THE USE OF DENTAL MORPHOLOGY TO IDENTIFY AN ONTARIO IROQUOIS OSSUARY POPULATION

by

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ABSTRACT

The Kleinburg ossuary population is known to be a protohistoric Iroquois group, but little else has been discovered. The non-metric dental morphology was observed and compared to that of three contemporary Iroquois groups known in an archaeological context in an attempt to more precisely identify the Kleinburg population. Twenty-eight characters were used for comparisons. Two statistical methods were chosen, both giving estimates of overall divergence between samples. A modern white sample was included to test the validity of the method.

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CHAPTER I

INTRODUCTION

The dentition has been a traditional tool used by both primate and human palaeontologists to study evolutionary changes. It has only been recently that the dentition has come into focus in the study of modern human groups. As with the cranium, discrete morphological variations rather than metrical seem to be more suitable for differentiating or relating populations.

The teeth have many advantages for this type of study. Once erupted, the form of the tooth is not affected by environmental factors other than attrition and caries. Of the commonly studied traits, only tooth size has been shown to be affected by internal environmental influences during development (Kirveskari 1974). The dentition is generally resilient to factors affecting the development of other tissues (Wright 1975). The teeth are the hardest and most durable of body tissues. They are available from archaeological collections even when skeletal material has been badly damaged. Because teeth are easily studied in living populations, it is possible to observe changes in a particular dentition over time. There are also a large number of traits readily recorded on the dentition as a whole, and on each individual tooth.

The number of studies using the dentition to relate populations is gradually increasing. Early works generally dealt with large populations. We find papers on the dentition of the North American Indian (Dahlberg 1949; Wissler 1931) or comparisons of Mongoloid and Indo-European populations (Tratman 1950). This led to the definition of a basic Mongoloid dental complex (Hanihara 1967; Moorrees 1962). With the accumulation of data on dental variation, the emphasis has shifted from general patterns to more specific differences between smaller groups of people. Moorrees (1957) demonstrated differences between the East and West Aleuts and this variation was later shown to be due to local evolution rather than European admixture (Turner 1967). Papago and Pecos Indians can be differentiated using dental morphology (Morris 1965). Kirveskari (1974) studied dental characters in an attempt to determine the origins of Skolt Lapps. He concluded that their dentition is distinct from that of both Mongoloids and Caucasoids, but the frequency of traits suggested closer affiliations with the latter. Using deciduous molar characters, Japanese-White and Japanese-Negro hybrids could be distinguished from Japanese, American White and American Negro groups (Hanihara 1963). Recently dental morphology has been used to compute distance statistics representative of the genetic distance between populations (Brewer-Carias et al. 1976; Sofaer et al. 1972). The latter concluded "that tooth morphology has the potential of providing moderately good discrimination" (Sofaer *et al.* 1972:364). The former also had positive results, and state that "the pattern of micro-differentiation suggested by dental traits is roughly comparable to that projected by other types of biological traits whose genetic basis is more firmly established" (Brewer-Carias *et al.* 1976:13).

CHAPTER II

OBJECTIVES AND APPROACH

Historical Perspective

The Kleinburg ossuary was excavated in the summer of 1970 by F.J. Melbye, University of Toronto. The site is located in Kleinburg, Ontario, north of Toronto. An associated village site has yet to be discovered. A date of 1600 ±15 years has been assigned the site based on the presence of certain limited trade goods (Melbye pers. comm.).

At that time two distinct branches of the Late Ontario Iroquois Stage existed; the Neutral-Erie branch in southwestern Ontario and New York, and the Huron-Petun branch in south-eastern Ontario (Wright 1972). Both branches had evolved from the Middleport substage of the Middle Ontario Iroquois Stage by 1400 A.D. (Wright 1966). Prehistorically the Huron-Petun branch was divided into a Northern division in Huronia proper and a Southern division along the north shore of Lake Ontario. The Southern division gradually shifted northward. Fusion with the Northern division by 1550 A.D. resulted in the historic Huron and Petun groups. The Neutral division of the Neutral-Erie branch was centred in the Hamilton-Brantford area (Wright 1974). It was at this time, 1615-1625 A.D., that the Recollets and Jesuits began their missionary work in Huronia. By 1654 A.D. all the Ontario Iroquois had been absorbed into the Iroquois League of Nations (Wright 1972).

Both branches of the Ontario Iroquois practised ossuary burials. The Neutral lined their ossuary pits with clay, a practice apparently not followed by the Huron-Petun (Wright 1966). In other aspects the Huron and Neutral were similar. Corn was the staple food, supplemented by beans, squash and some meat and fish. Hunting and fishing were of greater importance in the Neutral-Erie branch. The material culture of both branches was generally the same although specific differences allow archaeological separation of the two.

Objectives

It will be my primary purpose to place the Kleinburg ossuary in this general scheme of Ontario archaeology. The date and location of the site suggest it was a Huron ossuary. Data on the dentition of three contemporary ossuary populations are available for study (Wright 1974) and it is through comparison with these groups that I hope to shed some light on the Kleinburg people. Although analysis of the entire Kleinburg ossuary is nearing completion, no works have been published, and no comparative analyses have been done. This thesis will be the first attempt to relate the populations to other contemporary groups.

Having placed the ossuary in the archaeological context, this thesis will provide a thorough and extensive description of an Iroquois dentition, be it Neutral or Huron. Such a complete consideration of Ontario dental morphology has been lacking. Osteological studies have largely ignored the teeth, mentioning only the more striking traits of shovel shaping, protostylid, Carabelli's cusp and cusp and groove pattern.

The most complete work on Iroquoian odontology has been Wright's The Dental Morphology of Three Ontario Iroquois Ossuary Populations (1974). However, this work is wanting in several aspects. Wright has used several traits unsuitable because a subjective judgement of size or orientation is necessary. Other traits which are easily studied in samples of loose teeth, and which may be important are missing; root morphology has been ignored. Perhaps the main weakness in Wright's work is the small size of his samples. The Kleinburg sample is many times larger than Wright's three samples pooled. Wright has provided excellent references for standardization of the traits and categories. Where appropriate, these same references will be included here.

A complete description of such a large ossuary as Kleinburg will be a baseline to further comparative studies. It will allow comparisons not only with other protohistoric groups, but also with living Iroquois groups and will contribute to our growing knowledge of dental variability. It is impossible to form hypotheses of the adaptiveness of tooth form, a question which concerns palaeontologists and anthropologists, unless a total range of possible variation is known.

As Turner states:

> "It is no longer sufficient to talk of the American Indian dentition as if the teeth of every Indian had been cast in the same mold." (1969:25)

Approach

1. The Dental Traits. The traits selected for study are those with known discriminatory value which were readily recorded and which are thought to be independently expressed (Hanihara 1963; Kirveskari 1974; Mayhall 1976; Sofaer et al. 1972; Wright 1974). Some traits which have yet to be studied in detail but which promise to be of value were also included. The criteria for classification were largely those used by previous researchers, although some simplification was necessary. All traits are defined in Chapter III. Those used for distance analyses are marked with an asterisk.

2. Genetical Control of Traits. The genetic component of dental traits has long been known (Hrdlička 1911; Krogman 1960; Lasker 1950). This was orginally concluded from the observed population differences in the frequencies of traits. Since these early conclusions, studies on monozygotic (MZ) and dizygotic (DZ) twins have further demonstrated that tooth from is largely under genetic control. Lundström (1963) was able to correctly diagnose zygosity in 117 of 124 pairs of twins on the basis of permanent tooth morphology. Korkhaus (1930) observed shovel shaping, fissure pattern and cusp formation in twins and concluded that these traits were

inherited. Considering only traits on the mandibular first premolar, Kraus (1957) found that MZ twins showed significantly more concordances than DZ twins and unrelated pairs. He and his associates (1959) found that premolar morphology equalled dermatoglyphics as a method of diagnosing monozygosity. Wasser (1953) observed five traits on upper premolars and found the number of concordances in MZ twins to be more than expected by chance. More recently Biggerstaff (1973) found he was able to distinguish MZ twins on the basis of Carabelli's trait alone.

Little is known about actual mechanisms of inheritance but polygenic inheritance appears to be most likely (Dahlberg 1962; Bailit et al. 1974). This, plus the quasi-continuous nature of the traits has made genetic analysis difficult. A quasicontinuous trait behaves somewhat as a discrete trait in that it is present or absent. However there is a continuous gradation of variation for each trait. When a trait is present it is so in varying intensities. Below a certain point on this scale of variation the trait does not appear at all (Grüneberg 1952).

Some attempts have been made to determine modes of inheritance. Turner (1967) assumed equilibrium and applied the Hardy-Weinberg theorem to arrive at expected values of incidences for various traits. This approach has since been shown to be invalid (Sofaer 1970). Kraus (1951), Goose and Lee (1971) and Portin and Alvesalo (1974) have also attempted to determine modes of inheritance. These studies will be considered in more detail when traits are discussed individually.

3. General Methodology. Two major problems are encountered in this type of study. The first is that of bilaterality of traits, the second is sex differences.

Most traits are expressed on both sides of the mouth. The degree of expression may differ, however, although this is rarely by more than one category (Biggerstaff 1970). Kraus (1957) found 20-30% occurrences of asymmetrical traits on the mandibular premolars. Garn *et al* (1966a) found asymmetry was not a problem in mandibular first molars but it was more pronounced in second molars. Biggerstaff (1973) found an unexpectedly high incidence of asymmetry in the expression of Carabelli's trait in twins, but the frequency of asymmetry in the general population was less. Goose and Lee (1971) found left and right sides to be the same. Only the occurrence of three-rooted mandibular molars has been shown to be significantly asymmetrical (Tratman 1938; Turner 1967). This problem has been handled in various ways. Some workers have used only one antimere for analysis on the assumption that symmetry existed (Moorrees 1957). Kirveskari (1974) compared the total frequencies for each side, and finding no significant differences followed the same procedure as Moorrees. Turner (1967) considered one side only if there was less than 5% asymmetry for a trait. If there was more, he used each tooth separately. The frequencies from these methods are not directly comparable. In dealing with an ossuary one must use the latter method, what Turner terms 'tooth' count. Each tooth is considered, and any comparisons are made by side (Wright 1974). There are then two sets of observations for the sample.

Sex differences in the expression of traits are evident, but rarely are they significant (Kirveskari 1974; Pedersen 1949; Turner 1967). Turner (1967) found only two traits with significant differences; first maxillary molar cusp number and the occurrence of three-rooted mandibular molars. This latter trait shows a sex difference in symmetry as well (Tratman 1938;Turner 1967). There is a male preponderance for shovelling in Whites, Negroes, Texas Indians and Japanese (Goldstein 1948; Hrdlička 1920;Suzuki and Sakai 1966). The opposite seems to be true in Chinese and Teso (Barnes 1969; Hrdlička 1920). Males have more lingual tubercles on the incisors in Whites and coloured populations (Hrdlička 1921). Carabelli's trait is more common in males, as is larger cusp number in mandibular molars (Garn <u>et al</u> 1966b; Goose and Lee 1971; Meredith and Hixon 1954;Turner 1967). However, none of these differences proved to be significant. Most researchers have pooled their samples for analysis (Bang and Hasund 1972; Kirveskari 1974; Moorrees 1957). It then seems reasonable to assume that in the Kleinburg sample, which cannot be sorted by sex, sex differences will not significantly affect the observed frequencies regardless of the true ratio of sexes.

4. Recording. Where possible standard models or photographs were used to maintain scoring consistency. Detailed references are given below. Categories for each trait were numbered for recording purposes and are presented as such. To test for repeatability a sample of loose teeth was observed by J.T. Mayhall. In no instance did our results differ by more than one category, nor was there discordance in present/absent classification. Repeatability was not determined for individual traits, but overall repeatability was in the order of 85%.

5. Terminology. For the purposes of this work the major molar cusps are named by location. These terms with the older terms suggested by Osborn (1888) are given below:

Maxillary Molars

Paracone	Mesiobuccal cusp
Protocone	Mesiolingual cusp
Metacone	Distobuccal cusp
Hypocone	Distolingual cusp

Mandibular Molars

Protoconid	Mesiobuccal cusp
Metaconid	Mesiolingual cusp
Hypoconid	Distobuccal cusp
Entoconid	Distolingual cusp
Hypoconulid	Distal cusp

CHAPTER III

DEFINITION OF TRAITS

Maxillary Incisors*

1. Lingual Cervical Area

The lingual cervical area of the incisors and canines is often referred to as the cingulum. A true cingulum, however is rarely seen in hominids (Kirveskari 1974). Tubercles and ridges in this area are considered to be the remnants of a cingulum (Carbonell 1963; Kirveskari 1974). Tubercles occur most frequently on maxillary canines, then lateral incisors and rarely on central and mandibular incisors.

There do occur population differences in the appearance of tubercles, but the frequency of occurence is generally low except in Arctic populations (Carbonell 1963).

The expression of lingual tubercles and the degree of expression of shovel-shaping are related in Japanese (Suzuki & Sakai 1966). Other data suggest the traits are not generally related (Carbonell 1963; Hrdlička 1921; Lasker 1950). The categories for recording are taken largely from Wright (1974:19) and Barnes (1969:184).

1.0 Absence of pits, tubercles or ridges.

1.1 Presence of one or more small tubercles. A tubercle must have a groove between it and the rest of the tooth (Barnes 1969). If the groove was slight and the tubercles had a partly-free apex, it was recorded as small.

1.2 Presence of one or more large tubercles.
A large tubercle is clearly elevated with a free apex (Kirveskari 1974).

1.3 Presence of finger-like projections.
Parallel ridges of elevated enamel separated by grooves were seen. Shallow grooves with no clear enamel elevations were not included (Barnes 1969).

1.4 Presence of one or more pits.

1.5 Presence of both one or more pits and one or more tubercles.

1.6 Presence of a single groove where marginal ridges meet.

2. Lingual Marginal Grooves

Single or multiple grooves may dissect either the mesial distal or both marginal ridges, extending from the lingual cervical area to the cementum (Kraus *et al*. 1969:21). Any groove which could be felt by the fingernail and extended onto the cementum was recorded.

Kraus, Jordan and Abrams (1969) mention this trait as a variation on lateral incisors only. The incidence on both incisors was recorded here using the following categories.

2.0 Absence of marginal grooves.

2.1 Presence of one or more mesial grooves (see photograph: Kraus *et al*. 1969:22, Fig.1-30)

2.2 Presence of one or more distal grooves.

2.3 Presence of both mesial and distal grooves.

3. Lingual Shovel Shape*

The mesial and distal lingual ridges of the incisors may be elevated producing a 'shovel-shaped' incisor. The lateral incisors are more often affected by shovelling (Carbonell 1963; Lasker & Lee 1957). The degree of expression is concordant for monozygotic twins (Korkhaus 1930; Lasker 1950). Tests for modes of inheritance have been made by Turner (1967) and Portin and Alvesalo (1974). In both instances a model of two codominant alleles fit the data, although the distribution of expressions differed. Portin and Alvesalo did not rule out the possibility of polygenic inheritance.

The categories used were based originally on Hrdlička's classification with some alterations (Carbonell 1963: Fig. 1; Hrdlička 1920: 449). Plaque 1 of Dahlberg's reference series was used to record categories 3.1 to 3.4.

3.0 Absence of shovel trait; no trace, faint or imperfect rim.

3.1 Trace of shovel shape; slight but distinct ridges.

3.2 Semi-shovel shape; enamel rim is distinct but fossa is still shallow.

3.3 Shovel shape; enamel rim and fossa are well-developed.

3.4 Marked shovel shape; enamel rim is extremely developed.

3.5 Peg-shaped; reduced incisor with cylindrical crown.

3.6 Barrel-shaped; shovelling is so extreme as to form a continuous rim of enamel which projects incisally for at least 2/3 the length of the crown.

4. Labial Ridging*

A build-up of enamel may occur on the labial surface of incisors both on the margins and in the central lobe (Carbonell 1963:218; Dahlberg 1949:141).

Central incisors are affected more than laterals (Kirveskari 1974; Snyder 1960). The relative intensity of the expression of labial ridging compared to that of shovel-shaping is not the same for all populations (Kirveskari 1974).

When either of the marginal ridges or both were elevated more than the central lobe, labial ridging was said to be present (Kirveskari 1974).

4.0 Absence of labial ridging.

4.1 Presence of labial ridging.

<u>Maxillary Canines</u>*

1. Lingual Cervical Area

As in the incisors, tubercles sometimes occur on the canines. These are also of cingular origin (Carbonell 1963).

The method for recording was taken from Wright (1974:23).

1.0 Absence of pits or tubercles.

1.1 Presence of one tubercle with no pits.

1.2 Presence of one tubercle with one or multiple pits.

1.3 Presence of multiple tubercles.

1.4 Presence of multiple tubercles and one or multiple pits.

1.5 Presence of one or multiple pits.

Maxillary Premolars*

1. Distal Transverse Ridge

An accessory ridge may lie between the buccal triangular ridge and the distal marginal ridge on the occlusal surface (Kraus *et al* 1969:60; Wright 1974:24). The ridge is more frequently seen on second premolars (Kraus *et* al. 1969).

1.0 Absence of distal transverse ridge.

1.1 Presence of distal transverse ridge (see photograph: Kraus *et al*. 1969:60, Fig. 1-97).

2. Occlusal Marginal Ridge Continuity

Both the mesial and distal marginal ridges may be continuous or may be cut by one or more grooves. Tubercles may also be present both mesially and distally (Kraus *et al*. 1969:60; Morris 1965:33; Wright 1974:23). The system for scoring is an expansion of that used by Wright (1974:23).

2.0 Absence of mesial or distal marginal grooves or tubercles.

2.1 Presence of mesial marginal groove.

2.2 Presence of distal marginal groove.

2.3 Presence of a mesial marginal accessory tubercle with or without a distal groove.

2.4 Presence of a distal marginal accessory tubercle with or without a mesial groove.

2.5 Presence of both a mesial and distal marginal groove.

2.6 Presence of both a mesial and distal accessory tubercle.

3. Root Number

First premolars usually have two roots, second premolars one (Kraus *et al*. 1969). The double-rooted form is rarer in Mongoloid populations (Pedersen 1949; Turner 1967). The definitions for single and double roots follow Pedersen's system for root classification (1949:74).

3.1 Presence of a single root.

3.2 Presence of two roots; roots must be free for at least ½ their length.

3.3 Presence of two roots fused; roots are free for less than ½ their length.

Maxillary Molars

1. Cusp Number*

Variation in cusp number is due to presence or absence of the distolingual cusp, although other cusps vary in size (Dahlberg 1949:168; Turner 1967:58). Reduction is rare in the first molar, more common in the second and third (Dahlberg 1949).

Reduction of the distolingual cusp in the maxillary molars is associated with third molar agenesis (Keene 1965). Cusp reduction seems to be of more value in distinguishing between two closely related groups than as a diagnostic racial trait (Kirveskari 1974).

Dahlberg's diagrams of degrees of cusp reduction (1949:168) were used for recording. Two new categories were introduced to accomodate the observations; 1.6 and 1.7.

1.1 Presence of four well-developed cusps.

1.2 Presence of four cusps; distolingual cusp reduced.

1.3 Presence of three cusps with faint expression of the distolingual cusp.

1.4 Presence of three cusps only.

1.5 Presence of two cusps with a distal tubercle.

1.6 Presence of two cusps only.

1.7 Presence of more than four cusps.

2. Carabelli's Trait*

Carabelli's trait is a series of expressions ranging from pits to large cusps. The trait occurs on the mesio-lingual cusp. The frequency of occurence decreases from first to third molars (Dahlberg 1949).

The trait is a relatively recent derivative from the cingulum (Dahlberg 1949: Kirveskari 1974). It has been suggested that the fullest expression of the trait compensates for reduction in tooth size (Dahlberg 1965). Keene (1965) found a negative correlation between Carabell's cusp expression and third molar agenesis. Others have found no correlation between trait expression and molar size or suppression of the third molar (Bang & Hasund 1972; Garn *et al*. 1966b).

Several possible genetic mechanisms have been suggested. A model of simple Mendelian dominant was proposed (Lasker 1950) and was supported by application of the Hardy-Weinberg theory to population data (Hanihara 1963). The same method also supported a model of two autosomal codominant alleles (Turner 1967) which had earlier been suggested from pedigree analysis (Kraus 1951). As this model has been shown to be inadequate and invalid (Goose & Lee 1971; Kraus 1959; Sofaer 1970) it seems probable that inheritance is multifactorial.

The system used for classification and recording was Dahlberg's (1963:159).

2.0 Absence of Carabelli's trait.

2.1 Presence of a single furrow; any groove was recorded however shallow.

2.2 Presence of a pit.

2.3 Presence of a Y-shaped groove.

2.4 Presence of a double furrow.

2.5 Presence of bulging on the tooth surface with or without a Y-shaped groove or double furrows.

2.6 Presence of a small cusp.

2.7 Presence of a large cusp.

3. Lingual Enamel Extension

An extension of enamel onto the root may occur at the cemento-enamel junction. These occur on lingual or buccal aspects, or both (Pedersen 1949:74; Turner 1967:101). Enamel pearls are often found in the same populations which have extensions (Lasker 1950).

Mandibular molars show a greater incidence of the trait (Andrews 1975;Turner 1967). The second molar in each arch is more frequently affected (Andrews 1975; Wright 1974). Three-quarters of all extensions occur on buccal surfaces and are slight (Andrews 1975).

Pedersen (1949:74) proposed a system of classification which has been reduced for the purposes of this analysis.

3.0 Absence of lingual extension.

3.1 Presence of lingual extension which does not extend between roots (see diagram: Andrews 1975:51, Fig.8).

3.0 Absence of lingual extension.

3.1 Presence of lingual extension which does not extend between roots (see diagram: Andrews 1975:51, Fig. 8).

3.2 Presence of a lingual extension which extends between the roots.

4. Buccal Enamel Extension

The categories for buccal enamel extensions are the same as for lingual extensions.

5. Anterior Transverse Ridge*

An extra ridge may be present on the occlusal surface between the mesial marginal ridge and the triangular ridge of the mesiobuccal cusp (Kraus et al. 1969:90). The ridge can be present in a range of sizes, but because of attrition presence or absence only was considered.

5.0 Absence of an anterior transverse ridge.

5.1 Presence of an anterior transverse ridge (see photograph: Kraus et al. 1969:91, Fig. 1-145A,B).

6. Lingual Groove Termination

Both the lingual and buccal grooves vary in form. They may be shallow and blend into the tooth surface; they may end abruptly, or in a pit (Kraus et al. 1969:90; Morris 1965:45; Wright 1975:31). Observations were made on four-cusped molars only and were recorded as suggested by Kraus et al. (1969:90).

6.0 Absence of lingual groove.

6.1 Lingual groove blends smoothly into the tooth surface.

6.2 Lingual groove ends abruptly.

6.3 Lingual groove ends in a pit.

7. Buccal Groove Termination

Buccal groove termination was observed on all molars. Again method of recording is taken from Kraus *et al*. (1969:90).

7.0 Absence of buccal groove.

7.1 Buccal groove blends smoothly into the tooth surface.

7.2 Buccal groove ends abruptly.

7.3 Buccal groove ends in a pit.

8. Root Number

Maxillary molars usually have three roots although this can vary. Both Pedersen (1949) and Turner (1967) considered root number. A derivative of Pedersen's classification (1949:75) has been used here. Any roots partially fused but free for at least half their length were considered as separate.

8.1 Presence of single root.

8.2 Presence of two roots fused; i.e. single root with double apex.

8.3 Presence of two roots with double or triple apex; the condition of two roots results from fusion of any two of three roots.

8.4 Presence of three roots.

8.5 Presence of three fused roots; i.e. single root with three apices.

8.6 There is an increase in the number of roots regardless of fusion; this includes any extra rootlets even if the normal roots are fused.

Mandibular Incisors

1. Lingual Cervical Area

Tubercles can appear on the mandibular incisors although the variation seen in the maxillary anterior teeth is missing (Morris 1965:46; Wright 1974:33). Categories used are similar to those used for Maxillary Incisors.

1.0 Absence of tubercles or grooves.

1.1 Presence of a slight tubercle.

1.2 Presence of a prominent tubercle having a free apex.

1.3 Presence of one or more pits.

1.4 Presence of a single groove in the centre where marginal ridges meet.

2. Lingual Shovel Shape *

Shovel shaping on mandibular incisors is less pronounced than on the maxillary (Dahlberg 1949; Hrdlička 1920). A condensed system of scoring was used, taken from Mayhall (1976: 62).

2.0 Absence of shovel trait.

2.1 Trace of shovel shape.

2.2 Semi-shovel shape.

2.3 Marked shovel shape.

2.4 Peg-shaped incisor.

2.5 Barrel-shaped incisor.

3. Labial Ridging*

3.0 Absence of labial ridging.

3.1 Presence of labial ridging.

Mandibular Canines

1. Lingual Cervical Area

Tubercles are seen less frequently on mandibular canines than on maxillary (Turner 1967). Scoring is the same as for maxillary canines.

1.0 Absence of pits or tubercles.

1.1 Presence of one tubercle with no pits.

1.2 Presence of one tubercle with one or more pits.

1.3 Presence of two or more tubercles.

1.4 Presence of two or more tubercles with pits.

1.5 Presence of one or more pits.

Mandibular Premolars

1. Lingual Cusp Number*

Mandibular molars generally have one buccal cusp and one or two lingual cusps (Kraus & Furr 1953:559; Turner 1967: 51). The condition of two lingual cusps is less common in the first premolar (Kraus et al. 1969).

Any cusp with a partially or wholly independent apex was recorded.

1.0 Absence of lingual cusp (see photograph: Kraus et al. 1969:71, Fig. 1-114A).

1.1 Presence of one lingual cusp.

1.2 Presence of two lingual cusps (see photograph: Kraus et al. 1969:71, Fig. 1-114C).

1.3 Presence of three or more lingual cusps.

2. Occlusal Marginal Ridge Continuity

The occlusal marginal ridges connect the buccal and lingual cusps mesially and distally. The ridges can be continuous, divided by a groove or can possess a tubercle (Kraus & Furr 1953:559-560; Kraus et al. 1969:61; Morris 1965: 52; Wright 1974:37).

2.0 Both margins are continuous.

2.1 Presence of a mesial marginal groove.

2.2 Presence of a distal marginal groove.

2.3 Both margins grooved.

2.4 Presence of a mesial marginal tubercle.

3. Accessory Transverse Ridges

The main transverse or occlussal ridge may be bifurcated. As well, extra transverse ridges may be present (Kraus & Furr 1953:560; Kraus et al. 1969:72; Ludwig 1957: 267-268). Only accessory ridges and not the total number of ridges were counted (Ludwig 1957).

3.0 Absence of accessory ridges.

3.1 Presence of one accessory ridge.

3.2 Presence of two or more accessory ridges.

3.3 Presence of bifurcated main ridge.

3.4 Presence of bifurcated ridge with one accessory ridge.

3.5 Presence of bifurcated ridge with two or more accessory ridges.

4. Root Number

Mandibular premolars generally have one root, but occasionally there may be two (Kraus _et al_. 1969:72).

4.1 Presence of one root.

4.2 Presence of two roots.

4.3 Presence of two roots fused; one root with double apex.

Mandibular Molars

1. Variation of Distal Cusp

The distal cusp may be present in varying degrees of expression or may be absent (Dahlberg 1963:170; Kirveskari 1974:39). The number of cusps decreases from M1 to M3 to M2 in the mandible (Kirveskari 1974).

Although it has been the practice to record cusp number and cusp pattern together, they have been shown to be unrelated in incidence (Garn _et al_.1966c; Jorgensen 1955). However, reduced cusp number is related to tooth agenesis

(Davies 1968; Keene 1965), and there is a tendency for smaller teeth to have fewer cusps (Dahlberg 1962).

The mode of inheritance for the distal cusp is unknown. Simple models are inadequate to explain the collected data (Biggerstaff 1970).

Some researchers have recorded size (Morris 1965; Wright 1974) while others have recorded presence or absence only (Kirveskari 1974; Turner 1969). The former was chosen here and Wright's categories (1974:42) were used.

1.0 Absence of distal cusp.

1.1 Presence of a distal cusp smaller than ½ the size of any other cusp.

1.2 Presence of a distal cusp at least ½ the size of any other cusp.

1.3 Presence of a distal cusp equal in size to any other cusp.

1.4 Presence of a distal cusp, size undeterminable.

2. Tuberculum Sextum*

An extra cusp may occur on the distal marginal ridge between the distal and distobuccal cusps (Hellman 1928:164; Kirveskari 1974:46; Kraus et al. 1969:110). The frequency of this cusp tends to increase from M1 to M3 (Kirveskari 1974). This cusp occurs independently of the distal cusp (Mayhall:pers. comm.).

The method of recording is taken from Kirveskari (1974:47).

2.0 Absence of tuberculum sextum.

2.1 Presence of grooves or small tubercle.

2.2 Presence of a distinct cusp of small or medium size.

2.3 Presence of a distinct cusp of large size; comparable to distal cusp in size (see photograph: Kirveskari 1974:46, Fig. 15).

2.4 Presence of a cusp, size undeterminable.

3. Tuberculum Intermedium*

A small cusp, sometimes term C7, may be found on the distal ridge of the mesiolingual cusp (Hellman 1928:164; Kirveskari 1974:46; Kraus _et al_. 1969:110). This cusp decreases in frequency from M1 to M3 (Kirveskari 1974). An association between the occurrence of this cusp and Carabelli's cusp was found in the Teso (Barnes 1969). Tuberculi intermedii are seen less often in individuals missing third molars (Keene 1965).

The method of recording is taken from Kirveskari (1974:48).

3.0 Absence of tuberculum intermedium.

3.1 Presence of double grooves or weak cusp; without a free apex.

3.2 Presence of a distinct cusp of small or medium size.

3.3 Presence of a distinct cusp of large size (see photograph: Kirveskari 1974: 46, Fig. 15).

3.4 Presence of a cusp, size undeterminable.

4. Protostylid*

The protostylid is a continuous variable occurring on the buccal or mesiobuccal portion of the mesiobuccal cusp (Dahlberg 1950:15). Expressions of the trait range from pits and furrows to large cusps. The incidence and degree of expression decrease from M1 to M2 (Dahlberg 1950, 1963), although Turner (1967) found the second molar of Northern Indians and Eskimos to be most affected.

Carabelli's trait and the protostylid were found to be associated in the Japanese (Suzuki & Sakai 1954; Sakai 1955 cited in Kirveskari 1974). This association was not evident in Peruvians where Protostylid cusps appear more often with 'advanced' cusp patterns (Goaz & Meller 1966). The genetic mechanism controlling the trait is most likely multifactorial (Dahlberg 1950).

Dahlberg's classifications were used (1963:163) as suggested by Mayhall (1976:80). Pits occurring at the end of the buccal groove were not included here.

4.0 Absence of protostylid.

4.1 Presence of a pit or furrow.

4.2 Presence of distal deviation of the buccal groove.

4.3 Presence of irregularities of the cusp surface.

4.4 Presence of a prominence.

4.5 Presence of a prominence with a furrow, including diagonal grooves.

4.6 Presence of a small cusp.

4.7 Presence of a large cusp.

5. Buccal Groove Termination

The buccal groove, separating the mesiobuccal and distobuccal cusps can be very prominent or barely discernible (Dahlberg 1949:160; Kraus et al. 1969:110; Morris 1965:61). It often ends in a pit. Dahlberg (1963) includes this pit as an expression of the protostylid. The distribution of the pit appears to be independent of other protostylid expressions (Kirveskari 1974; Mayhall 1976). Devoto et al. (1972) found an association between the occurrence of buccal pits and protostylid, but did not consider them to be the same trait.

The classification suggested by Kraus et al. (1969: 111, Fig. 1-181) was used.

5.0 Absence of buccal groove.

5.1 Buccal groove blends smoothly into the tooth surface.

5.2 Buccal groove ends abruptly.

5.3 Buccal groove ends in a pit.

6. Lingual Enamel Extension

Lingual enamel extensions were recorded in the same manner as for maxillary molar extensions. Both lingual and buccal extensions are more frequent in mandibular teeth (Andrews 1975).

6.0 Absence of lingual enamel extension.

6.1 Presence of lingual extension which does not extend between the roots.

6.2 Presence of lingual extension which extends between the roots.

7. Buccal Enamel Extension

7.0 Absence of buccal enamel extension.

7.1 Presence of buccal extension which does not extend between the roots.

7.2 Presence of buccal extension which extends between the roots.

8. Cusp and Groove Pattern*

Cusp and groove pattern until recently has been recorded with cusp number. Three patterns are commonly recorded; Y, +, and X (Jørgensen 1955:195). The incidence of the Y pattern decreases from M1 to M3; the opposite is true for the X pattern (Kirveskari 1974).

8.1 Presence of Y pattern; ML and DB cusps touch, MB and DL cusps do not.

8.2 Presence of + pattern; all four cusps are adjacent.

8.3 Presence of X pattern; MB and DL cusps touch, ML and DB cusps do not touch.

8.4 Presence of irregular pattern.

9. Root Number

Mandibular molars have two roots, but more or less are often seen (Tratman 1938:264; Turner 1967:133). The trait of triple roots was thought to be a sex-linked dominant (Tratman 1938). Turner (1967) tested for sex-linked recessiveness. Neither model fit both sets of data. A sex-limited autosomal mode of inheritance may be more appropriate (Turner 1967).

A system of classification based on that of Pedersen (1949:75) was used.

9.1 Presence of two roots; they must be separate for at least ½ their length.

9.2 Presence of two roots, fused; two roots not separate for ½ their length.

9.3 Presence of three roots.

9.4 Presence of three roots fused in any manner.

9.5 Presence of a single root.

CHAPTER IV

OBSERVATIONS OF DENTAL MORPHOLOGY OF THE KLEINBURG SAMPLE

The analysable dental sample includes only those teeth which could be accurately indentified and which were sufficiently intact to allow scoring of at least one trait. The total sample numbers 8,459 teeth. Of these 2,653 were in 454 mandibular and 533 maxillary fragments. The remainder were loose. The composition by tooth group is given in Table 4.1.

TABLE 4.1

KLEINBURG DENTAL SAMPLE

Tooth Type	Left	Right
Maxillary incisors	483	474
Maxillary canines	359	334
Maxillary premolars	471	467
Maxillary molars	935	932
Mandibular incisors	420	405
Mandibular canines	336	333
Mandibular premolars	523	509
Mandibular molars	735	743
Total	4262	4197

All observations for all tooth groups are presented although not all were used in the comparative analyses.

TABLE 4.2

OBSERVATIONS OF DENTAL MORPHOLOGY

Maxillary Incisors

Trait	Central		Lateral	
	Left	Right	Left	Right
Lingual Cervical Area				
1.0 Smooth	161	152	109	134
1.1 Small tubercle(s)	1	3	15	11
1.2 Large tubercle(s)	2	2	0	0
1.3 Finger-like projections	19	9	0	0
1.4 Pit(s)	5	2	10	15
1.5 Pit(s) and tubercle(s)	0	1	6	2
1.6 Single groove	16	9	53	45
	204	178	193	207
Lingual Marginal Grooves				
2.0 Absence	214	191	114	121
2.1 One or more mesial	11	3	19	28
2.2 One or more distal	9	11	44	54
2.3 Mesial and distal	0	1	4	4
	234	206	181	207
Lingual Shovel Shape				
3.0 Absence	6	7	7	5
3.1 Trace	83	69	63	55
3.2 Semi-shovel	72	74	59	71
3.3 Shovel shape	17	23	23	25
3.4 Marked	2	1	4	1
3.5 Peg-shaped	0	0	3	3
3.6 Barrel shaped	0	0	2	3
	180	174	161	163
Labial Ridging				
4.0 Absence	228	186	171	183
4.1 Presence	23	26	11	13
	251	212	182	196

TABLE 4.3

OBSERVATIONS OF DENTAL MORPHOLOGY

Maxillary Canines

Trait	Left	Right
Lingual Cervical Area		
1.0 Smooth	273	229
1.1 Single tubercle	8	9
1.2 Single tubercle with pit(s)	1	2
1.3 Two or more tubercles	0	0
1.4 Multiple tubercles with pit(s)	0	0
1.5 Pit(s) only	13	14
	295	254

TABLE 4.4

OBSERVATIONS OF DENTAL MORPHOLOGY

Maxillary Premolars

Trait	First		Second	
	Left	Right	Left	Right
Distal Transverse Ridge				
1.0 Absence	203	188	110	133
1.1 Presence	8	5	33	19
	211	193	143	152
Occlusal Ridge Continuity				
2.0 Continuous	48	35	72	67
2.1 Mesial groove	45	43	7	8
2.2 Distal groove	5	1	6	4
2.3 Mesial tubercle	36	24	6	12
2.4 Distal tubercle	6	8	3	3
2.5 Mesial & distal grooves	9	12	0	4
2.6 Mesial & distal tubercles	6	16	0	5
	155	139	94	103
Root Number				
3.0 Single root	108	100	139	142
3.1 Two roots	12	5	4	2
3.2 Two roots fused	53	60	0	0
	173	165	143	144

TABLE 4.5

OBSERVATIONS OF DENTAL MORPHOLOGY

Maxillary Molars, First and Second

Trait	First Left	First Right	Second Left	Second Right
Cusp Number				
1.1 Four	234	225	21	52
1.2 Four, DL reduced	122	116	204	198
1.3 Three, DL faint	0	1	71	59
1.4 Three	0	0	7	10
1.5 Two, distal tubercle	0	0	0	1
1.6 More than four	1	2	1	1
	357	344	304	321
Carabelli's Trait				
2.0 Absence	65	64	171	200
2.1 Single furrow	66	57	17	18
2.2 Pit	31	19	12	8
2.3 Y-shaped groove	27	26	7	5
2.4 Double furrow	9	8	2	5
2.5 Bulging	15	17	0	4
2.6 Small cusp	3	4	0	0
2.7 Large cusp	3	5	0	0
	219	200	209	240
Lingual Enamel Extension				
3.0 Absence	86	125	87	108
3.1 Presence, not between roots	43	23	55	53
3.2 Presence, between roots	0	1	2	1
	129	149	144	162
Buccal Enamel Extension				
4.0 Absence	109	122	20	32
4.1 Presence, not between roots	112	125	117	156
4.2 Presence, between roots	40	32	118	75
	261	279	255	263
Anterior Transverse Ridge				
5.0 Absence	16	18	64	83
5.1 Presence	79	77	50	34
	95	95	114	117
Lingual Groove				
6.0 Absence	0	1	11	14
6.1 Blends smoothly	30	26	84	100
6.2 Ends abruptly	245	255	100	101
6.3 Ends in pit	35	18	19	14
	310	300	214	229

TABLE 4.5 (cont'd)

Trait	First		Second	
	Left	Right	Left	Right
Buccal Groove				
7.0 Absence	0	0	1	0
7.1 Blends smoothly	279	284	227	273
7.2 Ends abruptly	20	20	25	20
7.3 Ends in pit	15	13	10	12
	314	317	263	305
Root Number				
8.1 Single root	0	0	12	15
8.2 Two roots, fused	0	1	1	2
8.3 Two roots, three fused	3	0	26	37
8.4 Three roots	108	90	90	93
8.5 One root, three fused	0	0	2	2
8.6 Increase	0	0	0	1
	111	91	131	150

TABLE 4.6

OBSERVATIONS OF DENTAL MORPHOLOGY

Maxillary Molars, Third

Trait	Left	Right
Cusp Number		
1.1 Four cusps	1	0
1.2 Four cusps, DL reduced	20	38
1.3 Three cusps, faint DL	56	45
1.4 Three	120	75
1.5 Two cusps, distal tubercle	22	25
1.6 Two cusps	2	10
1.7 More than four	1	0
	222	193
Carabelli's Trait		
2.0 Absence	158	144
2.1 Single furrow	8	5
2.2 Pit	10	15
2.3 Y-shaped groove	1	2
2.4 Double furrow	1	2
2.5 Bulging	4	1
2.6 Small cusp	0	0
2.7 Large cusp	1	0
	183	169
Lingual Enamel Extension		
3.0 Absence	116	111
3.1 Presence, not between roots	60	43
3.2 Presence between roots	3	5
	179	159
Buccal Enamel Extension		
4.0 Absence	23	20
4.1 Presence, not between roots	84	91
4.2 Presence, between roots	98	81
	205	192
Anterior Transverse Ridge		
5.0 Absence	85	95
5.1 Presence	38	27
	123	122

Table 4.6 (cont'd)

Trait	Left	Right
Lingual Groove		
6.0 Absence	17	34
6.1 Blends smoothly	39	39
6.2 Ends abruptly	17	14
6.3 Ends in pit	9	2
	82	89
Buccal Groove		
7.0 Absence	14	28
7.1 Blends smoothly	175	133
7.2 Ends abruptly	22	20
7.3 Ends in pit	10	11
	221	192
Root Number		
8.1 Single root	85	83
8.2 Two roots, fused	18	11
8.3 Two roots, three fused	21	14
8.4 Three roots	19	13
8.5 One root, three fused	7	9
8.6 Increase	2	2
	152	132

TABLE 4.7

OBSERVATIONS OF DENTAL MORPHOLOGY

Mandibular Incisors

Trait	Central Left	Central Right	Lateral Left	Lateral Right
Lingual Cervical Area				
1.0 Smooth	219	185	169	169
1.1 Slight tubercle	0	0	0	0
1.2 Prominent tubercle	0	0	0	0
1.3 Pit(s)	0	0	1	1
1.4 Single groove	14	31	6	8
	233	216	176	178
Shovel Shape				
2.0 Absence	122	103	87	77
2.1 Trace	44	54	50	61
2.2 Semi-shovel	2	0	0	0
2.3 Marked	0	0	0	0
2.4 Peg-shaped	0	0	0	0
2.5 Barrel shaped	0	0	0	0
	168	157	137	138
Labial Ridging				
3.0 Absence	169	154	137	137
3.1 Presence	6	7	11	5
	175	161	148	142

TABLE 4.8

OBSERVATIONS OF DENTAL MORPHOLOGY

Mandibular Canines

Trait	Left	Right
Lingual Cervical Area		
1.0 Smooth	283	278
1.1 Single tubercle	0	0
1.2 Tubercle with pit(s)	0	0
1.3 Two or more tubercles	0	0
1.4 Two or more tubercles with pit(s)	0	0
1.5 Pit(s)	1	1
	284	279

TABLE 4.9

OBSERVATIONS OF DENTAL MORPHOLOGY

Mandibular Premolars

Trait	First Left	First Right	Second Left	Second Right
Lingual Cusp				
1.0 Absence	10	8	3	2
1.1 Single cusp	254	252	204	201
1.2 Two cusps	15	6	25	23
1.3 Three or more cusps	0	0	0	0
	279	266	232	226
Occlusal Marginal Ridge				
2.0 Continuous	128	133	96	78
2.1 Mesial groove	96	75	43	29
2.2 Distal groove	0	2	1	4
2.3 Mesial & distal groove	11	3	4	2
2.4 Mesial tubercle	0	0	5	8
	235	213	149	121
Accessory Transverse Ridges				
3.0 Absence	21	23	19	17
3.1 One accessory ridge	51	47	26	19
3.2 Two or more	31	37	56	51
3.3 Bifurcated main ridge	5	16	2	3
3.4 Bifurcated with one accessory ridge	32	37	2	4
3.5 Bifurcated ridge with two or more ridges	14	9	3	5
	154	169	108	99
Root Number				
4.1 Single root	177	175	172	163
4.2 Two roots	2	1	0	0
4.3 Two roots, fused	18	15	1	0
	197	191	173	163

TABLE 4.10

OBSERVATIONS OF DENTAL MORPHOLOGY

Mandibular Molars, First and Second

Trait	First Left	First Right	Second Left	Second Right
Distal Cusp				
1.0 Absence	0	1	12	19
1.1 Smaller than ½ size of other cusps	31	33	54	52
1.2 At least ½ size of other cusps	138	122	39	51
1.3 Equal in size	41	45	13	8
1.4 Size undeterminable	76	78	79	63
	286	279	187	193
Tuberculum Sextum				
2.0 Absence	55	55	60	75
2.1 Grooves, small tubercle	21	28	14	15
2.2 Small, medium cusp	35	29	21	17
2.3 Large cusp	16	24	18	14
2.4 Size undeterminable	15	10	14	12
	142	146	127	133
Tuberculum Intermedium				
3.0 Absence	196	201	154	195
3.1 Grooves, faint cusp	17	20	17	8
3.2 Small, medium cusp	7	9	1	0
3.3 Large cusp	5	5	4	2
3.4 Size undeterminable	0	0	0	0
	225	235	176	205
Protostylid				
4.0 Absence	160	145	123	129
4.1 Pit or furrow	0	0	3	3
4.2 Distal deviation	5	3	1	1
4.3 Irregularities	2	3	10	6
4.4 Prominence	1	2	7	5
4.5 Prominence with furrow	3	4	4	6
4.6 Small cusp	0	0	0	0
4.7 Large cusp	0	0	1	1
	171	157	149	151

TABLE 4.10 (cont'd)

OBSERVATIONS OF DENTAL MORPHOLOGY

Trait	First Left	First Right	Second Left	Second Right
Buccal Groove				
5.0 Absence	1	1	6	5
5.1 Blends smoothly	8	5	33	36
5.2 Ends abruptly	201	184	98	119
5.3 Ends in pit	63	74	85	75
	273	264	222	235
Lingual Enamel Extension				
6.0 Absence	103	97	116	126
6.1 Presence, not between roots	138	132	98	94
6.2 Presence, between roots	2	2	0	2
	243	231	214	222
Buccal Enamel Extension				
7.0 Absence	60	58	18	22
7.1 Presence, not between roots	118	125	90	100
7.2 Presence, between roots	42	41	102	104
	220	224	210	226
Cusp & Groove Pattern				
8.1 Y Pattern	196	186	28	13
8.2 + pattern	16	18	107	111
8.3 X pattern	9	10	46	62
8.4 Irregular	0	1	12	6
	221	215	193	192
Root Number				
9.1 Two roots	95	81	86	68
9.2 Two roots, fused	1	0	25	30
9.3 Three roots	3	3	3	0
9.4 Three roots, fused	0	0	0	0
9.5 Single root	0	0	0	0
	99	84	114	98

TABLE 4.11

OBSERVATIONS OF DENTAL MORPHOLOGY

Mandibular Molars, Third

Trait	Left	Right
Distal Cusp		
1.0 Absence	35	34
1.1 Smaller than ½ size of other cusps	29	39
1.2 At least ½ size of other cusps	17	14
1.3 Equal in size	26	25
1.4 Size undeterminable	25	16
	132	128
Tuberculum Sextum		
2.0 Absence	54	74
2.1 Grooves, small tubercle	13	10
2.2 Small, medium cusp	8	13
2.3 Large cusp	10	14
2.4 Size undeterminable	5	2
	90	113
Tuberculum Intermedium		
3.0 Absence	109	110
3.1 Grooves, faint cusp	10	7
3.2 Small, medium cusp	1	6
3.3 Large cusp	1	14
3.4 Size undeterminable	1	0
	122	137
Protostylid		
4.0 Absence	52	41
4.1 Pit or furrow	9	13
4.2 Distal deviation	0	2
4.3 Irregularities	15	27
4.4 Prominence	6	7
4.5 Prominence with furrow	21	28
4.6 Small cusp	3	2
4.7 Large cusp	7	10
	113	130
Buccal Groove		
5.0 Absence	11	7
5.1 Blends smoothly	79	91
5.2 Ends abruptly	20	32
5.3 Ends in pit	18	19
	128	149

TABLE 4.11 (cont'd)

Trait	Left	Right
Lingual Enamel Extension		
6.0 Absence	58	60
6.1 Presence, not between roots	55	54
6.2 Presence, between roots	2	1
	115	115
Buccal Enamel Extension		
7.0 Absence	17	14
7.1 Presence, not between roots	57	62
7.2 Presence, between roots	34	38
	108	114
Cusp & Groove Pattern		
8.1 Y pattern	7	3
8.2 + pattern	6	12
8.3 X pattern	56	59
8.4 Irregular	43	55
	112	129
Root Number		
9.1 Two roots	20	21
9.2 Two roots, fused	26	23
9.3 Three roots	1	3
9.4 Three roots, fused	1	2
9.5 Single root	0	0
	48	49

Anomalous Conditions

Although anomalies were not recorded for purposes of comparisons, some unusual conditions were noted. Three supernumerary maxillary incisors were found, two on the left and three on the right out of 403 maxillary pieces with the front part intact. There was evidence of one congenitally missing incisor in 487 mandibles. One instance of fused mandibular central incisors was discovered.

The canines in both maxillae and mandibles seemed to be free from striking anomalies, as did the maxillary premolars. Four interesting cases of what appear to be supernumerary premolars were found in the mandibles. One mandible was affected on both sides, and two others were affected unilaterally. There were a total of 567 mandibular pieces which could be examined in the premolar region. There was one instance of an occlusal tubercle.

Several anomalies were noticed on the molars. On the maxillary teeth, 46 enamel pearls were scored. All but two of these were on the second and third molars. The breakdown is as follows: left M1-1, right M1-1, left M2-12, right M2-11, left M3-10, right M3-11. Mesiobuccal parastyles or pits seemed to be common although I am not aware of other researchers noting this type of condition. One parastyle was seen on a first molar, and twenty were seen on second molars. The incidences were the same for each side; twelve on the left and eight on the right. These numbers were increased slightly on the third molars with thirteen on the left and eighteen on the right.

Enamel pearls were also noted on the mandibular molars. Only one left and two right second molars had enamel pearls. Only three pearls were noted on third molars also. No other conditions occurred on the mandibular molars.

CHAPTER V

STATISTICAL ANALYSIS

The primary purpose of this thesis as stated above, is to find biological affinities of the Kleinburg sample with hopes of contributing to the knowledge of the origins of this population. The dentition of three contemporary ossuary groups has been analysed by Wright (1974) and these data were available for comparison. Shaver Hill, dated 1600-1620 A.D. and Carton dated 1590-1610 A.D. are considered to be Neutral ossuaries on the basis of arachaeological evidence. Sopher, dated 1580-1610 A.D. is Huron (Wright 1974). Wright concluded that the two Neutral populations were closer biologically than either were to the Huron population. If his conclusions are valid, it should be possible to relate the Kleinburg people to one or the other group. In addition, an unrelated sample of North American whites was included to test the validity of the methods chosen, and as a reference point with which to compare the results of the Indian-Indian comparisons. Casts from the Burlington Growth Centre were kindly made available. A total of 52 casts were examined, 26 of each sex.

Statistical Method

Rather than compare each trait separately it was decided to use a statistic that allowed an estimation of overall genetic relationship. Two techniques were chosen with the intent of comparing results; Sanghvi's χ^2 (1953) and C.A.B. Smith's Measure of Divergence as first used by Grewal (1962). Both methods have successfully been applied in studies of dental morphology (Berry 1976; Sofaer *et al.* 1972).

Sanghvi's χ^2 allows direct comparison of several characters even when the number of categories differs for each trait. It is essentially a cumulative χ^2 possible only when the traits considered are independent of one another.

It is not known that the dental characters are unrelated. Some traits appear to be related in some populations but not in others. For example, Carabelli's cusp was found to be associated with the protostylid cusp in the Japanese (Suzuki & Sakai 1954) but not in the Peruvians (Goaz & Meller 1966). Data concerning the other traits are equally inconclusive. Specific instances are included in Chapter III where individual traits are discussed. Generally, there may be a correlation between extra cusps and tooth size (Dahlberg 1961, Garn *et al.* 1966b, Keene 1965). There were no correlations between the 17 traits on mandibular premolars studied by Kraus and Furr (1953). Out of 31 traits considered throughout the mouth by Berry (1976) seven showed associations with others, and of these five were in the anterior teeth. The only significant correlation in the molar region was between Carabelli's cusp and the condition of more than four cusps on first maxillary molars, and this was only found in one of her two groups. Sofaer et al (1972) felt correlations were not important when only considering relative distances between groups, so assumed independence. Brewer-Carias et al (1976) chose traits which from the available literature appeared to be most independent, but did not consider the problem further. Others not using cumulative statistical techniques have not dealt with the possibility of associations between traits (Kirveskari 1974, Wright 1974). The inconclusive data, plus the fact that the traits considered here are spread throughout the mouth, support the treatment of the characters as independent.

The χ^2 value obtained is a mean of the individual χ^2 values and is therefore an estimate of mean divergence between a pair of populations. Sanghvi's χ^2 is equal to:

$$\frac{\sum_{1}^{n}\sum_{1}^{r} \frac{(P_1-Q)^2}{Q} - \frac{(P_2-Q)^2}{Q}}{df}$$

where P_1 and P_2 are the percentage incidences of each of r classes in which a character is recorded in two populations, $Q = (P_1 + P_2)/2$, n is the number of characters and d.f. = n(r-1). Sanghvi (1953) used this value to represent the distance between populations. It is the square root of this value which is a true distance function (Sofaer et al. 1972). This method allows comparison of several χ^2 values based on relative size of the values. A larger figure indicates a larger genetic distance between the populations. The significance of any one value cannot be tested.

Smith's Measure of Divergence (Berry & Berry 1967; Grewal 1962) likewise gives a mean measure of divergence for the total number of traits, and is "a quantitative expression of the separation of the populations" (Berry & Berry 1967:373). In other words the larger the value, the greater the difference between the groups. The procedure first involves the angular transformation of the frequencies of the traits into a Theta value measured in radians by the following formula

$$\Theta = \arcsin\ (1-2k/n)$$

where k/n is the observed frequency of the trait. The variance of Theta is 1/n where n is the sample size. For small sample sizes this relationship no longer holds true and variance of Theta is not 1/n (Green & Suchey 1976). An alternate transformation, that of Freeman and Tukey (1950) has been shown to be the best transformation for stabilizing variance with small samples (Green & Suchey 1976). The formula for this method is:

$$\Theta = \tfrac{1}{2} \arcsin \frac{1 - 2k}{(n-1)} + \tfrac{1}{2} \arcsin \frac{1-2(k+1)}{(n+1)}$$

where k/n is the observed frequency for a trait. Because four out of the five samples were of small size, this transformation was chosen. Transformed Theta values are presented in Table 6.1.

The mean measure of divergence as suggested by Berry and Berry (1967) can be calculated using the following formula:

$$M.D. = \sum_{i=1}^{r} \frac{(\theta_2^i - \theta_2^i)^2 - (1/n_1^i + 1/n_2^i)}{r}$$

where θ_1^i = transformed frequency of the ith trait in the first population.

θ_2^i = transformed frequency of the ith trait in the second population.

n_1^i = number of teeth in the first population examined for trait i.

n_2^i = number of teeth in the second population examined for trait i.

r = number of traits.

When using the Freeman-Tukey transformation, $(n_1^i + \frac{1}{2})$ and $(n_2^i + \frac{1}{2})$ must be substituted for n_1^i and n_2^i in the above formula.

It is possible to test for significance of the Measure of Divergence value (MD). If the MD is equal to or greater than twice the standard deviation, the difference between the populations is significant. The variance of MD as suggested by Sjøvold (1973) is:

$$\frac{2}{r^2} \sum_{i=1}^{r} (1/n_1^i + 1/n_2^i)^2$$

Again, when the Freeman-Tukey method is used $(n_1^i + \frac{1}{2})$ and $(n_2^i + \frac{1}{2})$ must be inserted for n_1^i and n_2^i (Green & Suchey 1976).

Computations

A total of 90 sets of observations were made on the Kleinburg material. This figure was reduced to 28 for the following reasons. The 28 included those traits which were observed on all five groups, which could be reduced to present/absent categories and which were scored using the same objective aids as Wright (1974) to maximize scoring consistency. The traits and frequencies for each population are presented in Table 5.1.

In all computations present/absent categories only were considered. Calculations for left and right sides were done separately. That is, left sides were compared to left and right sides to right. A correlation coefficient was calculated to compare results for each side using Spearman's rank method (Arkin & Cotton 1970). Each sample was compared to every other sample using both statistical methods. Spearman's rank coefficient of correlation was calculated to compare the results from each method. Additional Sanghvi's χ^2 were computed for the Indian groups using only seven and two traits (see Table 5.2). These groupings correspond to traits found by Sofaer et al. (1972) to have greater than 90% and 95% repeatability. Those traits with greatest repeatability were most discriminating between closely related samples (Sofaer et al. 1972). Individual traits were not tested for repeatability here, but it seemed a fair assumption that the same traits having the most discriminating power in Southwest Indians would also show differences in Ontario Indians (Mayhall pers. comm.).

TABLE 5.1 (Part 1)
INCIDENCE OF DENTAL VARIANTS - Left Side

Character Present	Kleinburg		Shaver Hill		Carton		Sopher		Burlington	
	No.	%	No.	%	No.	%	No.	%	No.	%
Maxilla										
Lingual Shovel on I_1	114/180	96.66	15/15	100	3/3	100	12/12	100	18/50	36.00
Labial Ridging on I_1	23/251	9.16	6/16	37.50	1/3	33.33	4/10	40.00	5/51	9.80
Lingual Tubercles on I_1	36/204	1.47	3/17	17.65	1/3	33.33	0/11	00	1/46	2.17
Lingual Shovel on I_2	154/161	95.65	9/10	90.00	12/12	100	9/9	100	20/47	42.55
Labial Ridging on I_2	11/182	6.04	4/10	40.00	1/10	10.00	2/8	25.00	0/51	00
Lingual Tubercles on I_2	15/193	7.77	3/11	27.27	1/12	8.23	2/10	20.00	3/45	6.67
Lingual Tubercles on C	9/295	3.05	0/15	0	10/32	31.25	2/10	20.00	3/58	5.17
Anterior transverse ridge on Pm_1	8/211	3.79	3/26	11.54	0/35	00	3/14	21.43	3/45	6.67
" " " " " " " " on Pm_2	33/143	23.08	4/9	44.44	16/28	57.14	10/19	52.63	25/48	52.08
Carabelli's trait on M_1	154/219	70.32	13/32	40.62	26/54	48.15	14/32	43.75	44/52	86.21
Anterior transverse ridge on M_1	79/95	83.16	12/14	85.72	17/19	89.47	13/21	61.91	25/29	84.62
Four cusps on M_2	225/304	74.01	7/25	28.00	15/27	55.56	7/21	33.33	32/48	66.67
Carabelli's Trait on M_2	38/209	18.18	3/24	12.50	1/32	3.12	1/20	5.00	16/49	78.38
Anterior transverse ridge on M_2	50/114	43.86	5/11	45.45	5/12	41.67	1/16	6.25	29/37	32.51

TABLE 5.1 (Part 1) ctd.

Character Present	Kleinburg		Shaver Hill		Carton		Sopher		Burlington	
	No.	%	No.	%	No.	%	No.	%	No.	%
Mandible										
Lingual shovelling on I_1	46/168	23.38	7/9	77.77	5/9	55.56	5/6	83.33	1/50	2.00
Labial ridging on I_1	6/175	3.43	2/8	25.00	0/8	00	0/7	00	3/52	13.46
Lingual shovelling on I_2	50/137	36.50	8/9	88.89	7/11	63.64	6/6	100	3/52	5.82
Labial ridging on I_2	11/148	7.43	2/7	28.57	1/9	11.11	1/6	16.67	2/51	3.93
Two or more lingual cusps on Pm_1	15/279	5.38	5/19	26.32	4/22	16.67	6/19	31.58	12/47	25.53
" " " " " " " " Pm_2	25/232	10.76	1/13	7.69	6/25	24.00	1/18	5.56	35/50	60.00
Protostylid on M_1	11/171	6.42	0/26	00	2/51	3.92	5/34	14.71	3/49	6/12
+ groove pattern on M_1	16/221	7.24	1/30	3.33	5/45	11.11	1/33	3.02	2/17	11.76
Tuberculum sextum on M_1	87/142	61.27	8/22	36.36	9/20	45.00	12/33	36.36	10/34	29.41
Tuberculum intermedium on M_1	29/225	12.89	6/27	22.22	8/42	19.05	7/34	20.59	11/48	22.92
Protostylid on M_2	26/149	17.44	2/26	7.69	2/46	4.35	1/21	4.76	1/49	2.04
+ groove pattern on M_2	107/193	55.44	3/14	21.44	25/46	50.00	8/21	47.62	15/25	60.00
Tuberculum sextum on M_2	67/127	52.75	3/15	20.00	7/23	30.43	4/18	22.22	1/14	7.14
Tuberculum intermedium on M_2	22/176	12.50	2/24	8.33	1/42	2.38	5/21	23.81	4/38	10.53

TABLE 5.1 (Part 2)
INCIDENCE OF DENTAL VARIANTS - Right Side

Character Present	Kleinburg		Shaver Hill		Carton		Sopher		Burlington	
	No.	%	No.	%	No.	%	No.	%	No.	%
Maxilla										
Lingual Shovel on I_1	166/174	95.98	12/12	100	7/7	100	15/15	100	15/45	33.33
Labial Ridging on I_1	26/212	12.26	9/13	69.23	4/6	66.67	7/15	46.67	5/52	9.62
Lingual Tubercles on I_1	6/193	3.37	0/13	00	1/7	14.29	2/15	13.33	1/47	2.13
Lingual Shovel on I_2	158/163	96.93	10/11	90.91	14/14	100	7/7	100	19/50	38.00
Labial Ridging on I_2	13/196	6.63	5/8	62.50	3/12	25.00	7/15	46.67	1/52	1.92
Lingual Tubercles on I_2	13/207	6.28	2/11	18.18	2/13	15.38	1/8	12.50	5/48	10.42
Lingual Tubercles on C	11/254	4.33	5/17	29.41	6/19	31.58	5/18	27.78	6/49	12.24
Anterior transverse ridge on Pm_1	5/193	2.59	1/11	9.09	3/33	9.09	5/22	22.73	8/46	17.39
" " " " " " " " on Pm_2	19/152	12.50	5/19	26.32	11/25	44.00	5/9	55.56	23/48	47.92
Carabelli's trait on M_1	136/200	68.00	22/42	52.38	33/64	51.56	27/36	75.00	28/32	87.50
Anterior transverse ridge on M_1	77/96	81.05	20/20	100	20/23	86.96	17/25	68.00	47/54	87.04
Four cusps on M_2	250/321	77.88	2/22	9.09	16/38	42.11	10/17	58.82	31/46	67.39
Carabelli's Trait on M_2	40/240	16.66	0/21	00	0/39	00	3/17	17.65	31/44	70.45
Anterior transverse ridge on M_2	34/117	29.06	3/9	33.33	10/22	45.45	1/14	7.14	17/39	43.59

TABLE 5.1 (Part 2) ctd.
INCIDENCE OF DENTAL VARIANTS - Right Side

Character Present	Kleinburg		Shaver Hill		Carton		Sopher		Burlington	
Mandible										
Lingual Shovel on I_1	54/157	34.39	6/9	66.67	1/3	33.33	5/7	71.43	3/52	5.77
Labial ridging on I_1	7/161	4.35	0/7	00	0/2	00	0/8	00	5/52	9.62
Lingual shovelling on I_2	61/138	44.20	8/8	100	4/8	50.00	7/10	70.00	2/52	3.84
Labial ridging on I_2	5/142	3.52	3/8	37.50	0/6	00	0/10	00	1/52	1.92
Two or more lingual cusps on Pm_1	6/266	2.25	2/12	16.67	9/22	40.91	5/20	25.00	12/47	25.53
" " " " " " " " on Pm_2	23/226	10.18	7/19	36.84	4/27	14.81	4/14	28.57	22/50	44.00
Protostylid on M_1	12/157	7.64	2/33	6.45	3/57	5.26	1/18	5.56	3/51	5.88
+ groove pattern on M_1	18/215	8.37	3/32	9.37	4/52	7.69	1/18	5.56	3/18	16.67
Tuberculum sextum on M_1	91/146	62.33	8/26	30.77	11/22	50.00	6/16	37.50	7/25	28.00
Tuberculum intermedium on M_1	34/235	14.47	8/32	25.00	15/48	31.25	4/18	22.22	7/50	14.00
Protostylid on M_2	22/151	14.56	1/24	4.17	4/39	10.26	0/26	00	1/48	2.08
+ groove pattern on M_2	111/192	57.81	6/21	28.57	14/40	35.00	9/25	36.00	10/28	35.71
Tuberculum sextum on M_2	58/133	43.61	4/11	36.36	7/22	31.82	7/20	35.00	2/16	12.50
Tuberculum intermedium on M_2	10/205	4.88	2/22	9.09	2/35	5.71	5/25	20.00	7/41	17.07

TABLE 5.2

"PERCENTAGE REPEATABILITY OF TRAITS USED FOR ADDITIONAL SANGHVI'S χ^2"

Lingual shovel on Maxillary I1.	99
Barrel shape on Maxillary I2.	99
Presence of 4 cusps on Maxillary M2.	94
Protostylid on Mandibular M1.	94
Tuberculum sextum on Mandibular M1*.	93
Tuberculum intermedium on Mandibular M1*.	93
Presence of +groove pattern on Mandibular M2.	93

*Substituted for mandibular M1 cusp number.

CHAPTER VI

RESULTS AND INTERPRETATIONS

Results

The results of all the calculations of Smith's Measure of Divergence are presented first, then compared to the results of the Sanghvi's χ^2. The transformed Theta values for the five samples are presented in Table 6.1.

Indian-Burlington

All the Indian groups showed significant differences from the Burlington sample. The values for the right and left sides were in agreement (see Table 6.2).

Indian-Indian

The first comparisons were between each of the three samples considered by Wright (1974). Wright's conclusion, that the Neutral samples Shaver Hill and Carton were closer to each other than either were to the Huron group Sopher was tested. The estimated MD values and their standard deviations are presented in Table 6.2. For the left side, there were no significant differences, but for the right Shaver Hill and Sopher did show a significant difference. There was no obvious subgrouping of the populations into Huron and Neutral.

The Kleinburg sample differed significantly from the three Indian samples for both right and left sides. The data from Shaver Hill, Carton and Sopher were pooled and another MD was calculated. Again the Kleinburg sample differed significantly for both sides (Table 6.3).

TABLE 6.1*

ANGULAR TRANSFORMATIONS OF FREQUENCIES,LEFT

Kleinburg	Shaver Hill	Carton	Sopher	Burlington
-.2684	-1.3181	-1.0472	-1.2898	.2781
.9502	.2380	.2618	.1836	.9089
1.3094	.6594	.2618	1.2780	1.2166
-1.1373	-.8240	-1.2898	-1.2490	.1464
1.0641	.1836	.8240	.4644	1.4317
.9977	.4317	.8867	.5808	1.0132
1.2107	1.3181	.3724	.5808	1.0799
1.1678	.8359	1.4033	.5645	1.0132
.5642	.1007	-.1385	-.0501	-.0408
-.4165	.1829	.0364	.1216	-.7470
-.7159	-.7334	-.8513	-.2295	-.7765
-.4992	.4373	-.1074	.3242	-.3327
.6859	.8055	1.1471	1.0371	.3470
.1220	.0837	.1549	.9757	-.5858
.4664	-.5275	-.1007	-.6193	1.2310
1.1843	.4644	1.2310	1.2094	1.0523
.2714	-.7854	-.2536	-1.1832	1.0523
1.0079	.3881	.7854	.6194	1.1308
1.0958	.4676	.6556	.3581	.4999
.8965	.9126	.5242	1.0089	-.4031
1.0478	1.3771	1.1308	.7563	1.0366
1.0186	1.1334	.8653	1.1535	.8104
-.2257	.2642	.0955	.2680	.4117
.8315	.5659	.6497	.6087	.5595
.7032	.9553	1.1076	1.0497	1.2275
-.1085	.5645	-.0852	.2295	-.1937
-.0547	.5994	.3848	.5555	.9358
.8417	.9303	1.2003	.5244	.8786

* The Theta values are for the traits listed in Table 5.1, Parts 1 and 2, and are presented in the same order.

TABLE 6.1 cont.*

ANGULAR TRANSFORMATIONS OF FREQUENCIES, RIGHT

Kleinburg	Shaver Hill	Carton	Sopher	Burlington
-1.1266	-1.2898	-1.2094	-1.3181	.3323
.8499	-.3663	-.2931	.0627	.9154
1.2029	1.3002	.6858	.7616	1.2204
-1.2028	-.8574	-1.3096	-1.2094	.2376
1.0412	.0000	.4817	.1890	1.2375
1.0557	.6267	.7019	.7401	.8882
1.1429	.4002	.3581	.4354	.8336
1.2328	.8574	.9191	.5497	.6926
.8407	.4676	.1157	-.1007	.0408
-.3664	-.0465	-.0308	-.5083	-.8154
-.6410	-1.3508	-.7889	-.3538	-.8147
-.5895	.9020	.1545	-.1677	-.3475
.7260	1.3559	1.4120	.6594	-.4116
.4282	.3064	.0871	.9358	.1254
.3153	-.3064	.2618	-.3881	1.0523
1.1373	1.2094	.9553	1.2310	.9154
.1154	-1.2310	.0000	-.3740	1.1351
1.1764	.2256	1.1832	1.2645	1.2375
1.2577	.6666	.1750	.4971	.4999
.9157	.2530	.7469	.4127	.1179
1.0007	1.0242	1.0756	1.0089	1.0472
.9768	.9089	.9830	1.0089	.6855
-.2474	.3797	.0000	.2380	.4373
.7862	.5065	.3763	.5555	.7841
.7810	1.0827	.8877	1.3771	1.2240
-.1561	.4220	.2971	.2728	.2797
.1272	.2536	.3557	.2901	.7872
1.1155	.9020	1.0400	.6157	.6986

* The Theta values are for the traits listed in Table 5.1, Parts 1 and 2, and are presented in the same order.

Sanghvi's χ^2

This statistic does not allow a test for significance of the divergence values. The calculated χ^2 values can be seen in Table 6.4. The three Indian groups studied by Wright (1974) are most distant from Burlington for both the left and right sides. The Kleinburg-Burlington value is smaller than expected for the left side, but is closer to the other Indian-Burlington values on the right. All the Indian-Indian comparisons gave values in the same range with one exception; the Shaver Hill-Kleinburg pair on the right side had an unexpectedly large value. To summarize, the Indian-Indian comparisons gave smaller values than Indian-Burlington comparisons with two exceptions. This number of exceptions out of twenty comparisons is not too large to be explained by chance.

Sanghvi's χ^2 values were calculated using reduced numbers of characters for the Indian-Indian pairings. There were no differences in the divergence values than when considering the larger number of traits (Table 6.5).

Correlation measurements

The correlation between the sets of calculations was measured by Spearman's rank formula:

$$r = 1 - \frac{6\Sigma(D^2)}{N(N^2-1)}$$

where r = measure of correlation

D = difference between the ranks of each pair of populations for each set of calculations.

N = number of pairs, in this case the number of comparisons.

The pairs are ranked from the smallest MD value to the largest for each series. The difference between the ranking for the two sets being measured is squared then added and inserted into the formula. The closer the value to 1.0, the greater the correlation between series.

The coefficient of correlation between right and left sides for Smith's Measure of Divergence is +.867. The side to side coefficient for Sanghvi's is +.752. The critical value for r at α = .05 and N = 10 is +.564; at α = .01 the value is +.764 (Thomas 1976, Table A.13). The observed correlation in both cases is more than the critical values, therefore is statistically significant.

The measure of correlation between the Smith and Sanghvi values is +.964 for the left side and +.879 for the right. The same critical values used above apply here, and the correlation between the two methods is again significant.

Interpretation

In general it is expected that Indian and White groups differ significantly, and this in fact is what was found. The MD value for the Kleinburg-Burlington comparisons are smaller than expected, even though significant. Ossenberg (1976) found that within race MD values were significantly smaller than between race MD values. The results for the three known Indian samples paired with themselves, then Burlington support this. However the Kleinburg-Burlington MD value for the left side appears to be no larger than the MD value for the Kleinburg-Indian comparisons. The number of MD values was not sufficiently large to allow testing for differences between within-race and between-race values.

The rather large and significant MD values between Kleinburg, a postulated Huron population and the other Ontario Iroquois are surprising and must be explained. Again the values for the Sopher, Shaver Hill and Carton comparisons agree with Indian-Indian values found using cranial traits (Ossenberg 1976), and it was expected that the Kleinburg population would be no less close. The Kleinburg ossuary was very large, containing over 600 individuals. In this respect it is atypical. It is also atypical in that no associated village site has been found. The Kleinburg sample may not be representative of any one population. Or the data assigned the site, 1600 A.D. may be incorrect. A larger temporal gap between the populations may account

Alternately the traits chosen may not be those traits best reflecting the genetic differences between the populations. Those traits demonstrating between-race differences may not be suitable for within-race comparisons. Lastly, the reduction of the categories to present/absent scoring causes a loss of information which may affect MD values.

TABLE 6.2

MEASURES OF DIVERGENCE AND THEIR STANDARD DEVIATIONS (brackets) OF SAMPLES TAKEN IN PAIRS

	Left	Right
Shaver Hill-Sopher	.0028 (.0405)	.0911* (.0400)
Shaver Hill-Carton	.0314 (.0452)	.0473 (.0479)
Carton-Sopher	.0556 (.0485)	-.1416 (.0476)
Kleinburg-Carton	.1197* (.0300)	.1416* (.0320)
Kleinburg-Burlington	.2663* (.0100)	.4045* (.0100)
Kleinburg-Shaver Hill	.2701* (.0200)	.3478* (.0223)
Kleinburg-Sopher	.2950* (.0236)	.1675* (.0200)
Carton-Burlington	.3727* (.0339)	.4291* (.0254)
Shaver Hill-Burlingon	.4796* (.0258)	.6695* (.0264)
Sopher-Burlington	.6995* (.0282)	.4160* (.0083)

TABLE 6.3

MEASURES OF DIVERGENCE CALCULATED WITH POOLED DATA

	Left	Right
Kleinburg-Pooled data	.2644* (.0100)	.2142* (.0083)

* indicates a significant value.

TABLE 6.4

SANGHVI'S χ^2 VALUES FOR SAMPLES TAKEN IN PAIRS (√)

	Left	Right
Shaver Hill-Sopher	2.7112	3.3205
Shaver Hill-Carton	3.1344	3.1835
Carton-Sopher	3.0871	2.5883
Kleinburg-Carton	3.0403	3.2016
Kleinburg-Burlington	3.9074	5.1039
Kleinburg-Shaver Hill	3.9441	4.8468
Kleinburg-Sopher	3.9312	3.4425
Carton-Burlington	5.3468	4.4807
Shaver Hill-Burlington	5.8780	4.7340
Sopher-Burlington	5.4390	5.7297

TABLE 6.5

SANGHVI'S χ^2 VALUES FOR 7 AND 2 TRAITS (√)

	7 Traits		2 Traits	
	Left	Right	Left	Right
Kleinburg-Carton	2.6972	2.7932	2.2009	1.7263
Kleinburg-Sopher	2.3805	2.5024	2.4294	2.3660
Kleinburg-Shaver Hill	3.6704	4.5237	1.5241	1.7263
Shaver Hill-Carton	2.3778	2.3825	.4365	.2739
Shaver Hill-Sopher	2.0330	3.1200	2.4252	2.2851
Carton-Sopher	1.6541	1.6480	.2125	2.0180

CHAPTER VII

CONCLUSIONS AND SUMMARY

Conclusions

Having demonstrated that there is no difference biologically between Huron and Neutral groups it is not possible to identify Kleinburg as one or the other. The population is distinct from the other Indian groups and from the White population. When considering the magnitude of the MD values, Kleinburg seems to fall somewhere in the middle of the continuum from the three known Indian groups to the White sample. The location of the site suggests it is Huron. The evidence from the dental morphology indicates that Kleinburg is significantly different from a known Huron sample (Sopher).

There are several factors which might provide an explanation for this intermediate relationship of the Kleinburg sample. Microevolutionary trends become apparent in morphological traits over time (Anderson 1968). If all the Indian groups are contemporary, microevolutionary changes will be of little significance. If, however, the assigned date of 1600 A.D. for Kleinburg is too early, some microevolutionary change might be expected, increasing the divergence between Kleinburg and the other Indian groups. Wright (1974) points out the apparent parallel between biological divergence and archaeological divergence. If this parallel is real, biological divergence between Ontario Iroquois would increase over time from prehistoric to historic. Again, if the Kleinburg population dates later than 1600 A.D. it would support this hypothesis. Another consideration is the amount of contact between the Kleinburg population and other Indian groups. The large size of the ossuary hints at a mixed population. Little is known about the extent of trading during protohistoric times nor about the practice of adopting individuals from outside the population. In historic times the Huron acted as middlemen between the French and other Indian groups in trading (Wright 1966). It is also known that in times of famine Neutral groups at least, visited Huronia (Wright 1974). Continuous contact would have produced a population quite different from Shaver Hill, Carton and Sopher.

The results of the investigation do not allow any definite conclusions. Hopefully further research on the Kleinburg ossuary sample will clarify the identity of the group. The accumulation of information on microevolutionary change in Ontario Iroquois will permit a more conclusive interpretation of the data presented here.

Summary

1. The non-metric morphology of the permanent dentition of the Kleinburg population was observed and compared to that of three contemporary Indian populations; Shaver Hill, Carton and Sopher. All four Indian groups

were compared to a modern white population, Burlington.

2. For comparative purposes twenty-eight traits were considered. These included those traits observed on all five populations, which could be reduced to present/absent categories and which were scored using the same objective aids.
3. The Kleinburg population is distinct from other contemporary Iroquois groups and from a white population. It cannot be conclusively identified as either Huron or Neutral.
4. Sanghvi's χ^2 and Smith's Measure of Divergence give comparable estimates of biological distance when considering relative distances.

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