♂ 50	6.0%	20.0%	26.0%	26.0%	22.0%
			♀ 33	18.1%	12.1%	27.2%	36.3%	6.0%
Texas Indians	Goldstein	1948	♂ 196	--	5.1%	24.5%	35.2%	35.2%
			♀ 174	--	10.3%	36.2%	29.9%	23.6%
Indian Knoll	Snow	1948	♂ 264	--	4.4%	21.8%	41.3%	32.5%
			♀ 189	--	9.2%	24.7%	40.8%	25.3%
Arkansas Indians	Mehta	1966	21	--	25.7%	61.9%	11.9%	.7%
Libben Indians	Fanno	1968	88	1.1%	24.7%	45.3%	26.1%	2.6%

School of Dentistry Library

TABLE 31

PROXIMAL ATTRITION

Location	Number Of Observations	Mean Attrition
7 - 6 |	47	.470 mm.
| 6 - 7	45	.460 mm.
Upper Molars	92	.465 mm.
7 - 6 |	42	.440 mm.
| 6 - 7	39	.430 mm.
Lower Molars	81	.435 mm.
5 - 4 |	54	.470 mm.
| 4 - 5	49	.470 mm.
Upper Premolars	103	.470 mm.
5 - 4 |	52	.450 mm.
| 4 - 5	55	.460 mm.
Lower Premolars	107	.455 mm.
Total Molars	173	.450 mm.
Total Premolars	210	.468 mm.
Total Uppers	195	.468 mm.
Total Lowers	188	.445 mm.

School of Dentistry Library

could not be considered significant. The reasons were: (1) because of the anatomy of the contacting surfaces, (2) because of the eruption times of the teeth involved, and (3) because of the small difference in the data. These three factors must be carefully evaluated before conclusive statements about such trends of proximal attrition could be made. Since this was the first time the method was tried, the significance of small differences in the data was not known. Applying the technique to other skeletal collections and comparing the findings should yield some judgment on the use and limitations of this proposed method of measuring proximal attrition.

School of Dentistry Library

CHAPTER VII

DENTAL PATHOLOGY AND ANOMALIES

Review Of Literature

Oral disease was very prevalent in the Libben Indians. Caries, periapical abscesses, enamel hypoplasia, and erosion were the major dental maladies which afflicted the population. In this chapter oral anomalies such as congenital absence or impaction of teeth, malformation of teeth, and bony overgrowths will also be discussed.

In 1883 Barrett (7) examined the teeth of certain prehistoric American races which were part of the Peabody Museum collection. Although his description of his observations was made 85 years ago, it could apply to the present sample as well.

> In the jaws of all the people whose skulls I examined, I found traces of all the diseases known to modern dentistry. There was caries of the most formidable character, black, white, and brown. There were the marks of abscesses which devastated great regions of tissue. There was necrosis which had caused the loss of great sloughs of bone . . . . There were great masses of tartar enveloping all the teeth in the jaw. There were indications of all kinds of inflammation of soft tissues. There were exostoses and hypertrophies, absorptions and malformations, denudations and abrasions, exfoliations and irregularities.

Hrdlicka (62) in 1909 while studying the dentitions of the Louisiana and Arkansas Indians made the observation

School of Dentistry Library

that the first teeth to be affected by caries, both in frequency and time, were the molars, especially those of the lower jaw. In his work on the Delaware Indians, Hrdlicka (65) reported that females had a higher rate of decay than males and reiterated his previous findings that the first teeth lost or decayed were the lower molars.

Hooten (59, 60, 61), Fisher (39), Funkhouser (41, 42), and Newman and Snow (96) in their work on various Indian sites consistently mentioned that caries were common and present in almost every conceivable size, shape, and condition, that supernumeraries were occasionally seen, that third molars were reduced in size, impacted, or missing, and that abscesses were numerous and affected incisors as well as molars. None of these men revealed exact data as to the frequency, location, and extent of these pathologies and/or anomalies. The mere mention of their presence was insufficient to make comparative studies with the Libben population findings. Similarly Snow in reports by Webb (125, 126, 127) and in his own publications (118, 119) casually referred to the presence of decay, supernumeraries, abscesses, and exostoses in Adena and Indian Knoll material but specific, useful information had not been provided.

In 1925 Leigh (80) compared the incidence of caries and periapical lesions of the Algonquins, Sioux, Arikara, and Zuni Indians. He described the two most susceptible

School of Dentistry Library

areas of their teeth as: (1) sulci or pits on the occlusal surface and buccal pit of lower molars, and (2) exposed cementum at the cervix following atrophy of the gums. The latter was named senile caries because exposure of the cervical cementum was subsequent to marked attrition, loss of contact, or loss of teeth and because there were no cases in children or young adults. The incidence of caries increased with age on this highly susceptible area. The lower second molar was the most often affected. The incidence of periapical lesions seemed to parallel that of caries when comparison of degree of severity was made among the four tribes. Developmental hypoplasia, supernumerary teeth, palatal tori, and temporomandibular joint arthritis were infrequently present in his samples.

Leigh (81) also studied the dental pathology of the Eskimo. Only 4 carious lesions were found in 395 crania. Obviously resistance to dental caries was greater in the Eskimo than in any tribe of American Aborigines. However, almost 19 per cent of the Eskimo crania had alveolar abscesses as a result of attritional pulp exposure, tooth fracture, and periodontoclasia.

Bentzen (11) in 1929 found that the Mimbres people were not immune from caries. The outstanding feature of the caries was that 80 per cent of it occurred at the cervical line. The most frequent location was on the distocervical surface of upper molars.

School of Dentistry Library

Bodecker (12) in 1930 wrote an article discussing the defects in the enamel of teeth of ancient American Indians. Although the theory had been accepted that enamel fissures or flaws and pits in the protective covering of teeth were of modern origin, Bodecker discovered that the ancient Amerindians had the same type of defects. Yet it did not predispose them to caries. He gave possible reasons why the teeth of the Indians did not decay in spite of the defective enamel fissures and buccal pits. They were: (1) energetic mastication of coarse, gritty food, (2) natural, unrefined low-carbohydrate diets, and (3) normal health which maintained resistance. He believed that the formula for rapid and excessive attrition was thorough mastication of gritty food which yielded early obliteration of enamel fissures within three to five years after eruption of the tooth. Therefore, decay was most rampant and the tooth most susceptible during the first three post-eruption years.

Sedwick (113), Leigh (82), Rabkin (104), Webb (128), Goldstein (46), Mehta (88), and Sarnas (108) recorded the percentage of the skulls with carious teeth in their samples of various Indian tribes. Occlusal and buccal pits were mentioned most frequently for the younger segments of the population, but cervical caries after gum recession was the rule for the older members of the groups. Supernumeraries and congenital absence were

School of Dentistry Library

reported mostly involving upper anteriors and third molars respectively. Enamel hypoplasia was mentioned in each of the above studies. Pits of various sizes were observed along with deep bands or grooves of poorly developed enamel and dentin across the labial and buccal surfaces of the teeth. Both Leigh and Webb theorized that these areas of hypoplasia were due to either a congenital defect or more likely to a severe nutritional disturbance or illness early in the life of the individual.

These primitive tribes were generally considered to be superior to modern civilized peoples in their dental equipment and dental health. The possibility that the superiority might have been in chemical differences in tooth composition or that their primitive diet might have produced a different sort of calcified product was explored.

French (40) and others made calcium, phosphorus, and carbon dioxide determinations on all the dentin and all the enamel of 32 precolumbian teeth. It was revealed that as for modern teeth there was a remarkable constancy of composition of enamel and dentin. Especially for calcium and phosphate contents, precolumbian teeth and modern teeth have nearly identical chemical composition; in fact, the calcium and phosphorus values were near the theoretical for hydroxyapatite. Therefore, the superior dental health of precolumbian Indians could not be attributed

School of Dentistry Library

to major differences in the principal inorganic constituents.

Congenital absence of third molars and upper lateral incisors had been the subject of investigation by many. Hellman (56), Pedersen (100), Dahlberg (24), Goldstein (46), and Brothwell (15) have published their findings in the distribution of missing third molars and lateral incisors in the various populations of the world. Missing teeth are a genetic trait which was thought by some to be an abnormality and by others to be a variation within the range of normality. Inheritance and occurrence of certain types of illness or dietary deficiencies at certain periods in the development of a tooth had been proposed as possible etiological factors. However, most geneticists seemed to agree that anodontia and oligodontia were caused by a detrimental mutant gene and that individually missing teeth were phenotypic expressions of such genes.

The occurrence of supernumerary teeth was investigated and reported by many dentists and anthropologists including Klatsky (74), Tratman (122), Stafne (121), Leigh (82), Pedersen (100), and others. Klatsky (74) in 1956 made an extensive study of the incidence of 6 anomalies of the teeth and jaws, one of which was supernumerary teeth. In Klatsky's report he stated that supernumerary teeth occurred in the lower primates (1.3

School of Dentistry Library

per cent) at a much higher percentage than most investigators found in humans, even exceeding the highest estimate in the human given by Stafne (121) in 1932 on White Americans. He examined 48,550 patients with the use of x-ray and found an incidence of 0.9 per cent. It was felt that supernumeraries were also caused by mutant genes, hence their hereditary distribution within a population.

Torus palatinus is a bony growth along the median suture of the hard palate, and torus mandibularus is a bony growth on the lingual surface of the lower jaws in the premolar region. Both were considered by some to be an abnormality of a hereditary nature.

Ju Kang Woo (134) in 1950 made a review of tori and refuted the theories that they were caused by presence of palatine glands, by the pressure of mastication, by the recurrence of primitive ancestral characters, or by the irritation of the mucous membrane of the hard palate. He contended that a torus was a normal anatomical variation, had no connection with pathology, was specifically a hominid character determined by heredity, and varied in size and form. He also found that a torus grew with maturity and ceased with age, was slightly more prevalent in females than males, and had the greatest frequency of occurrence in Mongoloids (Eskimos, Amerindians) than in any other race.

Library of Dentistry

Another area of study had been the reduction in the size of some teeth. The formation and development of a tooth are controlled by a gene complex. The pattern, size, and shape of each tooth are regulated by different genes and gene modifiers. Phenotypic change in the size and form of a tooth is due to an alteration in one or more of the gene modifiers as distinguished from those genes which are actually responsible for the formation of a tooth. Dahlberg (23) contended that some teeth were stable and others variable. The lower central incisors, upper lateral incisors, the second premolars, and second and third molars were the unstable teeth. This variability factor explained why they were more susceptible to reduction than others and often developed in reduced size and abnormal shape. Such reduction and change in shape had been reported by many of the previously mentioned authors in their surveys of various Amerindian populations.

Findings And Discussion

Coronal and radicular caries were the two main types found in an analysis of this sample. In the young age groups caries occurred most frequently on the occlusal surface where it had invaded the pits, fissures, and enamel defects. Pits on the buccal surface of lower molars were also attacked. See Plates XVI to XVIII on pages 219 to 221. Smooth surface caries occurred very

School of Dentistry Library

infrequently in the young segment of the population. As adulthood was reached and recession of the gingiva began thereby exposing the cervical cementum, another type of caries became prevalent and in some cases rampant. Radicular caries was observed on all exposed root surfaces, but it occurred mainly on mesial and distal root surfaces of the posterior teeth. See Plates XIX to XXIII on pages 222 to 226. Heavy occlusal and proximal attrition and periodontal bone destruction were common companions of this radicular caries. Because of the time of occurrence, location on the tooth, and associated destructive lesions, radicular caries seemed to have a certain fortitude which rapidly led to the loss of the tooth via pulp exposure and periapical abscess. See Plate XXIV on page 227. Table 32 on page 128 is a summary of a complete breakdown of caries location and frequency versus age. For more detailed information, the reader is referred to the Appendix on page

Root caries occurred in the deciduous dentition as well as in the permanent. The table reveals that the distocervical was the most frequent carious surface for the entire population. This finding was the same as Bentzen (11) had reported for the Mimbres. The occlusal surfaces followed by the buccal surfaces were the most vulnerable areas for attack by coronal caries. As previously mentioned, these two surfaces had the enamel pits

Library of Dentistry

TABLE 32

CARIES LOCATION AND FREQUENCY vs. AGE GROUP

Age Group	Number of Teeth	Mesial Root	Distal Root	Buccal Root	Lingual Root	Root	Radicular Total	Mesial	Distal	Buccal	Lingual	Occlusal	Coronal Total	Pulp Exposed Roots Remain	Total
Infant	132	--	--	--	--	--	--	--	--	--	--	1	1	--	1
Children (D)	155	--	5	4	--	1	10	4	4	2	--	6	16	--	26
Children (P)	38	--	--	--	--	--	--	--	--	2	--	2	4	--	4
Children (T)	193	--	5	4	--	1	10	4	4	4	--	8	20	--	30
Young Adult	299	1	2	--	--	--	3	2	1	6	3	20	32	--	35
Adult	1,609	91	109	24	3	13	240	17	15	26	6	122	186	48	474
Senile	347	45	68	11	1	4	129	3	4	3	2	13	25	20	174
Total	2,580	137	184	39	4	18	382	26	24	39	11	164	264	68	714

School of Dentistry Library

and fissures and other aberrations which invited food retention and its destructive consequences. For both the adult and senile groups, radicular caries was significantly more frequent than all other types of coronal caries. Table 33 on page 130 relates the number of tooth surfaces present in each age group to the number of surfaces that were carious.

Percentage of radicular caries increased with age while the percentage of coronal caries decreased. Radicular caries was present in 7.4 per cent of the surfaces in the senile age group. This was its highest frequency which was more than three times the highest percentage of surfaces affected by coronal caries. Almost 50 per cent of the lesions had their initiation at the cervix on the proximal surfaces. This was similar to the results of Leigh (82) in his study of the California Aborigines in which the proximocervical cavities predominated by more than 50 per cent. Table 34 on page 131 continues this description by showing the distribution of caries in individual teeth of both the upper and lower jaws.

The lower central incisors had the lowest caries rate followed by the upper centrals and the upper and lower laterals. As could be expected, the molars had the greatest frequency of decay. More than 50 per cent of the lower second molars were carious which was more than any other tooth in the sample. This was similar to

School of Dentistry Library

TABLE 33

PERCENTAGE OF CARIOUS SURFACES vs. AGE GROUP

Age Group	Number Of Teeth	Number Of Surfaces	Radicular Total	Percentage	Coronal Total	Percentage	Pulp Exposed Roots Remain	Total
Infant (D)	132	660	0	0.0%	1	0.2%	0	1
Children (D)	155	775	10	1.3%	16	2.1%	0	26
Children (P)	38	190	0	0.0%	4	2.1%	0	4
Children (T)	193	965	10	1.0%	20	2.1%	0	30
Young Adult	299	1,495	3	0.2%	32	2.1%	0	35
Adult	1,609	8,045	240	3.0%	186	2.3%	48	474
Senile	347	1,735	129	7.4%	25	1.4%	20	174
Total	2,580	12,900	382	3.0%	264	2.0%	68	714

School of Dentistry Library

TABLE 34

DISTRIBUTION OF CARIOUS TEETH BY TOOTH TYPE

Tooth Type	Number Of Teeth Observed	Infant	Children		Young Adult	Adult	Senile	Total Number Of Teeth Carious	Percentage
Centrals	158	0		0	0	9	4	13	8.2%
Laterals	175	0	(1)		0	17	3	21	12.0%
Cuspids	183	0	(4)		0	27	8	39	21.3%
1st Bicuspids	175	0	(7)		0	19	10	36	20.6%
2nd Bicuspids	186	0	(4)		0	30	12	46	24.7%
1st Molars	151	0		1	7	41	6	55	36.4%
2nd Molars	144	0		0	3	43	12	58	40.3%
3rd Molars	122	0		0	0	36	4	40	32.8%
Upper Total	1,294	0	(16)	1	10	222	59	308	23.8%
Centrals	166	0		0	0	7	3	10	6.0%
Laterals	188	0		0	0	9	8	17	9.0%
Cuspids	190	0		0	0	7	8	15	7.9%
1st Bicuspids	192	0	(5)		1	12	14	32	16.7%
2nd Bicuspids	178	(1)	(2)		1	19	10	33	18.5%
1st Molars	132	0		3	10	38	8	59	44.7%
2nd Molars	121	0		0	8	43	10	61	50.4%
3rd Molars	119	0		0	0	34	8	42	35.3%
Lower Total	1,286	(1)	(7)	3	20	169	69	269	20.9%
Grand Total	2,580	(1)	(23)	4	30	391	128	577	22.4%

School of Dentistry Library

the findings of Leigh (80) in 1925. The lower first, second, and third molars had a greater rate of decay than their upper counterparts. Upper cuspids had almost three times the amount of caries as lower cuspids. Caries prevalence in the Libben population as assessed by percentage of teeth present which were carious appeared to increase with age of the individual until senility was reached. Actually, in advanced age premortem tooth loss was high, and thus it was evident that the true rate for seniles was necessarily underestimated. Unlike contemporary populations the children and young adults had little decay. The adults experienced thirteen times the dental caries as the juveniles; this was a significant factor which was unique among primitive Amerindians previously studied. Of the 2,580 teeth in the sample, almost 23 per cent (577 teeth) were carious. This was very high compared to other Indian populations.

Mehta (88) in his study of Arkansas Indians found 4.5 per cent of the teeth to be carious. Webb (128) in his study of the Louisiana Indians and Bentzen (11) in his study of the Mimbres found 12 per cent and 8 per cent of the teeth to be carious respectively. Table 35 on page 133 shows the distribution of caries by surfaces both for the upper and lower jaws. Much of the factual information and interrelationships of the findings was verified in this table. An average of 5.5 per cent of

TABLE 35

DISTRIBUTION OF CARIOUS SURFACES BY TOOTH TYPE

Tooth Type	Teeth Observed	Infant	Children	Young Adult	Adult	Senile	Total	Total Surfaces Carious	Per-centage
Centrals	158	0	0	0	13	4	17	790	2.2%
Laterals	175	0	(1)	0	18	3	22	875	2.5%
Cuspids	183	0	(4)	0	32	13	49	915	5.4%
1st Bicuspids	175	0	(8)	0	23	11	42	875	4.8%
2nd Bicuspids	186	0	(4)	0	35	13	52	930	5.6%
1st Molars	151	0	1	7	58	10	76	755	10.1%
2nd Molars	144	0	0	3	56	15	74	720	10.3%
3rd Molars	122	0	0	0	39	4	43	610	7.0%
Upper Total	1,294	0	(17) 1	10	274	73	375	6,470	5.8%
Centrals	166	0	0	0	7	4	11	830	1.3%
Laterals	188	0	0	0	9	9	18	940	1.9%
Cuspids	190	0	0	0	7	11	18	950	1.9%
1st Bicuspids	192	0	(7)	1	14	17	39	960	4.1%
2nd Bicuspids	178	(1)	(2)	1	20	13	37	890	4.2%
1st Molars	132	0	3	14	48	17	82	660	12.4%
2nd Molars	121	0	0	9	55	15	79	605	13.1%
3rd Molars	119	0	0	0	40	15	55	595	9.2%
Lower Total	1,286	(1) 0	(9) 3	25	200	101	339	6,430	5.3%
Grand Total	2,580	(1) 0	(26) 4	35	474	174	714	12,900	5.5%

School of Dentistry Library

the tooth surfaces in each individual of the sample was carious. There were more upper tooth surfaces decayed than lower. This was considered a valid observation because the number of upper teeth present in the sample (1,294) was essentially equal to the number of lower teeth (1,286). Caries affected 683 surfaces of 549 teeth in the 88 adults which meant that 1.25 surfaces were involved per carious tooth.

In order to summarize all the results of the caries aspect of the analysis, Table 36 on pages 135 and 136 was compiled. The number of carious teeth and surfaces was related to the ideal number of teeth and surfaces of each group as well as the number of teeth and surfaces actually present. The average number of carious teeth and surfaces per skull of each group was also computed. The mean percentage of carious teeth was calculated for each age group by dividing the sum of the number of carious teeth present and the number of premortem tooth loss by the sum of the number of teeth present and the number of postmortem tooth loss. Two assumptions were made in the computation of this mean percentage: (1) that every tooth lost premortem was carious, and (2) that every tooth lost postmortem was not. The mean percentage of carious teeth demonstrated the rapidly decreasing dental health of the individual Libbenite as he grew older. The mean of 33 per cent for adults was more than triple that for the young adults and less than

...of Dentistry Library

TABLE 36

SUMMARY OF CARIES ASPECT OF THE LIBBEN INDIANS

Age Group	Number of Skulls	Ideal Number of Teeth	Number of Teeth Present	Present ÷ Ideal	Number of Carious Teeth	Carious ÷ Present	Number of Carious Teeth Per Skull
Infant	7	140	132	94.3%	(1)	0.8%	.14
Children	8	207	193	93.2%	$(\frac{23}{4})$	14.0%	3.40
Young Adult	10	320	299	93.4%	30	10.0%	3.00
Adult	59	1,888	1,609	85.2%	391	24.3%	6.60
Senile	19	608	347	57.1%	128	36.9%	6.70
Total	103	3,163	2,580	81.6%	577	22.4%	5.60

TABLE 36--Continued

SUMMARY OF CARIES ASPECT OF THE LIBBEN INDIANS

Ideal Number of Surfaces	Number of Surfaces Present	Present ÷ Ideal	Number of Carious Surfaces	Carious ÷ Present	Number of Carious Surfaces Per Skull	Number of Premortem Loss	Number of Postmortem Loss	Mean Percentage of Carious Teeth Per Group
700	660	94.3%	(1)	0.2%	0.14	0	8	1.0%
1,035	965	93.2%	(26) 4	3.1%	3.80	(5)	8	16.0%
1,600	1,495	93.4%	35	2.0%	3.50	1	20	10.0%
9,440	8,045	85.2%	474	5.8%	8.00	173	107	33.0%
3,040	1,735	57.1%	174	10.0%	9.20	194	67	78.0%
15,815	12,900	81.6%	714	5.5%	6.90	373	210	34.0%

half that for the seniles. This amplified the finding that the percentage of teeth present that were decayed increased by more than 50 per cent from adulthood to senility. Of course, this was simultaneous with the increase in number of carious surfaces by 100 per cent from adulthood to senility. This occurred in spite of the fact that the premortem loss of teeth had increased. Therefore, the results of the present study were at best an underestimation of the true caries picture of the adults and seniles in this population. To clarify the caries picture in these adult and senile age groups, the following explanation is given. There were 59 adult skulls which had 173 teeth lost premortem compared to 19 senile skulls which had 194 teeth lost premortem. This was why the average number of carious teeth per skull between the two groups was about the same while the average number of carious surfaces per skull between the adults and seniles had increased significantly.

It would have been an understatement to say that caries plagued the Libben Indians. Only 3.4 per cent of the people with permanent dentitions were caries free, and conversely 96.6 per cent had one or more cavities. This was extremely high among the American Aboriginal populations. By referring to Table 37 on page 138, which reviews the percentage distribution of caries and alveolar abscesses of various Indian populations, which had been studied during the past 50 years, it can be seen that the Libben Indians

...Dental... Library

TABLE 37

POPULATION COMPARISON OF THE FREQUENCY OF CARIES AND ABSCESSES

Population	Investigator		Percentage Of Population With Caries	Percentage Of Population with Alveolar Abscesses
Madisonville Indians	Hooten	1920	♂ 22.0%	44.0%
			♀ 63.0%	31.0%
Turner Indians	Hooten	1922	20.6%	24.1%
Kentucky Indians	Leigh	1925	30.0%	48.0%
Sioux Indians	Leigh	1925	11.0%	16.0%
Arikara Indians	Leigh	1925	28.0%	35.0%
Zuni Indians	Leigh	1925	75.0%	52.0%
Eskimo	Leigh	1925	1.0%	18.8%
Pecos Indians	Bodecker	1930	3.0%	--
Wisconsin Indians	Fisher	1931	24.0%	--
Pecos Indians	Rihan	1932	47.9%	26.0%
New York Indians	Sedwick	1936	90.0%	41.6%
Pecos Indians	Nelson	1938	48.0%	--
Pickwick Indians	Newman & Snow	1942	44.0%	39.0%
Kentucky Indians	Rabkin	1943	21.0%	--
Louisiana Indians	Webb	1944	70.0%	20.0%
East Greenland Eskimo	Pedersen	1947	0.4%	--
Texas Indians	Goldstein	1948	♂ 32.5%	30.7%
			♀ 37.0%	22.7%
Indian Knoll	Snow	1948	♂ 30.7%	--
			♀ 27.4%	--
American Whites	Dept HEW	1962	99.4%	--
Indian Knoll	Sarnas	1964	♂ 42.0%	--
			♀ 47.0%	--
Arkansas Indians	Mehta	1966	61.2%	--
Libben Indians	Fanno	1968	96.6%	70.5%

had the highest percentage of caries and alveolar abscesses of any Amerindian population that had been reported to date.

In fact, the results of this analysis were close to the United States Department of Health, Education, and Welfare's (123) statistics of 1962 on the dental health of contemporary Americans. Less than 1 per cent of living Americans were found to be caries free. Sedwick's (113) study of New York Indians was the only other analysis in which the percentage of caries occurrence within a population approached the present findings. This was in complete contrast to Pedersen's Eskimo findings. Only 0.4 per cent of the individuals in his sample had one or more carious teeth. The percentage of Libben Amerindians with alveolar abscesses was almost double that of any other population.

Such unique results demanded explanation, and although only theories could be made, such discussion may be meaningful. Was the experimental accuracy of previous work limited, or did a composite effect of genetic, environmental, and dietary factors predispose the Libben Indians to dental caries? The answers are not known, but certain facts are known. The cementum of their teeth was more prone to decay than the enamel even in areas of developmental defects. Cemento-cervical caries was accompanied by marked attrition, a flat occlusal table,

wide proximal contact area, and periodontal bone destruction. This combination of factors promoted interproximal food retention which literally feed the invading bacteria within the dentin of the tooth.

Microradiographic sections revealed that these lesions were definitely acquired premortem. Pulpal response to dentinal alteration had been dramatic as seen by the presence of reactionary dentin at the pulpal ends of the tubules involved in the superficial damage. The marked change in the dentin indicated clearly the pathway of the lesion. In the microradiographs the affected dentin showed numerous characteristics which resembled those of carious lesions in modern teeth. See Plates XXV and XXVI on pages 228 and 229. These included regions of decreased mineral content, areas of occluded tubules, and hypercalcified bands in the deeper regions of the lesion. An interesting observation was that occlusion of the tubules as well as the hypermineralized bands seemed to have made these affected regions of the dentin impervious to the postmortem structural changes that occurred in the remaining dentin. Hence the tubules' present appearance after 1,100 years of interment was understood.

Other aspects of the analysis included variations in tooth number, variations in tooth size and form, and osteological evidence of disease and trauma. Only 3.4 per cent of the present sample of skulls had congenitally

missing third molars. As Table 38 on page 142 reveals, all of the populations previously studied had a higher percentage of missing third molars. For the most part third molars in this population were useful, functional teeth that carried their part of the masticatory load. Occasionally impaction, reduction, or congenital absence affected the third molar, but the incidence was not as high as in some other Indian and Eskimo groups.

In addition to third molars, the anomalous shape and congenital absence of lateral incisors had been reported in almost all population groups. These were related phenomena for in the same family or individual one of these anomalies was frequently accompanied by another (Dahlberg 23). For example a barrel lateral was frequently found present when lower second premolars or third molars were anomalous or absent. All of these teeth had been classified by Dahlberg as variable teeth. Although the reports of congenital absence and anomalous shape of upper lateral incisors varied in different populations, the average was rather low as seen in Table 39 on page 143. Because of the variance of reports on the same populations, caution must be taken in comparisons. Generally speaking, however, the incidence of these conditions was lower in the Amerindian than in other groups.

In the present sample no skull indicated the congenital absence of an upper lateral incisor; however, 5

TABLE 38

PERCENTAGE DISTRIBUTION OF MISSING THIRD MOLARS

Population	Investigator	Number Of Jaws Examined	Percentage Of Missing 3rd Molars
Chinese	Hellman 1928	19	32.0%
Mongolians	Hellman 1928	21	17.0%
Eskimo	Hellman 1928	55	13.0%
American Indian	Hellman 1928	55	13.0%
Australian Aborigines	Hellman 1928	20	13.0%
American Negro	Hellman 1928	119	11.0%
Pecos Indians	Hooten 1930	♂ --	8.5%
		♀ --	3.7%
Northwest Eskimo	Goldstein 1932	232	15.5%
American White	Hellman 1936	♂ --	21.7%
		♀ --	30.8%
Texas Indian	Goldstein 1948	173	19.5%
Blackfoot Indian	Dahlberg 1949	25	8.0%
Angmagssalik Eskimo	Pedersen 1949	257	26.7%
East Greenland Eskimo	Pedersen 1949	81	23.5%
Labrador Eskimo	Dahlberg 1949	23	16.0%
Libben Indians	Fanno 1968	88	3.4%

...vol Of University Ltd
University Library

TABLE 39

PERCENTAGE DISTRIBUTION OF MISSING AND ANOMALOUS LATERAL INCISORS

Population	Investigator		Congenital Absence	Anomalous	Both
Chinese	Hrdlicka	1920	0.15%	7.7%	7.9%
Japanese	Hrdlicka	1920	1.10%	4.7%	6.0%
American Negroes	Hrdlicka	1920	2.00%	3.7%	5.7%
American Whites	Hrdlicka	1921	3.20%	3.1%	5.2%
Pecos Indians	Nelson	1938	--	0.4%	--
Texas Indians	Goldstein	1948	0.60%	--	--
East Greenland Eskimos	Pedersen	1949	2.00%	--	--
Angmagssalik Eskimo	Pedersen	1949	1.20%	1.0%	--
Pima Indians	Dahlberg	1949	0.50%	8.0%	8.5%
Indian Knoll	Dahlberg & Snow	1949	0.00%	10.7%	10.7%
Libben Indians	Fanno	1968	0.00%	5.7%	5.7%

School of Dentistry Library

barrel laterals were noted. See Plate VI on page 209. These results were quite comparable with those of other Indian groups. Dahlberg and Snow (23) found no congenital absence of upper laterals in the Indian Knoll material while 0.5 per cent and 0.6 per cent were recorded for the Pima Indians and Texas Indians respectively.

The occurrence of supernumerary teeth had also been reported in the various populations of the world along with congenitally missing teeth. Only one supernumerary tooth was observed in the Libben sample. See Plate XXVII on page 230. It was in the upper right cuspid area and obviously had contributed to the impaction of the permanent cuspid. Even though the supernumerary was small in size compared to the permanent cuspid, the space had closed in the arch and firm contact was established both mesially with the lateral incisor and distally with the first premolar. In Table 40 on page 145 a comparison of the percentage of occurrence of supernumerary teeth among the various populations of the world is presented. The Libben Indians had a frequency of 1.1 per cent which was not as high as some Indian populations such as the Pecos, yet higher than the Arizona and New Mexico Indians.

Niswander (97) in 1963 reported an incidence of supernumeraries of 5.3 per cent in Japanese males which was more than twice as high as his findings for Japanese females (2.2 per cent) and the highest percentage reported

Wellcome Library

TABLE 40

PERCENTAGE DISTRIBUTION OF SUPERNUMERARY TEETH

Population	Investigator	Number In Sample	Cases With Supernumerary	Percentage Of Supernumerary
Eskimo	Leigh 1925	325	7	2.2%
American Indians	Leigh 1925	400	7	1.8%
Bushmen	Drennan 1928	50	1	2.0%
Pecos Indians	Hooten 1930	--	--	1.6%
American Whites	Stafne 1932	48,550	441	0.9%
U. S. Whites	Byrd 1943	2,835	14	0.5%
Texas Indians	Goldstein 1948	173	6	2.2%
East Greenland Eskimo	Pedersen 1949	52	1	1.9%
Chinese	Tratman 1950	2,863	23	0.9%
Chinese	Klatsky 1956	52	0	0.0%
Eskimo	Klatsky 1956	222	0	0.0%
Aleut	Klatsky 1956	50	0	0.0%
Kentucky Indians	Klatsky 1956	83	2	2.4%
California Indians	Klatsky 1956	32	0	0.0%
Arizona Indians	Klatsky 1956	232	2	0.9%
New Mexico Indians	Klatsky 1956	450	3	0.7%
Japanese	Niswander 1963	♂ --	--	5.3%
		♀ --	--	2.2%
Libben Indian	Fanno 1968	88	1	1.1%

...of Dentistry Library

for the occurrence of supernumeraries to date. He stated that over half of his sample was the offspring of biologically related parents and therefore, was not representative of the total Japanese population. Care should be exercised in using his data for comparative purposes.

Although the presence of tori had been considered to be an anatomical variation within the normal range by most authorities, intensive study had been carried out by two investigators, Woo (134) and Klatsky (74), on the skeletal remains of the various populations of the world. In Table 41 on page 147 the Libben findings are listed with the results of Woo's and Klatsky's studies for comparative analysis. According to Woo's data, tori were more prevalent in females than in males and in Mongoloids than in Whites or Negroes. Klatsky found the occurrence of palatal tori to be much less frequent than Woo. Moreover, Klatsky's results were more in accordance with the findings of the present survey. Of all the Libben skulls studied, 15 per cent had a palatal torus while no mandibular tori were observed.

Klatsky (74) also investigated the frequency of congenitally missing teeth, microdontia or reduced teeth, and impacted teeth among the various populations. Included in Table 42 on page 148 is a list of his results of the many Mongoloid groups that he studied, along with the Libben findings and those of other investigators. There

TABLE 41

PERCENTAGE DISTRIBUTION OF PALATAL AND MANDIBULAR TORI

Population	Investigator		Number In Sample	Percentage With Palatal Tori	Percentage With Mandibular Tori
Pecos Indians	Rihan	1932	--	20.0%	47.4%
American Negro	Ju-Kang Woo	1950	♂ 575	36.0%	--
			♀ 298	41.0%	--
American White	Ju-Kang Woo	1950	♂ 540	42.0%	--
			♀ 127	47.0%	--
Mongolian	Ju-Kang Woo	1950	♂ 93	44.0%	--
			♀ 70	50.0%	--
American Indian	Ju-Kang Woo	1950	♂ 96	50.0%	--
			♀ 79	59.0%	--
Eskimo	Ju-Kang Woo	1950	♂ 193	63.0%	--
			♀ 173	70.0%	--
Chinese	Klatsky	1956	52	0.0%	0.0%
Eskimo	Klatsky	1956	222	9.5%	8.1%
Aleuts	Klatsky	1956	50	24.0%	6.0%
Kentucky Indians	Klatsky	1956	83	0.0%	0.0%
California Indians	Klatsky	1956	32	15.6%	3.1%
Arizona Indians	Klatsky	1956	232	4.7%	5.2%
New Mexico Indians	Klatsky	1956	450	1.6%	4.2%
Libben Indians	Fanno	1968	88	15.0%	0.0%

Dentistry Library

TABLE 42

PERCENTAGE DISTRIBUTION OF MISSING, REDUCED, AND IMPACTED TEETH

Population	Investigator	Number In Sample	Missing Teeth	Reduced Teeth	Impacted Teeth
American Whites	Byrd 1943	--	2.8%	--	--
Texas Indians	Goldstein 1948	♂ 196	--	--	3.3%
		♀ 174	--	--	6.0%
Chinese	Klatsky 1956	52	4 (7.7%)	0 (0.0%)	0 (0.0%)
Eskimo	Klatsky 1956	222	39 (17.6%)	14 (6.3%)	2 (0.9%)
Aleuts	Klatsky 1956	50	8 (16.0%)	5 (10.0%)	0 (0.0%)
Kentucky Indians	Klatsky 1956	83	3 (3.6%)	3 (3.6%)	3 (3.6%)
California Indians	Klatsky 1956	32	7 (21.9%)	3 (9.4%)	0 (0.0%)
Arizona Indians	Klatsky 1956	232	21 (9.1%)	6 (2.6%)	11 (4.7%)
New Mexico Indians	Klatsky 1956	450	58 (12.9%)	7 (1.6%)	9 (2.0%)
Japanese	Niswander 1963	♂ --	5.8%	--	--
		♀ --	9.2%	--	--
Libben Indians	Fanno 1968	88	8 (9.1%)	7 (8.0%)	7 (8.0%)

Dentistry Library

were 9.1 per cent of the Libbenites with congenitally missing teeth which was exactly the amount Klatsky reported for Arizona Indians. The Libben congenitally missing list consisted of two upper third molars, one lower third molar, four lower second premolars, and one lower lateral incisor. In addition 8 per cent of the Libben Indians had reduced teeth, all of which were upper third molars. See Plate XXVIII on page 231. Similarly, 8 per cent of the Libben Indians had impacted teeth, all of which were lower third molars with the exception of an upper right permanent cuspid. The Libben impaction percentage was higher than any of Klatsky's observations on various Mongoloid groups.

Other dental and osseous pathologies and anomalies were observed in the Libben people. Alveolar abscesses were found almost exclusively in the adult and senile groups. The three main causes of these lesions were pulp exposure due to attrition or caries, trauma, and periodontal disease.

Structural defects of the enamel surface of the teeth were also noted. These included grooves, deep bands, and pits in the enamel surface which were thought to be the result of nutritional disturbance or severe illness during the time when the affected teeth were forming. See Plate XXIX on page 232. Such aberrations in development (enamel hypoplasia) were found in every age group. Similarly, defects in calcification were also

Dentistry Library

recorded. Opaque areas, white spots, and discolored areas showed variations in the calcification of the enamel matrix. Shafer (114) contended that food shortages, dietary mineral deficiencies, and exanthematous diseases were responsible for such aberrations in the calcification of enamel and dentin. As in the case of structural defects of the enamel, calcification defects occurred throughout the population.

Loss of tooth structure in the form of erosion was another factor present in this population. Occurring most often at the cementoenamel junction on the buccal or labial surfaces of the teeth, erosion was frequently seen in a limited region of the mouth. For example, one skull had erosion which affected every tooth from the upper right first molar to the upper right central incisor. Another had erosion of the teeth between the lower left cuspid and the lower right first bicuspid. Shafer (114) stated that erosion was a loss of tooth substance by a chemical process that did not involve bacterial action. High acid intake or citrate content of the saliva had been suggested as possible explanations. These lesions varied in size and shape and appeared as areas of advanced decalcification. The tooth substance on the surface could be easily removed, leaving a shallow, broad, smooth scooped-out depression.

Table 43 on page 151 shows the incidence of erosion by age group as well as abscesses and structural and calcification defects.

TABLE 43

DISTRIBUTION OF DENTAL AND OSSEOUS PATHOLOGIES AND ANOMALIES

Age Group	Number Of Skulls	Alveolar Abscesses	Structural Defects	Calcification Defects	Erosion
Infant	7	0	12	39	3
Children (D)	8	0	1	20	17
Children (P)	--	0	7	23	0
Young Adult	10	2	29	28	7
Adult	59	145	187	166	176
Senile	19	98	36	11	32
Total	103	245	272	287	235

Table 44 on page 153 summarizes the infrequent pathologies and anomalies that were seen in this sample. Included were exostoses and temporomandibular joint arthritis which were almost exclusively observed in the senile age group. Specific diagnosis of the bone destructive lesions (tumors) was not possible from the osteological material alone. See Plate XXX on page 233 for an example of such osteoclasia.

Kennedy Library

TABLE 44

SUMMARY OF INFREQUENT PATHOLOGIES AND ANOMALIES

Disease	Number Of Cases	Remarks
Exostoses	11	Exclusively in senile group
Tumors	3	Specific diagnosis unknown
TMJ Arthritis	8	Exclusively in senile group
Fusion	1	Lower right lateral and cuspid
Twinning	1	Upper left lateral incisor
Cleft Palate	0	Hard palate only
Syphilis (Congenital)	0	Looked for occurrence of Hutchinson's triad

Dentistry Library

CHAPTER VIII

PERIODONTAL CONDITIONS

Review Of Literature

Relatively little study had been done in the past on the manifestations of periodontal disease in skeletal material. One of the first investigations in this area was Hirschfeld's (57) in 1923. He discussed how anatomical variations often resembled the destructive consequences of a disease process. Noninfectious alveolar deficiencies and root exposure of a tooth were two examples of such variations. When teeth were used to excess via mastication or vocation, the roots tended to protrude from the alveoli in proportion to the amount of occlusal wear. The appearance of marked exposure of roots simulated alveolar bone loss concomitant with periodontal disease.

Hirschfeld also contended that accentuated alveolar borders and thickened outer alveolar plates and margins were not the result of pathology but normal anatomical variation which developed possibly in response to the pull of the gingiva by the fibers of the buccinator muscle. He felt that it was essential to avoid confusion between anatomical variation and mechanical wear and destruction resulting from disease during life.

In 1926 Hirschfeld (58) made further studies of skulls in relation to periodontal disease. He described how occlusal wear changed the occlusal contour of a tooth, the form and size of the pulp chamber, and the periodontium. At the time of the eruption of the posterior teeth, the buccolingual dimension between cusp points was small, and the occlusal prominence of the cusps was great, thereby providing maximum functional efficiency and minimum strain on the periodontium.

According to Hirschfeld, this was nature's plan because during the eruptive stage the roots were only partially formed, the periodontal membrane was thick, the alveolar process was thin, and the musculature was weak. However, as the cusps wore, the crushing power of the occlusal planes was less, and therefore, more force and rigidity of parts were required. By this point in development, the oral musculature was strong, the alveolar process had thickened, the roots were fully formed, and the periodontal membrane was thin. The aggregate of all these factors provided the increased force and rigidity necessary to compensate for cuspal wear. Nevertheless, attrition continued and the cusps were completely worn away. Resulting concavities in the exposed dentin appeared on the occlusal surface of the tooth. The buccolingual diameter of the teeth was at a maximum which resulted in still greater strain. To compensate for this factor, the

eccentric borders of the occlusal surface produced tremendous leverage. This leverage plus maximum muscle development enabled the dental apparatus to remain healthy with little or no destruction to the periodontium. Hirschfeld did not believe that attrition was the major factor in the destruction of the periodontium of prehistoric races but that various local and systemic factors were the predominate destructive forces in periodontal disease.

Leigh (80) in 1925 compared the manifestations of periodontal disease among four Amerindian populations. In the Kentucky Indian material the only lesions found were localized and for the most part about the molars. The disease was most advanced about the third molars. The greatest single factor in the causation of the destruction of the walls of the alveoli was the loss of contact. This occurred most frequently in the senile age group between the second and third molars. Deposits of calculus on the teeth were rare. Leigh found that 14 per cent of the Kentucky crania had calcareous deposits on the molars yet none of the crania had deposits on the lingual of the lower anteriors. With the Sioux Indians disease of the supporting dental tissues was almost negligible except in persons of advanced years. Their teeth were free of calcareous deposits indicating a healthy periodontium. Thirty-three per cent of the Arikara Indians had osseous

pathology localized about the molars which was indicative of periodontal disease. As in the Kentucky Indians the greatest and most advanced lesions occurred in seniles around the third molars and with decreasing frequency about the second and first molars. There were no instances of infrabony pockets about the incisors of either arch. Leigh observed heavy deposits of calculus on the buccal surface of the upper molars. The most severe periodontal conditions of the four tribes were found in the Zuni Indians. Fifty-six per cent of them had signs of periodontal disease. They were not restricted to the molars as in the other groups but affected all the teeth, and in many skulls generalized bone destruction was observed. Unlike the Sioux and Arikara the Zuni had salivary calculus and stains on most of the teeth, and considering their caries rate, they had the poorest dental health of the four tribes compared.

Leigh (81) also studied the periodontium of the Eskimo. He found that 61 per cent of the Eskimo crania exhibited some degree of periodontal disease. The molar teeth were involved for the most part although there were some generalized cases. Unlike the findings in modern man, involvement of the lower incisors was very infrequent. Periodontal disease was rare in persons younger than 40.

Leigh described how he determined the normal and abnormal height of the alveolar crest. He measured the

Library

distance from the enamel border to the crest of the alveolus in a group of young adults. For upper first molars the average was 1 millimeter. An appreciable increase of this measurement was taken as an indication of pathology.

He also described two kinds of destruction of the alveolar process: (1) an even, uniform atrophy of the free margin of the alveolus without an appreciable enlargement of its lumen, and (2) the marked destruction of the inside wall of the alveolus, with evidence of chronic infection (infrabony pocket). Ten per cent of the Eskimo skulls had heavy buccal calculus; however, little was found on the lingual surfaces of lower anteriors.

In 1928 Leigh (82) studied the aboriginal Californian and found alveolar bone destruction occurring in 50 per cent of the cases that he examined. His results were much like those that he described in a previous work on the Zuni Indians.

In his study of the dental conditions among the Mimbres in 1929, Bentzen (11) found that the majority of the teeth had deposits of calculus on their labial, buccal, and lingual surfaces. He attributed this to the alkalinity and high lime salt content of the water. He stated that crest resorption of the alveolus in all the specimens was in direct proportion to the amount of calculus on the teeth and that the only specimen that had perfect crests was devoid of calculus.

Rihan (106) reported that 13.3 per cent of the Pecos Indian skulls that he studied had periodontal disease. Webb (128) in his survey of the Louisiana Indians stated that over half had "pyorrhea." No details or descriptions of kind, extent, or range of periodontal disease were given in either publication.

Sedwick (113) in 1936 reported that in New York Indians 48 per cent had alveolar bone destruction and 18.7 per cent had calculus which was more frequent in the lower than in the upper teeth.

Funkhouser (41, 42), an anthropologist, in his studies of the skeletal materials from both the Norris and Wheeler Basins reported:

> Various types of pyorrhea were found. The commonest form appears to be an alveolar periodontoclasia usually seen at the bases of the incisors and canines.

In 1938 Nelson (93) in his examination of the teeth of the Pecos Indian crania commented that in observing the extent of alveolar bone degeneration about the teeth it was extremely difficult to determine exactly what was pathology and what was not. Despite his difficulty he concluded that approximately 34 per cent of the 136 skulls showed some evidence of alveolar bone destruction.

Findings And Discussion

Considerable evidence of periodontal disease was found in the present study of the Libben Indians as

demonstrated by the appearance of gross deposits of calculus, large numbers of dehiscences and fenestrations, loss of alveolar bone height, and multi-walled infrabony pockets. See Plates XXXI to XXXIII on pages 234 to 236. Unlike many of the observations concerning the periodontal conditions of other precolumbian Amerindian populations made in the past, 100 per cent of the adults had calculus. Over 70 per cent of these had moderate or heavy deposits on both the crown and the roots of the teeth. Heaviest deposits were most often seen on the labial and lingual surfaces of the lower anterior teeth and the buccal surfaces of upper molars.

Similar to Bentzen's (11) observations on the Mimbres were the many cases of the present study which had deposits of calcareous material on both buccal and lingual as well as proximal surfaces of every tooth. The amount of calculus on the teeth increased with age.

Table 45 on page 161 shows the percentage distribution of calcareous deposits in the different age groups. There was a steady progression of the mean score from infancy to senility. The increased frequency of occurrence of radicular calcareous deposits with age reflected the presence of other associated periodontal lesions such as infrabony pockets, interproximal craters, and alveolar bone resorption. All these associated lesions resulted in an increase in alveolar bone destruction and loss of the

TABLE 45

PERCENTAGE DISTRIBUTION OF CALCULUS AMONG THE VARIOUS AGE GROUPS

Age Group	Number Of Skulls	0 No Calculus	Percentage Of Skulls With Score 0	1 Slight Coronal Calculus	Percentage Of Skulls With Score 1	2 Moderate Coronal And Radicular	Percentage Of Skulls With Score 2	3 Severe Coronal And Radicular	Percentage Of Skulls With Score 3	Mean Score Of Group	Standard Deviation
Infants	7	7	100.0%	0	0.0%	0	0.0%	0	0.0%	0.00	.00
Children	8	6	75.0%	2	25.0%	0	0.0%	0	0.0%	0.25	.43
Young Adults	10	0	0.0%	7	70.0%	3	30.0%	0	0.0%	1.30	.46
Adults	59	0	0.0%	17	28.8%	26	44.1%	16	27.1%	1.98	.73
Senile	19	0	0.0%	3	15.8%	10	52.6%	6	31.6%	2.20	.88
Total	103	13	12.6%	29	28.2%	39	37.9%	22	21.3%	1.68	.94

Library

teeth. Such loss of alveolar bone height exposed the roots of the teeth. See Plate XXXII on page 235. These lesions were more severe in those cases which had heavy deposits of calculus.

In an attempt to learn more about the exact nature of these deposits of 850 A.D., x-ray diffraction technique was employed. Samples of the raw calculus were taken from the teeth during the cleaning of the dentitions for various analyses. Mixed powder patterns were obtained consisting of an apatite component and other superimposed lines. See Plate XXXIV on page 237. When a pattern was made from the accompanying sand, the extra lines of the original mixed powder pattern were accounted for. In addition, when a very slight amount of external surface material was removed from the calcareous deposit prior to being ground, the resulting pattern was solely that of apatite. The conclusion was that the bulk of the calculus was apatite, with a slight superficial contamination by environmental sand.

Several phosphate compounds had been detected in calculus isolated from modern man. According to Schroeder (111), these were apatite, brushite, whitlockite, and octocalcium phosphate. They were present in varying proportions but apatite was usually a major component and often the only component. In the present material it was not known whether there might have been other phosphates besides apatite present originally because these various

phosphate compounds can be converted to apatite by hydrolysis. At any rate the Libben calculus did not appear to be compositionally different from contemporary finds. What was surprising was the uncontaminated nature of the major portion of the calculus after centuries of interment.

As previously mentioned, the amount and location of calculus mirrored the alveolar bone health. Table 46 on page 164 presents the frequency of occurrence of various alveolar bone pathologies. Periodontal lesions were so prevalent that the average adult in this sample had 4.2 fenestrations, 5.8 dehiscences, and 6.7 infrabony pockets. These were considered to be high frequencies for an Amerindian population. As seen in Table 46, mesial pockets were more prevalent than distal ones for the entire sample but especially in the adult group where the ratio was almost two to one. Buccal pockets outnumbered lingual pockets four to one. The average number of infrabony pockets constantly increased from infancy to senility which illustrated the progressive deterioration of the supporting tissues of the teeth in these people.

Previous studies by other investigators in the field of dental anthropology had indicated that most of the severe periodontal lesions were strictly localized about the molars, especially the third molars, and that these conditions were usually found in the seniles of the population. They contended that loss of contact between the molars subsequent

TABLE 46

FREQUENCY OF OCCURRENCE OF ALVEOLAR BONE PATHOLOGY BY AGE GROUP

Age Group	Number Of Skulls	Fenestrations	Number Of Fenestrations Per Skull	Buccal Dehiscences	Lingual Dehiscences	Number Of Dehiscences Per Skull	Mesial Pocket	Distal Pocket	Buccal Pocket	Lingual Pocket	Number Of Pockets Per Skull
Infants	7	7	1.0	17	0	2.4	0	0	0	0	0.0
Children	8	18	2.3	34	0	4.3	14	3	0	0	2.1
Young Adults	10	28	2.8	63	0	6.3	16	9	1	0	2.6
Adults	59	246	4.2	335	8	5.8	222	130	32	9	6.7
Senile (2 not applicable)	17	33	1.9	88	0	5.2	64	51	8	2	7.4
Total	101	332	3.3	537	8	5.4	316	193	41	11	5.6

to advanced attrition predisposed these people to a constant interstitial impaction of food which resulted in the destruction not only of the soft tissue and supporting bone but of the teeth themselves via proximocervical caries. The Libben findings shown in Tables 45 and 46 on pages 161 and 164 do not completely support their contention.

Both fenestrations and dehiscences occurred in greater frequency in the anterior than the posterior teeth. Such protrusion of the apices through the facial plate or the complete loss of this plate exposing the entire root was believed by Leigh (81) to be a part of a generalized senile osseous atrophy of the maxilla and mandible which was to initiate the shedding of the permanent dentition. Table 47 on page 166 shows that the greatest number of buccal dehiscences was associated with the anterior teeth, especially the cuspids. Fenestrations of the buccal bony plate over the mesial root of the upper first molar and the upper cuspid occurred more frequently than in any other areas of the mouth.

Infrabony pockets did occur predominantly among the posterior teeth. Regions approximating the mesial surfaces of the lower second molars were the most susceptible areas, followed by the mesial surfaces of the upper first and second molars. The occurrence of infrabony pockets was more frequent at the mesial surface of upper and lower third molars than at the distal surfaces.

TABLE 47

FREQUENCY OF OCCURRENCE OF ALVEOLAR BONE PATHOLOGIES

Tooth	Fenestration	Buccal Dehiscence	Lingual Dehiscence	Total Fenestrations And Dehiscences	Mesial Pocket	Distal Pocket	Buccal Pocket	Lingual Pocket	Total Pockets
Upper									
Central	28	55	--	83	2	4	1	1	8
Lateral	33	63	--	96	6	3	1	2	12
Cuspid	42	62	--	104	5	3	--	--	8
1-Bicuspid	29	25	--	54	12	16	1	--	29
2-Bicuspid	24	8	--	32	20	20	--	--	40
1-Molar	48	19	6	73	39	26	3	2	70
2-Molar	22	11	2	35	37	28	5	1	71
3-Molar	3	5	--	8	42	10	3	1	56
Upper Total	229	248	8	485	163	110	14	7	294
Lower									
Central	16	52	--	68	4	2	1	--	7
Lateral	20	48	--	68	1	1	--	--	2
Cuspid	26	60	--	86	8	5	1	--	14
1-Bicuspid	16	52	--	68	10	5	2	1	18
2-Bicuspid	7	22	--	29	19	12	1	--	32
1-Molar	14	40	--	54	31	17	8	1	57
2-Molar	2	11	--	13	45	28	7	--	80
3-Molar	2	4	--	6	35	13	7	2	57
Lower Total	103	289	--	392	153	83	27	4	267
Grand Total	332	537	8	877	316	193	41	11	561

Unlike contemporary populations infrabony pockets seldom occurred about the lower anterior teeth in Libbenites and with similar sparseness among the upper anteriors. This was exactly opposite Funkhouser's (41, 42) findings from his studies of the crania of the Norris and Wheeler Basins.

Lesions of the alveolar bone in the present study did occur predominantly among the molars, but they were not strictly localized nor was the third molar most frequently affected. Both upper and lower second molars led the list, followed by the first and third molars in that order. Severe periodontal conditions were not just limited to the senile age group nor were they always associated with severe attrition. The amount of calcareous deposits seemed to be the determining factor in the Libbenites and not the wear of the teeth or the age group of the individual. Periodontal health of the individual skull seemed to be a constant for both jaws. Either there were heavy deposits of calculus, numerous infrabony pockets, and other osseous defects associated with the disease process or there were slight deposits of calculus, nearly normal alveolar crests, and few signs of intra-osseous pathology. With few exceptions severe localized periodontal disease was not observed in this population.

Table 48 on page 168 gives additional information about the health of the supporting structures of the teeth. Thickening of the alveolar bone margins, blunting

TABLE 48

FREQUENCY OF OCCURRENCE OF CONTRIBUTORY OSSEOUS PATHOLOGIES

Pathology	Infant (7)	Chil-dren (8)	Young Adult (10)	Adult (59)	Senile (19)	Total
Thickened Margins	0	3	4	34	6	47
Blunting Resorption	0	0	8	38	10	56
Furcation Involvement	0	0	1	30	16	47
Interproximal Crater	0	1	0	22	9	32
Stains	3	2	2	37	11	55

resorption of the interproximal bone, pathological involvement of the furcations, cratering of the interproximal bone, and presence of brown stains were the contributory characteristics of periodontal disease that were looked for in the present survey. With the exception of interproximal bony craters, the above characteristics occurred in approximately half of the sample.

Without fear of overstating the case, it could be said that the 88 Libben adults had progressive and widespread periodontal disease. Almost 70 per cent had alveolar bone destruction in addition to their calcareous deposits. This was high among Amerindian populations. As mentioned in the discussion of dental caries of the Libben Indians, the results of this analysis were an underestimation of the true dental conditions because of premortem and postmortem tooth loss. Even though the findings indicated almost universal and often severe periodontal disease, they were an underestimation and represented only a part of the total number of lesions.

In Table 49 on page 170 which reviews the percentage distribution of periodontal disease (alveoloclasia) among various Indian populations, it can be seen that the Libben Indians had the highest percentage of periodontal disease of any other Amerindian population that had been reported in the literature at this time. Leigh's (80) study of

TABLE 49

PERCENTAGE DISTRIBUTION OF ALVEOLOCLASIA AMONG VARIOUS POPULATIONS

Population	Investigator	Number In Sample	Percentage With Alveoloclasia
Eskimo	Leigh 1925	324	61.0%
Kentucky Indians	Leigh 1925	66	11.4%
Sioux Indians	Leigh 1925	92	Negligible
Arikara Indians	Leigh 1925	129	33.0%
Zuni Indians	Leigh 1925	113	56.0%
California Indians	Leigh 1928	--	50.0%
Pecos Indians	Rihan 1932	289	13.0%
New York Indians	Sedwick 1936	48	48.0%
Pecos Indians	Nelson 1938	136	34.0%
Louisiana Indians	Webb 1944	30	50.0%
Indian Knoll	Snow 1948	307	7.5%
Libben Indians	Fanno 1968	88	69.0%

the Zuni Indians was the only other analysis in which the percentage approached that of the present study.

The significant points concerning the periodontium of the Libben Indians were: (1) Heavy deposits of calculus and severe osteoclasia occurred concurrently in this population, (2) Advanced attrition was present in many cases, but in the vast majority the proximal contact of the teeth had not been eliminated. It would thus seem that the predominance of infrabony pockets in the interproximal areas of upper and lower molars could not be explained on the basis of attrition, (3) The Libben population had the highest percentage of both dental caries and periodontal disease of any Amerindian group thus far reported, and (4) Periodontal disease in this sample occurred even in the children and was not limited to the older persons of the group. The interrelationships of all these facts will require further study of the diet, the genetic makeup, the general health, and the total environment of these people.

CHAPTER IX

CEPHALOMETRY AND OCCLUSION

Review Of Literature

The scientific measurement of the relationship of the various parts of the skull to the jaws and/or dentitions of precolumbian Amerindian populations had been very limited. With the exception of Sarnas' (107) work in 1955 on some of the cranial and facial changes during growth in the Indian Knoll material, x-ray cephalometric investigations had not been carried out. It is hoped that the cephalometric measurements and findings, which will appear in the next section of this chapter, can be used in future comparative studies of various Indian populations and in growth studies of their skulls and dental apparatus.

In the past, craniometric measurements provided a means of describing and analyzing fossil remains. Many anthropologists, Hooten (59, 60, 61), Snow (118, 119), Funkhouser (41, 42), and others had employed craniometric techniques in order to classify and compare skeletal form and size among the Amerindian populations which they were studying. Such anthropometric measurements and indices were not considered to be a part of an analysis of the dentition. However, the cranial material is presently

available for anthropometric study which could reveal useful information about the characteristics of the Libbenites and their genetic relationships with other precolumbian populations.

In addition to the cephalometric analysis, the mesiodistal diameters of newly erupted teeth were measured and recorded for comparative purposes. Bentzen (11) reported in 1929 that the size of the Mimbres' teeth were somewhat larger than those of modern Americans. He measured both the mesiodistal and the buccolingual diameters of the crowns of only the first permanent molars.

Nelson (93) in 1938 did a comprehensive statistical study of the size characteristics of the teeth of the Pecos Indians of New Mexico. With the aid of a micrometer, he obtained not only the mesiodistal and buccolingual diameters of the crowns of the teeth but also the length of the crown and the length of the root. Regardless of the aspect, maximum dimensions were recorded when measuring the crowns of these teeth. When comparing his findings, he ascertained that the sizes of the Pecos teeth were in an intermediate position among the various racial types of man. Generally the Pecos Indians had smaller teeth than the Australian Aborigines but larger teeth than the modern White. This position, which had confirmed Hrdlicka's work, was determined to be representative of most of the Amerindian populations studied to date.

Moorrees (91) compared the mesiodistal crown lengths of the maxillary teeth of the Aleuts with those of other Mongoloid groups, including the East Greenland Eskimos and the Pecos Indians. Considering all these groups together, their incisor measurements followed the same general pattern when they were compared to the modern Whites. The centrals were consistently narrower and the laterals consistently broader than those in Whites. Therefore, the four maxillary incisors were more nearly the same size in these groups. This similarity of the size of lateral and central incisors was seemingly a characteristic for Mongoloids as a race. No common trend was observed for the cuspids and bicuspids, but the molars of the Aleuts were smaller than those of modern Whites.

Mehta (87) in 1966 published his study on the attrition of the teeth of Arkansas Indian crania. To determine the amount of occlusal attrition, he measured the crown heights of all the teeth. The mesiodistal diameters were also recorded in order that the amount of proximal attrition could be studied. Even though his measurements were of worn teeth, the mean mesiodistal diameters were not smaller than those of modern man. He calculated the mesiodistal arch length necessary to house these dentitions and observed a tendency toward crowding of the teeth when the mesiodistal arch length was short of its mean value. Nevertheless, malocclusion was rare in

these Arkansas Indians. Of the 21 skulls in the sample, there was only 1 case which showed very mild overjet. No cases were observed in which the overbite was deep.

In 1925 Leigh (81) discussed 44 cases of Class I malocclusions which he observed in his study of 324 Eskimo crania. Rotations were the most frequent problem of which mesial rotations of upper premolars were the most common. He contended that overretention of the deciduous cuspids often resulted in impaction or malposition of the permanent successor and malocclusion. In Leigh's (80) studies of Amerindians, an edge-to-edge relationship of the upper and lower incisors was a constant observation. However, the mesiolingual depression of the upper central incisors that he had observed in Amerindians was not seen in his Eskimo sample. One case of mandibular prognathism, Class III malocclusion, was observed.

Malocclusion among the American Aborigines was relatively infrequent. Fisher (39), Rihan (106), Sedwick (113), Funkhouser (41, 42), Newman (96), Rabkin (104), Webb (128), Snow (119), Mehta (88), and Lewis (83) had surveyed various Indian populations and had reported that the occurrence of malocclusion was rare, that there was a predominance of an edge-to-edge occlusion of the incisors, and that there was an occasional crowding or malalignment of individual teeth. Many instances of bilateral mesial

rotation of the maxillary central incisors were described by these authors.

Dahlberg (29) had termed this characteristic irregularity of the alignment of the maxillary central incisors of Mongoloids "winging." He stated that the frequencies of bilateral winging among the contemporary Indian tribes varied from 22 to 38 per cent but dropped to 10 per cent for Japanese and to 3 per cent for Chicago Whites.

Lasker (78) in 1957 discussed how little was known about the influence of environmental factors on such racial and genetic features as dental arch form, rotation of teeth, type of occlusion, and relationship of the jaws. He commented on the effect of inbreeding on the teeth of some of these isolated Amerindian populations:

> However, crowded teeth are common in some inbred groups, they vary with environment (Lasker 1945), and small teeth in large jaws are rarer than large teeth in small jaws, although both should be equally frequent in persons of biracial origin if genetic reassortment were the explanation.

Hunt (69) published a lengthy article on malocclusion and civilization. It is common knowledge that severe malocclusions are more prevalent in civilized human groups than in most primitive populations. He discussed the possible causes for this rapid evolutionary trend in human growth and development. They were: (1) the effect of the environment on facial growth, (2) the effect of hybrization of human ethnic stocks on the occurrence of malocclusion,

and (3) the effect of maternal age and birth order on the sibling's dental development. These potential genetic forces were often contributing factors to a malocclusion and could influence the entire dentofacial complex.

Hunt contended that the most significant part of the story was the differences in the use of the jaws and in attrition of the teeth between primitive and civilized populations. He concurred with Begg's (9) theory that attrition was of paramount importance in the development of a healthy, normal occlusion in primitive man. Discrepancies between jaw size and tooth mass seen so frequently in modern populations were nonexistent in primitive races. The attrition kept the teeth in a constant state of change both in size and in position within the arch, resulting in an edge-to-edge anterior occlusion and a tendency for a Class III molar relationship.

Although Begg and Hunt were referring to the occlusions of the Australian Aborigines, many groups of Amerindians and Eskimos had occlusions which were not much different. The discussion of the relationships of the jaws and the skull, the size of the teeth, and the type of occlusion of the Libben Indians is presented in the next section.

Findings And Discussion

A cephalometric analysis was done on each of 33 skulls which were exhumed completely intact and unwarped.