TOOTH WEAR AND THE SEXUAL DIVISION OF LABOUR IN AN INUIT POPULATION

by

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ABSTRACT

The purpose of this thesis is to distinguish patterns of wear that can be attributed to the use of the teeth as tools. In particular, it examines the sexual division of labour within an arctic population of Inuit and attempts to correlate gender based differences in tooth use with patterns of dental wear.

In many ways, Inuit groups are ideal for such a study. There is both documented ethnographic evidence for use of teeth as tools by various Inuit populations, as well as morphological evidence for the adaptation of the Inuit cranium for the generation and dissipation of heavy vertical occlusal forces, in particular for anterior biting. Combined with this evidence is a well developed sexual division of labour and a lack of task specialization among the Inuit. Therefore, with the basic assumption that the diet is the same for both the men and the women, any differences in wear or trauma between the genders may be ascribed to the use of the teeth in a paramasticatory function.

The specific focus of this study is the Sadlermiut population of Southampton Island. The Sadlermiut were an isolated group of Inuit who perished in the winter of 1902-03 as the result of a European introduced epidemic. Eighty-one individuals from this collection were examined: 30 females, 32 males, six individuals of unknown age and sex and 13 subadults. One thousand and eighty-three teeth were looked at. Observations of the teeth focused primarily on the degree of wear, antemortem trauma, including chipping, flaking and crushing of the teeth, as well as any sort of unusual surface forms including grooving that could point to tool use of these teeth. Also examined were patterns of ante- and postmortem loss and abscessing. Epoxy casts of the teeth were made for future study.

A series of hypotheses were tested in a comparison of teeth both between the genders as well as between different sections of the mouth. Statistically significant differences were found in wear, chipping, flaking, pitting, the presence of buccal striations, labial rounding and grooving both between the mouth parts in the population as a whole, and between the genders. Further gender differences were discovered in post- and antemortem loss and abscessing. All were related to what is known of the Sadlermiut way of life, sexual division of labour and their use of the teeth as tools. The thesis illustrates that gender differences in tooth wear and trauma related to the use of teeth as tools can be found, and it may be possible to generalize from these findings to populations in which the use of teeth as tools, as well as a sexual division of labour are only suspected.

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CHAPTER ONE: INTRODUCTION

Introduction

Even in our industrial society teeth are used casually for a variety of tasks aside from or in addition to masticating food. Teeth are most often used as a temporary third hand, leaving the hands free to perform other functions while clutching an item. Teeth are also used as cutting implements, clipping thread or tags from items. On occasion, they are subject to more stressful uses as, for example, impromptu bottle openers. Use of teeth in paramasticatory functions was more pronounced in many traditional societies, a common cultural habit in a groups' adaptive practices. Furthermore, since most such societies there is a sexual division of labour, the ability to recognize the use of teeth as tools, as well as a difference in this use between women and men, would be a useful addition to the interpretation of sexual divisions of labour in the reconstruction of past societies.

Teeth are uniquely valuable as objects of study in physical anthropology. Surface enamel is a "blank slate" upon eruption, and all that is "written" on it, apart from possible erasure by continuous tooth tissue loss, remains. This is in sharp contrast to bone, which retains the ability to remodel throughout life and therefore conceal much of its life-history. Teeth are a three-dimensional record of many of the forces that have been acting upon them throughout life (Molnar and Ward 1977).

The problem is reading this "slate", the correlation of the three dimensional forms to the sculpting activities. For much of the history of physical anthropology, this problem was considered unsolvable, the many variables contributing to wear bewildering, and as a consequence it received little attention. However, articles written by Molnar (1971a,b, 1972; and see Smith 1983) reanimated interest in tooth wear studies. Most such research has been concerned with dietary factors, linking wear patterns to the habitual consumption of certain foods, generally along a hunter-gatherer/agriculturalist dichotomy. As a result, these studies have concentrated on wear in the post-canine region: the premolars and molars, teeth whose grinding surfaces are engaged in the processing of the food bolus (Molnar et al. 1983a; Molnar and Molnar 1990; Smith 1983). Little attention has been paid to the anterior teeth, those teeth most likely to be involved in paramasticatory activities, and even less to the possible effects of the use of these teeth as tools.

Research Design and Theoretical Implications

The purpose of this thesis is to distinguish patterns of wear that can be attributed to the use of the teeth as tools. In particular, it examines the sexual division of labour within an arctic population of Inuit and attempts to correlate gender based differences in tooth use with patterns of dental wear.

In many ways, Inuit groups are ideal for such a study. Although the use of teeth as tools has been documented for many non-industrial peoples, (e.g. Barrett 1977; Milner and Larsen 1991; Molnar 1971b, 1972, etc), and suspected in fossil hominids (Brace 1975; Brace et al. 1981; Ryan 1980; and see Wallace 1975), perhaps the group for which this practice is best known is the Inuit of northern Canada and Greenland. Early explorers and later ethnographers remarked upon the extensive demands the Inuit placed on their dentition, and the extreme wear that resulted (de Poncins 1941,1949; Parry 1840). Combined with this evidence is a well developed division of labour (Giffen 1930) and a lack of task specialization (Merbs 1983). Thus one has a population in which it is unlikely that women and men performed the same tasks, (certainly not on a habitual basis), and which is not further complicated by within gender specializations. As will be expanded upon later, sexual division of labour extends to the use of the teeth as tools.

The specific focus of this study is the Sadlermiut population of Southampton Island. Analysis of teeth from a previously collected Sadlermiut skeletal sample is concerned primarily with the degree of wear, antemortem trauma, and any sort of unusual surface form that could point to tool use. In light of the information available on Inuit paramasticatory habits several predictions can be made and tested.

1. The women's extensive use of their teeth to soften skins might be expected to result in a greater degree of tooth wear, especially along the anterior dentition, and possibly back along some of the posterior teeth.

2. The women's practice of softening skins might further result in greater incidence of labial rounding of the dentition, in particular the lower anterior teeth (see Lous 1970; Pedersen and Jakobsen 1989).

3. The women's task of sinew preparation may result in the occurrence of more grooving patterns, in a mesial-distal direction along the tooth row (see Lous 1970; Pedersen and Jakobsen 1989).

4. The men's use of their teeth in a greater variety of vise-grip tasks might result in greater incidence of antemortem tooth trauma, in particular along the buccal surfaces of the anterior teeth.

5. The male variety of vise-grip tasks may also result in more occurrences of notched teeth (Blakely and Beck 1984; Milner and Larsen 1991).

6. The men's use of the bow drill may result in a greater incidence of teeth with labial abrasive patterns (Lukacs and Pastor 1988).

Much of the earlier references to the Inuit use of their teeth as tools has been of an anecdotal nature, passing references to a phenomenon that was of interest, but not systematically studied. Later, more detailed studies of Inuit dentition by physical anthropologists have resulted in conflicting information as to the extent and rate of Inuit tooth wear (Leigh 1925a; Hylander 1972; Pedersen 1938, 1947, 1949). Thus a study of Inuit dentition within the framework of this thesis may help alleviate some of this confusion.

Organization of Chapters

The thesis has been organized as follows. Chapter Two consists of a literature review of tooth wear studies and the many factors that can affect tooth wear. It will become obvious upon reading this chapter that controlling for all of these influences is beyond the scope of this, or any study. However, any person investigating tooth wear needs to be aware of their possible effects. Chapter Three discusses in more detail Inuit paramasticatory functions, presenting ethnological and biological evidence for this use. Investigations of Inuit dentitions are further reviewed and the population under study in this thesis, the Sadlermiut of Southampton Island are introduced. Chapter Four details the methods and problems in this investigation. Chapter Five presents the statistical operations performed on the dentitions and discusses the results. Chapter Six concludes the thesis, commenting on the findings and suggesting areas of further research.

CHAPTER TWO: LITERATURE REVIEW

Introduction

Not only are teeth in direct contact with an individual's environment, they retain within their structure a record of the stresses encountered throughout the course of an individual's life. This, coupled with their durability, and their inability to remodel, makes them uniquely valuable as objects of study (Beynon 1986; Foley and Cruwys 1986; Hillson 1986; Klatsky 1939; Larson and Kelley 1991; Molnar et al. 1983a; Pedersen 1952; Robinson et al. 1986; Schour and Sarnat 1942). Studies of tooth wear have been hampered by the multitude of factors causing wear and the difficulties in distinguishing among them. This has led some researchers to question the value of any sort of tooth wear analysis, noting that a variety of processes could obscure or otherwise complicate cultural effects on wear, most notably diet and paramasticatory choices, in which anthropologists are most interested (Barret and Brown 1975; Smith 1983). However abrasives in the diet, the use of the teeth and jaws as tools or to supplement tools, and the intensity of tooth to tooth contact during mastication are probably the principal factors involved in the destruction of tooth surfaces in traditional populations (Foley and Cruwys 1986; Molnar 1972; Molnar et al. 1983b; Molnar and Molnar 1990; Smith 1983; Tomenchuk and Mayhall 1979; Williams and Woodhead 1986).

Studies of teeth and tooth wear patterns have been used in palaeontology both to distinguish between and to assign taxa as well as to infer dietary habits (McKee and Molnar 1988; Murphy 1959a, 1959b; Smith 1983). Although the Piltdown fraud led anthropologists on a search for a single human pattern of dentin exposure (Murphy 1959a), it quickly became apparent that despite a basic wear pattern shared by all hominoids due to shared morphological features (Smith 1983,1984), archaeological populations exhibit variable and characteristic rates and patterns of tooth wear. Interpretations of these variations can provide a greater understanding of past life ways, allowing researchers to make informed assessments concerning diet and food preparation techniques, as well as any habitual activity involving teeth (Brace and Molnar 1967; Brothwell 1981; Molnar 1972; Molnar et al. 1983a; Walker et al. 1991). Studies of dental wear have concentrated primarily on cause of wear and the relationship between degree of wear and the age of the individual (Cross et al. 1986) In the course of such investigations tooth wear studies generally look at one or all of the following interrelated processes: the actual degree of wear exhibited; the rate of wear; and the pattern of wear. Methods include both macroscopic and microscopic investigations (Ryan 1980).

Macroscopic methods involve the examination of tooth wear with the unaided eye. More recent microscopic studies describe wear features observed under either an optical light microscope or a scanning electron microscope (Ryan 1980, Teaford 1988a). The most commonly found features in microwear studies include pits or compression fractures, areas of polish, and striations. Pits or compression fractures have been defined as roughly oval features created by the localized crushing of the enamel prisms - a microfailure of the enamel. Areas of polish refer to any area of flat, featureless enamel while striations are linear depressions with well-defined troughs, greater in length than width (Ryan 1980, 1981). There is increasing use of the scanning electron microscope in the investigations of the patterns of attrition, abrasion and even erosion on teeth. The superior resolution of three-dimensional structures by the scanning electron microscope, its greater depth of field and its capacity for higher magnification allows for more subtle distinctions in the examination of tooth wear (Bullington 1988; Harmon and Rose 1988; Hillson 1986; Teaford 1988a,1991; Walker and Teaford 1988). Most microwear studies have focused either on the relationship between patterns of microwear and diet or in the use of microwear features to identify masticatory movements (Bullington 1991; Foley and Cruwys 1986; Ryan 1980; Teaford 1988a,1991).

Degree of Wear

In early studies, wear on teeth was considered to be an abnormal, even pathological occurrence, and in industrial societies was treated as such (Campbell 1939; Hinton 1981a; Klatsky 1939; Patterson 1984; Smith 1983; Williams and Woodhead 1986). In modern populations the amount and rate of tooth wear is primarily affected by antemortem tooth loss which places a greater burden on the remaining teeth. Other influences are bruxism, as well as parafunctional and dietary factors (Williams and Woodhead 1986). Tooth tissue loss in industrial populations is generally mild. In prehistoric populations however, tooth wear was a natural or common process, resulting from a tougher diet and more vigorous mastication. This was enhanced by the use of the teeth in a variety of manipulatory functions (Molnar 1972; Smith 1983; William and Woodhead 1986). It is not overstating the case to claim that a good set of teeth were an aid for survival (Larsen 1985). Indeed in faunal studies, the longevity of an animal is often determined by the time it takes the teeth to be completely worn (Boyde 1989; Foley and Cruwys 1986).

The purpose of enamel is to provide a wear-resistant surface that will allow it " ... to damage food, yet itself [ ] remain undamaged" (Boyde 1989:310). Furthermore, as there are only two waves of teeth in mammals, the deciduous and the permanent, enamel in these organisms must survive for a greater functional lifetime. Thus its structure is more complex than that found in the reptilia, teleost and elasmobranchs. Enamel is composed of calcium phosphate, water and special proteins, which serve to make it hard yet tough (Boyde 1976).

Wear is characterized by the progressive loss of enamel, from the appearance of faceting, to the exposure of dentin and, in extreme cases, the pulp chamber (Barrett 1977). There are three primary mechanisms by which enamel is lost. Included here are 1) erosion, the demineralization of enamel by nonbacterial acids, 2) abrasion, caused by contact with foreign items, including food and accompanying dietary grit, and 3) attrition, tooth to tooth contact, occlusally, or interproximally (Lukacs and Pastor 1988; Robb et al. 1991; Smith 1983; Wallace 1974).

Macroscopically, these mechanisms are not readily distinguishable, not least because they often operate in tandem on the teeth to produce the wear (Robb et al. 1991; Smith 1983). Ryan (1980) warns of a fundamental problem, both in the use of the terms abrasion and attrition, as they are often defined differently by researchers, causing confusion in the literature, as well as the difficulties in distinguishing between their results. Researchers have often independently explained wear on the same collection of teeth by either process exclusively. Ryan suggests that any distinctive pattern of wear must be described before it can be attributed to either process. In terms of definitions of the wear mechanisms, in my thesis I will use the term tooth tissue loss interchangeably with wear to avoid the problems associated with the use of the term "attrition" in a general sense and inadvertently ascribing the mechanism of tooth to tooth contact (Williams and Woodhead 1986).

Once removed, enamel is not replaced. However, dentin and cementum are produced in a modified form throughout life and the deposition of secondary dentin on the pulp chamber walls, as well as the apparent retreat of the pulp chamber itself apically with age, often serve to protect teeth from the consequences of extreme wear. In effect, if wear and production of secondary dentin are sufficiently balanced, a tooth can remain functional and uninfected even if it is worn to the roots (Barrett and Brown 1975; Campbell 1939; Klatsky 1939; Leigh 1925b; Pedersen and Jakobsen 1989; Powell 1985; Smith 1983).

Differing mechanisms of wear may leave different marks microscopically. Abrasion tends to create more and varied microwear features, as compared to tooth tissue loss resulting from erosion and attrition (Teaford 1991). A study of the dental microwear in stillborn guinea pigs, an animal that erupts and begins to wear its teeth *in utero* revealed that tooth-to-tooth contact, the only possible contact in this case, produced enamel chipping, but left no striations. Tooth to tooth contact later in life is easily obscured by abrasives adhering to the teeth, creating differing patterns (Teaford and Walker 1983). Greater wear on teeth will create the secondary enlargement of some microwear features, in particular pits, as they are subjected to continual scouring (Gordon 1982). As the tooth wears, the extent and location of shearing and grinding surfaces on the tooth change considerably, altering proportions of pits and striations. Depending on the degree of wear on the teeth, microwear patterns on softer layers of inner enamel and dentin may not be as sharp or may be more easily erased or reworked. Microwear features found in dentin may not be as informative as those found in enamel (Foley and Cruwys 1986).

Although most tooth wear analyses focus on the occlusal surfaces, wear also occurs between the teeth, interproximally along the distal and mesial tooth faces (Barrett 1972; Hillson 1986; Hinton 1982; Jacobson 1982; Smith 1983; Whittaker 1986). Teeth are not cemented in place in the mandibular and maxillary arches; they have a certain play of movement. Teeth reside in what is technically a joint, made of the periodontal ligaments (Hillson 1986). During mastication, bite forces acting on the teeth have a mesial component, which results in the grinding or rubbing together of adjoining teeth in a mesial direction. Added to this is a lateral component, especially in the molars, further contributing to the amount of interproximal wear undergone by the teeth. This tooth-to-tooth friction results in a shortening of the mesial-distal tooth dimension.

It has been suggested by a number of researchers that the magnitude and rate of the interproximal wear has a direct relationship to the magnitude and frequency of the occlusal bite forces acting upon the dentition. Jacobson (1982) found that South African Negro females exhibited less interproximal wear than their male counterparts. This suggested to him that "muscular and chewing vigor, to a larger extent, govern the anterior component of force, which in turn is mainly responsible for the tendency for mesial migration and subsequent interproximal attrition" (Jacobson 1982:58).

Rate of Tooth Wear

Tempo of tooth wear is of great interest to physical anthropologists. Most would agree that the single most important factor in the determination of rate of wear is the introduction of abrasives into the mouth, either with food or during non-dietary chewing (Molnar and Molnar 1990). Smith (1977) used "rate of attrition" as a measure of the occlusal demands to which the teeth were subject, and as a means of evaluating the possible use of teeth in paramasticatory activities.

Rates of wear are often determined by matching a degree of wear to an independent age indicator, such as tooth eruption or bone fusion (Hillson 1986). Thus the amount of wear undergone between specific ages can be assessed. Such a correlation is less easily performed in adults for whom changes with age are degenerative rather than developmental and which do not correspond well with any one chronological age. In this case the rate of tooth wear is often derived by an assessment of the gradient of tooth wear, or the difference in degree of wear between adjacent teeth. Most often this is taken from molars, less often premolars, and most rarely from the anterior dentition where wear is more erratic and variable (Miles 1963,1978;

Murphy 1959b). For example, knowledge of the space in time between molar eruptions - the roughly six year gap between the eruption of the first and second molars, allows one to assess the amount of wear undergone by the first molar during this time.

Wear gradients have been used in cross-species and inter-population comparisons in an attempt to avoid the problems involved in associating a specific age with a specific degree of wear (Scott 1979; Smith 1972). However, degree and rate of wear are affected by more than the length of time a tooth has been in occlusion. Wear can be influenced by the interaction of other erupting teeth in the dental arcade as well as by a variety of cultural factors. Studies that use rate of wear as derived from wear gradients as an age independent method of comparison have been criticized for ignoring chronological age factors by either assuming the sample age distributions are the same, or that the wear gradient differences measure rates of wear that are stable with age (Smith 1983). Rate of wear is not linear throughout the life of a tooth.

A degree of caution in the use of gradients is therefore advised. Any comparative use of gradients, as well as rates of wear, should take into account not only cultural differences in diet and paramasticatory function, but physical differences in enamel thickness, cusp morphology, and root angulation. In addition the presence and position of pathologies, the nature of occlusion, and arch and cranial shape needs to be considered (McKee and Molnar 1988; Molnar and Ward 1977; Molnar and Molnar 1990; Smith 1983). Smith (1983) feels that age, and the location of the bite point, in humans generally in the second premolar-first molar region (Hall 1977; Smith 1983), are the most important factors affecting gradient. A further point to be kept in mind in the comparison of gradients is the fact that they reflect the attrition scoring method used (Hillson 1986; Smith 1983).

Rates of wear may also fluctuate interproximally. Kieser et al. (1985) suggest that while interproximal rates of wear decrease with the attainment of full third molar occlusion, it later increases with changes in the shape of the interproximal contact surface. It appears that the flat contact surfaces between the teeth of younger individuals are more resistant to wear than are the sinuous contact surfaces found in older individuals.

It is anticipated that the quantitative study of dental microwear will be of great service in studies of rates of wear in living animals (Teaford 1991). Studies of the rate of wear of microscopic features indicates a high turn-over. Microwear features have a short life span, ranging from only hours up to two to six weeks, depending on the diet (Teaford and Oyen 1988,1989; Walker and Teaford 1988). People in non-traditional cultures have the longest duration of microwear features; tooth brush or polishing scratches have lasted as long as twelve weeks (Teaford and Oyen 1989; Teaford and Glander 1991). Feature turn-over is accomplished either by catastrophic destruction or a more gradual erasure (Teaford and Oyen 1989; Teaford and Glander 1991) and it has been found that it's rate varies not only between dentin and enamel surfaces, but also between enamel surfaces on the same tooth (Teaford and Oyen 1989). One of the overall consequences of this process is what Grine (1986) has referred to as the "Last Supper" phenomenon, in which the microwear found on the occlusal surfaces of the teeth only represents items introduced into the mouth during a short period of time prior to the organism's death. Not surprisingly, rates of wear on macroscopic and microscopic levels can be correlated. There is a direct relationship between high turn-over of microwear features and rapid tooth tissue loss (Teaford and Oyen 1989).

This rapid turnover of microwear features provides a more manageable time frame than that of the months or years it can take teeth to wear macroscopically (Teaford 1991). Thus studies of microwear have the added potential of being able to document age and sex related intra-populations differences via the demonstration of differing rates of wear and oral behavioral changes through relatively short periods of time (Teaford and Oyen 1988, 1989; Teaford and Glander 1991; Walker and Teaford 1988).

Pattern

In many ways, the pattern of tooth wear is a function of the rates and degrees of wear. This is mediated by the effects of the uses to which the tooth was put, the form of the tooth itself, the interaction of the mandible and maxilla, and the chewing patterns (Hillson 1986; Hinton 1981a; Molnar 1972; Murphy 1959b; Smith 1972; Smith 1983). Wear patterns, then, are the end product of all these processes, frozen at the moment of an individual's death. Patterning can be characterized by the orientation and form of the wear and wear facets, the planes formed on the occlusal surface, and the location and degree of exposed dentition. This can be studied not simply in regard to a particular tooth. Rather it incorporates the differences or similarities in dentin exposure down the tooth row, between dental fields, and the teeth within these fields, between the maxilla and mandible, and the left and right sides of the dental arcade as well as the orientation and form of the wear facets (Hillson 1986; Molnar 1971a). These variables lead to the formulation of several questions: Does the anterior dentition experience greater wear than the posterior? Is this typical of the population as a whole? Does this vary from population to population? What could explain this?

Lukacs and Pastor (1988) identify two types of patterns. First are patterns of attrition, patterns which are record the biomechanical forces acting upon the dentition. Second are patterns of abrasion, records of the diet, dietary grit and food preparation methods, as well as any paramasticatory activity carried out by the population. Lukacs and Pastor (1988:377) suggest that patterns of abrasion resulting from habitual paramasticatory activity are "diffuse and irregular in direction, severity, and distribution." Generally, paramasticatory patterns are not limited to the occlusal surface of the tooth (Lukacs and Pastor 1988) and are likely restricted to a certain area of the dental arch (Molnar 1972).

The best known and most studied 'pattern' of attrition is the helicoidal plane (McKee and Molnar 1988). The helicoidal plane is a wear pattern seen on the posterior dentition that is characterized by changes in molar surface orientation. The first upper molar is worn sloping lingually, the second upper molar is nearly horizontal in orientation, and the third upper molar slopes buccally. The opposite slopes occur in the lower molars. A major factor producing this wear is thought to be the differing arch diameters between the maxilla and mandible at each of the molars (Campbell 1925 as cited in Molnar and Molnar 1990:386,393; Hall 1977). Also suggested as a causative factor is the axial tilt of the molars (Smith 1983). Smith (1984) has further attributed the development of the helicoidal plane to differences in food preparation rather than the wider arch diameter of the maxilla. She notes that the helicoidal plane occurs more often, and more markedly in agriculturalists with their ground and prepared food. Mastication of such food incorporates more tooth to tooth contact and less puncture-crushing, in marked contrast to hunter-gatherers with their more lateral mastication of tough and fibrous foods. She found the maxillary overjet to be about the same in both types of populations. Hall (1977) and Richards and Brown (1986) feel that one can expect to find the helicoidal plane in all individuals who subject their dentition to a lifetime of heavy attrition, although this has not always proved to be the case (Molnar and Molnar 1990).

Other patterns have been perceived in the differing degree of wear between the maxilla and the mandible. Although most North American aboriginals tend to wear their maxillary molars faster than their mandibular molars, wear among Australian aborigines occurs in reverse fashion (McKee and Molnar 1988; Molnar 1971a; Molnar et al. 1983a; Murphy 1959b and see Leigh 1925a). Murphy (1959b:181) found that "the essential difference between the jaws in dentin exposure [lay] in the gradients between the first and second molar". McKee and Molnar (1988) noted that patterns of wear in the mandibles and maxillas of the Australian aboriginal group they studied were surprisingly independent. The reasons for these variations are as yet unknown, although it has been suggested that craniofacial shape and premolar eruption precedence are contributing factors (Molnar et al. 1983a) as is the intervening bolus of food (McKee and Molnar 1988).

Molnar (1971a,b) discovered differences in wear type and degree between males and females in a skeletal Amerindian population from a "Middle Horizon" site (2-3, 000 B.P.) located in California's Central Valley. Although he could not definitely attribute this to a sexual division of labour, he did feel that this pointed to some contrast between male and female activities. Such contrasts did not exist in a comparative sample of agriculturalists.

Smith (1983) observed that while the incisors in hunter-gatherer groups were worn in a horizontal fashion, the incisors of agriculturalists exhibited more angled wear, most notably in the lingual surface of the upper incisors. She attributed this to differing levels of masticatory force as well as the use of the anterior teeth by hunter-gatherers to hold or tear food or objects. The angled wear on the agriculturalists was, in her view, what could be expected from tooth-to-tooth contact.

Whittaker (1986) found significant differences in the interproximal wear on the mesial and distal surfaces of molar and premolar teeth of a Romano-British skeletal population. Although most teeth exhibited flat facets mesially and distally, concave wear was seen most often on the mesial surface of premolars and molars, while convex facets were most often seen on the distal surfaces of these teeth. He tentatively attributed this phenomena to the differential movement of the teeth within their sockets, drawing upon the analogy of the production of convex and concave shape from the rubbing together of two surfaces of equal hardness, as in the manufacture of telescopic mirrors. The forces responsible for the production of the helicoidal plane could create these differential movements and the concomitant convex and concave interproximal wear plane shapes.

Patterns found in microwear are a function of the frequency of occurrence of various features of wear. Fortunately, the high rate of microwear turnover has not obscured the existence of consistent microwear patterns. As previously noted, the most commonly observed microwear features are pits, striations, and areas of polish. Gordon (1982, 1988:1140) has further distinguished a fourth microwear feature: the "gouge", defined as "a small subset of scratches which are sinuous and exhibit more than one angle of orientation". The difference between pits and striations is arbitrary. Most commonly, striations must have a 4:1 length to width ratio, although ratios varying from 10:1 to 2:1 have been used (Bullington 1988, 1991; Gordon 1988; Hillson 1986; Ryan 1980). Gordon (1982:210) has suggested that pits and striations are not the result of different process or agents, but "simply represent opposite poles of a continuum characterized by varying degrees of compression and shear during occlusion." Pits result from compression, striations from shear. However, the arbitrary division of this continuum is valuable as the relative proportions of pits to scratches found on a tooth surface has led to useful distinctions between groups (Gordon 1988).

Early studies in microwear patterns focused on comparisons between animals with markedly different diets. Generally, the average microwear measurements were computed for individuals in a group, and the results compared between samples using analysis of variance, multiple comparison and other statistical tests. A basic assumption has been that the more a diet or cultural practice brings abrasives in contact with the teeth, the greater the density of microwear on the tooth's occlusal surface. With some exceptions, this generally holds true (Teaford 1991).

Causes of dental patterns are likely myriad, varying from diet, to tool use, to cranial shape and eruption factor, to occlusal loading gradient. Recently, Molnar and Molnar (1990) have suggested that arch shape, relative tooth size and occlusion are important factors in the production of distinctive patterns. There is hope that if the patterns are carefully described and analyzed they may be an important tool in the reconstruction of past behavior, providing more subtle information about dietary and paramasticatory activity (McKee and Molnar 1988; Smith 1983).

FACTORS AFFECTING TOOTH WEAR, RATE, AND PATTERN

Biological and cultural factors combine to produce wear. To some extent, among *Homo sapiens* as a whole, biological factors provide a constraining effect on wear variability. However, population differences in the morphology of the teeth, and the hardness and thickness of the enamel and dentin as well as craniofacial differences and their effect on the force and direction of masticatory movements are sufficient to produce distinctive wear rates and patterns. To these variables are added the effects of culture including diet and dietary preparation, the presence of bruxism, and paramasticatory activities (Richards and Brown 1981). Admittedly, the situation is complex, and the attribution of a degree, rate, or pattern of wear to any one factor, difficult.

Biological Factors

<u>Age.</u> Age and increased tooth wear are inextricable processes. Even in contemporary industrial societies with their heavily processed foods, teeth wear with increasing age. As soon as teeth erupt they come in contact with, aside from other teeth, anything and everything a child can put in its mouth (Bullington 1988, 1991).The inability of teeth to remodel renders all attritional, abrasive, and erosional contacts cumulative. Thus, over the course of a life, something as undramatic as tooth-to-tooth contact will leave its mark.

It follows therefore, that one of the first and most obvious goals of tooth wear analysis has been its use in the estimation of an individual's age. This is not as straight forward as it might appear; not only is the relationship between stage of wear and age not entirely linear, but cultural differences in diet and custom can cause significant variation in the rates and patterns of tooth wear between populations. An arbitrary assignment of universal age to a certain degree of wear is therefore inappropriate. However, it can be said that in general, the greater the age of a person, the greater the wear on the teeth (Smith 1972). Once a population specific wear rate has been determined, it is possible to assess an age range for an individual from within the population.

Miles (1963, 1978) used differences in molar wear to develop a method for aging adults. Ages determined by the formation and eruption of teeth in immature individuals are fairly accurate and allow one to assess the amount of wear undergone by a first molar until the attainment of occlusal height by a second molar. As a marker, this documents the amount of wear one would expect on a tooth with a functional age of six. Functional age refers to the length of time a tooth has been in occlusion (functioning). By matching this six year functional age of wear of a first molar to an individual with a similar wear on the second molar, one can extrapolate an eighteen year functional age, and a twenty-four year chronological age. Chronological age is the age of a person since birth. Noting that there is a gradient in rate of wear between the molars, Miles developed a simple ratio of 6:6.5:7 to account for the slower rate on the posterior molars. It takes seven years for the third molar, and six and a half years for the second molar to attain the degree of wear exhibited in a first molar. More recently this method has been refined by Lovejoy (1985) and Walker et al. (1991).

Good age estimates from the evaluation of gradients of wear have been reported on contemporary populations (Molnar et. al. 1983a; Richards and Brown 1981; Richards and Miller 1991; Tomenchuk and Mayhall 1979; Walker et al., 1991). Walker and colleagues (1991) do caution that these populations are consuming an increasingly refined diet and that the extent to which this interrelationship can be extended back to ancestral archaeological populations is not yet known. However, they also note that the interrelationship between age and wear is stronger in prehistoric populations due to their more abrasive diet, and the resulting rapid tooth tissue loss. Smith (1983) and Richards and Miller (1991) claim that aging by tooth wear is arguably as good as aging by any other criteria.

In a study of deciduous dentitions in thirty-six individuals ranging in age from 6 to 27 months, Bullington (1988, 1991) found that microwear began as soon as a tooth erupted, a phenomenon she attributed in large measure to teething activities. She further discovered that frequencies of microwear features increased in older individuals. This is in direct contrast to Gordon's (1982) work in which juvenile chimpanzees were observed to have a higher density of microwear features than the adults. To an extent this contradiction can be explained by possible differences between deciduous and permanent enamel, as well as by the fact that there is a large gap in the age ranges between the two samples. It may well be that microwear density increases initially but, past a certain age, decreases. A study of individuals spanning all ages would verify this. It is also possible that greater wear exposing softer subsurface enamel and dentin results in microwear that is easily blurred and obliterated. Alternatively or additionally, at some point cumulative wear erases the earlier features. Certainly, the changing topography of a teeth wearing with age will alter the orientation of enamel prisms relative to the wear plane, thereby affecting microwear patterning (Bullington 1988, 1991; Gordon 1988).

Craniofacial and Mandibular Morphology. Biomechanical factors, including the morphology and positioning of the skeletal and muscular elements involved in mastication, both affect and are affected by tooth wear. Populations who place heavy demands on their teeth are more likely to evince robust facial and mandibular features, broad zygomatic arches and pronounced gonial eversion (Smith 1983). Muscle attachment areas for all muscles actively involved in mandibular movements are roughened and enlarged. These consist of the temporal and masseter muscles and to a lesser extent the pterygoids and the diagastrics. The extent to which these traits are genetic or arise in response to the generated stimuli of the masticatory demands is not known (Hylander 1972,1977).

There is some evidence that arch shape will influence the pattern of wear. Molnar and Molnar (1990) identified four basic arch shapes which they linked to certain patterns of wear. These include hyperbolic (divergent tooth rows), parabolic (less divergent tooth rows), hypsiloid ('U'-shaped tooth rows), and ellipsoidal (convergent tooth rows). For example, hypsiloid shaped maxillae frequently exhibit a buccal oriented wear while parabolic or hyperbolically shaped maxilla display a more lingually oriented wear. Smith (1983) also noticed a subtle difference in molar occlusal angle between the circular palates of the Thule Inuit group she studied as compared to the more 'U-shaped' palates of Nubian and Australian aboriginal peoples. For the most part less extreme angulations were found in groups with longer, straighter palates.

Additional morphological factors influencing wear are the condition and manifestation of the temporomandibular joint (Molnar and Ward 1977:564). A relationship between condyle, eminence contact and occlusal loading has been noted by Angel (1948), Campbell (1925 as cited in Molnar and Ward 1977:560), Brace and Molnar (1967), Molnar (1968), Hinton and Carlson (1979) and Hinton (1981b). It would appear that a positioning of the condyles on the eminentia rather than the glenoid fossa aids in a transfer of forces to the anterior dentition. In skeletal populations, this is demonstrated by the flattening of the eminentia in those skulls that exhibit worn incisors (Molnar and Ward 1977) or worn dentitions as a whole, as well as antemortem loss of teeth (Hinton 1981b).

Hinton (1981b) found there to be increasing depth in the glenoid fossa throughout young adulthood in a group of Eskimos and Australian aborigines, but that this trend reversed in later life, with the fossa becoming shallower in older individuals. He tentatively linked this to similar life ways for the two groups. Tough diet, the large occlusal forces generated, and the use of the dentition, in particular the anterior dentition, as a "third hand" are common features of both populations.

Molnar's (1968) experimental work also suggested a relationship between modified eminences, shallow fossae and heavily worn incisors. In these experiments, an appartus, "CANIBAL", duplicated various chewing motions in order to reproduce commonly found wear patterns in archaeological populations. When CANIBAL was set up to replicate the masticatory biomechanics of individuals with heavily worn incisors, the mandible was found to rest on the slope of the articular eminence, (in this case a mechanical counterpart), rather in the glenoid fossa. In addition, Hinton and Carlson (1979) found that overall size of the temporal joint (length and breadth, especially breadth) was larger in hunter-gatherer groups than agriculturalists. They suggested that larger fossa size in the hunter-gatherer groups represented "a means of equilibriating increased joint reaction forces resulting from vigorous oral function [in particular incisal biting], perhaps indirectly as an accommodation to increased condyle size" (Hinton and Carlson 1979:332).

Occlusal Loading, Tooth Position and Eruption Sequence, and Masticatory Function. Wear on teeth can be seen as a graphic representation of the forces acting upon the dentition during mastication (Maas 1991; Mills 1978; Molnar and Ward 1977). The relationship between the degree of wear on a tooth and the magnitude of load applied to it has been demonstrated experimentally (Brace and Molnar 1967; Molnar 1968).

Kay and Hiiemae (1974) demonstrated that wear on teeth was the result of two distinct kinds of masticatory actions, puncture crushing and chewing proper. Puncture crushing reduces the introduced substance to a consistency amenable for chewing. Tooth to tooth contact does not occur in this action but all available tooth surface is used. At this time the introduced substance and any included abrasives can blunt the anterior and posterior tooth cusp tips. Microscopically, this can show up as a pitted or polished surface (Ryan 1980).

There are two chewing modes: incisal, a symmetric nipping action; and molar, an asymmetric molar chewing (Shipman et al. 1985). The asymmetrical nature of molar chewing allows most people to have a preferred chewing side in the mastication of food. This may lead to differing degrees of wear between the left and right tooth sides. Chewing cycles can be divided into three strokes, beginning with the up, or preparatory stroke, in which the mandible moves from the point of maximum gape, into the power stroke, in which the food is actually chewed, and ending with the closing or recovery stroke in which the mandible is returned to the point of maximum gape (Kay and Hiiemae 1974; Shipman et al. 1985). During this process, post-canine teeth are worn on the slopes of the cusps and in the basins.

The power stroke can be further divided into Phase I and Phase II. During Phase I the post-canine teeth shear and crush food as the mandible moves up and anterior-medially into centric occlusion. Tooth-to-tooth or tooth-food-tooth contact occurs. Microscopically, this can show up in the form of parallel striations (Ryan 1980). In Phase II, food is ground in tooth basins as the mandible drops downward and continues in the anterio-mesial direction out of centric occlusion.

Microscopically this can show up in humans in the form of striations occasionally surrounded by marked pitting. Macroscopically this has resulted in the identification of puncture-crushing, shearing and grinding facets on the tooth surfaces (Kay and Hiiemae 1974; Ryan 1980; Shipman et al. 1985).

An additional factor affecting wear, both macroscopically and microscopically is the existence of a mesiodistal gradient of occlusal loading over the post-canine dentition. Axial loading in primates is greatest in the posterior dentition, in particular in the teeth closest to the working side condyle, the side in which the food is being processed. In contrast, the balancing side condyle absorbs the bite force. Compression forces are highest on the third molar, diminishing progressively in the anterior direction (Gordon 1982; Molnar and Ward 1977). In a direct inverse relationship, shear increases as you move anteriorly up the tooth row to the first molars. A tooth located further from the working side condyle goes through a greater arc in the final phase of the power stroke. Microscopically these mesiodistal gradients result in greater frequencies of striations (due to shear) in anterior molar teeth, and in greater frequencies of pits (due to compression) in posterior molar teeth. Striations are also longer on anterior molars, and feature frequency is lowest on shearing facets (Gordon 1982, 1984).

Consequently, intra-specific variability in microwear may be due more to the individual's age and sex, wear facet type, and the position of the tooth in the tooth row (i.e. biomechanical factors) than to diet (Gordon 1982, 1984). Of these, facet type and the position of the tooth in the tooth row may be the most important (Gordon 1988) as measurements and orientation of microwear on cusp tips (puncture-crushing facets), Phase I (shearing facets) and Phase II (grinding facets) facets from homologous cusps on the molars will differ considerably. Therefore any comparison of tooth wear microscopically must ensure that the same facets are being observed Gordon (1982, 1984). This could produce the need for separate data bases for each age, sex, body size, and tooth position - a daunting prospect. However, although dental microwear patterns may vary between the upper and lower first and third molars, Teaford and Walker (1984) found the microwear patterns on the maxillary and mandibular second molars to be indistinguishable. They have also noted that intra-species differences on homologous facets are less than those found in inter-specific comparisons.

Working backwards from this, it can be seen that an analysis of microwear, in particular the orientation of the features, can lead to a better understanding of masticatory movements (Ryan 1980, 1981; Teaford and Byrd 1987; Teaford 1991). As striations may dislodge enamel prisms a knowledge of their orientation could allow one to deduce the direction of movement. On flat surfaces, pits may indicate direction since the widening of a striation into a pit occurs at the end of its trajectory (Teaford and Walker 1982,1983). A study of such features allows for the reconstruction of jaw movements (Ryan 1980, 1981).

Longitudinal studies on monkeys and humans can reveal differences between the rates of wear on the shearing or grinding facets. Teaford and Glander (1991) found that the howler monkeys wore their shearing facets faster than their crushing-grinding facets. The reverse of this was observed in the comparative sample of humans and laboratory monkeys, and likely related to different mastication habits. Such work allows for a finer assessment of how teeth are being used in natural or laboratory settings.

Macroscopically, differing masticatory patterns may leave distinctive wear patterns. For example, Molnar (1968) has linked a protrusive-retractive motion of the mandible to the production of a flat molar wear pattern and suggests a relationship between this type of wear and the utilization of the anterior dentition.

In addition to, effecting, and being affected by the occlusal loading, the position of the tooth relative to the arch as a whole, as well as the timing and sequence of tooth eruption will lead to variations of dentin exposure (Molnar 1971b; Murphy 1959b). For example, upon eruption, the first molar, due to its large size and position posterior to the deciduous molars, forms the main grinding surface for six years, the average time elapsed until the second molar erupts. Should the population be one in which the deciduous dentition is worn rapidly, the first permanent molar will exhibit a fair amount of wear at the end of this time period. However, the concurrent, or nearly concurrent eruption of the premolars as well as the second molars, serves to increase the grinding surface of the tooth row. The load on the molar region is lessened, and the molars posterior to the first molar are worn at a slower rate. This slowed rate is generally most marked in the third molars, as they are little used in human mastication (Molnar and Ward 1977; Molnar and Molnar 1990; Smith 1983). However, Murphy (1959a) related that in his study the second and third molars shared an equal degree of attritional stress. This stress increased until it was greater than that borne by the first molars, effecting equalizing attritional levels attained by the molars and lowering the gradient. Thus the occlusal load levied on a particular tooth fluctuates in response to arch growth, increased mass of muscles used in mastication and the eruption of other teeth (Molnar and Ward 1977; Molnar et al. 1983a).

It is not always possible to link, even taking the above factors into account, the amount of dentin exposure to the length of time a tooth has been erupted. There are exceptions to the expected pattern in which the first molar has a greater amount of exposed dentin than the does second as found by Murphy (1959b) in his study of molar gradients. He found a significant number of second molars with greater wear than first molars. Consequently, the use of eruption sequence to explain degree of wear should be done conservatively.

Occlusion. Many physical anthropologists attribute the frequency of malocclusions seen today to the decreased demands being placed by increasingly refined diets on the developing masticatory apparatus. Peoples, who in the recent past had exhibited good occlusal relationships, became increasingly prone to malocclusion upon introduction to western diets (Collins 1932; Corruccini 1991). Begg (1959 as cited in Corruccini 1991:310) attributes the better occlusions of peoples with traditional lifestyles to their more greatly worn teeth. He reasoned that shortening of the mesial-distal tooth dimension due to the more extensive interproximal wear exhibited by such groups, would reduce the effects of crowding. While this sounds logical, certain problems with this theory have been put forth. For example Corruccini (1991) points out that a greater occlusal loss on the deciduous teeth would in fact promote permanent anterior tooth crowding, not alleviate it. As well, it would seem that Begg overestimated the actual amount of tooth material lost due to interproximal wear (Corruccini 1991).

This increased incidence in malocclusion in the shift from traditional to industrial diets and habits may be slightly romanticized. Pedersen (1949) has noted that although healthy teeth and good occlusions predominated, crowding of the upper and lower incisors and canines, as well as some irregularities in the premolars, are not uncommon in the Greenland Eskimo. Malocclusion will shift occlusal loads, affecting all aspects of tooth wear.

Edge to edge occlusion is seen frequently in hunter-gatherer populations. There has been some debate as to whether this occlusion is controlled genetically or is the result of function. The weight of the evidence would seem to support the latter explanation (Jacobson 1982; Molnar and Molnar 1990; Smith 1983). Experimental studies by Brace and Molnar (1967) and Molnar (1968) indicate that edge-to-edge wear is the result of heavy occlusal attrition on the entire dental arch. Many researchers note that over-bite decreases in depth in juveniles, gradually resulting in an edge to edge occlusion as adulthood and higher levels of attrition are reached (Ryan 1980; Smith 1983).

Tooth morphology. Humans have three basic tooth shapes which correspond roughly to the four dental fields. These are spatulate incisors, cone-shaped canines,and multicuspid premolars (two-cusped) and molars (four to six cusped) (Hillson 1986). These have evolved to fulfil the masticatory tasks of shearing, chopping and grinding (Foley and Cruwys 1986). Kay and Hiiemae (1974) have stated that molar form is intimately and primarily related to food consistency and has evolved to meet the requirements of the diet. It has been theorized that shovel-shaped incisors are adaptations to counter the effects of considerable pressure on these teeth, and render them less likely to fracture and chip (Hylander 1977). Such an incisor form occurs frequently in Inuit populations well known for their use of the anterior dentition. It takes only a short leap to recognize that differently shaped teeth will be differently affected by the processes of wear (Campbell 1939).

Non-metric morphological traits, such as cusp patterns on the molars or the presence or absence of shovel-shaped incisors have been used by physical anthropologists to assess the biological relatedness of different archaeological populations (Foley and Cruwys 1986; Mayhall 1979; Turner 1967). Although the genetic inheritance of such traits appears to be complex, results of these studies are encouraging (Hillson 1986).

Other researchers feel that the rapid dental wear found in archaeological populations and fossil hominids indicates that cusps functioned only as guiding mechanisms to train the erupting dentition into the proper alignments for masticatory activity (Molnar and Ward 1977; Smith 1983) and therefore were not subject to selective processes in evolution. Mills (1988 as cited in Corruccini 1991:310) was perplexed by the appearance and evolution of unworn teeth, feeling that mastication was aided by the combination of differing hardnesses found in teeth with a degree of dentin exposure.

Tooth size has been the subject of a great deal of investigation. Like other features, it is a product of genetic and environmental factors. Studies rate genetic control between 60-90%, while the most influential environmental factor is felt to be nutrition (Hillson 1986). Bearing in mind that absolute tooth size is of less importance than its relative size in relation of other aspects of body size, large teeth are thought to be an adaptation of organisms engaging in activities that produce heavy wear on the teeth. The larger the teeth, the longer the teeth can be subjected to these occlusal pressures. The prolonged functional age of the teeth extends the life span of the individual possessing them (Brace et al., 1991; Calcagno and Gibson 1991; Collier 1982).

The increase in anterior tooth size through much of the Pleistocene, culminating with the Neanderthals, has been attributed to the use of these teeth in a variety of nondietary functions (Brace 1962,1964). The subsequent dietary and food preparation shifts of the late Pleistocene and Holocene resulting in a softer food bolus was the catalyst for the reduction in tooth size through this period (Brace et al. 1991; Calcagno and Gibson 1991). Brace et al. (1991) link this shift to the "Probable Mutation Effect" in which a lessening pressure for the selection of large teeth allows for a greater occurrence of smaller teeth. Smaller teeth are not being actively selected for, but they are not being selected against. On the other hand, Calcagno and Gibson (1991) link the shift to the "Selection Compromise Hypothesis" in which smaller teeth are being actively selected for to fit into increasing smaller mandible and maxillas. Thus the problems inherent in crowded teeth, such as traumas and infections are avoided. Others have suggested that decrease in tooth size throughout the later Pleistocene was due to the reduction of non-dietary selection factors on the teeth, as technologies became more complex (Foley and Cruwys 1986).

Tooth Hardness, Enamel Structure and Enamel Thickness. Enamel is one of the hardest substances in the human body due to its high mineral component, 95-98% mineral by weight, and greater than 85%-91% by volume (Beynon 1986; Boyde 1989; Maas 1991). The remaining tooth volume is taken up by the organic matrix and water (Boyde 1989). Enamel hardness will obviously affect rate and degree of wear. However, absolute hardness is difficult to assess, varying as it does both between and within populations. Tooth hardness may be a factor either of differences in proportions of bone salts, or the patterns of the enamel prisms (Jacobson 1982). Furthermore, decidous and permanent enamel are chemically and structurally different (Rose and Marks 1985). It is generally assumed that tooth hardness is reasonably consistent throughout a population group (Jacobson 1982; William and Woodhead 1986). This may not in fact be the case, as enamel is not structurally homogeneous, varying within the individual, and even within the tooth (Maas 1991). Such inter-and intra-species differences in the enamel may affect microwear patterns and frequencies (Gordon 1988). Differences in prisms patterns and the extent of decussation, or the degree to which "enamel prisms pursue a wavy or straight-line path from surface to amelo-dentinal junction" (Foley and Cruwys 1986:5), have served to distinguish between taxa. However, there is likely a biomechanical component affecting such differences in enamel structure, causing their independent occurrence.

Enamel is formed as ameloblasts (tall columnar cells) migrate from the amelo-dentinal junction, leaving behind them the protein organic matrix in which the hydroxyapatite crystals grow. These crystals are long and thin and are oriented perpendicularly from the amelo-dentinal junction (Boyde 1976). Bundles of approximately 10,000 crystals form the prisms, the basic structural unit of enamel (Beynon 1986; Boyde 1989). If enamel formation is disturbed for a number of days, there is a distinct area of disruption running through the enamel creating severe changes in prism direction corresponding to brown striae of Retzius, or to incremental or disturbed growth lines (Boyde 1976,1989). These are observable on the surface of the teeth as perikymata (Boyde 1976).

The structure of enamel serves in some measure to alleviate the effects of wear (Boyde 1980). The amelo-dentinal junction is serrated or scalloped (Boyde 1976). This serves to minimize the occurrence of cracking along this juncture. It is also widely felt that complications in the course of enamel prisms, such as its decussation and the presence of Hunter-Schreger bands, regions where prisms are doing roughly the same thing, either increase enamel strength or minimize the length of cracking or fracturing along the prisms boundaries by the complicating curves, or both (Boyde 1989). The three patterns of prisms when seen in cross-section may also lend differing strengths (Foley and Cruwys 1986). When prism orientation is perpendicular to the wear plane, the enamel surface is fairly wear resistant, i.e. there are no structural discontinuities that would be vulnerable and easily broken away in a masticatory or paramasticatory function. When prism orientation is parallel to a wear surface however, the presence of incremental lines and/of brown striae of Retzius as well as groups of prisms are more likely to fracture or cleave from the surface of the tooth (Boyde 1989). For example, in the human upper incisor, the prisms are more parallel in orientation on the labial side than the lingual, Once dentin is exposed, this leads to a greater chipping of the labial edge. The opposite phenomenon occurs in the lower incisors (Boyde 1989).

In general, enamel is found to be thickest on the occlusal surfaces and edges, and thinnest at the neck of the tooth (Boyde 1989). A preliminary study on primate enamel thicknesses by Molnar and Gantt (1977) echoes other studies of human enamel thickness (Gillings and Buonocore 1961a,b; Hand 1968; Shillingburg and Grale 1973). They demonstrated that enamel thickness was greatest on the areas subjected to greatest wear, the cusps of the molars and premolars, and the buccal surfaces of the teeth. Thicker enamel in these areas would increase the life of the molar (Molnar and Ward 1977). It is hypothesized that enamel is also thicker in developmental grooves (Molnar and Ward 1977) and there is some suggestion that enamel is thicker in larger teeth. "Enamel is thickest over biting edges and biting surface, and thinnest at the neck, or cervix, or the tooth, where it tapers to nothing " (Boyde 1989:310-311). Again, enamel thickness is likely subject to some population variation (Shillingburg and Grale 1973).

Sexual Dimorphism. Female/male differences exist between the size of teeth and their supporting masticatory apparatus, between the tooth eruption sequences, and quite possibly between enamel thickness and hardness (Hillson 1986; Jacobson 1982; Molnar et al. 1983a; Trodden 1982). It is difficult to separate the effects of culture and genetics in this sexual dimorphism. Although there is a large genetic component involved in such traits, within culture differences between diet or occupation are considered possible factors contributing to the sexual dimorphism found in tooth sizes at, for example, chalcolithic Mehrgarh and in Europe during the Upper Palaeolithic (Lukacs and Hemphill 1991). Indeed, most differences in wear between sexes have been attributed to culture. Yet until we know more about variation between genders in terms of enamel thickness and hardness, and how these could affect wear, some caution should be used in these interpretations (Richards and Brown 1981).

Men tend to have larger teeth than women, so much so that it may be possible for researchers to sex skeletal populations by tooth dimension (Hillson 1986). In terms of tooth tissue loss however, this size difference is more likely to affect the rate rather than the pattern of wear (Collier 1982). Jacobson (1982) notes that in general, males wear their teeth more rapidly and to a greater degree than do females, a function of their ability to place greater occlusal force on their dentition due to their heavier skeletal framework and masticatory musculature. In a South African Negro sample, Jacobson (1982 as cited in Molnar et al. 1983a:64) found that wear was advanced in females until 31 years of age, when the attritional index equalized. Smith (1982 as cited in Molnar et al. 1983a:64) observed that Bedouin males underwent an increase in wear rate where "attrition doubled between 20 to 40 years of age".

Alternately, many other studies find that from early adolescence on females wear their teeth more rapidly than do males. This is generally explained by the craft usages to which females put their teeth, in particular the chewing of plant fibers and animal skins or to their tougher diet (Benfer and Edwards 1991; Campbell 1939; Jacobson 1982; Molnar 1971b,1972; Molnar and Molnar 1990). The fact that female teeth tend to erupt earlier than male teeth may account for some of the differences (Mayhall et al. 1978; Miles 1978; Molnar et al. 1983a; Trodden 1982). Females also tend to experience more dental disease, for much the same reasons.

When using discriminate analysis to consider longitudinal changes in both pattern and degree of wear facet location and area in the molars of a group of young Australian aborigines, Molnar et al. (1983a) found a clear sexual distinction in rate of wear. This was particularly obvious in the patterning, or the shifting of occlusal loading with increasing growth (and age). Males wore their first molars more rapidly while females wore their second molars more rapidly, and more evenly. It would follow that the distribution of occlusal loading was more equitable in females than males. Overall female tooth wear occurred more rapidly than with males, mandibular molars were worn more rapidly than maxillary molars, and there appeared to be greater asymmetry in occlusal loading in the maxillary arch. In this case, attributing the female-male difference to a more fibrous diet in the women was less convincing since all had a less abrasive diet. Neither did arch shape show sexual dimorphism (Molnar and Molnar 1990), although it may be that complexities in the growth of the arch were factors. The eruption sequence may be contributing to this difference. Teeth, with the exception of the upper central incisor and mandibular lateral incisor, erupted as much as six to ten months earlier in girls than boys. However even the six month lead on the part of the girl's first molars was not considered sufficient to account for the magnitude of the differences in wear facet area found.

To add to the confusion, difference in wear between males and females only existed if wear facets were compared. If the cusp height was considered, it was the males who were experiencing the more rapid wear. Furthermore, the maxillary molars were losing cusp height at a greater rate than the mandibular molars in the males, in the females the rate was about the same (Molnar et al. 1983b). This could be explained by "variations of enamel thickness, wear pattern, or of cusp morphology" (Molnar et al. 1983a:64).

Microscopically, facets on third molars of female dentitions often show higher proportions of striations to pits than do those of the males. Striations also tend to be shorter on female molars (Gordon 1982). However, it is felt that sex differences "may complicate, but not overwhelm, interspecific comparisons" (Teaford 1991:346; Teaford and Walker 1984; Teaford and Robinson 1989).

Cultural Factors

Diet. Teeth evolved to process, and in some cases, obtain food (Brace et al. 1991; Hillson 1986; Kay and Hiiemae 1974). Thus it should come as no surprise that diet and dietary abrasives are considered to be the major factor affecting the degree and rate of tooth wear, nor that most studies in dental anthropology focus on this inter-relationship (Campbell 1939; Hinton 1981a; Molnar and Ward 1977; Molnar et al. 1983a; Powell 1985). Not only is the nature of the actual food eaten important, but also the means by which it is collected, stored, prepared and consumed (Brace et al. 1991; Molnar 1972; Murphy 1959b; Smith 1983). The percentage of added abrasives is felt by many researchers to be the most important factor in explaining degree of wear (Jacobson 1982; Molnar and Molnar 1990). Foley and Cruwys (1986:16) are of the opinion that wear is not particularly sensitive to the relative amount of meat in a diet, but that it better differentiates between amounts of vegetable material which in their enormous variety of hardness and fibrosity, "are more likely to be reflected in macrowear than animal/vegetable proportions."

Generalizations resulting from most studies concern the broad differences in wear rates and patterns between hunter-gatherers and agriculturalists. On the whole, it has been observed that the rate of dental wear in agriculturalists and increasingly urbanized groups is markedly reduced as compared to wear rates in hunter-gatherer groups (Molnar 1972; Rose and Marks 1985; Tomenchuk and Mayhall 1979). As well, there is less sexual dimorphism in tooth wear among agricultural groups (Tomenchuk and Mayhall 1979).

Smith (1983, 1984) has demonstrated that hunter gatherer populations tend to have a flatter wear on the molars, as opposed to the helicoidal plane found in agricultural groups. This is attributed, in part, to the more lateral movements of the mandible necessary to masticate the tougher foods in a hunter-gather diet. Tough or fibrous foods also require the generation of higher maximum bite forces, in which, theoretically, there is a high anterior component of force. This should contribute to heavier occlusal and interproximal wear (Smith 1983). Hinton (1982) also found greater interproximal wear in groups that lacked extensive food preparation techniques.

In one of the few studies of anterior dentition, Hinton (1981a) found that agriculturalists had greater wear on their posterior teeth as opposed to their anterior teeth, a relationship that was reversed for hunters and gathers. He also found a greater occurrence of labial rounding on the anterior lower teeth of hunters and gathers, while agricultural groups had cupped wear on their upper anterior dentition. This cupping was associated with a loss of the molars, forcing the anterior teeth into a grinding role. The labial rounding resulted from the use of anterior dentition in a "third hand" role. Molnar (1972) has also noticed the association between the cupping of anterior teeth and the antemortem loss of the molars. Hartnady and Rose (1991) report the occurrence of greater wear on the anterior teeth of an archaic period archaeological population which they attribute to the practice of pulling and shredding of grit laden plant material through the teeth. This resulted in anterior lingual enamel loss and obliquely worn teeth with cresent-shaped enamel surfaces.

Cultural factors intervene to provide exceptions to these generalizations. For example, certain methods of food preparation used by agricultural groups, such as the use of stones to grind grain, add grit to the diet thereby increasing the wear (Brace et al. 1991; Leigh 1925a,b; Smith 1972). Smith (1972) found a greater rate of wear in materials excavated from sites with incipient but intensive grain utilization, and less wear in a group with more of a hunting-gathering lifestyle, a finding she attributed to the "self cleansing non-abrasive foods" utilized by hunting groups. As well, the cultivation of corn by North American natives increased the rate of tooth wear because corn epidermis contains an opal content that is harder than enamel (Leigh 1925b; Smith 1983). The cultural habit allowing men preferential food choices and access, with women consuming whatever was left may also contribute to intrapopulation differences in wear between genders (Campbell 1939; Jacobson 1982), as well as a greater consumption by women of the coarser terrestrial plant foods for which they traditionally foraged (Benfer and Edwards 1991; Campbell 1939; Holliman 1991; Molnar 1971b,1972; Molnar and Molnar 1990).

Less often considered environmental factors such as wind-blown sand can add to abrasives introduced into the mouth (Molnar and Molnar 1990). Even more rarely seen and studied, food chemistry may also have an effect, with highly acidic diets eroding enamel (Foley and Cruwys 1986; Teaford 1991; Williams and Woodhead 1986).

The majority of research in the study of microwear has focused on linking particular patterns of features to diets (Grine 1981; Teaford and Oyen 1986). There is the hope that correlations between diet and pattern can aid in dietary reconstruction in fossil hominids (Grine 1986; Teaford and Walker 1984). Seasonal shifts in diet, in particular any systematic shifts between relatively hard and soft diets, can affect the microwear patterning. Specimens of *Cebus nigrivittatus* living in a dry tropical woodland and collected during the wet season exhibited more features, but fewer and smaller pits than those collected in the dry season (Teaford and Robinson 1989). The same species, when collected from a humid tropical forest site did not exhibit such seasonal differences. The chewing of hard objects will obliterate microwear patterns produced by the eating of soft foods at a more rapid pace than the converse. Hard diets also show a greater percentage of new features over the same time period as well as a higher rate of feature turnover (Teaford and Oyen 1989). However, recent research indicates that while intraspecific variation due to biomechanical and seasonal differences is detectable, depending on environmental zone, it is not of high magnitude. Consequently it is not likely to seriously affect any inter-species comparisons especially between organisms consuming broadly differing diets (Teaford and Walker 1984; Teaford and Robinson 1989; Teaford and Glander 1991). Care should be taken however, in the study of museum specimens. Keeping in mind the possible intraspecies differences found in the microwear, as well as knowing the environmental conditions and timing of the animal's capture will help avoid any complications that might arise (Teaford and Glander 1991).

The finding of a higher rate of wear on the shearing facets of the howler monkeys, as opposed to the grinding/crushing facets is hypothesized to be a result of diet. The diet of the howler monkeys is composed predominantly of mature leaves. Thorough mastication of these leaves is likely to involve more shearing and cutting actions by the dentition than are required to process the more prepared diets of humans and laboratory animals (Teaford and Glander 1991).

Additionally, orientation of striations may aid in dietary reconstruction (Hillson 1986). Teaford (1991:346) and Gordon (1988) caution however that sample sizes in all studies have been small and that the methodology of microwear analysis is still being worked out.

Much of the work in human dentitions has been carried out by Rose and co-workers (Rose 1984; Rose et al. 1981,1983; Rose and Marks 1985; Rose and Harmon 1986), as part of a bioarchaeological component in a series of research reports conducted for museums and state surveys in the southeastern area of the United States. Molars from several prehistoric sites in the states of Oklahoma and Arkansas have been examined under the scanning electron microscope. Analysis was primarily qualitative, but resulted in several reliable observations. Pitting was associated with the consumption of hickory nuts, or hard objects in general, a dietary habit confirmed both by the presence of these nuts on site and in coprolites. Based on the short life span of microwear features and the assumption that nuts would be more readily available and commonly consumed during that latter part of the year, a fall/winter season of death was tentatively assigned to those individuals on whose occlusal surfaces a great deal of pitting was observed (Rose and Marks 1985). Presence of enamel surface polishing was linked to consumption of vegetable fibre, possibly including seed husks, a correlation confirmed by coprolite analysis and dry cave food remains. The absence of such polish indicated either the lack of such material in the diet, or its extensive processing (Rose et al. 1981). Lack of polish also contributed to a relatively longer life span for the striations. Less abrasive diets exhibited striations with rounded margins that were being obliterated by numerous small striations. Striations were felt to result from the accidental contamination of food stuffs by grit; chipping of enamel from the occlusal edges was attributed to large debris inclusions (Rose et al. 1969,1981,1983; Rose 1984). Consumption of shellfish was also thought to leave large striations

(Rose et al. 1981; Rose and Marks 1985). Large striations, frequent small striations and roughened surface textures indicated the use of stone utensils. Rose and co-workers also correlated a shift from sharp to round striation margins with a cultural shift from stone to wood grinding implements. Stone grinding implements produced a greater rate of attrition than did wood grinding implements. The use of wooden implements was associated with a horticultural diet that was soft and nonabrasive. The microwear patterns often seen here consisted of old and jagged striations that were being obliterated by other striations. This obliteration occurred through infrequent accidental abrasive contaminants in the otherwise nonabrasive diet and were not a result of polish. Chipping observed on the marginal edges of teeth was associated with the mastication of hard foods such as nuts, the occasional chewing of hard objects such as bone, or possibly the use of the teeth as tools (Rose et al. 1983; Rose and Marks 1985; Rose and Harmon 1986).

An interesting shift between post and pre-contact North American aboriginal groups in the southeastern United States has recently been observed in the study of microwear patterning on the maxillary first molars. Pre-contact molars exhibit a greater number of pits and significantly wider striation widths that post-contact molars. Early-contact molars showed patterns intermediate between these two extremes. This would indicate that the pre-contact peoples were ingesting hard food items, in greater number and frequency than the post-contact groups. It is felt that the influence of the Spanish missions shifted the aboriginal subsistence base away from hunting and gathering to maize agriculture (Larsen et al. 1990 as cited in Teaford 1991:349-350).

Non-dietary Chewing. Molnar (1972) in his review of tooth functions in prehistoric populations, mentions the importance of "non-dietary" chewing. This involves the mastication of items such as milkweed, cattails or yucca, not unlike the chewing of gum or tobacco quids in industrial populations. It further encompasses the chewing, and subsequent removal, not ingestion, of material either to extract the nutrients or prepare it for medicinal purposes. Items are also introduced into mouth to induce the production of saliva, necessary in some gum or ochre preparations (Barrett 1977).

Savouring, a more prolonged masticatory action while eating may also affect rates of wear (Jacobson 1982; Molnar et al. 1983a). Abrahams (1947 as cited in Jacobson 1982:40) claimed that tooth tissue loss resulting from chewing habits would create oblique tooth surfaces. Tooth tissue loss as a consequence of a fibrous diet would not only be less than that caused from chewing habits, but would leave a horizontal tooth surface. However, to my knowledge, no research has proven this claim.

Bruxism, a nonfunctional tooth to tooth contact, is a phenomenon that refers to the clenching, grinding and/or tapping of teeth in addition to the chewing of the cheeks and lips. It can also include the chewing of introduced nondietary items such as pencils or pipes (Clarke et al. 1984). It often occurs during sleep.

Three explanations have been proposed to account for this phenomenon. Firstly bruxism is thought to be an expression of a nervous habit. Secondly bruxism might be the result of malocclusion. Finally it might also be caused by some chronic pain or discomfort (Williams and Woodhead 1986). Currently, however, malocclusion is thought to be an unlikely agent. Clarke and Townsend (1984) point out that no link between bruxism and malocclusion has been demonstrated in controlled experiments.

Researchers have found bruxism to be practically universal in populations, although psychological stress is possibly a catalyst (Clarke et al. 1984; Clarke and Townsend 1984; Nadler 1968 as cited in Williams and Woodhead 1986:111). In early experiments, Uhlig (1960) found that out of 147 individuals examined, roughly half ground their teeth, while the other half clenched them. Seventy percent experienced some muscle contraction throughout the night. Clarke et al. (1984) found that all of their ten subjects bruxed. Clarke and Townsend (1984) have linked bruxism and REM (rapid eye movement) sleep and suggest that bruxism is the result of impulses from the central nervous system.

Bruxism may lead to wear or to the loosening of teeth and their supporting structures (Clarke et al. 1984; Clarke and Townsend 1984; Uhlig 1960). Although the relation of bruxism to wear is unclear (Williams and Woodhead 1986) and has not been precisely studied (Clarke et al. 1984) wear is thought to be created and continued by the fragments of the enamel prisms broken off during grinding. The amount of muscle contraction and force involved is generally no larger than that which can be exerted by conscious clenching, but that this conscious clenching "represents an enormous force in comparison to usual masticatory and other functional forces" (Clarke et al. 1984a:126). This may lead to trauma in the masticatory system.

Wear resulting from bruxism is claimed to be even, uniform and horizontal (Molnar et al 1983a). However, it may be hard to distinguish from wear resulting from other chewing activities. Clarke et al. (1984a:124) found "that the muscle activity associated with most grinding episodes could not be discriminated from ordinary oral movement." Greater wear on the posterior dentition of males has been attributed to greater bruxism by men in work or stress situations (Johanson, '72 as cited in Tomenchuk and Mayhall 1979:67). It is this factor to which Tomenchuk and Mayhall attribute greater wear (approximately 30%) on the male maxillary molars in the contemporary group of Eskimos they studied. However, Williams and Woodhead (1986) feel that only very extreme bruxism would contribute significantly to tooth tissue loss, as marked wear is not seen in modern populations.

Dental health. Cultural practices greatly affect the manner and rate of occurrence of various dental diseases. Most well known is the virtual absence of cavities in most hunter-gatherer groups, and their abundance in agricultural groups (Hinton 1981a; Leigh 1925a,b; McEuan 1938; Powell 1985; Smith 1983, 1984). This is linked both to the higher proportion of carbohydrates in the agricultural diet as well as to the greater wear on the hunter-gatherer dentition. Worn teeth have fewer crevices in which caries can begin (Drennan, 1929). Comparable findings have been observed in the switch from traditional diets to the processed and heavily sugared foods of industrial peoples, in which the consumption of high status 'western' food will lead to a increased occurrence of cavities and a decreased occlusal wear (Collins 1932, Mayhall 1970).

Pathologies will shift chewing loads. Often, heavily worn first molars, susceptible to abscesses and sensitive to pressure, will cause the individual to shift the majority of chewing to the back molars (Smith 1983). Although the effects of antemortem tooth loss are not clearly known, it seems reasonable to suppose such loss would cause some disruption of chewing patterns, and would certainly create a greater stress on the remaining teeth (Molnar 1972; Poirier 1972) Williams and Woodhead (1986) suggest that antemortem tooth loss is a major factor in tooth tissue loss in present day populations. As well, bilateral differences in tooth wear can often be explained by the presence of a periodontal inflammation (Molnar 1971b; Molnar and Ward 1977). As regards the masticatory system as a whole, Sheridan et al. (1991) have linked temporomandibular joint degeneration to increased reliance on the anterior dentition as a result of the long term antemortem loss of the posterior dentition.

Holliman (1991) reports a difference in dental pathology between men and women in the Chumash Indians of southern California that can be linked to a sexual division of labour. In the earlier periods the classic 'man the hunter - women the gatherer' situation is thought to have existed. This allowed men greater access to proteins while women consumed a larger quantity of the more carbohydrate-rich plant foods and experienced a higher incidence of caries as a result.

Tool Use of Teeth. Gauchos of South America, Australian aborigines, American Indians and Inuit groups have all intrigued European observers by their use of teeth as tools, as, in effect a third hand (Barrett 1960, 1977; Brace and Molnar 1967; Hartnady and Rose 1991; Hinton 1981a; Hylander 1972, 1977; Lukacs and Pastor 1988; Milner and Larsen 1991; Molnar 1972; Pedersen and Jakobsen 1989; Smith 1983). Australian aborigines have been observed using their teeth to soften sinews, peel, strip and grip objects, sharpen tools, and hold objects (Barrett 1977) and it seems that a paramasticatory use of the teeth, in particular the anterior teeth may have been a common adaptation in prehistoric human populations. Such a use of the teeth may result in distinctive patterns of wear (Barrett 1977; Brothwell 1981; Frayer and Russell 1987; Hartnady and Rose 1991; Molnar 1972; Molnar and Ward 1977; Tomenchuk and Mayhall 1979) and it is not inconceivable that it could have contributed significantly to overall wear in some populations (Molnar 1968, 1971b;1972; Smith 1983). Both recent and fossil populations have shown peculiar occlusal and interproximal wear patterns which have been attributed to unique paramasticatory activities (Frayer and Russell 1987; Lukacs and Hemphill 1991; Larsen 1985; Molnar 1972; Molnar and Ward 1977; Schultz 1977). Blakely and Beck (1984) have contended that patterns that can be correlated with tooth use have in fact been under represented, and have often been mistaken for intentional mutilation.

The rounding of the anterior teeth in Neandertals has been attributed by some to their use of these teeth to hold objects, or as an all purpose tool (Brace 1975; Brace et al. 1981; Ryan 1980; Wallace 1975). Wallace (1975) argued against such a function, feeling that teeth could be rounded through the action of dietary grit. He claimed that open bite, a situation in which the anterior teeth do not, and are not able to, meet because of advanced wear when brought into full normal occlusion, was closely associated with rounded wear. In such an instance, when the teeth are unable to cut food in a normal fashion, one would have to manipulate it by "manually pulling it over the incisor stumps or alternatively, by fixing it in hand whilst the stump-like incisors were raked side-to-side and for-and aft like shredders " (Wallace 1975:395). It is these pulling or raking activities that lead to the rounding of the teeth. However, as Brace (1975) points out, incisors are more likely to be used as a clamp in conjunction with a knife rather than to cut objects scissor-fashion as Wallace suggests. As well, most diets heavy in grit have resulted in edge-to-edge wear, not anterior rounding (Howells 1975). Besides the dangers inherent in trying to approximate an occlusion in life from dry bone, Wallace's thesis does not rule out the possibility of paramasticatory use: nondietary objects manipulated in the same way as Wallace's 'food item' would produce the same effects. In any case, to quote Koritzer (1975:398): "[labial rounding] may be attributed to a dietary peculiarity or use of the teeth as tools, but the result is the same. There must be hand-assisted tooth functions that developed the vectorial forces in this case". Finally, Pedersen (1952) attributed instances of open bite in Greenland Inuit to the practice of softening skins by women.

The presence of grooves on the occlusal and interproximal surfaces of teeth have been found in many archaeological populations and have been attributed to everything from toothpick use, sinew pulling, and crafts such as weaving and basketry, to localized antemortem erosion and the results of grit-laden saliva (Berryman et al. 1979; Frayer and Russell 1987; Larsen 1985; Lukacs and Pastor 1988; Pedersen 1947; Schultz 1977; Ubelaker 1971; Ubelaker at al. 1969; Wallace 1974). Notches found in the corners of maxillary incisor crowns have been linked to a possible vice-grip type of use-related wear such as holding a net while fishing, or during the processing of fibres (Blakely and Beck 1984; Milner and Larsen 1991).

Antemortem tooth trauma (Patterson 1984; Pedersen 1947, 1949; Turner and Cadien 1969), in the form of chipped, flaked, crushed or fractured enamel, is felt to be evidence of the use of teeth in hard biting, during either a dietary or tool-use function (Calcagno and Gibson 1991; Hylander 1972; Milner and Larsen 1991; Rose et al. 1983; Rose and Marks 1985). This damage ranges in size from the loss of minute chips of enamel to the dislodgement of irregularly shaped block-like pieces (Milner and Larsen 1991). Fracturing, the loss of at least one-quarter of the tooth's surface and involving the breaking away of both dentin and enamel occurs less frequently (Milner and Larsen 1991; Patterson 1984). Hillson (1986) notes that fracturing is most common on the upper incisors, but Milner et al. (1983) and Sauer et al. (1979) found fracturing more commonly in the molar region. Schour and Sarnat (1942) cite the holding of items in the mouth as being a factor often responsible for the chipping or fracturing of enamel.

Although little research has been done in the area of the use of teeth as tools, and there is a need for standardization in the analysis and presentation of data, (Milner and Larsen 1991; Patterson 1984) some generalizations can be made (Table 1). Enamel chipping occurs primarily along the occlusal edge. In most populations trauma is located most commonly and to a greater degree in the posterior dental region. As well, minute enamel chips are often found near and around the interproximal tooth facets of posterior teeth. Not surprisingly, in overall terms of wear, the buccal edge of the mandibular molars and the lingual edge of the maxillary molars exhibit the most trauma. There appears to be a direct relationship between the amount of chipping and wear; the greater the wear, the greater the chipping (Milner and Larsen 1991). Sexual dimorphism in trauma has been demonstrated in the Joman population of Japan wherein the women's teeth are the more traumatized (Milner and Larsen 1991). Ryan (1980) has suggested that differentiating between post- and antemortem trauma could be done more reliably at a microscopic level as there is a danger of mistaking postmortem trauma for antemortem and thereby artificially elevating its amount and occurrence.

Other phenomena taken to indicate the use of teeth as tools include the traumatic antemortem loss of teeth, a process which Merbs (1968,1983) elaborates on in his analysis of the Sadlermiut collection. Stoukal (1975) found a great deal of antemortem incisor loss in women from a group of burial grounds dating to the Middle Ages. He felt this could be due only to the use of these teeth as tools, although he did not specify in what capacity.

The presence of unusual abrasive patterns on the labial surfaces of the anterior dentition are cited as indicators of the use of teeth as tools. This includes transverse and oblique striations found on the labial surfaces of some Neandertal incisors thought to be caused by the cutting of a foreign object gripped between the anterior teeth. Carelessness in the cutting process would result in striations (Bermudez de Castro et al. 1988; Lukacs and Pastor 1988; Milner and Larsen 1991; Trinkaus 1983). Other activities that may have led to these patterns is the

Table 1: Antemortem Fractures and Chipping of Prehistoric Teeth

Skeletal Series	Sample Composition	Individual D*	N**	%	Source
Aleut	6-20 yr. max. and mand.	13	57	22.8	Turner and Cadien 1969
Aleut	Adult max. and mand.	10	44	22.7	Turner and Cadien 1969
Inuit	6-20 yr. max. and mand.	27	53	50.9	Turner and Cadien 1969
Inuit	Adult max. and mand.	106	132	80.3	Turner and Cadien 1969
N.A. Native	6-20 yr. max. and mand.	1	17	5.9	Turner and Cadien 1969
N.A. Native	Adult max. and mand.	6	21	28.6	Turner and Cadien 1969
Jomon, Japan	Adult max. and mand.	41	70	58.6	Turner 1979
American Bottom, Illinois	Adult max. and mand.	43	44	97.7	Milner 1984
		Teeth			
American Bottom, Illinois	Adult max. and mand.	542	1102	49.2	Milner 1984
Hesquait Harbour, B.C.	Adult max.	16	44	36.5	Cybulski 1978
Hesquait Harbour, B.C.	Adult mand.	60	234	25.6	Cybulski1978
Les Vecount Md. Ont.	Dec. max. and mand	30	180	16.7	Patterson 1984
Le.Vescount Md. Ont.	Perm. max. and mand.	167	366	45.6	Patterson 1984
Bennett, Ont.	Dec. max. and mand.	2	70	2.9	Patterson 1984
Bennett , Ont.	Perm max. and mand.	11	149	7.4	Patterson 1984
Kleinburg, Ont.	Dec. max. and mand.	30	402	7.5	Patterson 1984
Kleinburg, Ont.	Perm. max. and mand.	480	2803	17.1	Patterson 1984
Glen Williams Ont.	Dec. max. and mand.	30	727	4.1	Hartney1978
Glen Williiams Ont.	Perm. max. and mand.	266	2556	10.4	Hartney 1978
Milton, Ont.	Perm. max. and mand.	48	559	8.6	Hartney 1978
Christmas Island, Ont.	Dec. max. and mand.	5	330	1.5	Hartney 1978
Christmas Island, Ont.	Perm. max. and mand.	42	940	4.5	Hartney 1978
Indian Neck, Mass.	Adult max.	50	131	38.2	Magennis 1986
Indian Neck, Mass.	Adult mand.	65	134	15.0	Magennis 1986
		Dentitions			
Indian Neck, Mass.	Adult max.	13	13	100.0	Magennis 1986
Indian Neck, Mass.	Adult mand.	15	16	93.8	Magennis 1986
Reigh, Wisc.	Adol. and adult max.	8	28	28.6	Pfeiffer 1977
Reigh, Wisc.	Adol. and adult mand.	4	29	13.8	Pfeiffer 1977
Front. Is. N.Y.	Adol. and adult max.	12	55	21.8	Pfeiffer 1977
Front. Is. N.Y.	Adol. and adult mand.	9	56	16.1	Pfeiffer 1977

(Milner and Larsen 1991:368-369)

*D: number of damaged teeth, dentitions with damaged teeth, or individuals with damaged teeth.

**N: number of teeth, dentitions, or individuals observed.

wearing of lip plugs or labrets, retouching stone tools, the use of a mouthpiece in the manipulation of the bow drill, or the splitting of reed or bamboo stalks (Barrett 1960; Lukacs and Pastor 1988).

More subtle indicators of tool use patterns are differing degrees of wear between men and women, between tooth fields, and between maxillae and mandibles (Hartnady and Rose 1991; Leigh 1925b; Molnar 1971b). Leigh (1925b), observing undue wear on the lower anterior teeth of Zuni males, felt this was the result of holding pipes in the mouth. The adoption of quartz tools by Mesolithic forager -fisher peoples of Yugoslavia is thought to be responsible for the heavy anterior wear found on their teeth as the poor quartz cutting edges "may have necessitated greater anterior tooth use in biting and cutting" (y'Edynak 1978:616). The practice of softening hides by Inuit women is thought to contribute to excessive wear on the anterior teeth (Lukacs and Pastor 1988; Patterson 1982; Smith 1983; Tomenchuk and Mayhall 1979) as is the San practice of separating and chewing fibers for rope (Jacobson 1982). Lukacs and Pastor (1988) attributed the exposure of dentine on the lingual surface of the upper and lower incisors in association with the rounding of the lower incisors along the lingual-facial plane and the occurrence of buccal striations on the lower incisors and canines in the dentitions of skeletons from prehistoric Pakistan to the "pulling of material through tightly clenched teeth" (Lukacs and Pastor:398), in short, the preparation of animal hides. Interestingly, Pedersen and Jacobson (1989) make that same claim for teeth that have been rounded facially-incisally. However here there is a loss in the lower incisors of all the labial enamel, and the retention of only some in the upper incisors. Possibly the same activities with a different hand-held vector can cause different wear.

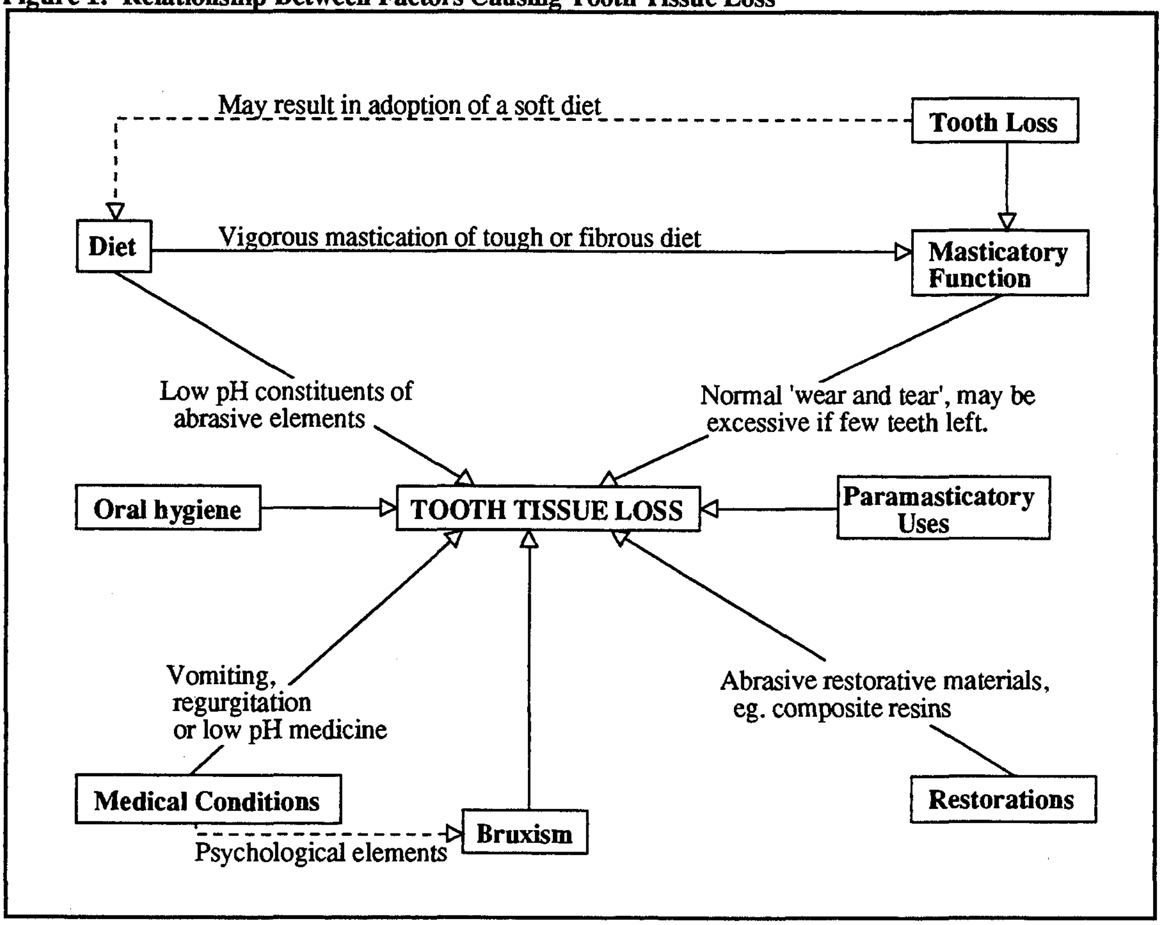
Tool use dental wear patterns are not limited to prehistoric peoples. Schour and Sarnat (1942), as recently as 1942, documented wear patterns that relate to habitual activities involving the teeth (see also Barrett 1977). Localized abrasive patterns occurred in situations in which items were held in the dentition for long periods of time. For example, fine notches are found among seamstresses, resulting from a holding of needles between the incisors and biting off thread. Larger notches were associated with carpenters, shoemakers and upholsterers, a result of their gripping nails in much the same manner. Depending on the placement of an instrument or pipe, musicians and smokers will also exhibit distinctive patterns of wear. However, it should be noted that such wear is often idiosyncratic: "not all pipe smokers exhibit an area of tooth tissue loss in relation to their pipe stem while even infrequent dressmakers may notch their teeth with pins" (Williams and Woodhead 1986:110).

In animals, the presence of microscopic striations have been associated with the action of grass phytoliths (Walker et al. 1978). It is possible that humans are affected by phytoliths, not so much in the ingestion of grasses, but through their manipulation in the mouth in the manufacture of baskets or nets. Little study of the use of teeth as tools has been done in terms of microwear analysis, with the exception of Ryan's (1980, 1981, 1989) work and the suggestion by Rose and Marks (1985) that the marginal chipping they observed could be related to the use of teeth as tools. Rather, in light of the fact that the anterior teeth are more likely to be affected by factors other than diet, few studies have looked at the anterior dentition in any fashion (Bullington 1988, 1991; Teaford 1988a).

Summary

Assigning a specific wear pattern or tooth surface form to a specific agent is complex, as this review of the literature makes clear. Williams and Woodhead (1986:119) have drawn a flow chart in which they attempt to illustrate the possible relationship between factors that cause tooth loss (Figure 1). I have added the use of the teeth in paramasticatory activity. The chart is read as follows: factors responsible for gross tooth tissue loss are at the top of the chart, while factors that account for localized wear are towards the bottom. The localized wear is thought to be the result of a isolated factors; the gross wear is thought to have occurred as a result of many interacting factors. The dashed line indicates a tenuous relationship.

Figure 1: Relationship Between Factors Causing Tooth Tissue Loss



After Williams and Woodhead 1986:120.

However, regardless of the many factors affecting wear, and their interrelationships, it can be reasserted that the primary causes of tooth tissue loss are considered to be abrasives in the diet, the intensity of tooth to tooth contact, and the use of the teeth as tools (Foley and Cruwys 1968; Jacobson 1982; Molnar 1972; Molnar et al. 1983b; Molnar and Molnar 1990; Smith 1983; Tomenchuk and Mayhall 1979; Williams and Woodhead 1986). Additionally, the factors in Figure 1 include all those between groups or populations; some of these factors can be held reasonably constant within a single population. Included here are tooth eruption, tooth form and position and, to a lesser degree, enamel thickness and hardness (Williams and Woodhead 1986). There also is some indication that even masticatory function may not be, in itself, a major influence on the wear of teeth as "[it] only becomes a factor when modified by other considerations e.g. tough or abrasive dietary elements, or tooth loss" (Williams and Woodhead 1986:110).

Most of the work involved in assigning a pattern of wear to a particular cause has involved considerations of diet (Ryan 1980; Smith 1983, 1984). Despite Molnar's early work (1971a, 1971b, 1972) investigating the use of teeth as tools, few studies have been directed towards this problem (Milner and Larsen 1991). Yet, due to the hypothesized localized area of such trauma (Foley and Cruwys 1986; Lukacs and Pastor 1988) it would seem to be a pattern more readily discerned and more confidently attributed to a specific agent. While work in anthropology is needed to make observations of the various uses to which people put their teeth, it is hoped that the investigation of an archaeological population which is further subdivided by a sexual division of labour and with a well documented use of teeth as tools, can aid in distinguishing such patterns.

CHAPTER THREE: MATERIALS

Introduction

Ethnographic evidence and cranial morphology demonstrate that arctic peoples placed extensive demands on their teeth. Well documented tooth use includes the chewing of a primarily meat-based diet and the use of the teeth as a third hand (de Poncins 1941; Nansen 1894). As early as 1915, Riecke, upon watching a group of Inuit eat, was impelled to wonder what an examination of their jaws and teeth would find (as cited in Furst and Hansen 1915: 41).

INUIT TOOTH DEMANDS - THE BIOLOGICAL EVIDENCE

Craniofacial Morphology

Physical anthropologists recognized early the distinctiveness of the Inuit cranium, in particular the robust masticatory apparatus and the pronounced facial flatness. The masticatory apparatus consists of a large and sturdy mandible with pronounced gonial eversion, low and robust coronoid processes, wide, low and oblique ascending rami, and shallow mandibular notches. As well it incorporates palatal and mandibular tori, an enlarged zygomaxillary region, high temporal lines with some sagittal keeling, robust muscle attachment areas for the masseter, internal pterygoids and temporalis muscles, and a shifting of the temporomandibular joint posterior to the sella turcica. The pronounced facial flatness is the result of an anterior shift in the positioning of the postorbital bar, zygomatic anterior root and zygomaxillary tuberosity. This contributes to an enlargement of the nasomalar and zygomaxillary angles. Inuit crania are further characterized by large vertical facial dimensions, high foreheads with reduced brow ridges, wide, spacious and squarish orbits, a narrow nasal aperture and reduced nasal bones, a thickened tympanic plate, and a high incidence of third molar agenesis (Anderson and Merbs 1962; Birket-Smith 1928; Furst and Hansen 1915; Hylander 1972, 1977; Jorgensen 1953; Leigh 1925a; Pedersen 1947, 1952).

For most of the first three-quarters of this century, two major theories conflicted in their explanation of Inuit craniofacial morphology. Some researchers explained it as a genetically selected cold adaptation (Coon 1962, 1965; Coon et al. 1950). Alternatively others felt that it was a response to the heavy masticatory demands placed on the teeth, the hard chewing hypothesis (Furst and Hansen 1915, Leigh 1925a). The hard chewing hypothesis seemed to explain the enlarged masticatory apparatus of the Inuit, but was less successful in accounting for the facial flatness, or the large gonial eversion and the thickened tympanic plate. On the other hand, the cold adaptation hypothesis explained the facial flatness, presenting a reduced surface area to the environment which was padded with fat in life, as a mean of protecting the sinuses and nasal passages from the cold (Coon 1962, 1965; Coon et al. 1950).

By the early 1970s, most researchers had discounted the cold adaptation theory (Dahlberg 1980; Forsius 1980; Hylander 1972, 1977). Steegman (1967,1970,1972) demonstrated that frostbite was a selective factor of only negligible strength in the arctic, and that there was any difference in the surface temperature of the face between arctic and non-arctic populations. In fact, some of his results indicated that the facial shape best adapted to a dry-cold was the exact opposite of the Inuit form (Steegman 1970, 1972). As Hansen et al. (1991:65) observe, "[there] is no essential difference between the temperature regulation of an Inuit and that of an African, despite the fact that one lives near the North Pole in a cold climate whereas the other lives in tropical sunshine and warmth." The Inuit ability to better withstand the cold is a product of physiological and cultural adaptations (Hansen et al. 1991; Hylander 1972, 1977; Leppaluoto and Hassi 1991); cultural adaptations that are so successful that the Inuit, "although living in the coldest environment, have developed better protective clothing, and hence show less adaptation to cold than for example, the Alacaluf Indians [from Tierra del Fuego]" (Leppaluoto and Hassi 1991:140). Hylander pointed out further weaknesses in the work of the cold adaptation proponents, noting that the features they claimed protected the face from cold, such as the flaring malars, were also found in Australopithecine crania, for whom cold adaptation would not be a priority. In his opinion as well, the Inuit cultural adaptations were enough to protect their faces from the cold (Hylander 1972, 1977).

In turn, Hylander (1972,1977) presented his own hypothesis, a pared down version of the hard chewing hypothesis that succeeded in explaining both the facial flatness and the pronounced masticatory apparatus. For Hylander the Inuit cranium is "the result of an adaptation for the GENERATION and DISSIPATION of heavy vertical occlusal forces" (Hylander 1977:135; capitals in original). Furthermore, many of the characteristic Inuit cranial features, in particular the reduced nasal bones and enlarged nasal processes of the maxilla, as well as the large vertical facial dimensions, are related to anterior biting. The enlarged nasal process of the maxilla are able to withstand the compressive forces that occur in anterior biting, while the large vertical facial dimensions counter the bending movements involved in anterior biting. This is of interest as anterior teeth are more likely to be involved in tool use functions (Ryan 1980, 1981, 1989), and the effectiveness of the anterior teeth as tools is in large measure dependent on the amount of force that can be applied to them (Merbs 1968). It would follow, in the case of the Inuit, that the anterior teeth would be highly effective as tools.

The increased facial flatness, a product of the anterior placement of the zygomaxillary complex as well as an accompanying forward shift in the positioning of the temporalis and masseter muscles produces a more mechanically efficient masticatory apparatus, better able to generate vertical occlusal forces. Closely associated with this are the enlarged masticatory muscles. Both factors allow the Inuit to produce extremely high bite forces. Experimental work in the early twentieth century using gnathodynameters has shown that Inuit peoples are capable of attaining bite forces that are as much as three times that of their modern European counterparts. Inuit males aged fourteen and over generated an average bite force of 287 pounds, females an average of about 267 pounds. In comparison, American university football players could only produce an average of 126 pounds (Waugh 1937, as cited in Hylander 1977:140-141; and as cited in Klatskey 1939:78). The Inuit craniofacial structure is often under a great deal of stress, and has adapted accordingly to deal with this (Hylander 1972, 1977).

Also found in many Inuit crania are shallow glenoid fossae (Hinton 1981b; Pedersen 1949), although Hinton found there to be an increasing depth in the fossa with an individual's increasing age. Shallow glenoid fossae have been linked to anterior occlusal loading (Molnar 1968; Molnar and Ward 1977).

The Dental Evidence

The dental evidence marshalled by Hylander to support his hypothesis concerning the generation of high occlusal forces is threefold: the presence of root resorption; the antemortem trauma present on the tooth crowns; and, to a lesser extent, the presence of mandibular and maxillary tori. Although there is evidence to suggest the tori arise as a result of high forces, there is also evidence of a strong genetic component (Hylander 1972,1977).

Pedersen had earlier commented on the root resorption evident in many Inuit living in Eastern Greenland (Pedersen 1947, 1949; Pedersen and Jakobsen 1989), as well as in the skeletal remains from Greenland as a whole. He reported that in the case of the incisors, root resorption could occur as early as adolescence, a process he felt was the result of the strenuous functions to which the teeth were put. Root resorption was so commonly found that Pedersen considered it almost normal (1949). Later Hansen et al. (1991) would observe the shortening of the incisor roots in the Greenland mummies from Qilakitsoq. Hylander (1972, 1977) cited dental studies to show that this shortening of the roots was most likely the result of localized stresses on the dentition in this area, although other factors could apply. Neither Hylander (1972, 1977) nor Pedersen (1949) found much evidence of resorption in the molar teeth, and in the non-molar teeth, the great majority of root resorption occurred in the incisors. Cederquist and Dahlberg (1977), also report the occurrence of root resorption, most notably in the maxillary incisors and in older as compared to younger groups.

Antemortem trauma has also been regularly observed on Inuit dentitions. Leigh (1925a) attributed 9.7% of the periapical abscessing in his study population (a collection of 324 Inuit crania collected from groups across the arctic region) to tooth-fracturing. Pedersen (1938, 1947) and Pedersen and Jakobsen (1989) found that small fracturings of enamel and larger fracturings of teeth were very common in Inuit living traditional lifestyles as well as in archaeological Inuit populations. Van Reppen (1918:221) cites the report of a Dr. Richard Lasch who had observed an Inuit woman filing smooth teeth that had been roughened by the fracturing of parts of the crown due to the use she had made of her teeth. Lasch noted that all Inuit made extensive demands on their teeth. Turner and Cadien (1969) reported a greater frequency of antemortem trauma in Inuit populations as compared to any other North American native population. Fracturing most commonly occurs in the posterior dentition (Merbs 1968) although Hansen et al. (1991) report the breaking off of a whole upper incisor crown. They (Hansen et al. 1991) also took note of small and large enamel chips on both deciduous and permanent dentition. These were again attributed to the chewing of hard food items and the use of the teeth as tools. Such a use of the teeth also created cracks in the tooth enamel, most often seen running down the crowns of the anterior dentition (Hansen et al. 1991).

It would seem obvious that any group which placed such high demands on its dentition would also exhibit teeth that were extremely worn. However, the evidence for wear in Inuit populations is contradictory. Hylander (1972, 1977) claims that a high rate and degree of wear is not necessarily a marker for a heavy use of the dentition. The Inuit he studied had a low rate of wear as compared to that found in some Native American populations. Laughlin et al. (1968) also noted a slower rate of wear, also as compared to agricultural groups, in a sample of Punuk Eskimos, at least in the early years of life. Hylander reiterates that the primary cause of a high rate of wear is a great deal of introduced abrasion. An Inuit meat-based diet did not, in his opinion, involve the intake of much grit. Davies and Pedersen (1955) agree with this, feeling that a vegetal diet would introduce more abrasion than would one of fat and meat. They add that dried fish and meat may add some abrasives, but that the "food of the Greenlanders is rarely contaminated by sand" (Davies and Pedersen 1955:41).

In his sample of 324 Inuit crania, Leigh (1925a) found only 107 to have wear more advanced than some dentin exposure and cusp obliteration. Leigh felt much of this wear was due to abrasion or tool use of the teeth. In comparison he found a greater degree and rate of wear in corn eating native Americans, due in this case to attrition (Leigh 1925b). He did note that female dentitions were more worn in Inuit populations, a result, he felt, of their use of teeth in skin preparation. He also found that although the production of secondary dentin generally protected the teeth, 26 individuals had undergone pulpal exposure on one or more teeth.

By contrast, many other researchers have commented upon the extreme tooth tissue loss demonstrated in Inuit populations (Birket-Smith 1940; de Coccola and King 1986; de Poncins 1941; Hrdlicka 1933; Parry 1840; Pedersen 1938; van Reppen 1981). Hanson et al. cite an early observation from Freuchen:

> ... due to many years of hard use, both in preparing skins and hunting implements as well as for chewing the often tough and gravelly food, the teeth were gradually worn all the way down to the gingiva so they can no longer chew their food but must swallow it whole instead, after which they have digestive problems, stomach pains, and die [Freuchen 1915 as cited in Hansen et al. 1991:82-83].

In addition, there is some disagreement as to the amount of abrasives actually contained in the Inuit diet.

Pedersen (1938) reported wear so severe on a sample of teeth he was studying that he could record non-metric traits only in the most superficial manner. In 1947 and again in 1949 Pedersen reported the presence of extensive wear in adult populations. In some cases the teeth were worn down to the gums. Tooth tissue loss in the Greenland mummies from Qilakitsoq was equally severe (Hansen et al. 1991). Pedersen attributed this tooth tissue loss to "the chewing of tough food, bruxism, and [..] the use of the teeth as implements" (Pedersen and Jakobsen 1989:123). In the first detailed analysis of dental attrition in Inuit populations, Davies and Pedersen (1955:39) found that the deciduous tooth wear "decreased with increased urbanization." Extending the comparison to first molars, the same relationship applied. Davies and Pedersen (1955) attribute the extreme wear found in traditional groups not to the food consumed but to the tremendous forces the Inuit are capable of generating in the strenuous and prolonged chewing of this food. Waugh (1937) reported that in those Inuit following a traditional lifestyle, the teeth were noticeably flattened by twelve to sixteen years of age. In contrast to Davies and Pedersen (1955) he attributed this to the mastication of meat and fish that had been contaminated by grit when lain on the ground prior to drying. Goldstein (1932) also felt that sand and grit were commonly mixed in with ingested food. Sundewall (as cited in Furst and Hansen 1915:44) considered the extensive tooth wear among Inuit he observed as being largely the result of the meat based diet, a claim Hylander (1972, 1977), as noted above, would later contradict. Dahlberg (1980) has commented that the chewing of a meat based diet results in a rounded wear on the teeth as opposed to the sharp edges found in populations subsisting on an abrasive diet. He also notes that excessive tooth wear was a problem in traditional Inuit lifestyles. Turner and Cadien (1969) have associated the presence of antemortem trauma on teeth as being due to a diet consisting primarily of meat.

Calcagno and Gibson (1991) separate the effects of a tough and an abrasive diet on selection for tooth size. A tough diet would select for a larger masticatory apparatus while an abrasive diet would require larger teeth. This supports Hylander's (1972) work in which he discovered that the Eskimo populations he examined had a relatively small dentition as compared to their chewing apparatus, a phenomenon he attributed to a less abrasive diet. Conversely, Turner (1967) and Turner and Cadien (1969) report that Inuit, in which the Sadlermiut were included, had larger, more complexly cusped teeth in comparison with other Mongoloid groups, something they felt was selected for by the use to which Eskimos put their teeth. This included incisor complexity in the form of shoveling and multicuspid premolars. Shovel shaped incisors are thought to be an adaptation to counter high occlusal forces on the teeth as the larger surface area lends the teeth more resistance to chipping and fracturing (Hylander 1977, Mayhall 1977) and are extremely prevalent in Inuit populations (Pedersen 1952). Turner also found the Inuit to have large teeth in general. However, Pedersen (1949) discovered that while the Inuit he studied had larger molar crowns than other populations, the premolars, canines and incisors were about the same size as those found in Caucasian groups. As a result, these teeth were smaller in proportion to molars among the Inuit, a perplexing finding in light of the extensive demands placed on this dental area by these people.

Mayhall (1972, 1977) studied the effects of a shift from a more traditional lifestyle to a wage oriented economy on the dentition on the Inuit residing in the settlements of Hall Beach and Igloolik. He found that older individuals of both sexes who had been living a traditional life had approximately the same crown height, but that the anterior teeth of the men were relatively unworn. The females demonstrated heavily worn anterior teeth and premolars. Mayhall further compared the dentitions of the living Inuit to skeletal material from two Thule sites. Examining antemortem loss of teeth, he theorized that patterns of loss reflected patterns of paramasticatory activity. In this regard Thule culture males had lost more incisors, in particular mandibular first incisors, than the recent group, but the recent group had experienced a greater antemortem loss of mandibular third molars. This was possibly the result of a much higher occurrence of cavities in the recent group. Thule females not only lost more anterior teeth, but also more premolars than the recent group. Again this loss was most striking in the mandibular dentition, in particular the mandibular incisors, canines and first premolar, although there was also a significant difference of loss in the upper central incisors. As well, Thule females had lost more posterior teeth than had the Thule males.

Mayhall attributed this differential loss to the gender specific tasks to which Inuit put their teeth. 'Male' tasks, involving the use of the teeth to grip objects, resulted in sudden sharp tooth trauma, and more dramatic losses. 'Female' tasks exerted a low level, but more constant degree of trauma. The female practice of drawing the skins over the lower teeth to soften them resulted in extreme wear on the anterior dentition, in particular the lowers. Such extreme wear would result finally in tooth loss (Mayhall 1977). Costa (1980) also found a sex-linked difference in antemortem loss of anterior teeth in an investigation of prehistoric Inuit samples from Point Hope and Kodiak Island. He tentatively related this to a sex-role paramasticatory function.

A more direct relationship between the wear pattern found on the teeth and a particular task occurs with the presence of 'sinew' grooves both in skeletal Inuit populations, and in those Inuit living traditional lifestyles (Hansen et al. 1991; Pedersen and Jakobsen 1989; Pedersen 1949). These grooves run in a mesio-distal direction across the anterior teeth, usually the incisors, but should these be lost, on the canines and premolars as well. They are attributed to the female practice of softening sinews for thread by pulling them across anterior tooth surfaces.

Ryan (1980, 1981, 1989) used a scanning electron microscope at a low level of magnification (45X) to examine the incisors and the canine-premolar complexes of a range of populations and species in an attempt to better relate patterns of microwear to specific actions. He chose a skeletal Inuit population from Point Alaska to represent a population that used its anterior dentition for a variety of paramasticatory activities. Comparisons with Amerindians from the Libben site, Ottowa County, Ohio, and modern American samples revealed differences between the Inuit wear and the other groups. Ryan attributed these differences to Inuit paramasticatory activities. He also compared human microwear patterns with those found in nonhuman primates to differentiate wear patterns resulting from the initial ingestion of food.

Certain microwear features showed up in all populations. Among these were: interproximal microflaking, a phenomenon Ryan attributed to the action of introduced grit trapped between teeth during a crushing activity; fine wear striae, mostly due to the drawing of fine abrasives across the occlusal surface; and small pitting, the postulated result of the crushing of gritty food or nondietary materials. In addition to these features, the Inuit population was characterized by the appearance of gouges, wide linear depressions that cut across enamel and dentin surfaces. Gouges were not found in any of the human or nonhuman primate groups to which the Inuit were compared (Ryan 1980, 1981, 1989).

Gouges were observed on both incisors and canines. Their appearance, as interpreted by Ryan, corresponded with the Inuit habit of clamping abrasive materials between their anterior teeth, and then pulling the material forward across the occlusal surfaces. In short the characteristic Inuit "power-grasping pulling activities", such as the pulling off of waterlogged boots, or tightening or pulling harness lines. Isolated gouges were hypothesized to represent points in which specific pulling activities originated (Ryan 1980:181; 1989). Fine wear striae, often found in conjunction with the gouges were thought to be created during the same actions, with the extreme size difference being attributed to varying grit diameters. This is debatable, as Maas

(1991) has demonstrated that striae size may be related more to enamel microstructure than grit diameter.

Evidence for the presence of high vertical forces acting on the teeth came in the form of two microwear features. On the edges of the teeth or between the dentoenamel interfaces, the high vertical occlusal forces resulted in microflaking, as the enamel or dentin came into strong contact with a hard nondietary substance or some grit contaminated item. In the central portions of the occlusal surface, these same forces resulted in the large isolated pits (.18 mm in maximum diameter).

About half of the anterior teeth displayed labial rounding. This feature has been observed by many researchers and has largely been attributed to the drawing of skins across the tooth surfaces or to the use of the anterior teeth for holding, clamping and pulling (Hansen et. al. 1991; Pedersen 1952; Pedersen and Jakobsen 1989). Brace (1967 as cited in Wallace 1975:393), and not without debate (Wallace 1975), considered the existence of labially rounded teeth to be evidence for the use of these teeth in a variety of cutting, tearing holding and shaping functions. According to Ryan, the labial rounding results from the microflaking of the labial tooth edge. The chipped surface is subsequently smoothed by drawing gritty materials across it. At this time the fine striae and gouges would be produced (Ryan 1980, 1989).

On the basis of the microwear, Ryan placed the canines and incisors in a functional unit, serving not only to shear and crush foods, but also to operate together in a variety of paramasticatory activities. The premolar microwear pattern differed from the anterior teeth, showing only pitting, evidence Ryan felt pointed to more of a masticatory activity (Ryan 1980, 1989). Although Ryan did concede that the precise mechanisms for the production of the patterns on the anterior dentition could not be known with certainty, he made a strong case for their being the result of paramasticatory uses.

Also utilizing a scanning electron microscope, Pedersen and Jakobsen (1989) and Hansen et al. (1991) observed the presence of fine parallel striations on the exposed dentin of a lower left molar, as well as furrows along a grooved right lower canine from a collection of Greenland Inuit skeletal material. They felt that these patterns might relate to task activities, but cited a need for further research.

INUIT TOOTH DEMANDS: THE ETHNOGRAPHIC EVIDENCE

Diet

Many of the ethnographic references for the demands the Inuit placed on their teeth concern dietary habits. Climatic constraints dictate that very little food of a vegetable nature was consumed. The staple of Inuit diet was meat, fish and blubber, which were often eaten raw, dried or frozen, sometimes slightly fermented and, when possible, in great quantities (Birket-Smith 1940; de Coccola and King; de Poncins 1941; Giffen 1930; Nansen 1894; Turner 1979; Tyrrell 1973).

In the short arctic summers, meat was preserved by drying on stones, in cairns or on drying racks; in winter, preservation was simple freezing. In times of famine, virtually anything was eaten, even tent skins and "it [was] not uncommon to hear of someone who [had] made soups of his trousers" (Mathiassen 1927a; Nansen 1894:94; Tyrrell 1973; Marsh 1987).

Caribou, walrus, seal and fish were most relied upon. "Liver, brains and blood are great favorites" (Birket-Smith 1940:13). When circumstances permitted, meat was boiled with blood and blubber in soapstone containers as a soup (Boas 1888; Parry 1840). Occasionally, in the summers, it might be roasted. However, more than one ethnographer has commented that if there was insufficient fuel, the meat would be eaten frozen or raw, bones and all, creating, one would suspect, heavy demands on the teeth and jaws (de Poncins 1941; Hylander 1972; Parry 1840; Waugh 1937). Waugh (1937) noted that children eating soft diets high in carbohydrates did not develop the rugged jaw dimensions of their parents (see also y-Edynak 1978). McEuen (1938:376-377) reports that at times the temperature of the water the meat was boiled in remained "so low that one's finger [might] comfortably by placed in it, and moreover, no odor of the food cooked comes off the pot." Boiling then, was no surety of tenderness. Similarly demanding, in a less dramatic way, was the consumption of whale, walrus or halibut skin, both of which, by reason of their toughness, go a long way (Nansen 1894:93; Tyrrell 1973). The grit found in the skins would add to tooth tissue loss. The practice of drying meat also toughens it, and may introduce grit.

Additionally, the temperature of the frozen food as well as its hardnesses may contribute to chipping on the teeth. Frozen food weakens the tooth enamel by inducing "thermal fatigue". This produces tiny cracks in the enamel surface, increasing, in this case, the possibility of fracture (Journal of Dentistry for Children 1971). There is conflicting information as to possible chemical effects of the Inuit diet. Foley and Cruwys (1986) attribute the consumption of the flourine-rich raw sea mammal meat for teeth with few enamel defects and "a high level of dental health" (Foley and Cruwys 1986:5). However, Pedersen and Davies (1955) attribute this same flourine-rich diet as being another factor responsible for their susceptibility to wear.

Although Hylander contends that Inuit diet was extremely efficient and that little needed to be eaten to provide energy for a day's work, eating was also a social event, and was done as often, and in as great a quantity, as possible (Boas 1888, 1901). As well, as in many other hunter-gatherer groups, people had the ability to go without food for long periods of time, and then to gorge when food was plentiful (de Poncins 1941; Freuchen 1961; Nansen 1894; Tyrrell 1973).

Marsh (1987:60) mentions that "[everyone] often eats frozen, raw meat and as many as thirteen or fourteen times a day. The meals aren't big but are snacks that provide the internal heat necessary for life."

The often described Inuit method of eating, stuff-and-cut, could also contribute to wear, especially on the anterior dentition (Brace 1962, 1975; de Poncins 1941; Merbs 1983). In this activity, meat is gripped between the incisors, and a bite sized piece is cut off with a knife. This has led Merbs (1983:147) to comment that "the anterior teeth of Inuit perform more as a grasping than cutting implement, even during eating." Brace (1975) feels that prior to the use of metal knives, such a method of eating would create strain on the teeth, and possibly a greater degree of wear.

Tooth Use and the Sexual Division of Labour

Inuit use of teeth as tools or to aid tools has long been of ethnographic interest. As a tool, the anterior teeth in particular acted like a pair of pliers or as a vise, crushing objects placed between them. The anterior teeth were often used in power grasping and holding as a catch-all third hand, freeing other hands for additional tasks as would be the case when one gripped a fish between the teeth while continuing to pursue others, or used the teeth to hold one edge of a skin while the hands were stripping the blubber from it (de Poncins 1941; Lous 1970).

The strength exerted in such tasks varied. Some, such as clutching a seal laden tow line behind a kayak and gripping a bow-drill between the teeth could exert forces that would pull the teeth from European mouths (de Poncins 1941, 1949; Merbs 1983; Nansen 1894). The teeth were used from everything from prying the lid from a gasoline drum (de Poncins 1941) to bending kayak ribs into shape (Mayhall 1977; Merbs 1983) to untying knots, stretching skins and shaping boot soles (van Reppen 1918). Women used their teeth extensively to ready skins for making clothes (Hansen et al. 1991; Maxwell 1985; Nansen 1894). Teeth were also used as a cutting implement, breaking lighter threads and cords (Giffen 1930). Although both women and men used their anterior teeth as tools, it appears as though men performed a greater variety of "power grasping" tasks than did women.

Traditional Inuit peoples had a strong division of labour which included the tasks to which the teeth were put (Freuchen 1961; Giffen 1930; Merbs 1968, 1983; Nansen 1984; Turner 1979). Broadly stated, men's work centred around hunting while women tended to the household, and most importantly, made and mended the clothing (Giffen 1930). Although women and men would sometimes perform the tasks traditionally performed by the other sex, this was generally only done in times of emergency (Marsh 1987); "under ordinary circumstances there are well-defined patterns into which the activities of the two sexes fall" (Giffen 1930:82). These roles complimented each other. The men provided much of the food, but had need of the women to prepare the skins and make their clothing, without which they could not survive. A woman or man who lost their spouse was in an unenviable, not to say life-threatening position (de Coccola and King 1986; Freuchen 1961; Hansen 1991; Nansen 1894; Turner 1979). However, beyond this basic division, and except for the skills of the angakot, the medical or religious leaders, tasks were not specialized. Thus all men performed all male activities, and all women, female activities (Inuktitut 1986; Merbs 1983).

The roles suitable for women and men were learned early (Giffen 1930; Maxwell 1985; Nansen 1894). From the ages of five to nine, boys were given toy hunting equipment and girls began to help their mothers in the preparation of the skins. By ages nine to twelve, training began in earnest, boys began to help with the hunt, and girls perfected their skills (Kaslah 1986).

<u>Female Tooth Use Tasks</u>.

> We have noted in other connections the use of the mouth and teeth of the housewife in the performance of their daily tasks, namely in the dressing of skins, the softening of boot soles, tearing of sinew thread, the extraction of blubber for burning the lamp and other uses, the cleaning of utensils and the chewing of food for puppies and for children and the washing of children.
>
> Though the men sometimes employ their teeth in working with hard materials, in softening their lines, untangling traces, holding the line by which the seal is towed behind the kayak, and crushing the heads of birds caught, they do not ordinarily chew skins. The fact that older women are often mentioned as having badly worn teeth, and that women were formerly chosen in marriage for their long and strong teeth leads us to conclude that the use of the mouth as a third hand may justly be associated with women's activities [Giffen 1930:80].

Many ethnographers and physical anthropologists have observed that the Inuit women's masticatory musculature was more developed and tooth wear more pronounced than that of the men (Leigh 1925a; Waugh 1937). As early as 1875 Emil Bessels, noting the difficulty in sexing Eskimo crania suggested sex determination on the basis of the worn front teeth "as only the women prepare the skins for clothes, shoes, reins etc." (as cited in Furst and Hansen 1915:451, see also Grant 1922, Jorgensen 1953, Pedersen 1952). Women's tasks were less traumatic, but more repetitive in nature. Female activities involving tooth use revolved primarily around the preparation and maintenance of skins, most notably the maintenance and preparation of clothing (Grant 1922; Giffen 1930; Hansen et al. 1991; Leigh 1925a). Well made clothing was essential to surviving in the freezing arctic temperatures. Evidence of clothing manufacture and the treatment of skins in the form of skin scrapers and ivory and bone needles as well as fragments of cut and sinew-stitched skins has been found in Dorset and Thule sites and it is likely that hide working and clothes manufacture has always been "a source of Inuit pride" (Hansen et al. 1991; Maxwell 1985; Taylor 1959b). The clothing of the Qilakitsoq mummies dating from the late fifteenth century was little different from that worn up into the twentieth century. This further demonstrates that the Inuit had early "developed a dress form that met the demands of insulation and freedom of movement" (Hansen et al. 1991:117). Softened skins were also needed for the tents, sleeping skins and kayak covers (Giffen 1930, Hansen et al. 1991).

In the arctic, more conventional tanning processes such as the use of smoke was not feasible, nor is there any evidence for the use of animal brain to tan skins. For a skin to be used in the manufacture of clothing, all the underlying connective tissue and fat had to be scraped from it, and the grain of the skin broken to render it flexible (Hansen et al. 1991; Marsh 1987; Maxwell 1985). Scraping of the hides involved gripping the skin between the incisors, stretching it across the left hand, and scraping downwards with the right. Teeth were also used for stretching skins and even the actual scraping (Hansen et al. 1991; Lous 1970; Nansen 1894; Pedersen and Jakobsen 1989). Hide preparation was an arduous task demanding both skill and experience (Hansen et al. 1991; Maxwell 1985; Stone 1990) and as noted there are indications that this procedure was used at least as early as the fifteenth century (Hansen et al.1991). Fat and other tissue may also be removed by the teeth, either by grasping the fat and pulling, or in the case of birdskins, by chewing the skins whole and ingesting the fat (Birket-Smith 1928; Freuchen 1961; Nansen 1894; Turner 1979). The hides of walrus and seal, both stiff and hard as wood when dried, must be softened by chewing, as must caribou skins (de Poncins 1941, 1949; Lous 1970; Inuktitut 1986; Marsh 1987; Nansen 1894; Stone 1990). Parry (1840:172) attributed the greatly worn teeth of elderly women as a result of "the habit of chewing the sealskins for making boots." Much note has been taken of the chewing of the sealskin boots by the Inuit women as these boots dried to the consistency of iron after they had been wet (Maxwell 1985; Stone 1990; Tyrrell 1973). Skins had to be softened each time the skin dried, a task described as never ending (Briggs 1970; de Poncins 1941; Fruechèn 1961; Hylander 1977; Marsh 1987; Tyrrell 1973).

Disagreement exists as to which teeth were being used in this softening process, as unfortunately, most writers simply describe this processes as 'chewing' without specifying which teeth were actually employed (Briggs 1970; Marsh 1987). Lous (1970) states that the hides were made pliable by incisal mastication. Pedersen and Jakobsen (1989:123) and Hansen et al. (1991:83) describe the softening of seal and other skins as being done by "rubbing' the skins over the lower incisors with the mouth partially closed. This creates both wear and rounding of the anterior dentition. Incisal chewing was also performed on the edges of skins before sewing and teeth were used to mark the seam of the inside of the skin (Marsh 1987). Pedersen (1952) has also described the process of hide chewing as involving the pulling the hides forward and downward between the anterior teeth, resulting in an open bite and labial rounding. Alternatively, Merbs (1983) inferred the chewing of skins involved teeth on the side of the jaw rather than those in front.

Tendinous thread used for sewing hides was softened by alternately pulling the thread across the clenched abraded edges of the incisors and then rolling it against the cheek (Birket-Smith 1928; Lous 1970; Pedersen 1952). Rolling the thread against the cheek served to moisten and soften the sinew (Pedersen and Jakobsen 1989). The whole process resulted in the formation of grooves running mesio-distally along the anterior dentition. Loss of the incisors resulted in the use of the canines and premolars for this purpose (Hansen 1991). de Poncins (1941) describes a women making thread from caribou sinew, drawing out the nerves, and twisting the sinew with her teeth. Marsh (1987) describes the softening of the sinew as it being simply drawn through the mouth.

Although men use their teeth more often as a vise or grip, such a use is not unknown among the women. When their hands failed, the women could remove wet sealskin boots with a tug of their teeth (de Poncins 1941). Women also held sewing implements in their teeth (Mayhall 1977).

Male Tooth Use Tasks. While women's use of their teeth frequently extended along the tooth row, men's use of their dentition for paramasticatory activities often concentrated pressure on a smaller number of teeth and a more localized area of the tooth row. Most male activities tended to involve the clenching of lines or other objects of small diameter (Merbs 1968). Men used their teeth mainly as a vise or grip, although some chewing was doubtlessly done, as when chewing a sealskin strap to soften it (de Poncins 1941). Perhaps the most dramatic of male tasks involving dentition is the use of the bow drill. Here the drill is guided by means of a mouth piece held between the incisors (Birket-Smith 1928; Lous 1970; Marsh 1987). The vibrations set up in this activity are considerable, placing extensive stress on the teeth, masticatory muscles and temporomandibular joint. Any slippage could result in labial abrasions on the anterior teeth as the displaced mouth piece scrapes across the labial surfaces of the anterior teeth (Lukacs and Pastor 1988). Equally demanding tasks to which the teeth may be put include the bending of kayak ribs, or the towing of a seal behind a kayak, with the tow line gripped between the anterior teeth (de Poncins 1941, 1949; Mayhall 1977; Nansen 1894). The teeth are also used to pull seals from the water (Mayhall 1977) and to hold the throwing board of the harpoon (Birket-Smith 1928). Tyrrell (1973) relates a case in which a man was so successful in sneaking up on sleeping seals that he could use his teeth to catch them.

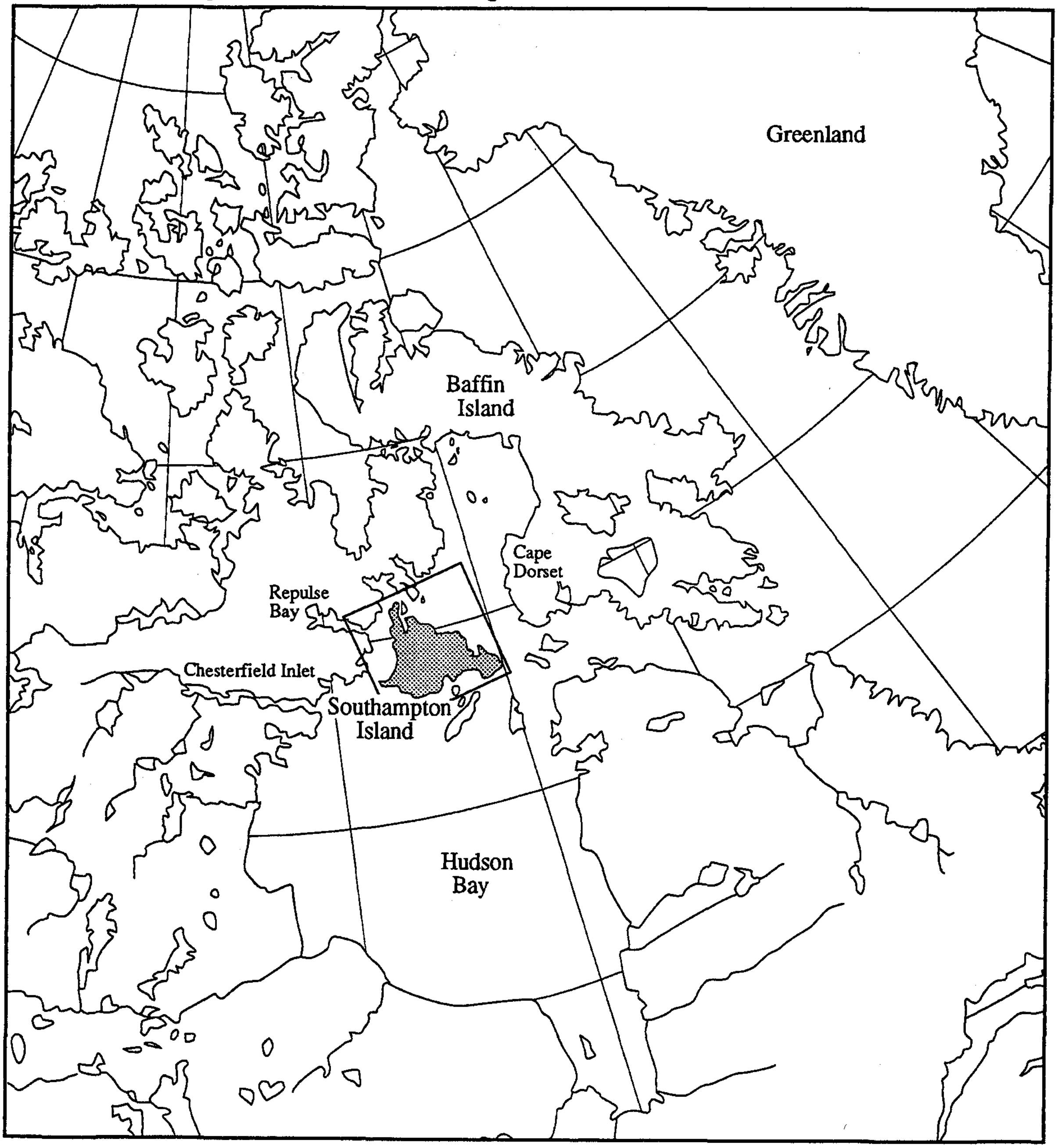
This vise-grip use of the teeth is more likely to result in a loss of teeth rather than their wearing away. In most gripping activities force is directed along the long axis of the tooth, which in itself would not tend to result in tooth loss. However, many male activities involve sudden labial or lingual directions of force producing intense stress on small areas of thin alveolar bone and resulting in localized tooth loss. For example, when men are untangling dog hardnesses and in the process hold the lines in their teeth, a sudden movement by the dogs could result in the loss of an incisor (Merbs 1983).

Pedersen (1947 and see Davies and Pedersen 1955) points out that male tooth wear may also be extreme and that the old men who did not chew the skins had teeth as worn as the women. Pedersen later modified this view somewhat noting that although "Eskimo men also had extreme dental attrition (e.g. Steenby 1910), the women ranked first in the use and abuse of their teeth" (Pedersen and Jakobsen 1989:123). However, Tomenchuk and Mayhall (1979) reported that contemporary male molars were worn to a greater degree than female molars, a finding they attributed to bruxism. Turner and Cadien (1969) also found greater wear in male rather than female teeth. Davies and Pedersen (1955:41) cited bruxism as a factor in the heavy wear observed in the teeth of traditional Inuit, claiming that the men would often firmly clench and probably grind their teeth "when performing heavy physical exercise such as kayak paddling". However, they admitted that the extent to which bruxism occurred in Inuit populations was not known, weakening the explanatory power of this phenomenon.

Summary

From the above evidence, both biological and ethnographic, it would seem clear that an investigation both of tooth use in paramasticatory functions and of gender differences in such use is appropriate in an Inuit population. The sample studied in this thesis is drawn from the Sadlermiut collection currently housed by the Canadian Museum of Civilization in Ottawa-Hull, Ontario-Quebec, Canada. The Sadlermiut were an Inuit group who inhabited Southampton Island, located in the northwestern corner of Hudson Bay. Generally lumped in the Central Inuit cultural groups, the Sadlermiut also had affinities with eastern Inuit groups, as well as having their own distinctive ethnic anomalies. The materials themselves are from the site of Tunirmiut at Native Point (see Figures 2, page 49, and 3, page 57).

Figure 2: Southampton Island and Surroundings



After Wissler (1918)

THE SADLERMIUT

Introduction

European introduced diseases created havoc in all known North American indigenous populations. In the case of the Sadlermiut, their impact was devastating. An epidemic of what is now thought to be enteric fever in the winter of 1902-03 left only five survivors, four of whom were children. This loss, coupled with the considerable lack of contact between the Sadlermiut and any other group, has left us with little direct knowledge about their customs. Sadlermiut way of life has been pieced together from the rare accounts of meetings with Europeans sailing the surrounding waters, recollections of members of neighboring Inuit groups, most notably the Aivilik (Aivilingmiut) Inuit who lived with or visited the Sadlermiut for a time, and later archaeological investigations.

Sadlermiut culture is enigmatic. Historically, ethnographically and archaeologically, the Sadlermiut appear to have been a people apart. There was little contact with, and possibly avoidance of, other Inuit groups as well as the incoming Europeans (Clark 1980,1981; Mathiassen 1927a; Maxwell 1985; Ross 1977; Taylor 1959a). As a consequence the Sadlermiut developed or retained certain unique cultural characteristics. These include differences in dialect, the retention of the Thule sod-and-stone winter house, a dwelling which had largely fallen out of use on the Central Arctic mainland, limestone lamps and cooking pots, as well as a distinctive dress and personal appearance. Perhaps their most definitive trait was their reliance on chipped stone tools instead of the ground-slate predominantly used by most other Thule peoples (Clark 1980; Merbs 1983; Taylor 1959a). Chipped stone tools in Thule culture sites are not unknown, but they are few in number and not particularly diagnostic (Clark 1980). Rather, chipped stone tools are Palaeo-Eskimo (Independence, Pre-Dorset, Dorset) cultural markers and their presence, as well as the other anomalies, led to early speculation that the Sadlermiut were a remnant Dorset population (Bielawski 1979; Clark 1980; Collins 1956b, 1956c; Oschinsky 1964; Taylor 1959b).

Biological Relatedness

Three possibilities as to the biological relatedness of the Sadlermiut to other groups have been examined. Mathiassen (1927, Freuchen 1961) thought that the Sadlermiut were a remnant Thule group. As already mentioned, Collins (1956b, 1956c) speculated they were a remnant Dorset group that had been influenced by Thule traits. Others have suggested that the Sadlermiut were simply a group of modern Inuit whose isolation had resulted in certain unique practices (Mayhall 1979).

Biological evidence suggests a Thule ancestry. Utermohle and Merbs (1979) employed Penrose's shape component on seven standard craniometric measurements on a sample of a minimum of ten adult individuals from Birnirk, Kamarvik, Sadlermiut, Silumiut, Old Labrador, North Eastern Greenland Inugsuk, Naujan, New Labrador, and Mackenzie Eskimos. They grouped the Sadlermiut most closely with the North Eastern Greenland populations. Both of these populations merged with the rest of Eastern Canada and Greenland materials. Utermohle and Merbs interpret this as possibly supporting Mathiassen's claim that "Southampton Island represent[s] a refugium of Thule culture individuals" (Utermohle and Merbs 1979: 443). A study by Jorgensen (1953) also grouped skeletal material from Southampton Island with skeletal material from Naujan and northeast Greenland.

Mayhall (1979), in an investigation of a possible population replacement of the Thule peoples by the extant Inuit of the northwest Hudson Bay area, analyzed the dentition of the (living) Iglulingmiut of the Foxe Basin, and the skeletal Thule culture and Sadlermiut remains. Of the measurements and morphological traits used, the only one that showed any difference between the Thule, Sadlermiut and recent Inuit groups was a higher frequency of Carabelli's trait in the recent Inuit. Attributing this to a Caucasian admixture, Mayhall concluded that "the Thule culture people, the Sadlermiut, and the Iglulingmiut [were] biologically similar" (Mayhall 1979:469). The Sadlermiut, and the modern Inuit shared a Thule ancestry (Maxwell 1985; Mayhall 1977).

It should be noted here, and indeed Utermohle and Merbs caution us, that this research is being done without an adequate comparative Dorset sample. If the Dorset are from the same 'subracial' group, differences between the populations will be extremely subtle, and difficult to detect. Based on the limited evidence available in 1964, Oschinsky found Dorset peoples to be morphologically Inuit (see also Taylor 1959b).

Sadlermiut house structures and most of their artifacts are closely related to the arctic Thule culture, indicating to most archaeologists that the Sadlermiut, along with all other modern Inuit, were of Thule ancestry (Bird 1953; Clark 1980; Mathiassen 1927a; Maxwell 1985; Mayhall 1979; McGhee 1978). Certainly they shared many activities with the Central Eskimo, hunting with harpoon, lance, and bow, raising dogs for traction, preparing skins by scraping and chewing, and the using of the kayak (Merbs 1983). Even with a Thule ancestry, however, cultural affiliations between the Sadlermiut and the Dorset seem to have existed, and it appears likely that a strong Dorset cultural influence operated, either directly or indirectly, on the Sadlermiut. The extent of any populations admixture remains debatable (Clark 1980; Collins 1956b, 1956c; Maxwell 1985; Mayhall 1979; Merbs 1983; Taylor 1960).

Historic Record

From the first European sighting of Southampton Island in 1613 to the demise of the Sadlermiut in 1902-03, contact between the Europeans and Sadlermiut was rare and fleeting. Parry, in 1821 and Back, in 1836-37 found evidence of the island's habitation but it was not until August 1824, some two hundred years after the 'discovery' of the island, that an actual contact between a European explorer and a Sadlermiut was recorded (Bird 1953; Lyons 1971; Manning 1943; Parry 1840; Ross 1977). Paddling out on three inflated seal skins to meet the landing party from the *HMS Gripper*, a young Sadlermiut man named Nee-a-kood-loo presented a roughly-chipped flint-headed arrow and a couple of dried salmon to Captain G.F. Lyons as a peace offering. Upon visiting the group of Sadlermiut on the shore of what is now known to be Coats Island, Lyons found them to be friendly, if shy. Although they showed no open surprise or curiosity towards either the sailors, or their guns, Lyons was of the opinion that they had never met Europeans before as they had no iron, and seemed extremely impoverished. Their sole European possessions consisted of a few needles made from iron nails and a small piece of deal, or ship's wood, which had likely washed up on their shore as drift. Differences between the Sadlermiut and other 'Esquimaux' noted by Lyons included their language, their chipped flint knives, the lack of any domestic toys, and their appearance, both in the dotted tattooing of the women and the hairstyle of the men in which the hair was plaited and rolled into a bun on the rise of the forehead. Their clothing resembled that of the Polar 'Esquimaux'.

Sadlermiut tents were small and ragged, and the people seemed to be subsisting on raw salmon, caught in a dam built across a nearby stream. In exchange for a quantity of this salmon, as well as some of the Sadlermiut implements, Lyons left butcher knives, boarding-pikes, beads and steel needles. He was impressed with their behavior, comparing it favourably with that of the other tribes with whom he had been in contact. He remarked that the Sadlermiut's lack of contact with Europeans made their good behavior "quite natural to them, and the fearless confidence which led Nee-a-kood-loo to put himself into [Lyon's] power, [was] the strongest proof of their ignorance of guile or treachery" (Lyons 1971:64).

This initial contact did not lead to a closer relationship between the Sadlermiut and the Europeans. Rather from 1865 when an American whaler came across natives at Manico Point to 1902 the Sadlermiut were seen only sporadically, and only in the south of the island. Manico Point seems to have been a major area of Sadlermiut settlement during this time. The sites in the Native and Prairie Point areas of South Bay were only discovered by the whalers as the Sadlermiut became extinct (Bird 1953; Manning 1942). When the Sadlermiut were visited by whalers their lack of iron and reliance on old stone implements were noted, however there was little attempt to incorporate the group into the European whaling economy (Ross 1977). This may have been a function both of the reticence of the Sadlermiut themselves and the fact that the whalers had already made firm relationships with other Inuit groups. The lack of contact between the Europeans and Sadlermiut may have been further augmented by the difficulties of access to the island; until the discovery of Coral Harbor at Native Point, no safe place of anchorage for boats drawing more than three or four feet was known (Bird 1953; Comer 1910; Manning 1942; Ross 1977).

Interestingly, for all of the reported Sadlermiut reluctance to make contact with other peoples, in all accounts of meetings the Sadlermiut were welcoming of the Europeans, which greatly impressed the latter. Peter Pitseolak (Pitseolak and Eber 1975) relates happiness among the Sadlermiut shortly before their deaths, a happiness his people felt was due to the new availability of "white man's things".

Robert Ferguson (1979), a whaler on the *Abbie Bradford*, writes of two contacts with the Sadlermiut, the first on September 8th, 1878, the second on June 28th 1879. Both meetings took place at the instigation of the Europeans who noticed the presence of too-picks (tents) along the west coast of Southampton Island. Curiosity impelled the first visit; the whalers had never seen any natives on the island. Upon landing, they found the people to be friendly, but incomprehensible.

By their actions and attitudes, Ferguson echoed Lyons in surmising that the natives had never seen Europeans before. The lack of any tobacco pipes further strengthened this impression. He was fascinated by their use of bone, ivory and horn to fashion artifacts that neighbouring groups made of iron and wood, materials the Sadlermiut lacked. Ivory tusks and sealskins surrounded their tents, which were carpeted with piles of bearskins. Surprisingly, the Sadlermiut Ferguson encountered did not seem to have kayaks.

Ferguson was much impressed by these people, noting that they appeared clean, healthy and good-natured. He found their clothing more attractive than that on the mainland surrounding Hudson Bay, closer fitting and smartly trimmed with white fox or polar bear fur. He remarks that "[their] needles were about as thick as a slate pencil, made of ivory, and with the hole for the eye bored with a piece of flint" (Ferguson 1979:43). He subsequently left the group with metal needles and thimbles, as well as beads, knives, and pocket mirrors.

George Comer (1910) spent 35 years as a whaler in the Cumberland Gulf and Hudson Bay, and ten winters on Southampton Island and the nearby mainland. His first encounter with the Sadlermiut (Saglernmiut) occurred in 1896 near Manico Point. Comer found their sod-and-stone houses of interest, as Eskimos on the mainland lived in snow houses in the winter, and in tents in summer. He had seen the ruins of stone and sod houses on the mainland but commented that "the natives of the mainland have no knowledge of the remote times in which they were occupied" (Comer 1910:87).

At this meeting the natives accompanying Comer acted apprehensively, and, although the Sadlermiut were not acting in a threatening manner, would not meet with the Sadlermiut until they had their firearms. Communication was difficult at first, although the women were much quicker to catch on than the men. Except for a man who may have been fifty years of age, there were no old people (as cited in Boas 1907:471-477). Comer was quite interested in the flint knapping ability of the Sadlermiut, something he recognized as being unique in the area (as cited in Boas 1907:476-477). Captain Murray of the *Active* would also be fascinated by this ability (Pitseolak and Eber 1975). A whaling harpoon, a lance, and some small items were traded for baleen. Later meetings in 1898 and 1899 resulted in little trade, but in exchanges of information and artifacts (Boas 1901, 1907; Comer 1910; Mathiassen 1927a).

With the establishment of an American whaling station between Manico Point and Cape Low in 1897 and a Scottish whaling station near Cape Low, relations between the Europeans and the Sadlermiut intensified. Even then however, the Sadlermiut remained both geographically and economically on the periphery of the station's operations. "They visited from time to time, sometimes joined in games of football with the station natives and occasionally bartered a few substandard fox and bear skins" (Ross 1977:4).

In the summer of 1902, the *Alert*, a Scottish steam whaler and supply ship arrived at the station at Cape Low. It carried with it an infectious disease, possibly gastric or enteric fever. Both the Aivilik Inuit who worked at the station and the Sadlermiut who were visiting fell ill. The incapacitated Sadlermiut were sailed back to the settlement of Tunirmiut at Native Point in the station's whaling boat.

When the site was visited in the winter of 1902-03, the inhabitants were dead, some in their houses on their sleeping platforms, others outside. Dogs ran freely, and there remained large stores of meat and blubber. Only five individuals survived, a woman and four children who were taken in by the Aivilingmiut (Ross 1977; Mathiassen 1927a; Merbs 1983).

Prior to 1902 there are some indications that the population was already under stress. The population size of 57 or 58 related to Comer in 1899 was down from a population of 78 that Comer had met in 1870 and the many house ruins on the island would seem to indicate a larger prehistoric occupation (Manning 1942; Mathiassen 1927a). This possible decline could be indicative of a group in a delicate relationship with its resource base, and into which the introduction of a comparatively large number of rifle-wielding hunters and trappers may have brought about crisis (Comer 1910; Ross 1977). Several years after the epidemic, Comer discovered a site on the west coast of the island in which the inhabitants appear to have died as the result of starvation. Thus, certain members of the Sadlermiut who camped in the western portion of the island and refrained from visiting the station during the summer of 1902 may have escaped infection, only to die of famine (Collins 1956b; Comer 1910; Ross 1977).

Mathiassen disputes the above claim. He states that there were large numbers of caribou on the island, adding that in any case, the Sadlermiut were not primarily dependent on the caribou and thus this animal's decimation would have little affected them. In turn, Mathiassen reports that one of his informants spoke of a war between the Sadlermiut and the Sikosuilarmiut (from Baffin Island) on Bell Peninsula which resulted in a large number of deaths. Yet as Mathiassen notes:

> ... we hardly need turn to war as an explanation of the decline of the Sadlermiut; such an isolated, fairly limited group of people will, in the course of time through constant intermarrying, be so undermined that it will inevitably suffer a rapid decline; and then when disease comes, the population will not have much power of resistance and will be quickly swept away [Mathiassen 1927a: 285].

Neighbouring tribes believed that the Sadlermiut fell victim to a curse laid upon them by a shaman, defeated by a Sadlermiut in a test of strength (Marsh 1976; Pitseolak and Eber 1975).

The Sadlermiut Oral History and 'Way-of-Life'

Archaeological evidence would indicate that the Sadlermiut have been on Southampton Island since at least 1200 A.D. (Clark 1980) although the unreliability of radiocarbon dates from the arctic (Maxwell 1985) leaves open the possibility of an earlier arrival. Sadlermiut occupation corresponds to the end of the Classic Thule cultural period, and the secondary climatic optimum, a period of warming that is thought to have allowed the whale-based Thule culture to expand rapidly through the Arctic region (McCartney 1977). The degree of contact with the earlier Dorset occupation is unknown. As already noted, some of the Sadlermiut characteristics suggest a strong Dorset influence, and one Sadlermiut legend of how they came to inhabit the island tells of a meeting with strangers:

> Once, long ago, there was a great famine among the Sikosuilarmiut in southern Baffin Land, and they all died except four, who went over the pack-ice on Fox Channel to Nuvualik, Bell Peninsula on Southampton Island, where they settled. Gradually, as their numbers grew, they spread over the island; during this advance they met at South Bay two Tunidjiut, big people, who had no bow but, by means of their throwing boards, threw the big arrows which they also used for caribou hunting. They killed one of these Tunidjiut whilst the other fled into the mountains and they never saw him again. These Tunidjiut lived in houses built of stone, but with skin roofs; they used to sleep with their feet straight up in the air. They hunted the walrus on thin ice by thrusting the harpoon through the animal's lips and dragging it up by the tusks, whereupon they broke its neck by bending the head back. They dragged the walruses up to the houses to flense them and one man could drag a whole walrus; they had no sledges or dogs [Mathiassen 1927a:283].

Legends of the Tunidjiut, or Tuniit (or Tunit or Tournit) are common among the Inuit (Mathiassen 1927b; McGhee 1981; and see Boas 1901, 1907 and Nansen 1894). In general the Tuniit were depicted as a gentle people, alternately described as dwarfs or giants, who the Inuit met as they journeyed from the western into the eastern Canadian arctic. They were extremely strong, had no dogs, and loved their wives dearly. Although relations between the Tuniit and Inuit were often initially friendly, they tended to degenerate into fighting, which eventually resulted in the extinction of the Tuniit (McGhee 1981). Tuniit are interpreted by anthropologists and archaeologists to be the Dorset, although the term has also been applied by modern Inuit to the Thule of 400-500 years ago (Mathiassen 1927; Maxwell 1985). There is a Dorset component at Native Point, the site from which the study sample in this thesis originates. The Early Dorset period at this site dates from 682-110 B. C., a Middle Dorset occupation is dated to 175 A.D., and there is an undated Late Dorset assemblage. The Late Dorset phase throughout the arctic is thought to have begun about 500 A.D. and remained a viable culture until around A.D. 1000-1100 (Collins 1965a,b; Maxwell 1985; Taylor 1960). The manner in which the Thule and Dorset interacted with each other as they met throughout the eastern Arctic is still unclear. Given the known occupation dates however, contact on Southampton island between the two groups was possible.

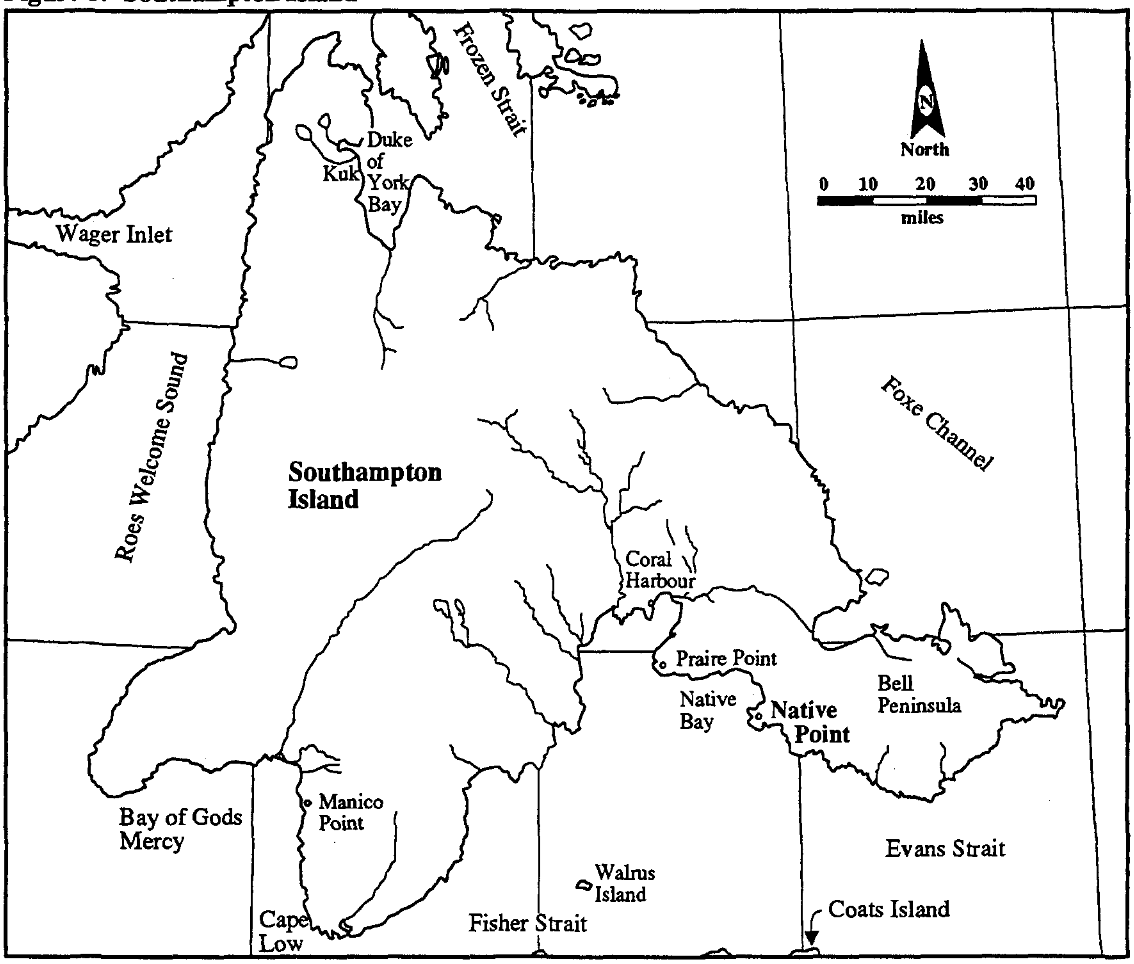
Neighbouring tribes considered the Sadlermiut to be 'Tuniit':

> An Aivilik Eskimo told [Mathiassen] that once his people lived in the interior of the country; they went out to the coast where they met the Tunit, big, strong people, who lived in permanent winter houses and hunted the whale and the walrus; their men wore bearskin trousers and their women long boots. When the Aiviliks settled down at the coast the Tunit left their settlements and went away to the north; only on Southampton Island did they remain; these were the Sadlermiut who died off in 1902 and whose most important settlement is still called Tunirmiut [Mathiassen 1927b:186].

The Sadlermiut deny that they are Tuniit (Pitseolak and Eber 1975).

There are two possible routes via which the Sadlermiut may have come to Southampton Island. The first, across Roes Welcome Sound or the Frozen Strait from the Keewatin mainland is a minimum distance of 15 miles. The second crosses the Foxe Channel from Baffin Island, a minimum distance of 90 miles. The Sadlermiut had legends concerning both routes, and it is quite possible that both were used. On the basis of distance alone, it would seem more likely that the Sadlermiut came from the Keewatin mainland (Bird 1953; Comer 1910). However, there appears to have been a strong eastern influence running through the Sadlermiut culture. Mathiassen (1927a and Two) and Comer (1910) commented on the Polar Eskimo appearance of the Sadlermiut themselves, some of their artifacts and most notably, their clothing (see also Freuchen 1961 and Wissler 1918). There is some mention of contact with natives of Baffin Land in the Sadlermiut oral history (Mathiassen 1927a), and on the basis of his archaeological findings on Kuk, Mathiassen (1927a) considered that at least a contact with Baffin Island peoples was possible. Peter Pitseolak (Pitseolak and Eber 1975) confirms this, relating that people from 'our side' (Cape Dorset, Baffin Island) used to visit the Sadlermiut (see figure 3).

Figure 3: Southampton Island



After Merbs 1983

As was the case with the Europeans, prior to the establishment of the whaling settlements, contact between the Sadlermiut and any neighboring tribes had been minimal (Maxwell 1985). Surrounding tribes were conscious of differences between themselves and the Sadlermiut, considering them to be "primitive and mysterious" (Collins 1956b:674). The Aivilingmiut had visited and possibly even lived on the north of Southampton Island for up to a year or more at a time, but as the Sadlermiut seem to have kept to the south of the island at this time, there was little interaction between the two (Manning 1942). Comer (1910) was told that during the winter of 1830 a group of five Sadlermiut visited a now-extinct tribe, the Nuvukmiut, to the south of

Wager Inlet. This seems to have been the first and only recent contact between the Sadlermiut and mainland peoples. The two tribes engaged in friendly combat, a custom which would establish amicable relations between them. There was contact with people from Baffin Island; but at the time of the last meetings, just before the Sadlermiut epidemic, the two tribes had not interacted in years (Pitseolak and Eber 1975).

Less deliberate meetings may have taken place when people caught on drifting pack ice 'migrated' from the mainland to Southampton Island (Comer 1910). It is also possible that people moved from the mainland to Southampton Island when the sea froze across Roes Welcome Sound or the Frozen Strait. Resulting contact may have had certain influences on the Sadlermiut culture. However, the coast of Southampton Island opposite the mainland is inhospitable to settlement, offering little incentive for a lingering stay by either the Sadlermiut or visiting tribes and therefore less chance of contact. In any case, contact seems to have been "rare and not looked for" (Bird 1953:58). McCartney (1977) speculates that the Sadlermiut isolation may have begun early. The warmer temperatures in 1100-1200 A.D. would have resulted in fewer occasions when Roes Welcome Sound iced over and a concomitant decrease in winter contacts between the Sadlermiut and the mainland tribes. Any communication would have had to have been maintained by open water boating.

Mathiassen (1927a) interviewed three Aivilik informants who had made contact with the Sadlermiut shortly before the Sadlermiut epidemic; Saorre, Angutimarik, and Aqat. Later, Manning (1942) talked to the main informant, Angutimarik, from whom he learned essentially the same information. Other data were obtained by Donald B. Marsh (1976), the Anglican Bishop of the Arctic. In 1938, he spoke with Jimmy Gibbons, an Aivilingmiut who had lived near Native Point as a child, and who had known and questioned the five surviving Sadlermiut. Finally, in the early 1970's, Peter Pitseolak told of how his people had met the last Tooniks (Pitseolak and Eber 1975).

The Sadlermiut seasonal round has been summarized as follows:

> From these permanent settlements they hunted the walrus and the seal, partly from the ice edge and partly at breathing holes. In the spring they hunted the utoq seal on the ice when the ice put a stop to kayak-hunting of seals and walruses. In summer they lived in tents; in the early summer some of them went inland where they hunted birds and caught salmon at the big lakes; in September they hunted caribou, especially in the narrows between Bell Peninsula and the island, as a large number of caribou moved in summer to this high peninsula in order to get away from the mosquitos and returned during the late summer. As soon as the rivers and lakes froze over, at the end of September to the beginning of October, they again moved into the winter settlements [Mathiassen 1927a:269].

For most of the year the Sadlermiut lived in permanent winter homes on the south coast of the island. Tunirmiut in South Bay was the most important terminal settlement. Two to four families would share the stone and sod houses which by the late prehistoric period at Native Point were being built on the ground surface, generally oriented to the south or west and facing down slope. Contrary to the reports of Comer (1910) and Mathiassen (1927a), terminal Sadlermiut houses, unlike those of the Classic Thule, were not semi-subterranean. They were large circular structures that often contained alcoves and insets as well as lateral benches and flag-stoned horizontal surfaces. There was a window over the door and a smoke hole in the ceiling. Lamps rested on a central stone table. Storage bins were found under the platforms and around the margins of the sleeping platforms. In the winter, storage cubicles were made from blocks of ice. Alcoves set into the entrance passage may have been used as kitchens. The roofs were framed with caribou antlers, and whale ribs, antlers and baleen as well as limestone. The most distinguishing feature of the terminal Sadlermiut homes was their use of Coats verticals: vertical stone slabs set along and projecting from the inner face of the sod house walls that functioned as sides for storage cupboards or as roof supports. These were used by the Sadlermiut in place of the more commonly encountered coursed stone work in mainland Thule dwellings (Clark 1981; Comer 1910; Comer as cited in Boas 1901:76; 1907:400-401; Mathiassen 1927a; Taylor 1960).

The flat topped summer tents were made from hairy seal skin, hair to the outside, draped across two four-sided, upright whale bone frames. (Bird 1953; Comer 1910; Mathiassen 1927a). Occasionally quarmats, round, roughly built stone walls covered with a skin roof, were built in the autumn when hunting for caribou made a return to the permanent settlements inefficient.

The Sadlermiut economy centred on the hunting of marine mammals, seals, walruses and whales. Of these animals, the walrus was the most important, although it is felt that whales may have been of equal importance prior to their decimation at the hands of Europeans (Comer as cited in Boas 1907:474; Mathiassen 1927a). Certainly whale bone was used extensively, both to build houses, make cups and pails, form blades for the sleighs and frames for kayaks. In many ways whale bone was analogous to wood for these peoples (Comer as cited in Boas 1907:474; Lyons 1971; Mathiassen 1927a).

Land mammals were important to the Sadlermiut, especially the caribou. Most Inuit peoples had to practice a dual economy since resources from both the land and the sea were needed to survive. The warmth obtained from caribou clothing, for example, is essential in the freezing Arctic temperatures, but caribou meat is too lean to allow the Inuit to subsist solely on them. Marine mammals are required for their blubber, both for food and light (Maxwell 1985). Bears were hunted with dogs or caught in traps. Smaller animals such as fox, hare, birds and fish were also valuable resources (Comer as cited in Boas 1907:474-475; Mathiassen 1927a; Part Two).

According to the Aiviliks, the Sadlermiut were a shy and suspicious people, wary of meeting newcomers and careful of ambush. In appearance they resembled the Polar Eskimo and although they were shorter than the Aiviliks, and had less of a beard, they were quite strong and stoutly built. The stature of the Sadlermiut is debatable. Merbs (1983) comments that in fact stature estimates performed on the Sadlermiut skeletal remains resulted in heights which were on average 3 cm taller than Aivilingmiut norms. According to Pitseolak (Pitseolak and Eber 1975) Kingwatsiak never mentioned that the Sadlermiut were short, although he did comment often on their strength. In addition, Marsh (1976) relates that the whalers found the Sadlermiut to be a tall and strong people. In games with the Aiviliks, the Sadlermiut would seize the Aiviliks and throw them over their shoulders. The women wore their hair in two braids close to the face with distinctive hair ornaments. Comer mentions that the braids are folded up (as cited in Boas 1907: 475). The men, as earlier observed by Lyons (1971) and Comer plaited their hair into a top-knot worn on the rise of their foreheads. The women were tattooed in various patterns on their face, arms, and lower limbs. Lyons (1971:62) mentions that it was done "in small dots, probably from their having no needles of sufficient fineness to draw a sooted thread under the skins in lines, as is the usual Esquimaux custom." Although the Aivilik informants claim the tattooing was done on a woman's marriage (Mathiassen 1927a) , Comer relates that it was done when the girl was twelve (as cited in Boas 1907:474) The chin markings were not added until the eldest son had killed his first seal (Mathiassen 1927a). A similarity between the tattooing of the Sadlermiut and that found on the Greenland mummies from Qilakitsoq has been noted (Hansen et al. 1991).

A lack of personal cleanliness was frequently commented upon, highlighted by the fact that when flensing a seal or whale, the Sadlermiut would cut a hole in a piece of blubber, pull it over their heads as a collar and in this way carry it up to their houses. In the winter houses, the blubber was stored in the rafters, and dripped down on everything. "[To] rid the platform skins of blubber, sand was strewn on them, well trodden in and then they were combed with large combs" (Mathiassen 1927a:269-270). The Sadlermiut were further covered by a layer of soot, as the women did not properly care for the lamps (Pitseolak and Eber 1975; Manning 1942; Mathiassen 1927a). Upon recontact with the Sadlermiut in the early 1900's, the Cape Dorset peoples renamed the Sadlermiut the "Pujite" or "dried up oil", a reference to their appearance. Comer (as cited in Boas 1907:474), while noting that in his opinion all Eskimo were filthy, (and the Sadlermiut especially so), defends this lack of cleanliness as being due to the difficulties inherent in washing in this climate. It is likely that most Inuit had some parasite problems due to less than hygienic conditions. The mummies found at Qilakitsoq were all infested by lice (Hansen et al. 1991; see also Milan 1980). Again, Ferguson (see above) came away with a markedly different impression, finding the natives he meet to be clean and healthy (Ferguson

1979; Manning 1942; Taylor 1959a). Manning (1942:27) cautions that "[some] of these things may have been exaggerated by the Aivilingmiut, as all Eskimo are fond of ridiculing the customs of other tribes with whom they do not often come in contact". However, Manning (1942), Marsh (1976), and Pitseolak (and Eber 1975) do agree about the inability of the Sadlermiut to tend for the lamps. It is likely that this inability to tend for the lamps resulted in the deposition of a large amount of soot in the lungs, something noted in the examination of the mummies at Qilakitsoq (Hansen et al. 1991).

Clothing, in particular the women's enormous boots and the men's bearskin trousers, resembled that of the Polar Eskimo (Mathiassen 1927a and Two). Comer (as cited in Boas 1907:476) felt that the clothing looked like that of the Hudson Strait Eskimo and Lyons (1971) was reminded of the garments worn by the natives of the Savage Islands. Clothing was chiefly made of caribou, seal or bearskin. Skins of birds were also occasionally used, in general for children's clothes, as were fox and dog skins. The men's polar bearskin were distinctive, worn with the hair to the outside. Young polar bear skins were preferred as they were less stiff. Even so, the inside of the trousers were often greased with blubber to prevent chafing (Mathiassen 1927a).

The Aiviliks claimed the Sadlermiut were unskilled in working skins, caribou skin in particular. They did not scrape it thin, and consequently the clothing made from it was stiff and uncomfortable. Scrapers were made of stone or bone, generally caribou scapula, the scraping board was made of whalebone. The Sadlermiut did not know how to tan with urine, and had no knowledge of white skin, a skin with both the fur and epidermis removed and used primarily for decorative purposes among many Inuit groups (Hansen et al. 1991). Skin for boots, sole and kayaks was allowed to half rot before hair was removed while bear skin was not even scraped, the fat and inner skin merely cut off with the terminal Sadlermiut tanged ulo. The Sadlermiut scraped skin in the Greenland fashion, with the palm down drawing the ulo towards them, not palm up pushing the ulo away as was done by the Aivilingmiut. This contrasts Ferguson's (1979, see above) description of well and attractively clothed individuals.

Sewing was done by using a bodkin to make a hole, after which the fragile bone needles were pulled through. Thread was made of sinews from walrus flippers and seal throats, as well as sinews from bear and caribou. Thimbles were of bearded seal skin, whalebone formed the cutting board. "Sewing was done in the usual manner: the thimble on the fore-finger, the stitches were made from right to left and the thread was all the time drawn to the seamstress" (Mathiassen 1927a:).

Food was primarily meat; there were no berries and very little of a vegetable nature was eaten. Meat was consumed boiled, raw and frozen. Occasionally it was roasted with blubber between flat stones. In the winter, limestone lamps were used for both light and cooking, but in summer food was cooked over bones and blubber in a small alcove in the doorway of the stone-and-sod houses, or on a small fireplace just inside or outside the tent. Meat was cooked in oval cooking pots made of cemented or sewn limestone. Baleen sided and sealskin based trays were also used to hold meat and blubber. The bone meat forks had only one point. Spoons were used less often, and commonly small cups of baleen were used as ladles. Sucking tubes approximately 30 cm long were made of swan thigh-bones, and were used both in the house and when caribou hunting (Marsh 1976; Mathiassen 1927a). Blubber was also eaten (Mathiassen 1927a) and blood was often drunk (Mathiassen 1927a; Pitseolak and Eber 1975).

Pyrite stones struck together to make sparks were used to make fire. Fire-boring (the use of the bow drill) was also implemented (Mathiassen 1927a and Two). Other evidence for bow drills has been found at Kuk in the form of a slender bow, a caribou astragalus mouthpiece, and a stone drill bit. As well, their presence is further indicated in the form of the many artifacts with drilled holes (Boas 1901; Mathiassen 1927b).

Meat was kept in the storage chambers along the passageway to the winter houses, or in high cairns. These cairns are distinct to the Sadlermiut group, built in such a manner that they are broadest on top, thus producing a 'mushroom shape' . Large, hollow, cone-shaped buildings housed drying salmon, walrus, skinned birds, bags of blubber and caribou meat. Access to these structures was from the top via the removal of two or three large flat slabs. Caribou-antlers were used as hooks for the meat, projecting inwards and suspending the meat out of reach of mice and weasels. Marsh(1976) describes a slightly different meat house with a V-shaped roof. It was built of stone and whale bone and entirely covered in moss, peat and sand. Access to these structures was from the front. In the summer meat depots, stone buildings two or three metres high, and as broad in diameter at the base, were used. Stone caches were built where the meat was taken, and meat was gathered as needed in the winter. At times, meat was hung on bone hooks inside the houses (Collins 1956b; Comer as cited in Boas 1907:475; Lyons 1971; Mathiassen 1927a).

Little is known about dietary restrictions. Menstruating women and any women assisting them could eat boiled meat only. According to the Aivilingmiut the Sadlermiut did not have any of the strict taboos regarding the separation of land and sea mammals (Mathiassen 1927a). These taboos are widespread throughout the arctic, and there are indications that they may date from Palaeo-Eskimo times (Maxwell 1985). Land and sea animals could not be eaten with or cooked in the fat of the other, and when hunting caribou, "one cannot crack bones or pierce any skin with a needle" (Maxwell 1985:55). However, Comer (as cited in Boas 1907:478) related an incident in which he visited an angakok over the loss of a whale. "The woman, in her trance, said that I had offended the goddess in the sea by cutting up caribou-meat on sea-ice, and by breaking the bones there" (Comer as cited in Boas 1907:478). As well, Marsh (1976:39) reports that "under no circumstances were the bones of one animal placed in the cupboard with the bones of another animal" a circumstance he attributed to the existence of taboos.

As previously noted, the Sadlermiut were clever at flint knapping. They used a flint flaker of walrus or polar bear rib and two pieces of leather or sealskin to protect the hands. A piece of flint was broken by the flaker, and the most suitable flake for the implement in mind was chosen. Lyons (1971) noticed that the natives only made use of the dark coloured flints, possibly due to the fact that the veined stones were more liable to split. Implements were pressure flaked. Whetting stones of bear's teeth, of sandstone or shale were used to keep the point of the flaker sharp. This allowed the flint knapper to determine the direction of pressure (Comer as cited in Boas 1907:476-477; Mathiassen 1927a; Pitseolak and Eber 1975). Clark (1980:77) characterizes the stone tool assemblages as having plano-convex cross-sections, predominantly unifacial retouch, lacking complete surfacial retouch on most artifacts, and lacking fine flaking techniques.

Although the Sadlermiut did not seem to have danced and drummed as did the rest of the central Inuit, they played ajagaq (a cup-and-pin game variant) and nughutang, football, blindman's-bluff, skipping and wrestling. But unlike the Aiviliks they did not fight with their fists. Children played at their adult tasks, the girls with dolls, and the boys with miniature weapons and sledges (Mathiassen 1927a). "As is true today among the Inuit, much of children's play was geared to preparation for adult activities" (Maxwell 1985:294, Nansen 1894).

Sadlermiut Archaeology

Captain Comer, whose interest in the Sadlermiut had led him to acquire many of their artifacts, conducted the first excavations on Southampton Island. However, these excavations were far from systematic and much information was lost (Mathiassen 1927a). The first reputable archaeology on Southampton Island was carried out by Therkel Mathiassen in 1922 (Clark 1980; Mathiassen 1927a).

Mathiassen concentrated on the Kuk settlement, located in Duke of York Bay to the north of the island. The site contains three stone house groups, situated progressively further from the shoreline. There also are a salmon dam, a large number of limestone meat caches, store houses, a characteristic Sadlermiut 'mushroom' cairn, tent rings, and graves.

The site traces the early development of Sadlermiut culture on Southampton island. The early stages of Kuk are Thule, roughly contemporaneous with Naujan, the site on Repulse Bay earlier excavated by Mathiassen and from which he had defined the Thule culture. In the later stages an increasing use of flint, readily available on the island, and flint flakers can be seen. Concurrently, limestone came to replace soapstone, the latter a commodity not present on the island and characteristic Sadlermiut assemblages including flat harpoon heads appeared. In the latest stages of this site a 'full blown' Sadlermiut occupation is represented (Clark 1980).

A further development of Sadlermiut culture occurs in the south of the island. A collection of 291 specimens that Mathiassen analyzed from the area around Native Point had artifacts not found in Kuk, indicating that "the culture of the Sadlermiut continued to develop and produce new forms after Duke of York Bay was deserted" (Mathiassen 1927a:267).

For Mathiassen, the Sadlermiut artifact assemblages was rendered unique by their two distinctive harpoon heads, tanged flint arrow heads and harpoon blades, the flint flaker with the accompanying flint artifacts, a use of limestone slabs to manufacture the cooking pots and lamps, pierced-gripped combs and ivory hair ornaments. Also characteristic of these assemblages was the lack of a salmon spear and grave goods. Other components of the assemblages, for example the flat harpoon heads, obliquely cut arrow heads and tanged ulos were in Mathiassen's view the outcome of the general cultural development in the area, and their adoption due to the influence of neighboring tribes (Mathiassen 1927a).

Mathiassen was slow to recognize the Dorset culture (de Laguna 1979; Maxwell 1985; Taylor 1959a, 1959b), and so ignored any role it may have played in Sadlermiut development. This is in part understandable due to the fact that the artifacts he examined were, with the exception of the flaked stone component and some interesting shaman's tubes, best assigned a Thule origin (Maxwell 1985). It was, in Mathiassen's view, the isolation of the Sadlermiut which led to their differences from mainland Thule cultures.

Further archaeological work on the island include excavations conducted by Manning in 1934 at Kirchoffer River and Gibbons Point, and later in 1938 at Expectation Point (Manning 1942). In 1950, Bird (1953) examined the Sadlermiut patterns. He found that at some point in prehistory much of the entire coast of Southampton Island had been inhabited (Bird 1953; Manning 1942:25) and that sites are most concentrated along the south coast. Bird concluded that the Sadlermiut settlement patterns were influenced by access to the mainland, the possible source of immigration; access to sea and land mammals and land resources; and access to specific features such as the presence of a river or portion of well-drained land (Bird 1953). The most important factor was access to marine animals and the suitability of the sea and ice for hunting them.

The most extensively examined site on Southampton Island is that at Native Point. Excavated by Collins in 1954 and 1955, Taylor in 1956 and Laughlin and Merbs in 1959, much of the Sadlermiut cultural material derives from this site. Collins' principal interests lay in the Dorset component, though he did recognize the Sadlermiut occupation and excavated about twenty graves. Two houses and some surrounding midden were partially excavated. Taylor studied the well-preserved terminal Sadlermiut house structures at Tunirmiut. Two houses were extensively excavated and the human skeletal remains encountered within them collected.

William S.Laughlin and Charles Merbs recovered over 150 skeletons from the Native Point area in the summer of 1959 (Collins 1956a, 1956c, 1957; Merbs 1983; Merbs and Wilson 1962; Taylor 1960, 1959). It is from this material that the study sample for this thesis has been obtained.

Artifacts uncovered at Native Point were similar to those found in the collections described by Boas (1901, 1907) and Mathiassen (1927a). In addition to harpoon and lance heads, fragments of bows, arrow shafts and arrow points, flakers, bolas and darts were recovered. Some textile fragments formed from willow roots or bark in a loose plane weave were also discovered. They may be remnants of a basket or bag (Taylor 1960). Rounded lumps of pyrite were commonly recovered in houses and graves. The mushroom shaped solid limestone cairns were also present (Collins 1956b).

Collins (1957) found no differences between artifacts in the upper sod layers of a refuse area used by some of the newer houses on the site, and those recovered in the deeper house level of an older house. This may indicate a fairly stable culture continuity, and one in which cultural practices were fairly conservative.

Faunal remains recovered from Native Point included seal, walrus, polar bear, caribou and dog skulls. Of these the most important food animal was seal (49.8% of the identified bone), followed by caribou (23.8%), walrus (10%) and bearded seal (7.1%). Polar bear remains were scarce (Collins 1956a, 1956c; Taylor 1960).

Collins (1956a, 1956c) saw Dorset influence not only in the flint-knapping aspect of the Sadlermiut technology, but also in the form of some of the Sadlermiut harpoon heads. These, presumably, were developed from earlier Dorset harpoon heads. They exhibit features of late Dorset types including bifurcated spurs, blade slot at right angles to the line hole, and semi-circular cross sections with the two openings of the line hole in the arch side. The enclosed socket in the Sadlermiut harpoons are round rather than rectangular as are the Dorset heads. As well, the Sadlermiut seem to have curated Dorset artifacts and both their tattooing and their hair-styles may also have been Dorset derived. As a consequence, Collins proposed that the Sadlermiut were a remnant Dorset population, occupying Southampton Island by 682 B.C., and were significantly influenced by the incoming Thule culture at around 1000 A.D. However, they were sufficiently isolated to remain distinct, and distinctive (Maxwell 1985; Taylor 1959a, 1959b; Collins 1956b, 1956c).

With regards to the above, Taylor (1960:86) notes that

> ... the open-socket heads, with paired line holes and symmetrical spurs in the Sadlermiut culture may constitute Thule or Dorset influence on Sadlermiut, or Dorset influence maintained by late Thule culture and passed on to the Sadlermiut. They might even mean a Dorset pattern maintained by Sadlermiut peoples and passed by them to the Thule culture.

Taylor and Collins were unable to resolve the Sadlermiut/Thule/Dorset interaction. The houses they excavated at Native Point and Coats Island were too recently occupied to shed much light on the subject, but the Coats verticals in the houses and the recovered Dorset-like stemmed and broadly notched flint blades remain puzzling (Maxwell 1985).

In 1977, Clark investigated the Lake Site, a Thule winter campsite , located a few miles north of Native Point and dated to approximately A.D. 1400-1600 . At the Lake Site, Clark found that the bone/ivory/antler component of the assemblage most closely resembled other Thule assemblages, but the chipped stone component was more closely affiliated to the Dorset or terminal Sadlermiut cultures, and not to Thule (Clark 1980, 1981). She also charted the progression of building styles on the island. The early houses at Kuk are classic Thule in form. By the fifteenth to seventeenth centuries, there still existed a considerable similarity between the houses built on Southampton Island and those built by the mainland Hudson Bay Thule with the difference being found in the Southampton use of side benches. On the mainland, the permanent sod and stone houses were abandoned around 1600, or at the very latest, upon early contact. It is possible as trading with whalers became increasingly important, the mainlanders became more mobile. Eventually mobility led to exclusive use of quarmats or snow houses. The Sadlermiut, not engaging in this trade, went on to build their distinctive permanent sod and stone houses.

From these excavations Clark (1980:78-79) has concluded that

> ... it appears likely that Sadlermiut culture developed *in situ* from a Thule culture ancestry not unlike that represented at the Lake Site. The Thule culture on Southampton Island rapidly took on a distinctive flavour, however, and some positive affiliations with the Dorset culture cannot be ignored. Directly or indirectly the Dorset culture must have had some strong influences on local Thule development. The nature of this influence is not presently understood.

Summary

In sum, the Sadlermiut were, by choice or accident or a combination of these factors an extremely isolated group. Their lack of contact with Europeans protected them from marked acculturation, so they followed a largely traditional lifestyle up until their deaths. Although the differences between the Sadlermiut and the Inuit groups have been much noted, Arctic peoples as a whole shared a fairly homogeneous culture (Giffen 1930; Inuktitut 1986). It is likely that far more was held in common than differed between the Sadlermiut and their neighbours.

TUNIRMIUT AND THE STUDY SAMPLE

The skeletal sample being studied in this thesis originates from the site of Tunirmiut or "Place of the Old People" at Native Point on Southampton Island (Taylor 1959a). As previously mentioned, this site was excavated by Collins in 1954 and 1955, by Taylor in 1956 and by Laughlin and Merbs in 1959 (Collins 1956a, 1956c, 1957; Merbs 1983; Merbs and Wilson 1962; Taylor 1960, 1959a). Tunirmiut, spread over a thirty acre expanse, is the largest of the known Sadlermiut settlements. In addition to the Sadlermiut and Dorset components the site also contains an Aivilik component of quarmats and tent rings. One hundred and eleven house ruins and adjacent middens, as well as over 100 stone graves are found on the site (Collins 1956a, 1956b, 1956c, 1957; Taylor 1960). Native Point is a prime settlement area, with access both to the floe edge in spring for hunting sea mammals as well as to rich inland tundra. Caribou passed by this area as they migrated to and from Bell Peninsula in the spring and autumn. In addition, the dryness of the site and the presence of large stones are ideal for house construction (Bird 1953). Although there is a Dorset component at Native Point dated to at least 1,000 B.P. (Taylor 1959a), Merbs (1983) estimates that the Sadlermiut occupied Tunirmiut for no more than 500 years. Only some of the remains collected and studied here are from the final epidemic.

Merbs and Wilson (1962) divided the Native Point skeletal collection into three categories: an early "village" series, an intermediate "peripheral" series, and a late "meat cache" series. This latter series represents the terminal Sadlermiut who died in the epidemic of 1902-03. Due to the short time period separating the three series, and their likely overlap, intra-group comparisons have not been carried out, and the series are lumped together here. The small number of specimens in the early "village" series render comparisons between it and the late "meat cache" series meaningless.

At Tunirmiut, the Sadlermiut placed their dead on the natural ground surface, (gravel, limestone shingles or cobbles) or more rarely on a limestone floor, and built a limestone vault or grave around them. In general, a grave contained only one individual, and was built full-length even if only a portion of the body had been recovered. Occasionally however, some individuals were lain on the surface "with only a surrounding enclosure of stones" (Collins 1956b:674) and some were buried in a flexed position on their right side in converted meat caches (Cassidy 1977). This corresponds fairly well to the reports of Mathiassen (1927a). Lyons (1971) related that the deceased was merely dressed in his or her clothes and covered with stones. The burials Lyons (1971) observed were flexed. Between 2 and 10 cm of matrix were found in the graves at Tunirmiut, consisting primarily of sand brought in by wind or water, as well as decomposed soft tissue, clothing and animal droppings. Although lichen had damaged some of the bones, the limestone environment allowed generally good preservation (Merbs 1983). At least one burial contained a grave offering of a small human figurine (Cassidy 1977). Ethnographically, it was unusual for the Sadlermiut to include grave goods (Mathiassen 1927a). Also collected were unassociated skulls lying on the surface in and about the site and skeletal materials from the house ruins (Collins 1956a; Taylor 1960).

Recovery of skeletal materials was fairly complete. Some bodies had been disturbed by foxes or polar bears, and small bones, such as the teeth, phalanges and carpals had been removed by lemmings and foxes. This occurs fairly often in arctic contexts. Lyons (1971) also observed a burial which had been disturbed by a nesting snow bunting. Of the 61 individuals for whom I have burial information, 29 were found scattered about the site, and of the 33 that had undergone or remained in some form of interment, 14 gave evidence for being disturbed. Small bones and teeth also had a tendency to slip between the limestone cobbles on the floor of the grave and be lost (Merbs 1983).

The Sadlermiut remains from Native Point have been studied in whole or part by Merbs and Wilson (1962), Mazess (1966), Turner (1967), Merbs (1968,1983), Turner and Cadien (1969), Cassidy (1977), Mayhall(1979) and Thompson et al. (1984). The collection has been aged and sexed several times. Individuals were aged by cranial suture closure, epiphyseal union and the face of the pubic symphysis based on the standards formulated by Todd (1920), Hanihara (1952) and McKern and Stewart (1957) (Merbs 1968; Merbs 1983; Merbs and Wilson 1962). Dental wear was used as a check for any major cranial-pelvic discrepancies, but these were few. The adult-subadult division was based on the closure of the spheno-occipital suture, which occurred at about age 18 in this population (Merbs and Wilson 1962). Any discrepancies of age between the three methods resulted in a re-evaluation of the entire skeleton. Independent age estimates were carried out by William Laughlin, Robert Meier, William Wilson and Charles Utermohle. The assigned ages are estimate means (Merbs 1983).

Sexing of the sample was accomplished by independent assessment of the pelvis and cranium. The sciatic notch and shape of the pubic element were the most useful in this regard (Merbs 1983; Merbs and Wilson 1962). Sexing has been done independently by William Laughlin, William Wilson, Robert Meier, Henry Collins, John Mayhall, Joseph Blumberg and Charles Utermohle. Only twice was there disagreement as regards sex, and both were resolved to the satisfaction of all (Merbs 1983).

There are no extremely aged individuals in this collection. This would substantiate Comer's observation (see above) in which he only met with one man that he felt was over fifty. Arctic populations die earlier and age more quickly than other populations (Thompson et al. 1984). A bone core analysis of the Sadlermiut revealed that they were undergoing age-related bone loss at an earlier age than American whites of the same age. Bones of the Inuit are as a whole low in calcium (Hansen 1991:98).

For this study 81 of these individuals were examined: 30 females, 32 males, 6 individuals of unknown age and sex, and 13 subadults (see Appendix A). Due to the ante and postmortem loss of teeth, an individual could be included in the study sample with only one anterior and posterior teeth. The breakdown as to age and sex was fairly equal (See Chapter Five), but tooth loss, as will be discussed shortly, was a problem, However, the collection was felt to be most suitable for the investigation of gender based differences in wear patterns in the use of teeth as tools due to the fact that it was reasonably well preserved and there was good ethnographic evidence for the use by Arctic peoples as whole to use their teeth as tools. In addition there is a well-defined sexual division of labour in traditional Inuit societies (Merbs 1983). The isolation of the Sadlermiut forestalled any marked acculturation and allows one to assume that the sexual division of labour remained in force throughout Sadlermiut history. Furthermore, the archaeological evidence pointing towards a stable culture allows one to assume that cultural practices were much the same throughout the time range of the recovered materials. Lastly, Merbs (1983, see below) had also found patterns in antemortem tooth loss and osteoarthritis of the temporomandibular joint that pointed to the use of teeth as tools in gender specific ways in this population.

PATTERNS FOUND BY MERBS TO POINT TO USE OF THE TEETH AS TOOLS

Merbs' classic study of the Sadlermiut and their activity-induced pathologies concentrated on degenerative joint disease and vertebral disorders on the postcranial skeleton (Merbs 1983). Discovered pathological patterns were correlated to Sadlermiut activities as reconstructed from the ethnographic, historic and archaeological accounts. More importantly, in terms of this thesis, Merbs examined patterns of anterior tooth loss and osteoarthritis of the temporomandibular joint and linked these to the use of the teeth as tools (Merbs 1968; 1983).

Osteoarthritis of the Temporomandibular Joint

Merbs found that Sadlermiut females as compared to males had twice the incidence, and a greater intensity of temporomandibular joint osteoarthritis (25%-10%). This was one of the few joints in the body in which he found the women to show greater involvement than the men.

Merbs attributed this finding to the women's use of their teeth to soften skins. Merbs felt this primarily involved teeth on the side of the jaw rather than those in front, resulting, presumably, in greater tooth wear and in the deterioration of the temporomandibular joint rather than tooth loss.

In males, where the temporomandibular destruction was roughly equal on both sides, tasks such as holding the mouth piece of the bow drill in the front and center of the mouth could be expected to affect both sides equally. As well, the men may have been performing a greater variety of functions by the teeth, equalizing the stress between the two sides.

Anterior Tooth Loss

The extensive loss of anterior teeth among the Inuit peoples has been long commented upon. Compared to other northern Mongoloid groups the Sadlermiut have the highest rates of incisor and canine loss and the highest percent (87.5% of the individuals) of pressure chipping on their teeth (Turner and Cadien 1969).

Hrdlicka (1940 as cited Merbs 1983:42-43) and later Cook (1981) attributed anterior tooth loss to ritual ablation. However, work done by Merbs (1968,1983), Mayhall (1972, 1977) and Costa (1980) argues against this explanation, correlating the patterns of loss to the use by the Inuit of their teeth as tools in gender specific ways. In the words of Pedersen and Jakobsen (1989:122): "[the] female Eskimo dentition is a precious tool, crucial to her social and matrimonial success in life. That she - or her community - would permit her to be deprived of this asset voluntarily would seem absurd."

Merbs looked at 71 skulls with intact incisor and canine alveoli and with no signs of extensive pathological alterations. He found that Sadlermiut females showed greater incisor loss than males (29%-16%), that loss on the left side was greater than on the right (24%-21%), and loss from the maxilla was greater than from the mandible (34%-10%). Canine loss was higher in females (13%-9%) and this loss occurred both in the maxilla and mandible of the women, while in the males it was limited to the maxilla. Seventy-one percent of adult Sadlermiut females had lost teeth antemortem compared to 59% of the adult males. Females also had more teeth missing per cranium - 2.82 to 1.95.

Tooth loss in males was likely traumatic in nature, due to their use of the anterior teeth as a vise-grip. This rendered them vulnerable to sudden labial or lingual directions of force. Women's tasks, although less traumatic, were more repetitive and spread the force over a wider area. Tooth use, especially when it involves activity beyond that of food mastication, results in wear. This wear will in time expose the tooth pulp chambers, potentially weakening the alveolar bone by making it susceptible to infection and subsequent tooth loss. The constant force will also shorten the tooth root, further aiding in tooth loss.

Sex differences in tooth loss appears to apply to all adult age categories. The higher rate of mandibular tooth loss in Sadlermiut women as compared to men was shared with women in other groups and is likely due to a common female specific task such as skin scraping (Merbs 1983).

Summary

Merbs (1983) has proposed that Aivilingmiut accounts of the Sadlermiut stressed cultural curiosities and differences rather than similarities between themselves and the Sadlermiut. Therefore Merbs assumed that the Sadlermiut shared most customs and activities with the Central Eskimo. Although cultural differences reported by the Aivilingmiut will be taken into account, Merbs' assumption regarding general cultural similarity with the Central Eskimo will apply in this study of Sadlermiut tooth wear. Therefore, although there is no ethnographic account of the use by the Sadlermiut of their teeth as tools, the finding of drill bits, and artifacts with drilled holes in them (Boas 1901; Clark 1980), ethnographic analogy and Merbs' (1983, 1968) analyses on anterior tooth loss and temporomandibular osteoarthritis demonstrates fairly convincingly that the teeth were being used for a variety of non-masticatory tasks.

CHAPTER FOUR: METHODS

Introduction

Tooth wear studies have been hindered by the lack of a consistent methodology for collecting and analyzing data (Kerr 1986; Patterson 1984; Scott 1979; Smith 1983, 1984; Tomenchuk and Mayhall 1979). Each study has used slightly different criteria to score wear, or disease, or any other characteristic of interest. As well, variation in methods of analysis have made comparisons between studies difficult.

To an extent, the study presented here does little to alleviate this problem. Although much of the work is based on the methodology of Smith (1983), Patterson (1984) and Jacobson (1982) the resulting amalgamation transforms these studies, rendering comparisons less than one to one. Part of this lies in the nature of the problems being solved; different researchers find different phenomena more important than others, and adjust their methods accordingly. The methods in this study reflect an interest in gender differences and paramasticatory activities. Additionally, each population seems to evince unique features, mandating some change in scoring.

Since the homogeneity of the population is established (Merbs 1983; Turner 1967), and because to a large extent a study of the morphology of the teeth and the group's genetic relatedness to others has already been done (Mayhall 1979; Turner 1967), this study concentrates more on metric phenomena. Measurements were taken directly on the teeth and skulls with Helios needlepoint calipers, Matui vernier calipers and coordinate calipers.

Units of Analysis

Tooth wear studies deal with two levels of analysis: the individual, and the teeth. Thus some of the observations are on an individual level, concerning the masticatory support structure as a whole, the individual's age, sex and overall health, while some pertain to each tooth separately.

Overall Pathology

To begin with, each dentition was assigned a grade of pathology, after Smith (1983:85). This enables one to pull from the analysis any dentitions that were so pathological their wear patterns could be considered anomalous for that reason. These grades are as follows:

I. Healthy:
No disease or generally healthy with minor fissure caries

II. Moderate pathology:
Several minor carious lesions and/or moderate periodontal destruction or one or two major carious lesions; minor abscesses, if any; zero to few teeth lost antemortem

III. Pathological:
Several major carious lesions and/or abscesses judged to be a possible disturbance to mastication; severe and widespread periodontal destruction; several teeth lost antemortem

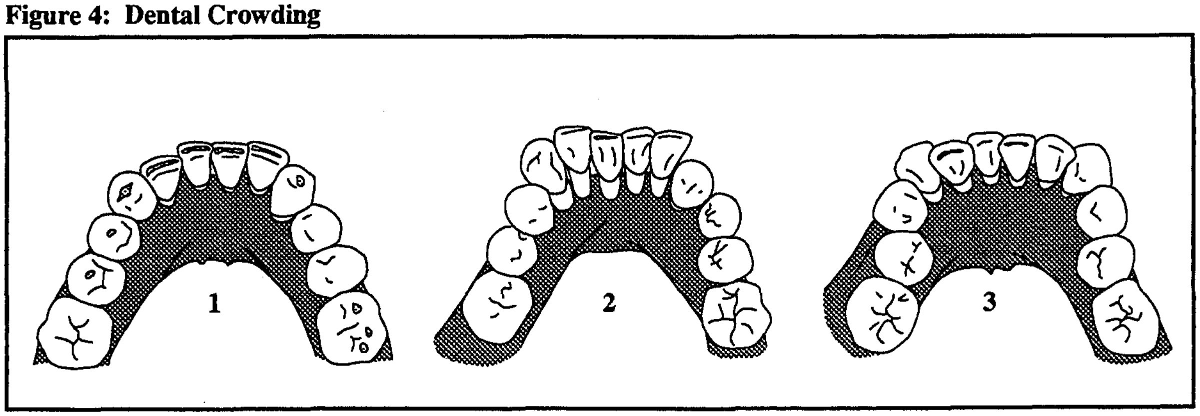
IV. Extremely pathological:
Several to most molar teeth with extensive caries or lost antemortem; roughly half the dentition shows substantial pathology.

Dental Crowding

The mandible and maxilla were also scored as to their degree of completeness, and the presence or absence of dental crowding was noted. Marked crowding can affect both occlusion and wear pattern and thus needs to be checked for (Jacobson 1982; Molnar 1971b; Patterson 1984). Crowding was assessed by reference to pictorial standards (see Figure 4) and rated as follows:

0	Absent
1	Mild
2	Moderate
3	Marked

Figure 4: Dental Crowding



After Jacobson 1982:23-24.

Severe crowding can also be a factor contributing to periodontal disease and subsequent alveolar bone loss (Calcagno and Gibson 1991; Jacobson 1982). To a lesser extent, crowding can reflect the rate and intensity of interproximal attrition. The mesio-distal shortening of teeth throughout life aids in alleviating crowding effects.

Tooth Status

The status of each individual tooth was determined (Table 2). In this way antemortem tooth loss, and the possible causes thereof could be differentiated from postmortem loss. If the loss was antemortem, the status also indicated whether the loss was due, as near as could be ascertained, to sudden or sustained trauma, or to disease. A large proportion of antemortem tooth loss in a dentition implies that some shift in occlusal loading to compensate for loss has occurred (Jacobson 1982, William and Woodhead 1986). Postmortem loss carries less of this implication. It is generally assumed that teeth lost after death exhibited the same proportion of wear or pathology as the teeth remaining. Although this may not always be the case (Patterson 1984) especially for more frequently lost teeth, it is an assumption that is being made in this study.

Table 2: Tooth Status

0.0	Missing, jaw not preserved in this region
0.1	Missing, unerupted or agenesis
1.1	Present, tooth in full occlusion
1.2	Present, tooth partially erupted
1.3	Present, but not yet past the bony alveolus
2.1	Lost antemortem, due to a pathological condition, socket shows little resorption
2.2	Lost antemortem, due to a pathological condition, socket mostly or completely resorbed
2.3	Lost antemortem, no sign of a pathological condition, socket shows little resorption
2.4	Lost antemortem, no sign of a pathological condition, socket mostly or completely resorbed
2.5	Lost antemortem, but unable to determine whether due to a pathological condition, socket shows little resorption
2.6	Lost antemortem, but unable to determine whether due to a pathological condition, or to congenital absence, socket mostly or completely resorbed
3.0	Lost postmortem
4.0	Tooth is present, but condition is undeterminable

(adapted from Smith, 1983; Patterson, 1984)

Tooth Wear

Initially, dental wear was to be scored quantitatively, following the methods laid out by Behrend (1977), Walker (1978), Richards and Brown (1981), Richards (1984); Molnar et al.

(1983a) and McKee and Molnar (1988). However, the Sadlermiut dentition was not as worn as had been expected. Comparisons of area of dentine exposure to overall tooth surface area, when this overall area was less than flat would not be an accurate assessment of the dentine-enamel ratio, defeating the purpose of this exercise. A subsequent attempt to assess the area of faceting on the tooth surface was hindered by the fact that the facets did not show up well in the photographs. Despite the use of low speed film (Ilford Pan F 50) and several experiments in oblique lighting and the use of light diffusers, there was too much glare off the enamel. It is likely that such a practice works better on photographed casts. Such difficulties have been met in other studies:

> The measurement of wear facet areas ... presents practical problems. Elaborate photographic and planimetric equipment is required to make the measurements. The precise limits of wear facets are often hard to determine on photographic enlargements, and this makes it necessary to refer frequently to the original specimen. Although the recording of wear facet areas can be automated to some extent with a computerized image analysis system, it is still a tedious , time consuming process (Walker et al. 1991:171).

There is also a possible problem in that the location and extent of wear planes and their position on the teeth do not, in and of themselves, always indicate where the greatest tooth tissue loss is taking place. Dentine exposure may be more useful in this regard, at least initially. Often faceting was found on all molar and premolars cusps, while extensive wear was only taking place on one of the cusps. This factor may account for some of the seemingly contradictory findings of Molnar et al. (1983a and 1983b), in which the females had greater areas of faceting on their teeth, but the males were suffering a greater rate of loss of cusp height.

Wear on teeth was therefore assessed on an ordinal scale, adapted from Smith (1983), with the addition of levels for secondary dentine (adapted from Patterson 1984). Ordinal scales have been used since Broca (1879) to score attrition and range in complexity from Broca's four stages for assessing a complete dentition to Scott's (1979) forty point assessment of molar wear. Disadvantages with ordinal scales are well known, centering around the difficulties of assessing a continuous process, tooth tissue loss, by stages. It is not known if the differences between the consecutive stages represent an equal amounts of wear. One is unable to perform some statistical procedures or to compensate for such factors as tooth size (Walker et al. 1991). As well, it is a subjective assessment that may vary between researchers (Walker et al. 1991). However, the procedure does not require elaborate equipment, and allows for fairly rapid data collection (Walker et al. 1991). In addition, it can be claimed that an eight point system (or more accurately, in my case, a fourteen point system) approximates a continuous variable. Although Scott's (1979) system does this best, it is only applicable to molars and premolars. This study looks at the entire dentition. Thus, an adaptation of Molnar's (1971a), Smith's (1983, 1984) and Patterson's (1984) stages was used.

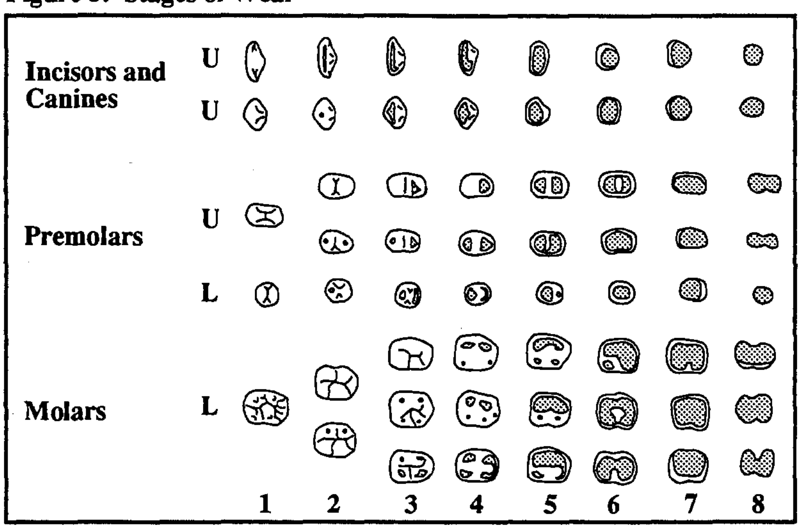
Basic tooth morphology dictates that no one tooth wear series can be used to evaluate the wear on all types of teeth (Molnar 1971a). Tooth fields were therefore scored individually, incisors and canines lumped in one category, premolars in another, and molars in a third (Table 3). Reference was often made to Smith's (1983) figure for tooth wear (Figure 5).

Table 3: Tooth Wear Stages

Incisors and Canines

0.0	Unworn
1.0	Polished or minimal wear facets
2.0	Point or hairline of dentin exposure
3.0	Dentin line of distinct thickness
4.0	Moderate dentin exposure, no longer resembling a line
5.0	Large dentin area with enamel rim complete
6.0	Large dentin area with enamel rim lost on one side, or very thin enamel only
6.5	Same as 6 with moderate to extensive secondary dentin
7.0	Enamel rim lost on two sides of small remnant of enamel remaining
7.5	Same as 7 with extensive secondary dentine
8.0	Complete loss of crown, no enamel remaining. Crown surface takes on shape of roots
9.0	Indeterminable

Figure 5: Stages of Wear



After Smith 1983:62.

Table 3: Tooth Wear Stages (Continued)	
Premolars	
0.0	Unworn
1.0	Polished or small facets (no dentin exposure)
2.0	Moderate cusp removal (blunting)
3.0	Full cusp removal and/or moderate dentin patches
4.0	At least one large dentin exposure on one cusp
5.0	Two large dentin areas (may be slight coalescence)
5.5	Same as 5, but with slight secondary dentin
6.0	Dentinal areas coalesced, enamel rim still complete
6.5	Same as 6, but with moderate to heavy secondary dentin
7.0	Full dentin exposure, loss of rim on at least one side
7.5	Same as 7, but with extensive secondary dentin
8.0	Severe loss of crown height. Crown surface takes on shape of roots
9.0	Indeterminable

Table 3: Tooth Wear Stages (Continued)	
Molars	
0.0	Unworn
1.0	Polished or small facets
2.0	Moderate cusp removal (blunting). Thinly enamelled teeth (human deciduous molars) may show cusp tip dentin exposure but human permanent molars have no more than one or two pinpoint exposures
3.0	Full cusp removal and/or some dentin exposure, pinpoint to moderate
4.0	Several large dentin exposures, still discrete
5.0	Two dentinal areas coalesced
6.0	Three dentin areas coalesced, or four coalesced with enamel island
6.5	Same as 6, but with slight secondary dentin
7.0	Dentin exposed on entire surface, enamel rim largely intact
7.5	Same as 7, but with moderate to extensive secondary dentin
8.0	Severe loss of crown height, breakdown of enamel rim. Crown surface takes on shape of roots
9.0	Indeterminable

(after Molnar 1971a; Smith 1983; Patterson 1984)

Erupted Crown Height

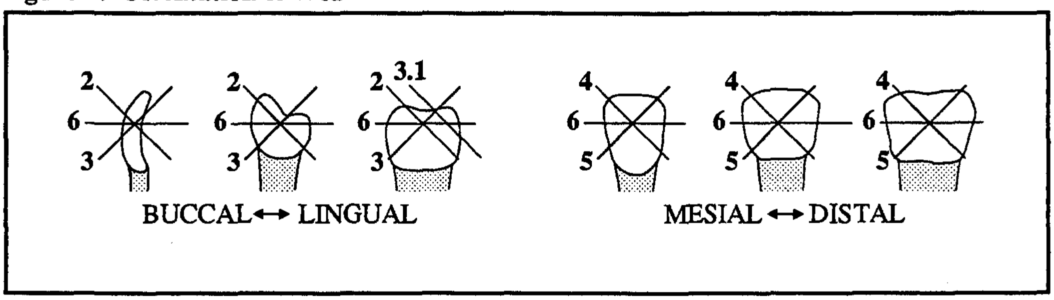
A means of reducing the problems associated with the use of an ordinal wear stage is the measurement of another continuous variable affected by wear, erupted crown height. This measures the effect of wear in a vertical plane (Kieser et al. 1985; Walker et al. 1991). Erupted crown height was measured fairly simply: from the highest point on the mesio-buccal cusp on the molars to the cemento-enamel junction, in a plane perpendicular to the tooth's occlusal surface. For teeth other than molars, the measurement was taken from the center of the tooth to the cemento-enamel junction, again on a plane perpendicular to the occlusal surface. The presence of a great deal of calculus on some of the teeth prevented the measurement from being taken in these cases.

Occlusal Topography

In 1971 Molnar (1971a,b) noted that although teeth were scored for dentine exposure their surface forms were not widely studied. Molnar felt, and largely demonstrated, that an analysis of tooth surfaces could provide a wealth of knowledge as to the uses to which teeth were put in particular concerning diet, masticatory biomechanics, and paramasticatory activities. To this end, he devised two descriptive charts: one which took into account direction of wear; and one that took into account the surface form. Additions were made to Molnar's forms as patterns specific to the group under study were found (Table 4, Table 5). Reference was also made to Molnar's (1971a) figures (Figure 6,7).

The extreme lingual eruption of the lower molars resulted in there being a great deal of wear on the buccal cusps, on lingual to buccal slant, but with the wear of the occlusal surface as a whole running in a buccal to lingual direction. The reverse was true, to a lesser degree in the upper molars.

Figure 6: Orientation of Wear



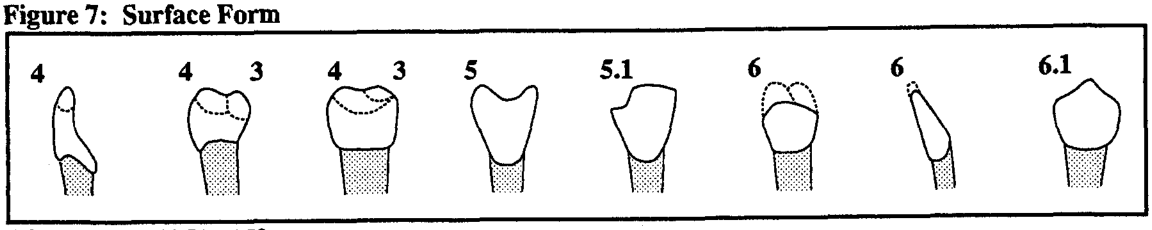
After Molnar 1971a:179.

Table 4: Direction of Occlusal Wear

1.0	Natural form
2.0	Oblique, buccal to lingual
2.1	Oblique, buccal to lingual on the lingual cusps (upper molar wear), little to no wear on the buccal cusp
3.1	Oblique, lingual to buccal on the buccal cusps (lower molar wear), little to no wear on the lingual cusp
4.0	Oblique, mesial to distal
4.1	Oblique, mesio-lingual to disto-buccal
4.11	Oblique, mesio-lingual to disto-buccal on the lingual cusps (upper molar wear), little to no wear on the buccal cusps
4.2	Oblique, mesio-buccal to disto-lingual
4.21	Oblique, mesio-buccal to disto-lingual on the lingual cusps (upper molar wear), little to no wear on the buccal cusps
5.0	Oblique, distal to mesial
5.1	Oblique, disto-lingual to mesio-buccal
5.11	Oblique, disto-lingual to mesio-buccal on the buccal cusps (lower molar wear), little to no wear on the lingual cusps
5.2	Oblique, disto-buccal to mesio-lingual
5.21	Oblique, disto-buccal to mesio-lingual on the buccal cusps (lower molar wear), little to no wear on the lingual cusps
6.0	Horizontal, perpendicular to the long axis of the tooth
7.0	Rounded, buccal - lingual
8.0	Rounded, mesial - distal
8.1	Rounded, buccal-lingual; mesial-distal
9.0	Indeterminate
10.0	Other

(after Molnar 1971a)

Figure 7: Surface Form



After Molnar 1971a:179.

Table 5: Surface Form

1.0	Natural form
1.1	Worn (blunted) natural form
2.0	Flat surface
2.1	Slight semi-circle
3.0	One half of surface cupped
4.0	Entire surface cupped
5.0	Notched
5.1	Notched on tooth corner
6.0	Rounded
6.1	Tooth comes to a point
7.0	Other
9.0	Indeterminable

(After Molnar 1971a)

The wear type "slight semi-circle" (2.1, Table 5) can be distinguished from cupped surface forms by the fact that both the enamel and dentine are depressed, not merely the dentine. The wear type "tooth comes to a point" (6.1, Table 5) was often found on the premolars, probably a result of occlusal factors. Teeth with a notch on the mesial or distal edge (5.1, Table 5) and notched (5, table 5) were grouped together in this analysis.

Interproximal Wear

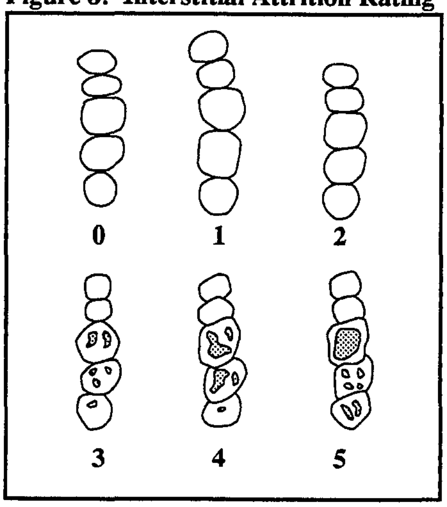
Bearing in mind that to date there is no good method to determine interproximal wear (Jacobson 1982; Patterson 1984), two interproximal wear was assessed as follows: degree of interproximal wear was rated with comparison to photographic standards (Table 6,Figure 8) (Jacobson 1982; Patterson 1984), and the mesial contact shape (Table 7) was recorded. An attempt was also made to assess interproximal wear more quantitatively by measuring the buccal-lingual breadth of the contact points between adjacent teeth (after Hinton 1982 and Kieser at al. 1985). However, this measurement did not seem very reliable, and was abandoned.

Table 6: Interstitial Attrition Rating

0	Absent, normal contact with no flattening of the approximal surfaces
1	Mild, broadening into contact areas with some flattening of the approximal surface
2	Moderate, with wearing of the proximal contours of neighboring teeth
3	Severe, with considerable flattening of the approximal surfaces involving the marginal ridges
4	Extreme, with attrition of the approximal surfaces beyond the marginal ridges with an open S pattern
5	Maximum approximal wear
9	Indeterminable

(Patterson 1984:396 after Jacobson 1982).

Figure 8: Interstitial Attrition Rating



After Patterson 1984:109.

Table 7: Mesial Contact Shape

1	Straight
2	Concave
3	Convex
4	Sinuous

(after Kieser et al. 1985; Whittacker 1986)

Tooth Dimensions

Odontometric measurements allow comparisons in size between populations and sexes. Such measures are of value because they are objective and can validly be used in many statistical calculations (Jacobson 1982). Two measurements were taken, mesiodistal length and buccolingual width. Metric measurements were taken with a Helios needle-tipped dial caliper. The mesiodistal length was taken from the maximum points on the contact between adjacent teeth (Smith 1983). In the anterior teeth this was modified somewhat to the points of a maximum length in a plane parallel to the occlusal plane (Wolpoff 1971). To a degree the mesiodistal length reflects the effects of interproximal wear (Calcagno and Gibson 1991; Smith 1983) as the mesiodistal length will shorten as the tooth wears interproximally.

The buccolingual width is therefore a more accurate, or at least more stable indicator of tooth size (Calcagno and Gibson 1991). Buccolingual width was taken on the maximum width of the tooth perpendicular to the mesiodistal length. In the anterior teeth, the maximum breadth was found at or near the cemento-enamel junction (Jacobson 1982; Smith 1983; Wolpoff 1971). Following Smith (1983), directions were established by tooth morphology, not arch morphology, unless there was a major rotation of the tooth. Such teeth were not measured.

Antemortem Tooth Trauma

Obviously, antemortem tooth trauma is important in an analysis of teeth as tools. Although already looked at by Turner and Cadien (1969) in their study, it was simply scored present/absent for the entire dentition. This study attempted a more specific analysis, looking at the frequency and distribution of teeth so damaged as well as specifying the nature of the antemortem trauma. Teeth were examined under a high intensity light, with the aid of a 10X hand lens.

The criteria set up by Patterson (1984) and Frayer and Russell (1987) were followed in distinguishing antemortem from postmortem trauma. Antemortem trauma was distinguished from postmortem trauma by:

1. presence of dental calculus in the flake scar

2. polishing of the enamel surface and consequent obliteration of microstructural detail in the flake scar

3. blunting, polishing, or rounding of the edges of the flake scar

4. presence of scratching of the facet (Frayer and Russell 1987; Patterson 1984) and

5. presence of staining on both the broken and adjacent intact surfaces (Milner and Larsen 1991).

Some of the postmortem damage was quite obvious. Exfoliating enamel generally dislodges cleanly from the dentine surface, leaving sharp vertical edges and exposing a lighter colored dentine below (Milner and Larsen 1991). Even with this criteria, however, it was sometimes difficult to distinguish between the post and antemortem trauma and a conservative approach was taken. If a mostly rounded chip had one straight edge, it was not included. As well, the long, linear flake running perpendicular to the occlusal surface of the anterior dentition described by Milner (1984a,b) and Milner and Larsen (1991) were not included. Viewing such a flake under the S.E.M. revealed sharp edges and well-defined microstructure, not blurred or obliterated as would be expected by the above criteria. Also, evidence of this postmortem chipping was found on posterior, as well as anterior, teeth.

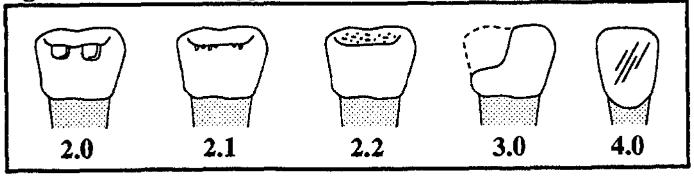
Five types of trauma were recorded: chipping, flaking, crushing or pitting, striations, and fracturing (Table 8, Figure 9). The location of the trauma on the tooth surface was also noted (Table 9). The number of chips and fractures on a tooth was counted but no attempt was made to quantify the flaking, crushing, or striations.

Table 8: Trauma

0.0	Absent
2.0	Chipped: loss of small enamel chips from the margin of the occlusal surfaces of the teeth, greater than or equal to 1 mm in size
2.1	Flakes: loss of small enamel chips from the margin of the occlusal surface of the teeth, less than 1 mm in size
2.2	Crushing or pitting of the occlusal surface
3.0	Fractured: the loss of a substantial portion of the tooth crown
4 .0	Striations across the buccal surfaces of the teeth, generally at an angle to the occlusal surface
5.0	Other types of trauma
9.0	Indeterminate

(after Patterson 1984)

Figure 9: Trauma Type



After Patterson1984:391.

Table 9: Trauma Location

0	Absent
1	Mesial edge
2	Distal edge
3	Lingual edge
4	Buccal edge
5	Mesio-lingual corner
6	Mesio-buccal corner
7	Disto-lingual corner
8	Disto-buccal corner
9	Buccal surface
10	Occlusal surface
11	Other

Grooving

Grooving has been observed in many populations. Its cause has been the subject of a great deal of debate. Grooves have been attributed to attrition, abrasion and erosion (Brown 1991; Brown and Molnar 1990; Schultz 1977; Frayer 1991; Frayer and Russell 1987; Formicola 1991;Ubelaker et al. 1969; Wallace 1974). To a large extent erosion, attrition, and tooth tissue loss due to the suction of grit-laden saliva through the teeth have been discounted as explanatory processes. More accepted mechanisms for the production of grooves include the use of tooth picks as palliative probes, especially when found in association with carious or abscessed teeth, or as a consequence of the processing of some plant fibre or sinew. Currently the formation of grooves as a result of probing the affected area with a toothpick has been questioned (Brown 1991).

Much of the attention paid to grooving has focused on that which occurs interproximally, most commonly in the posterior dentition. However, grooving also occurs on the occlusal surfaces, and grooves located here may be better associated with some sort of fiber processing or with the gripping of materials. In such cases, grooving from toothpick use is only feasible if the toothpick is habitually being clenched in the mouth. Pedersen (1949) and Pedersen and Jakobsen (1989) have observed grooving on female Inuit teeth, a phenomenon they associate with the manufacture of thread from sinew. Groóving was assessed as follows:

0	Absent
1	Shallow Groove
2	Groove
9	Indeterminate

Shallow grooves were scored when a channel or linear depression could be seen, but was not very deep and did not have well defined edges. Indeterminate referred to what were believed to be occlusal plane shifts, which resulted in shallow groove-like depressions into which the opposing teeth fit. Grooves were also scored as to location (Table 10). Where possible the maximum length and breadth of the groove was measured. The direction of the groove, moving from smallest to largest breadth was also recorded (Table 11).

Table 10: Location of Groove

1.0	Coronal: mesial side
1.1	Coronal: distal side
1.2	Coronal: buccal side
1.3	Coronal: lingual side
2.0	Cemento-enamel junction: mesial side
2.1	Cemento-enamel junction: distal side
2.2	Cemento-enamel junction: buccal side
2.3	Cemento-enamel junction: lingual side
3.0	Root: mesial side
3.1	Root: distal side
3.2	Root: buccal side
3.3	Root: lingual side
4.0	Occlusal surface: mesial half
4.0a	Occlusal surface: mesial edge
4.1	Occlusal surface: distal half
4.1a	Occlusal surface: distal edge
4.2	Occlusal surface: lingual half
4.3	Occlusal surface: buccal half
4.4	Midline: buccal-lingual
4.5	Midline: mesial-distal
5.0	Other
9.0	Indeterminate

Table 11: Grooving Direction

1.0	Mesial-distal (even)
1.1	Mesial-distal
1.2	Distal-mesial
2.0	Buccal-lingual (even)
2.1	Buccal-lingual
2.3	Lingual-buccal
3.1	Mesio-lingual - Disto-buccal (even)
3.2	Mesio-lingual - Disto-buccal
3.3	Disto-lingual - Mesio-lingual
4.1	Mesio-distal - Disto-buccal (even)
4.2	Mesio-distal - Disto-buccal
4.3	Disto-buccal - Mesio-distal
5.0	Other
9.0	Indeterminate

Pathology

Pathology was scored to assess the relative health of the tooth, and the effect any lack of health could have had on the wear. Both abscessing and periodontal disease were looked for. Caries occurred so rarely, that they were only noted in the comments.

Alveolar abscessing was scored as to its presence or absence (Table 12) and its location (Table 13). At times postmortem destruction made assessment difficult, and abscessing could only be suspected. No attempt was made to assess abscess etiology.

Table 12: Alveolar Abscessing

0	Absent
1	Present
9	Indeterminate

Table 13: Alveolar Abscessing: Location

0	Absent
1	Facial
2	Lingual
3	Both facial and lingual
4	Apical
5a	Interproximal, distal side of the tooth
5b	Interproximal, mesial side of the tooth

Recent research indicates that much of what was previously thought to be alveolar resorption due to periodontal disease may actually be continuous tooth eruption. Thus this category should be treated with caution (Clarke 1990; Clarke and Hirsch 1991; Watson 1986; Whittaker 1986) . It is difficult to assess periodontal disease from the appearance of the bone. Clarke (1990) and Clarke and Hirsch (1991) claim that periodontal disease has been over diagnosed, and is not as prevalent as has been claimed. Therefore

> [loss] of horizontal bone should be diagnosed only when the crestal bone has an altered morphological shape and/ or resorption of the cortical plate to reveal the underlying or porous cancellous structure. ... the Cement Enamel Junction - Alveolar Crest Distance should not be used as a criterion in the assessment of the prevalence of periodontal disease (Clarke 1990:372).

Periodontal disease was therefore scored very broadly, relying for the most part on the porosity of the alveolar bone. Periodontal disease was scored as to its presence or absence (Table 14), and its degree (Table 15).

Table 14: Periodontal Disease	
0	Absent, no obvious signs of periodontal disease present
1	Present
9	Indeterminate

(Patterson 1984)

Table 15: Periodontal Disease - Degree (Inflammation of the Interproximal Septum)	
0	Absent
1	Small amount of inflammation, with pitting of the surface
2	Extensive inflammation, with the surface looking like pumice stone
9	Indeterminate

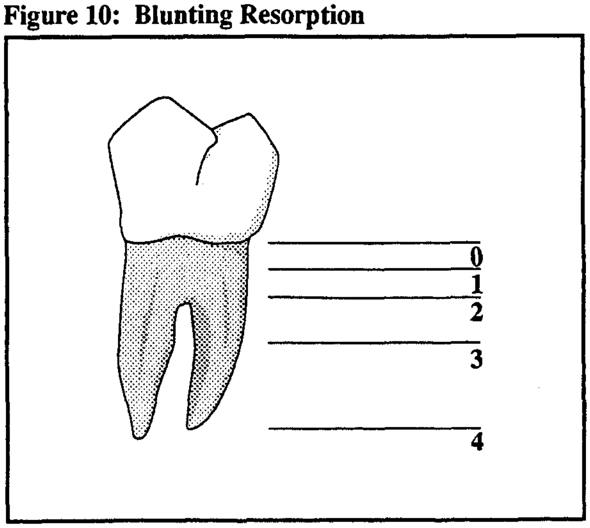
(Patterson 1984)

Again, scoring the blunting resorption may be a measure either of continuous tooth eruption, or of alveolar resorption. As continuous eruption is thought to occur in people who place a great deal of pressure on their teeth, and have a high degree of wear, one might expect to find this in Inuit populations. However, if the 'resorption' is accompanied by extensive inflammation, it is more likely to be due to periodontal disease (Table 16, Figure 10).

Table 16: Blunting Resorption	
0	Minimal alveolar crest atrophy involving bone loss which exposes less than 2 mm of root surface
1	Atrophy of alveolar crest bone involving exposure of the root from just below the margin to exposure of about one third the length of the root
2	Moderate amount of alveolar crest atrophy involving bone loss which exposes up to half the length of the roots in the molar region, there is exposure of the root bifurcation
3	Large amount of alveolar crest atrophy involving exposure of more than half the length of the tooth to almost complete loss of bone around the root
4	Complete loss of the tooth due to periodontal disease
5	Indeterminate

(Patterson 1984)

Figure 10: Blunting Resorption



After Patterson 1984:384.

Arch Dimensions

The following measurements were taken of the masticatory support structure: arch breadth, arch depth, and palatal length, bread, and depth. Measurements were taken directly on the teeth and skulls with Helios needlepoint calipers, Matui vernier calipers and coordinate calipers.

When the necessary teeth were present, several arch breadths and depths were taken. Arch breadths were taken at the points of greatest breadth on the buccal surfaces of the first, second and third molars, and the point of greatest breadth on the lingual surface of the first molar. Arch depths were taken from the labial surface of the central incisors to a line tangential to the distal surface of the first, second and third molars, perpendicular to the occlusal plane.

Palate length was measured from the craniofacial points orale and staphylion. Palatal breadth was measured from endomolar to endomolar. Palatal height was measured with the coordinate caliper. It was assessed as the height of a line between the endomolaria, in the median plane of the palate (Jacobson 1982).

Arch Shape

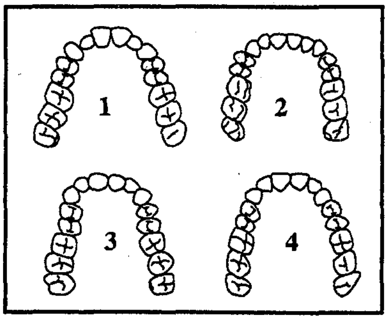
Arch shape was determined subjectively, with reference to diagrams and photographs found in Molnar and Molnar (1990) and Jacobson (1982). At least one tooth arcade needs to be present in order to classify the shape with any degree of reliability, a criterion the sampled teeth could rarely meet. However, due to the differences in wear pattern that Molnar and Molnar (1990) were able to attribute to arch shape, shape categorization was attempted where possible (Table 17, Table 18). Arch shape was assessed by reference to pictorial standards (Figures 11,12).

Table 17: Arch Shape Molnar and Molnar (1990)

1	hyperbolic (shape A): diverging tooth rows (.59 to .68 canine/molar diameter ratio)
2	parabolic (shape B): the tooth rows are less divergent (.69 to .72 canine/molar diameter ratio. [Maxilla at either end of this range are difficult to distinguish from shapes A or C, and are defined as intermediates: A/B or B/C. The divisions for this are arbitrary.]
3	hypsiloid (shape C): the post-canine tooth rows are nearly parallel and form a 'U' shaped palate (.73 to .80 canine/molar diameter ratio)
4	ellipsoidal (shape D): convergent rows in the posterior molar region

Molnar and Molnar (1990) considered all mandibles to be parabolic (after Boyd as cited Molnar and Molnar 1990).

Figure 11: Molnar and Molnar's Arch Shapes



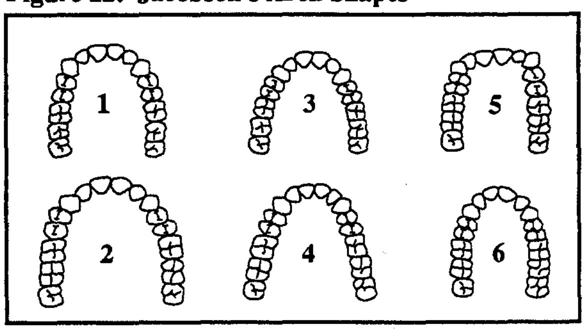
After Molnar and Molnar 1990:

Table 18: Arch Shape Jacobson (1982)

1	Ovoid - resembling half an oval
2	Hyperbolic - a relatively broad arch, the arms of which, from M1 backwards, are parallel or very slightly divergent.
3	Parabolic - the arms of the arch diverge, but somewhat less than in the hyperbolic type of arch.
4	Divergent - the arms are distinctly divergent.
5	Flattened anteriorly - various shaped arches which have a distinct flattened anterior segment
6	Very Narrow - particularly narrow arches of various shapes
7	Asymmetric and unclassifiable

Jacobson (1982) categorized both mandible and maxillae by these categories.

Figure 12: Jacobson's Arch Shapes



After Jacobson 1982:66.

Occlusal Variables

An attempt was made to score occlusal variation, however, the sample was less than adequate for this task. Even when there were enough teeth to attempt an occlusal assessment, generally more than one "goodness of fit" could be found. This is a problem many researchers have run across (Molnar and Molnar 1990). Of a sample of 460 skulls, Jacobson (1982) could

> Class I: The mandibular dental arch and body of the mandible are in normal mesiodistal relation to the maxillary arch. The mesiobuccal cusp of the maxillary permanent first molar occludes in the buccal groove of the mandibular permanent first molar when the teeth are approximated in centric occlusion. In the event of teeth in either or both jaws being irregular, the condition is designated as Angle Class I occlusion.
>
> Class II: In this group the lower dental arch and the body of the mandible is in a distal or posterior relation to the upper dental arch as reflected by the first permanent molar relationship. The mesiobuccal cusp of the maxillary first molar occludes in the space between the mesiobuccal cusp of the mandibular molar and the distal aspect of the buccal cusp of the second premolar.
>
> Class III: In this category the mandibular dental arch and body of the mandible are in bi-lateral mesial relationship to the maxillary arch. The mesiobuccal cusp of the maxillary permanent first molar occludes in the interdental space between the distal aspect of the distal cusp of the mandibular permanent first molars and the mesial aspect of the mesial cusps of the second mandibular permanent molars (Jacobson: 1982:15-17).

Occlusal type was also categorized as to whether it was unknown, overbite, overjet, overbite and overjet, edge-to-edge, underbite, cross-bite, open bite or other. Overjet refers to occlusions in which the upper incisors extend out past the lower incisors. Overbite refers to an occlusion in which the upper incisors extend down over the lower incisors, covering their labial surfaces to some extent. Edge-to-edge bite occurs when the occlusal surfaces of the central incisors meet and underbite when the lower incisors extend past the upper incisors. Cross-bite is an occlusion in which the individual is not able to achieve a symmetric occlusion so that she is unable to occlude upper and lower molar cusps bilaterally in one or more positions along the post canine tooth rows. Often these individuals have extremely narrow mandible to maxillary breadths (Molnar and Molnar 1990). This occlusion is thought to be "an efficient adaptation to masticatory function involving wide, powerful crushing and grinding strokes accompanied by progressive tooth attrition"(Brown et al. 1990:254). Open bite occurs when the central incisors do not meet.

Overbite was also qualitatively assessed as to whether it was edge-to-edge and the degree to which the upper incisors overlapped the lower incisors by one quarter, one third or one half or more (Jacobson 1982).

Mesial and distal steps were also measured to assess the relative positions of the maxillary and mandibular first molars. Mesial step refers to the phenomenon when the mandibular first molar was mesial to the maxillary molar. Distal step occurred when the maxillary first molar was mesial to the mandibular first molar. When the occlusion has a best fit, it is aligned along the sagittal plane, and the distance to which these molars are mesial is measured (see Smith 1983).

Occlusion, or the possible interaction of the upper and lower tooth rows was also assessed when strange wear patterns were found on the teeth. Abrupt plane changes on a tooth, for example, could often be explained as the result of wear from the opposing dentition. This prevented me from assuming such a pattern could be due to a localized paramasticatory use. The dentition would be placed in such a way as to account for the pattern, and the resulting 'occlusion' and positioning of the temporomandibular joint recorded.

Temporomandibular Joint Morphology

It has been found that rapid anterior tooth wear is associated with a flattening of the articular eminences and the flattening or cavitation of the mandibular condyles. Rapid posterior tooth wear is associated with a convex condylar shape (Richards 1987).

Although shape of the temporomandibular joint was not assessed in this study, the following measurements were used to describe temporomandibular joint morphology:

1. Maximum mediolateral dimension of the mandibular condyle: recorded parallel to the long axis

2. Maximum anterio-posterior dimension: measured with the beaks of the calipers perpendicular to the long axis of the condyle

Pathological changes were also noted, and scored broadly (Table 19).

Table 19: Temporomandibular Joint Pathology

0	No pathological change
1	Mild - erosive or proliferative changes affect less than half the joint surface
2	Severe - erosive or proliferative changes affect more than half the joint surface

Other Observations

The dentition was drawn and photographed to provide a visual check and reminder of the observations. Photographs were taken of the upper and lower occlusal rows and, when possible, with the teeth in occlusion. Lighting was provided by photo flood lamps set up at a forty-five degree angle to the crania. This light was filtered through a vellum light diffuser. Photographs of the occlusal surfaces of the upper and lower dental arcades were taken with a Pentax Spotmatic 500 camera using 50 macro lens, at a distance of 34 cm from the camera focal point. A level was used to ensure the tooth surfaces were on a perpendicular plane relative to the camera lens.

Photographs of the teeth in occlusion were taken at two distances. At a distance of 55 cm between the specimen and the film the entire skull (or cranium or mandible) was photographed in front and side views. At a distance of 20 cm between the specimen and the film a close up of the dentition in front and side views was taken. Any unusual features in a dentition, including notches or grooves were also photographed at this time. Both black and white photographs (Ilford Pan F 50) and colour slides (Ectachrome 160 Tungstun) were taken.

Any peculiarities in wear degree and pattern were noted in the comments for each individual.

CHAPTER FIVE: ANALYSIS

Introduction

The analysis began with a series of expectations. To reiterate the propositions put forward in chapter one it was thought that:

1. The women's extensive use of their teeth to soften skins might be expected to result in a greater degree of tooth wear, especially along the anterior dentition, and possibly back along some of the posterior teeth.

2. The women's practice of softening skins might further result in greater incidence of labial rounding of the dentition, particularly the lower anterior teeth (see Lous 1970; Pedersen and Jakobsen 1989).

3. The women's task of sinew preparation may result in the occurrence of more grooving patterns, in a mesial-distal direction along the tooth row (see Lous 1970; Pedersen and Jakobsen 1989).

4. The men's use of their teeth in a greater variety of vise-grip tasks might result in greater incidence of antemortem tooth trauma, in particular along the buccal surfaces of the anterior teeth.

5. The male variety of vise-grip tasks may also result in more occurrences of notched teeth in the anterior dentition (Blakely and Beck 1984; Milner and Larsen 1991).

6. The men's use of the bow drill may result in a greater incidence of anterior teeth with labial abrasive patterns (Lukacs and Pastor 1988).

Tooth Loss as a Problem

As is the case in all archaeological investigations, the sample is derived from an undefined population and is skewed by a number of factors including the disposition of the remains; taphonomic problems acting upon the materials as well as biases resulting from recovery, analysis and storage (Hillson 1986). Tooth loss, both antemortem and postmortem is a problem in this analysis. The antemortem tooth loss in the Sadlermiut is high compared to other populations. Merbs (1968, 1983) found that on average as many as 2.82 anterior teeth in females and 1.95 anterior teeth in males were lost during life. This is frequent even by Inuit standards; the overall incisor loss of the Sadlermiut was 22% while the incisor loss in the compared Paleo-Aleut collection was only 16%. Furthermore, as Merbs (1983) has noted, postmortem tooth loss occurred during interment either when small animals disturbed or ran off with the remains or in the recovery of the material itself, when the loose teeth slipped between the cobbled pavement. Some loss has occurred in storage as evinced by the unmistakable signs of glue within some sockets, but no tooth.

These problems are a common occurrence in Inuit materials. Partly they are a result of the very phenomena I wish to investigate. Some have suggested that the shortened roots of the anterior dentition are a reflection of the high forces placed on them in diet and paramasticatory activities which allow the teeth to slip from their sockets and be lost more easily, both pre- and postmortem (Merbs 1968; Hylander 1972, 1977; Pedersen 1949).

In Mayhall's (1979) study of tooth morphology and biological relatedness only 54 out of a total of 497 individuals had complete dentitions. The majority of these (45) belonged to the group of Inuit living at the time in the Foxe Bay area. By contrast the skeletal sample, consisting of 274 individuals had only nine complete dentition (Table 20).

Table 20: Mayhall's Sample

Population	Sex	Examined	Complete Dentitions	%
Igloolik	M	243	24	9.8
(living)	F	229	21	9.1
Hall Beach	M	87	5	5.7
(living)	F	81	4	4.9
Thule	M	109	0	0.0
(skeletal)	F	127	0	0.0
Sadlermiut	M	22	0	0.0
(skeletal)	F	19	0	0.0

(Mayhall 1979:454)

Although the nine complete skeletal dentitions belonged to the Thule sample and not the Sadlermiut sample, the Thule sample suffered greater tooth loss proportionately. Furthermore, the Thule sample did not derive from a single site, rather it was an accumulation of materials from several locales. Therefore although the collection falls well enough within a single cultural group and time frame it does so less fully than the Sadlermiut collection.

Pedersen's (1938, 1947, 1949) studies of Inuit tooth morphology and wear are a basic work in the field. Commonly cited and oft compared, most researchers relate their results to some of his findings (Hylander 1972, 1977; Merbs 1983). However, in a collection of 531 crania of which 24 were children, Pedersen had only 156 deciduous teeth and 7,606 permanent teeth. The dental situation can be summarized in the following table (Table 21).

Table 21: Pedersen's Sample

Number	Element	Average Permanent Teeth Per Jaw
390	Skull	12.3
102	Crania	5.5
1	Maxilla	8.0
26	Mandible	8.4
3	Fragments	4.3

(after Pedersen 1938, 1947)

In short, 59.8% of the permanent erupted teeth had been lost. Of this number 86.1% had been lost postmortem. Pedersen commented that antemortem loss occurred most often in the posterior dentition while postmortem loss occurred most often in the anterior dentition. In a later study of 52 crania Pedersen (1949) found that 60.5% of the permanent teeth present at death had been lost postmortem. Again, the greatest postmortem loss was in the anterior teeth, in particular the upper central incisor. To quote Pedersen (1949:68):

> A more considerable drawback to the study of the East Greenland dentition than disintegration, is the considerable postmortem loss of teeth. As will be shown later on, the Eskimo teeth generally have short roots, particularly when reaching mature age. Their roots are usually straight and only slightly divergent. These conditions together with the Eskimo customs of burial, result in the frequent tendency for the teeth, - especially the anterior teeth -, to fall out of the skulls in the graves.

The Sample

In this sample, tooth status has been summarized in Table 22. These figures were obtained by determining the proportions of teeth in each of the column categories for each individual, summing the results and dividing by the number of individuals to obtain the average amount of teeth in occlusion, lost ante- and postmortem and in the case of the subadults, erupting or visible in the tooth crypt. Unerupted teeth are not included in this table as I did not X-ray the jaws and so cannot accurately say whether or not teeth are unerupted or just not there.

Table 22: Tooth Status

Category	Crypt	Erupting	Occlusal	Post. Loss	Ante. Loss	?
Female						
Skull (n=24)	0	0	15	11	5	1
Maxilla	0	0	7	6	2	0
Mandible	0	0	8	5	3	1
Crania (n= 5)	0	0	5	9	2	0
Mandible (n= 1)	0	0	10	3	3	0
Male						
Skull (n=26)	0	0	17	8	6	1
Maxilla	0	0	10	4	2	0
Mandible	0	0	7	4	4	0
Crania (n=3)	0	0	7	5	4	1
Mandible (n=3)	0	0	7	7	2	0
Adult (Sex and Age Unknown)						
Skull (n=5)	0	0	11	17	3	1
Maxilla	0	0	5	9	1	1
Mandible	0	0	6	8	2	0
Mandible (n=1)	2	0	11	3	0	0
Subadult (Mixed Dentition)						
Skull (n=10)	2	1	15	14	0	0
Maxilla	1	1	7	7	0	0
Mandible	1	0	8	7	0	0
Crania (n=1)	0	0	15	1	0	0
Mandible (n=2)	3	1	5	7	0	0

On average the women retained 15 teeth out of the full dental arcade of 32. Of these, seven were in the maxilla and eight in the mandible. There is slightly greater postmortem loss in the maxilla than in the mandible. This is especially apparent when looking at women for whom only the cranium was recovered. Men retained slightly more teeth with more teeth present in the maxilla than the mandible, Postmortem loss was equal between the two tooth rows. In men for whom only a cranium or a mandible was recovered, more teeth were lost postmortem in the mandible. Overall, women lost slightly more teeth postmortem, men slightly more antemortem. Adults of undetermined sex and age lost the most teeth postmortem. Subadults retained an average of 15 teeth, a mixture of permanent and deciduous dentitions in most cases. For the sample as a whole, a total of 1,083 teeth were examined, 1,043 of which were permanent teeth and 40 of which were deciduous. Therefore 50.5% of the permanent teeth were present.

The bulk of the analysis focused on the adult females and males. Where applicable, observations made on the subadult dentitions and on those adults for whom a definite sex and age could not be ascertained will be related to the findings of the adult females and males.

Methods of Analysis

Due to the effects of post and antemortem loss, much of the statistical analysis of the sample is more appropriately used descriptively, rather than inferentially. Furthermore, as referred to briefly in Chapter Four, the analysis is on two levels, that of the individual and that of the tooth. This is somewhat problematic because although the teeth and to a lesser degree the supporting masticatory apparatus were the focus of the study, the primary interest of the investigation was the differences between individuals. In particular the differences between women and men due to the use of their teeth as tools in gender specific ways.

To indiscriminately lump the teeth into left versus right, upper versus lower and anterior versus posterior groups was not a legitimate method of comparing individuals. Teeth grouped in this manner cannot be considered independent and their further use in any sort of statistical comparison becomes questionable. Such pooled categories of teeth may contain more than one tooth from the same individual, and none from another. Teeth from the same tooth row are not independent. Single tooth to tooth comparisons could be made because in this case, each tooth represented a separate individual, and the units of comparison were independent However, this is a very fine level of comparison, and the small sample sizes involved could inhibit the detection of any female/male differences.

As a result, I returned to the data for the individual and divided the mouth into eight sections: upper right posterior (P2-M3); upper right anterior (I1-P1); upper left anterior (I1-P1); upper left posterior (P2-M3); lower right posterior (P2-M3); lower right anterior (I1-P1); lower left anterior (I1-P1); and lower left posterior (P2-M3). The total number of teeth present in each section were divided into the number of teeth exhibiting whichever of the particular traits I was investigating to obtain a proportion of affected teeth. For example, in the analysis of trauma, I would divide the teeth present exhibiting trauma by the total number of teeth present to get a proportion of traumatized teeth. These proportions became the basis for the comparisons between the individuals. Due to the failure to find statistical differences between the age and health structures of the adult females and males (see Tables 23 and 24), I was able to compare all the females to all the males. This kept the sample size as large as possible. Earlier comparisons involving a separation of the females and males into older (ages 31-45) and younger (ages 18-30) groups and including or excluding individuals with extremely pathological dentition in a series of Student's t-test and chi-squares resulted in few statistically significant differences. Any differences found in such a manner could simply be the result of chance due to the number of comparisons being made.

Table 23: Age Comparison

Sex	Count	Mean	Std. Dev.	Std. Error	D.F.	Unpaired t-value	Probability (2-tailed)
F	27*	30.7	6.349	1.222			
					52	0.9660	0.3385
M	27*	28.9	7.415	1.427			

*Numbers are lower than the sample as a whole as some individuals could be aged only as "young" or "old" adults.

Table 24: Health Comparison

Sex	Healthy	Moderate Pathology	Pathological	Extremely Pathological
F	7	10	6	7
M	4	13	7	8

Chi-square p=0.7315

Overall oral health between females and males in this sample was not significantly different, so a comparison of all individuals, even those with extreme pathologies, should not be skewed by these pathologies from one sex to the other.

Analysis of variance with nested factors was used to assess gender differences as well as regions of the mouth for each variable in the study. Assumptions for the ANOVA with nested factors is the multinormality of the vector of observations and the circularity of the variance-covariance matrix. The ANOVA table for each variable can be diagrammed as follows (Winer et al. 1991):

SOURCES OF VARIATION	
Between Individuals	DF
Sex	1
Error (Sex)	60
Within Individuals	
Right/Left	1
Upper/Lower	1
Anterior/Posterior	1
Sex*Right/Left	1
Sex*Upper/Lower	1
Sex*Anterior/Posterior	1
Right/Left*Upper/Lower	1
Right/Left*Anterior/Posterior	1
Upper/Lower*Anterior/Posterior	1
Sex*Right/Left*Upper/Lower	1
Sex*Right/Left*Anterior/Posterior	1
Sex*Upper/Lower*Anterior/Posterior	1
Right/Left*Upper/Lower*Anterior/Posterior	1
Sex*Right/Left*Upper/Lower*Anterior/Posterior	1
Error (Within)	N*-76

*Where N equals the number of observations, different for each variable.

Comparisons between a factor, such as between the upper and lower parts of the mouth, are identical to Student's t-tests. Here the hypotheses are set up as follows:

$$Ho: u_1 = u_2;$$

$$Ha: u_1 \neq u_2.$$

However, if I had some expectations as to the expression of a trait in which a directional hypothesis was used:

$$Ho: u_1 \leq u_2 \text{ or } Ho: u_1 \geq u_2;$$

$$Ha: u_1 > u_2 \text{ or } Ha: u_1 < u_2, \text{ where}$$

u_1 is the mean of the dependent variable in the upper part of the mouth, and
u_2 is the mean of the dependent variable in the lower part of the mouth.

In comparisons of the interactions between, for example, sex and anterior and posterior wear, hypothesis are set up in this manner:

$$Ho: u_1 = u_2$$

$$Ha: u_1 \neq u_2$$

or again, in a directional comparison

$$Ho: u_1 \leq u_2 \text{ or } Ho: u_1 \geq u_2$$

$$Ha: u_1 > u_2 \text{ or } Ha: u_1 < u_2.$$

In this case, u_1 = the difference between the means of the female anterior and posterior wear (u_{11}-u_{12}) or the difference between the female and male anterior wear means (u_{11}-u_{21}); and

u_2 = the difference between the means of the male anterior and posterior wear (u_{21}-u_{22}) or the difference between the female and male posterior wear means (u_{12}-u_{22}) when:

	A	P
F	u_{11}	u_{12}
M	u_{21}	u_{22}

Comparisons of the interactions between three factors, for example between the right and left sides of the mouth, the upper and lower jaws and the anterior and posterior halves, are dealt with as follows:

$$Ho: u_L = u_R$$

$$Ha: u_L \neq u_R$$

or, in the case of directional hypothesis:

$$Ho: u_L \leq u_R \text{ or } Ho: u_L \geq u_R$$

$$Ha: u_L > u_R \text{ or } Ha: u_L < u_R.$$

In this instance, $u_L = u_{L1} - u_{L2}$,
where u_{L1} is the difference between the means of the left upper anterior and upper posterior mouth parts ($u_{L11} - u_{L12}$) or the difference between the means of the left anterior upper and anterior lower mouthparts ($u_{L11} - u_{L21}$) and,

u_{L2} is the difference between the means of the left lower anterior and posterior mouth parts ($u_{L21} - u_{L22}$) or the difference between the means of the left posterior upper and lower mouth parts ($u_{L12} - u_{L22}$).

Concomitantly, $u_R = u_{R1} - u_{R2}$
where u_{R1} is the difference between the means of the right upper anterior and upper posterior mouth parts ($u_{R11} - u_{R12}$) or the difference between the means of the right anterior upper and anterior lower mouthparts ($u_{R11} - u_{R21}$) and,

u_{R2} = the difference between the means of the right lower anterior and posterior mouth parts ($u_{R21} - u_{R22}$) or the difference between the means of the right posterior upper and lower mouth parts ($u_{R12} - u_{R22}$), when

LEFT

	A	P
U	u_{L11}	u_{L12}
L	u_{L21}	u_{L22}

RIGHT

	A	P
U	u_{R11}	u_{R12}
L	u_{R21}	u_{R22}

The teeth had been studied without prior knowledge of the individual's age and sex in an attempt to control for unconscious bias. In other words, to avoid seeing what I expected to see. Statistical analyses were carried out on a MacClassic using Stat View 512+ and by the Statistical Consulting Service at Simon Fraser University using the SAS system.

One basic assumption of this study was that there is no significant difference in diet between women and men. Therefore, one can argue that any difference in tooth tissue loss is due to the other uses to which the teeth are put.

Replicability Study

Approximately ten months after the original study, nine individuals re-examined for tooth status, wear stage, crown height, mesio-distal length, bucco-lingual width, ante- or postmortem loss, and the presence or absence of notching, labial rounding, chipping, flaking, pitting, buccal striations, fracturing, grooving and abscessing. Nine individuals constitute 11.1% of the sample, while the 177 teeth examined constitute 16.3% of the total teeth. Replicability for the presence or absence of the trauma, grooving, abscessing, post and antemortem loss and notched or labially rounded teeth was analyzed fairly simply: the number of errors or differences were divided by the total number of observations. The resulting ratio was converted into a percentage (Patterson 1984).

Tooth status was scored the same 100% of the time, as was post and antemortem loss and the presence or absence of abscessing. Tooth wear was scored to the same degree 87.2% of the time, 15.6% of the time it was scored higher the second time, and 8.4% of the time it was scored lower. This is comparable to that of Smith (1983). At no time was a difference of over one wear stage recorded. Notching was scored the same 97.0 % of the time, chipping 97.6%, flaking 90.6%, pitting 77.1%, buccal striations 98.2% and grooving 98.2% of the time. Pitting was consistently scored more often in the second analysis; it would appear that I was less stringent in what I perceived as pitting the second time around. It should also be noted that the replicability estimates here are likely a bit high, as just by chance one would be expected to score a certain percentage of the phenomenon the same.

Measurement error for crown height, mesio-distal length and bucco-lingual width was also assessed simply, the differences between the repeated measurements were squared and then summed. This total was subsequently divided by the number of double determinations minus one, multiplied by two. It has been suggested that this "accidental error" only reaches significance when it is higher than 1.96, or the 0.05 level of significance (Patterson 1984:124). Measurement error was 0.011 for crown height, and 0.001 for both mesio-distal width and bucco-lingual length.

Comparison of Tooth Wear

Before performing a nested anova for wear, the tooth tissue loss for each mouth section in an individual was averaged. This average was entered into the analysis. Although wear was assessed by an ordinal scale, the fineness of this scale was judged to be sufficient to use interval level statistics. Significant differences were found in the total sample between the anterior and posterior wear, and nearly significant differences were found between upper and lower wear. Unsurprisingly, given all that is known of Inuit activities, anterior wear was significantly greater than posterior wear (Table 25). There is also some indication that lower wear was greater than upper wear, although a significant value was not reached (Table 26).

Table 25: Wear Comparison - AP

Dependent variable: wear

Source	D.F.	Type III SS	Mean Square	F Value	Probability
AP	1	66.078	66.078	106.76	0.0001

where:

Mouth Section	Count	Mean	Std. Dev.
Anterior	168	3.733	1.369
Posterior	165	2.745	1.089

Table 26: Wear Comparison - UL

Dependent variable: wear

Source	D.F.	Type III SS	Mean Square	F Value	Probability
UL	1	2.116	2.116	3.42	0.0656

where:

Mouth Section	Count	Mean	Std. Dev.
Upper	167	3.114	1.247
Lower	166	3.374	1.403

Single tooth-to-tooth comparisons of wear support these findings. Tooth wear was compared within each sex to assess possible left/right and maxillary/mandibular differences. None were found. Following this, the degree of tooth tissue loss for each tooth was compared between the sexes. Although statistically significant differences in wear were not discovered, it was found that the wear progressed in a characteristic pattern for the sample as a whole. Wear was highest on the central incisors, and decreased toward the premolars. It then increased on the first molars, although not to the heights reached in the central incisor, and declined again down to the third molars (Table 27, Figure 13). Wear was also seen to be heavier in the mandibular dentition and there was a suggestion that for the sample as a whole, wear was heavier on the left side of the mouth. Overall, male wear was slightly greater than female wear.

One interesting difference between the women and men occurs in the gradient between the lower central and lateral incisors. This gradient is much less abrupt in the male mandibles, due to the greater wear on the lateral incisors. It is possible that this relates to men's use of the bow drill when the gripping of the mouthpiece could create more even wear in the lower central incisors. However, this should logically have the same effect on the upper lateral incisors as well, which does not seem to be the case.

The higher anterior wear in this sample is common in hunter-gatherer groups in comparison to agriculturalists. Posterior wear is thought to reflect the demands of food mastication, while anterior wear reflects a variety of use from holding, tearing and cutting food to their use as tools (Hinton 1981a; Smith 1983).

Table 27: Wear Scores

	Female						Male					
	Left			Right			Left			Right		
	n	X	s.d.	n	X	s.d.	n	X	s.d	n	X	s.d.
Maxilla												
I1	6	4.6	0.9	5	4.0	0.9	9	4.4	1.0	8	4.0	1.0
I2	6	3.3	1.4	5	3.4	1.6	11	3.4	1.1	8	3.3	1.2
C	12	4.0	1.3	12	3.2	0.9	15	3.3	1.3	15	3.4	1.8
P3	8	3.2	1.0	8	2.6	0.7	15	2.6	0.7	12	2.7	1.2
P4	11	2.4	0.5	12	2.2	0.5	13	2.3	1.4	14	3.0	1.2
M1	15	2.8	1.1	15	2.9	1.2	16	3.1	1.5	17	3.4	1.6
M2	12	2.5	1.0	11	2.7	1.2	10	3.0	1.2	13	2.8	1.1
M3	8	2.0	0.5	7	1.6	0.7	8	1.9	1.4	8	2.0	1.9
Mandible												
I1	6	5.4	2.0	7	4.2	1.2	12	4.8	2.0	9	4.1	1.5
I2	10	3.5	1.2	9	3.8	1.5	13	4.6	1.8	12	3.8	1.5
C	12	3.6	1.4	11	3.4	1.4	12	3.7	1.4	17	3.6	1.4
P3	14	2.7	0.7	12	2.8	0.7	14	2.9	1.2	15	2.8	1.2
P4	9	2.3	0.5	11	2.2	0.7	14	2.6	1.3	16	2.6	1.2
M1	14	3.0	1.2	15	2.8	0.9	16	3.4	1.3	16	3.0	0.7
M2	11	2.3	0.6	12	2.2	0.4	16	2.7	1.6	13	2.3	0.6
M3	7	1.7	0.8	8	1.7	0.7	11	2.4	1.8	11	2.2	1.9

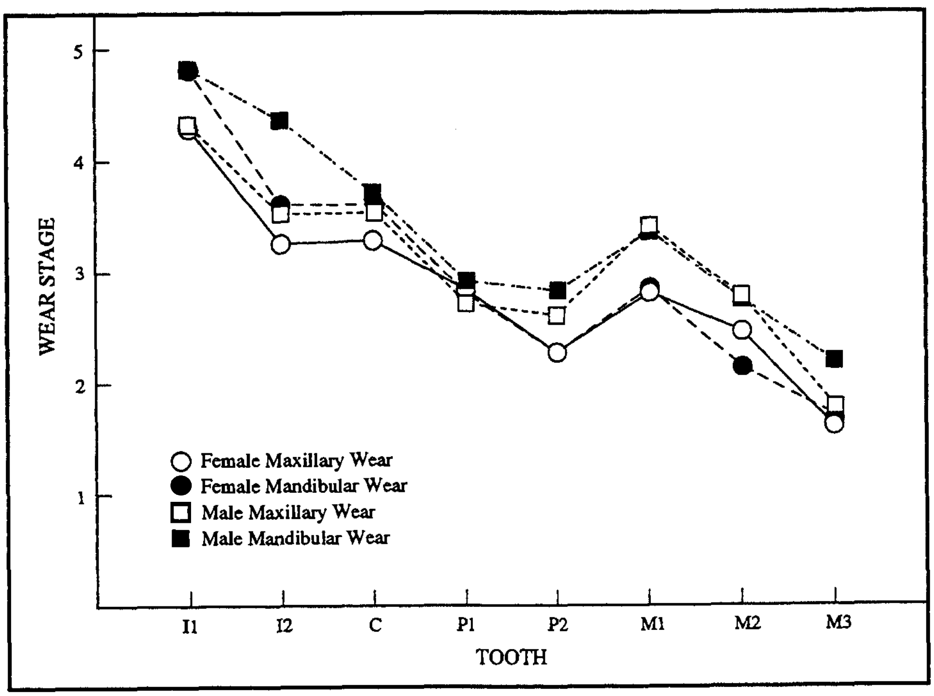


Figure 13: Wear Progression

For differences between sex, it was thought that females would exhibit a greater degree of wear in the anterior section of the mouth compared to the posterior sections than the males, due to their skin softening tasks (de Poncins 1941, 1949; Lous 1970; Hansen et al. 1990; Inuktitut 1986;

Merbs 1983; Nansen 1894; Stone 1990). In this case, the difference only neared significance (p = 0.0799) (Table 28).

Table 28: Wear Comparison - FM*AP

Dependent variable: wear

Source	D.F.	Type III SS	Mean Square	F Value	Probability
Sex*AP	1	1.230	1.230	1.99	0.0779

where:

		Mouth Part					
		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Sex	F	82	3.750	1.403	83	2.622	0.901
	M	86	3.715	1.344	82	2.870	1.244

It can be seen that the difference between female anterior and posterior wear is larger than the difference between male anterior and posterior wear (1.128 to 0.845). On average female and male teeth are worn to basically the same degree in the anterior section. Also the sample as a whole experiences greater wear in the anterior portion of the mouth. However, males seem to be wearing their teeth more evenly along the row. The anterior-posterior interaction is greater in the females. This would indicate a greater relative use of the anterior dentition in the females as compared to the males.

The above is further supported by a comparison of the I1-M1 gradient. Both teeth erupt at approximately the same time giving them a comparable functional age. Both are key teeth in the anterior and posterior dentition (Collier 1982).

In this analysis only individuals with at least one central incisor and one first molar along the tooth row were compared. In all but two cases, the central incisors and first molars were from the same side. The molar wear was subtracted from the incisor wear. If more than one gradient could be taken for an individual, an average gradient was calculated (Table 29). A possible complication affecting this analysis is the fact that not all individuals included had both maxillas and mandibles. Some had both, some only one or the other of the elements. Thus the 'n' in the tables refers to the number of the jaws (Collier 1982). Table 30 further summarizes the data.

A simple reading of Tables 29 and 30 reveal some points of interest. Only males (XIV-C:756, XIV-C:111) exhibit negative gradients, in which the first molar wear is greater than that found on the central incisors. Left and right gradients were fairly homogeneous, but in four cases there was a difference of at least 1.0 wear stage between the mandible and maxilla. In three instances there was a higher gradient in the mandible (XIV-C: 762, XIV-C:756, XIV-C:246; XIV-C:755). The sole occurrence of a higher maxillary gradient also exhibited a

Table 29: I1-M1 Gradients

Individual	Sex	Age	Maxilla Right I1-M1	Maxilla Left I1-M1	Mandible Right I1-M1	Mandible Left I1-M1	Average
XIC-V:750	F	20	1.0	1.0		1.0	1.000
XIV-C:752	F	23		2.5			2.500
XIV-C:744	F	25	1.0		1.0		1.000
XIV-C:741	F	25	2.5	2.5	2.5		2.500
XIV-C:760	F	25			2.5		2.500
XIV-C:112	F	26	(2)		(2)		2.000
XIV-C:762	F	26	2.5	2.5		4.5	3.500
XIV-C:749	F	28			3.5	3.5	3.500
XIV-C:758	F	34			0.0	0.0	0.000
XIV-C:104	F	36				2.5	2.500
XIV-C:221	F	36				1.0	1.000
XIV-C:244	F	38				4.5	4.500
XIV-C:769	F	?	(1.5)				1.500
XIV-C:737	M	19	2.0	2.0	2.0	2.0	2.000
XIV-C:742	M	20	1.0		1.0	1.0	1.000
XIV-C:756	M	20	1.0	1.0	0.0	-1.0	0.500
XIV-C:126	M	25		1.5	1.5	1.5	1.500
XIV-C:111	M	25	-1.0	-1.0			-1.000
XIV-C:736	M	26		2.5	2.5		2.500
XIV-C:246	M	27	1.0	1.5	2.5	2.5	1.875
XIV-C:748	M	28	2.5		(2.5)		2.500
XIV-C:182	M	29		2.5	2.5	2.5	2.500
XIV-C:243	M	37			-2.0		-2.000
XIV-C:755	M	32		0.5	2.5		1.500
XIV-C:753	M	35				0.0	0.000
XIV-C:179	M	36				2.0	2.000
XIV-C:217	M	36				1.0	1.000
XIV-C:287	M	43				3.5	3.500

negative mandibular gradient (XIV-C:756). Three of these cases involved males, the other a female and the general health of these individuals ranged from healthy (one) to moderately pathological (two) to extremely pathological (one); health therefore does not appear to be a significant factor in this variation in gradient differences. What this may indicate is that there was either greater wear on the mandibular anterior teeth as compared to their maxillary isomeres, as has already been suggested on the basis of straight wear comparisons and the nested anovas, or that there was a more uniform wear rate on the maxillary teeth. In all cases, the female gradient was larger than the male gradient, and the difference between gradients was larger in the mandible as opposed to the maxilla.

Male gradients are more evenly spread across the spectrum of differences, female gradients are almost bimodal in distribution, with the greater frequency of gradients being +1 or +2.5. No correlation between age and gradient was particularly visible, although the largest gradients in both the females and the males were from the oldest individuals.

Table 30: ADVANCE OF I1 WEAR OVER M1

	-2.0	-1.5	-1.0	-0.5	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
F	0.00	0.00	0.00	0.00	0.08	0.00	0.23	0.08	0.08	0.31	0.00	0.15	0.00	0.08
M	0.07	0.00	0.07	0.00	0.07	0.07	0.13	0.13	0.20	0.20	0.00	0.07	0.00	0.00

A one-tailed test of significance was used in the comparison of the women's and men's gradients as it had earlier been predicted that female anterior use should be greater than male anterior use. The null hypothesis predicted no difference in gradient between females and males, the alternative hypothesis predicted a greater wear gradient in the females (Table 31).

Separate comparisons of the gradients found in the maxillae and mandibles were made. No significant differences were found (Table 30). However, a comparison of the averaged maxillary and mandibular gradients did reveal a difference that was close to statistical significance ($p = 0.053$). In this case, the average gradient was calculated for each individual. The average thus obtained was the value used in the calculations of the compared female and male averages. As was found in the nested anova comparison of anterior and posterior wear, the women were found to have the greatest difference in wear between their central incisors and first molars, with their central incisors being the more worn.

Table 31: I1-M1 Gradients

Sex	Count	X	Std. Dev.	Std. Error	D.F.	Unpaired t value	Probability (One-tailed)
Maxilla							
F	7	1.857	0.6900	0.261			
					16	1.277	0.1160
M	11	1.250	1.1240	0.339			
Mandible							
F	11	2.273	1.472	0.444			
					23	1.329	0.0984
M	14	1.464	1.538	0.411			
Averaged Individual Gradients							
F	13	2.154	1.248	0.346			
					26	1.676	0.0529
M	15	1.292	1.445	0.373			

A further wear comparison of the interaction between the sexes and right/left, upper/lower differences resulted in a difference that neared statistical significance (Table 32).

Table 32: Wear Comparison - FM*UL*RL

Dependent variable: wear

Source	D.F.	Type III SS	Mean Square	F Value	Probability
Sex*RL*UL	1	1.993	1.993	3.220	0.0739

where:

Female

		Upper			Lower		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Side	**Right**	46	2.924	1.211	38	3.457	1.591
	Left	44	3.142	1.142	37	3.271	1.250

Male

		Upper			Lower		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Side	**Right**	38	3.271	1.327	47	3.332	1.313
	Left	39	3.153	1.340	44	3.433	1.484

The difference between the upper and lower and left and right sides of the women's dental arcade (.404) is much larger than the differences in the upper and lower left and right sides of the men's (.129). This indicates a more even wear in male dentitions. The difference is most marked in the right upper and lower sides, where the women have a gradient of .533, compared to the male gradient of .061. In both of these cases the wear is greater in the lower right section of the mouth.

Such a gender difference may indicate that females are doing something in the right lower sections of their mouths that is not occurring in other mouth portions, or in the men at all. Possibly this relates to the stretching of skins, in which the skins are being clamped or pulled over the right side of the mandible. This may further indicate handedness. A right handed person might be more likely to insert objects into the right side of the mouth.

Summary. In the sample as a whole, anterior wear is greater than posterior wear, and there is a suggestion that mandibular wear is greater than that found on the maxilla. Relatively speaking, the women have a greater difference in anterior and posterior wear, indicating that they are using the anterior teeth to a greater extent than are the men. Women may further be using the right lower section of their mouth preferably over all other portions. Men's teeth seem to be more evenly worn down the tooth row.

Erupted Crown Height

As earlier indicated in Chapter Four, crown height is another method of exploring amounts of wear. Again, crown height was averaged for each section of the mouth. This is not an ideal method of comparison as crown height is correlated to the original size and shape of the teeth. Therefore comparisons of upper and lower dentition, especially the incisors would likely give spurious results as the upper incisors are so much larger than the the lower incisors. A case can be made however for a straight left/right comparison as there is the same cross section of teeth on each side of the mouth. In fact, a significant difference has been discovered in a comparison between the right and left sides of the mouth for the entire sample (Table 33).

Table 33: Erupted Crown Height Comparison - RL

Dependent variable: erupted crown height

Source	D.F.	Type III SS	Mean Square	F Value	Probability
RL	1	0.052	0.052	3.97	0.0475

where:

Mouth Section	Count	Mean	Std. Dev.
Right	162	0.655	0.172
Left	162	0.638	0.156

This difference indicates a greater degree of wear on the left than the right side of the mouth for the sample as a whole. This accords with the findings for wear stage when compared by right and left sections of the mouth (Table 34).

Table 34: Wear Comparison - RL

Dependent variable: wear

Source	D.F.	Type III SS	Mean Square	F Value	Probability
RL	1	0.980	0.980	1.58	0.2095

where:

Mouth Section	Count	Mean	Std. Dev.
Right	169	3.235	1.360
Left	164	3.252	1.305

Trauma

Trauma in the form of chipping, pressure flaking, fracturing, and crushing was compared as follows. The proportion of scoreable teeth within a mouth section was compared. Information as to where the trauma was found on the teeth was lost in this comparison, as is the information as to the amount of chipping on a particular tooth. Hopefully, this information can be incorporated into later comparisons using these materials. When possible, a directional test of probability was employed.

Chipping. In the sample as a whole, a significant difference in chipping was found in a comparison of the upper and lower dentition (Table 35) where a greater proportion of maxillary teeth exhibit chipping in the sample as a whole.

Table 35: Chipping Comparison - UL

Dependent variable: chipping

Source	D.F.	Type III SS	Mean Square	F Value	Probability
UL	1	0.580	0.580	4.33	0.0383

where:

Mouth Section	Count	Mean	Std. Dev.
Upper	171	0.473	0.395
Lower	182	0.403	0.379

A further significant difference in the sample was found in the interaction between the upper and lower and right and left sides of the mouth (Table 36).

Table 36: Chipping Comparison - RL*UL

Dependent variable: chipping

Source	D.F.	Type III SS	Mean Square	F Value	Probability
RL*UL	1	0.586	0.586	4.38	0.0373

where:

		Mouth Part					
			Upper			Lower	
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Side	Right	84	0.526	0.411	90	0.368	0.365
	Left	87	0.422	0.375	92	0.437	0.391

A larger difference between the proportions of teeth exhibiting chipping on the right upper and lower sides is evident as compared to the difference between the left upper and lower sides. The difference is greater on the right side (.158) with the greater proportion of teeth with chipping being observed in the upper right section. Not only is the difference in the left side not as large (.015), the greater proportion of teeth with chipping is found in the lower left side. This may again indicate a greater use of the right side of the mouth, which is possibly related to handedness. However, it may also relate to preferential chewing sides.

There are at least two possible reasons as to why a greater occurrence of chipping is manifesting itself on the maxillary rather than the mandibular portions of the mouth. It may be that the greater wear on the mandibular teeth is erasing chipping in this region, or it may be that the dynamics of the forces involved are such that chips are more easily removed from the maxillary teeth. The involvement of a 'hand-held' vector, in which the object placed between the teeth is being pulled out and up may create this. An observation of the upper/lower - anterior/posterior interaction, although not statistically significant, indicates that the difference may be due more to something that is specific to lower anterior dentition as compared to the rest of the mouth. The greatest degree of wear is also found in this section (see above), and may well be erasing antemortem trauma.

		Side	
		Anterior Mean	Posterior Mean
Jaw	Upper	0.471	0.475
	Lower	0.377	0.431

where p = 0.5912

There is a difference between women and men in the anterior and posterior proportions of teeth exhibiting chipping. As it was earlier hypothesized that males would exhibit the greater proportion of chipped teeth due to their greater use of the teeth in vise-grip activities, a directional hypothesis was employed. This anticipated that the difference between women and men would be greater in the anterior section of the mouth, and less in the posterior section of the mouth, because of an assumed shared diet (Table 37).

Table 37: Chipping Comparison - FM*AP

Dependent variable: chipping

Source	D.F.	Type III SS	Mean Square	F Value	Probability
Sex*AP	1	0.636	0.636	4.76	0.0150

where:

		Mouth Part					
		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Sex	F	84	0.347	0.392	85	0.458	0.356
	M	93	0.487	0.399	91	0.449	0.394

Thus, men have a greater number of teeth exhibiting chipping in the anterior portion of their mouth than do women. This relationship is reversed slightly in the posterior section of the mouth, but not to the same extent. Assuming that the chipping in the molar region is the result of the mastication of bones or frozen meat, and trauma in the anterior portion of the mouth is more a factor of tool use, the similarity in the posterior region can be regarded as indicating the the women and men were in fact eating the same diet. The differences in the anterior region could be related to the more frequent male use of the teeth as a vice-grip.

Flaking. Again, a directional hypothesis was formulated, with the expectation being that males would exhibit more trauma. For the sexes as a whole a value nearing significance was reached (Table 38). Surprisingly, it was the females and not the males that exhibited the greater proportion of teeth exhibiting flaking.

Table 38: Flaking Comparison - FM

Dependent variable: flaking

Source	D.F.	Type III SS	Mean Square	F Value	Probability
FM	1	0.667	0.667	2.17	0.0732

where:

Mouth Section	Count	Mean	Std. Dev.
Female	169	0.554	0.398
Male	184	0.429	0.401

A further difference of statistical significance was found for the total sample in the interaction between the upper and lower sections of the mouth (Table 39).

Table 39: Flaking Comparison - UL

Dependent variable: flaking

Source	D.F.	Type III SS	Mean Square	F Value	Probability
UL	1	0.624	0.624	4.97	0.0266

where:

Mouth Section	Count	Mean	Std. Dev.
Upper	171	0.536	0.408
Lower	182	0.445	0.396

As was the case in chipping, the upper dentition contains a greater proportion of teeth with flakes.

A difference nearing statistical significance is found in the comparison of the interaction of proportions of teeth with flakes in the right/left, anterior/posterior, and upper/lower parts of the mouth (Table 40).

The difference between the variance between the right anterior upper and lower mouth sections and right posterior upper and lower mouth sections (.068) differs in degree and direction from that between the left anterior upper and lower mouth sections and left posterior upper and lower mouth sections (.228). On the right side of the mouth, the proportions of teeth exhibiting flaking are almost equal, unlike the left side of the mouth. However, there is some difference between the right posterior portion of the mouth in which the the upper jaw exhibits more teeth with flaking. The flaking on the right anterior side of the mouth exhibits less of a difference, with the greater proportion of flaking occurring again in the maxilla. This relationship is reversed on the left side where the greater difference is between the anterior maxilla and mandible even though the maxilla again displays the higher proportion of flaked teeth. On the posterior left side the difference in proportion of flaked teeth is not as marked and more flaking is occurring in the mandible. Overall, there are fewer incidences of flaked teeth on the left side, and greater differences between the left mouth parts. This might relate to the greater degree of wear found on the left side of the mouth for the total sample.

Table 40: Flaking Comparison - RL*UL*AP

Dependent variable: flakes

Source	D.F.	Type III SS	Mean Square	F Value	Probability
RL*UL*AP	1	0.392	0.392	3.12	0.0785

where:

Right

		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Jaw	Upper	39	0.566	0.428	45	0.591	0.387
	Lower	47	0.477	0.403	43	0.434	0.383

Left

		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Jaw	Upper	44	0.570	0.392	43	0.417	0.416
	Lower	47	0.392	0.411	45	0.476	0.390

Another trend being exhibited in flaking concerns the difference existing between the women and the men in the interaction between the upper and lower dentitions (Table 41).

Table 41: Flaking Comparison - FM*UL

Dependent variable: flakes

Source	D.F.	Type III SS	Mean Square	F Value	Probability
Sex*UL	1	0.361	0.361	2.87	0.0456

where:

Jaw

		Upper			Lower		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Sex	F	90	0.629	0.392	79	0.468	0.389
	M	93	0.433	0.402	91	0.426	0.402

The difference between the female maxilla and mandible is much greater that the difference in the male maxilla and mandible, although in both cases more teeth exhibit flaking in the maxilla.

The differences in flaking between the maxilla and mandible may be explained similarly to differences in chipping. Either the greater wear on the mandibular teeth erases mandibular trauma, or by the dynamics of the forces involved whereby flakes are more easily removed from the maxillary teeth. The involvement of a 'hand-held' vector, in which the object placed between the teeth is being pulled out and up may create this.

Men may be exhibiting greater proportions of chipping and women greater proportions of flaking due to differences in bite forces. Men are capable of exerting greater bite forces than the women, which may result in the dislodgement of larger pieces of enamel. The lesser bite force in the women might be capable of removing relatively smaller enamel fragments only. Also the nature of females tasks exerting a constant, low level force that is spread over a wider, less localized area of the mouth (Mayhall 1977; Merbs 1968; 1983) might create this higher incidence of flaking.

Pitting. Pitting occurred almost universally throughout the sample. This is probably the result of the same forces that are responsible for chipping and flaking on the occlusal edges. In scoring pitting, the occurrence of slight and marked pitting were differentiated. However, in entering the data into the statistical programs, only presence/absence was recorded. This likely over-exaggerated the occurrence of pitting as the difference between marked and slight was fairly noticeable. In future studies it is recommend that either only the marked pitting be noted, or the marked and slight pitting be entered separately into the analysis. Distinguishing between the slight and marked pitting might parallel results found in a comparison of the incidences of chips and flakes. It should also be remembered that pitting was re-scored with the least degree of agreement with the original assessment in the replicability study.

In the sample as a whole, a significant difference occurred the interaction between the anterior and posterior sections of the mouth and the mandible and maxilla (Table 42).

Table 42: Pitting Comparison - UL*AP

Dependent variable: pitting

Source	D.F.	Type III SS	Mean Square	F Value	Probability
UL*AP	1	0.430	0.430	4.25	0.0403

where:

		Mouth Part					
		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Jaw	Upper	83	0.763	0.380	88	0.696	0.399
	Lower	94	0.720	0.382	91	0.777	0.349

The difference between the upper and lower posterior half of the mouth is greater, and unlike than that between the upper and lower anterior sections of the mouth. There is more pitting in the anterior upper portions of the mouth and more and greater incidences of pitted teeth in the posterior mandible.

A significant difference arises between the anterior and posterior portions of the mouth between women and men (Table 43). A non-directional hypothesis was used, as gender difference in this phenomenon was not expected.

Table 43: Pitting Comparison - FM*AP

Dependent variable: pitting

Source	D.F.	Type III SS	Mean Square	F Value	Probability
Sex*AP	1	0.613	0.613	6.04	0.0146

where:

		Mouth Part					
		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Sex	F	84	0.684	0.414	85	0.777	0.356
	M	93	0.791	0.341	91	0.699	0.392

The difference between the incidence of pitting between female and male anterior portions of the mouth is greater than that found between female and male posterior sections of the mouth. As was the case with chipping, this again may be indicative of similar food being masticated in the posterior section of the mouth, while some tool use difference is creating the situation in the anterior portion of the mouth. Males are exhibiting more pitting in the anterior section of the mouth than females, while females exhibited a greater amount of pitting in the posterior section of the mouth.

Fracturing. Fracturing occurred quite infrequently in this sample, only three instances were recorded. As was would be expected (Milner et al. 1983; Sauer et al. 1979), fracturing occurred only in the posterior half of the mouth. A difference nearing statistical significance was seen between the right and left sides (Table 44).

Table 44: Fracturing Comparison - RL

Dependent variable: fracturing

Source	D.F.	Type III SS	Mean Square	F Value	Probability
RL	1	0.317	0.317	3.08	0.0805

where:

Mouth Section	Count	Mean	Std. Dev.
Right	174	0.025	0.145
Left	179	0.000	0.000

Fracturing in this sample has occurred only in the right side of the mouth. However, the rarity of fracturing in the sample makes it likely that this is a chance occurrence.

Summary. Trauma of some form was present in all individuals in this sample. Chipping and flaking occurred on a greater proportion of teeth in the maxilla than the mandible, while a higher proportion of teeth with pitting were situated in the anterior maxilla and posterior mandible. Due to the forces involved, maxillary teeth may be more vulnerable to being traumatized, especially with the addition of a hand-held vector. The greater wear on the anterior mandibular section may also be a factor. Differences between the sides of the mouth in the proportions of trauma are less easy to explain.

To an extent, comparisons of proportions of trauma between the sexes support the assumption that the diet of women and men was the same, as the proportions of teeth exhibiting pitting and/or chipping differ less between the sexes in the posterior portion of the mouth. In the anterior section of the mouth however, men not only have a higher incidences of chipping and pitting but this difference is significantly greater that that found in the posterior section of the mouth. This may be related to paramasticatory activity which also cause the higher incidence of flaking in women. Differences in bite-force between women and men might also explain some of this variation.

Buccal Striations

Diagonal striations across the buccal surfaces of the anterior teeth, most notably the incisors, were observed in a number of individuals (Figure 14, page 117). Such striations were looked for, but not found on the buccal surfaces of the posterior teeth. This is illustrated very clearly in the nested anova comparison between the anterior and posterior portions of the mouth (45).

Table 45: Buccal Striation Comparison - AP

Dependent variable: buccal striations

Source	D.F.	Type III SS	Mean Square	F Value	Probability
AP	1	0.769	0.769	33.01	0.0001

where:

Mouth Section	Count	Mean	Std. Dev.
Anterior	177	0.092	0.232
Posterior	176	0.001	0.025

As well, significant differences were found in the sample as a whole in the interactions between the upper and lower jaws and the right and left sides of the dental arch (Table 46). The difference between the upper left and right mouth portions differs from that between the lower left and right sections. More maxillary teeth exhibit striations on the left side of the mouth, while the opposite phenomenon occurs in mandibular teeth to a slightly greater extent.

Table 46: Buccal Striation Comparison - RL*UL

Dependent variable: buccal striations

Source	D.F.	Type III SS	Mean Square	F Value	Probability
RL*UL	1	0.154	0.154	6.62	0.0106

where:

		Jaw					
		Upper			Lower		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Side	Right	84	0.028	0.131	90	0.071	0.212
	Left	87	0.065	0.210	92	0.024	0.101

A further significant difference in the total sample occurs in the interaction between the maxilla and the mandible, the right and left sides of the mouth, and the anterior and posterior sections of the dental arch (Table 47). However, this duplicates the information already known; a greater occurrence of teeth with striations is found on the left side of the anterior maxilla, and on the right side of the anterior mandible.

Table 47: Buccal Striation Comparison - RL*UL*AP

Dependent variable: buccal striations

Source	D.F.	Type III SS	Mean Square	F Value	Probability
RL*UL*AP	1	0.099	0.099	4.24	0.0404

where:

		Right					
		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Jaw	Upper	39	0.060	0.189	45	0.000	0.000
	Lower	47	0.129	0.278	37	0.008	0.051

		Left					
		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Jaw	Upper	44	0.129	0.282	43	0.000	0.000
	Lower	47	0.046	0.138	45	0.000	0.000

Following the expectation that the male use of the bow-drill might leave them with a greater number of buccally striated teeth (Lukacs and Pastor 1988), a directional hypothesis between the sexes was applied. A difference nearing statistical significance was found for the interaction between the sexes and all parts of the mouth (Table 48) and in the interaction between the anterior and posterior sections of the mouth (Table 49).

Table 48: Buccal Striation Comparison - FM

Dependent variable: buccal striations

Source	D.F.	Type III SS	Mean Square	F Value	Probability
FM	1	0.088	0.088	1.94	0.0845

where:

Mouth Section	Count	Mean	Std. Dev.
Female	169	0.055	0.199
Male	184	0.039	0.140

Contrary to expectations, women exhibited the greater incidence of teeth with buccal striations.

Table 49: Buccal Striation Comparison FM*AP

Dependent variable: buccal striations

Source	D.F.	Type III SS	Mean Square	F Value	Probability
FM*AP	1	0.063	0.063	2.71	0.0505

where:

		Mouth Part					
		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Sex	F	84	0.111	0.272	85	0.000	0.000
	M	93	0.074	0.188	91	0.004	0.035

Again, the women exhibit slightly more teeth with buccal striations in the anterior section of the mouth than do males. This could mean that buccal striations are not the result of a slippage of the bow drill mouthpiece (Lukacs and Pastor 1988), although it should be cautioned that women may have used the bow-drill on an opportunistic basis, especially in the making of holes for toggles in the manufacture of clothing (Barbara Winters personal comment 1992).

Interestingly, with only one exception in the males (12.5%, N=8), and two exceptions in the females (18.2%, N=11), striae are running from left (highest point) to right (lowest point). This may be indicating a right handed action, such as would occur when using a knife drawn down from the left to the right sides in cutting an object held in the mouth (Bermudez de Castro et al. 1988).

Bermudez de Castro et al. (1988) also noted striations of this type on the buccal anterior teeth of some fossil human anterior teeth from the middle and early Upper Pleistocene. Such striations have been seen on Neanderthal teeth and are attributed to the use of the teeth as clamps holding items that are then cut by a stone knife. Carelessness with the blade would create the striations (Brace 1975). Bermudez de Castro et al. (1988) performed both a macro and microscopic investigation of this phenomena as well as carrying out some experimental work to assess the handedness of the individual. A basic assumption with their work was "that the tool-user scratched his/her own teeth, thus presenting the unique situation (in the sense of hominid cutmark studies) whereby the anatomical relation between the cutmark (teeth) and the hand (stone tool) are known" (Bermudez de Castro et al. 1988:403).

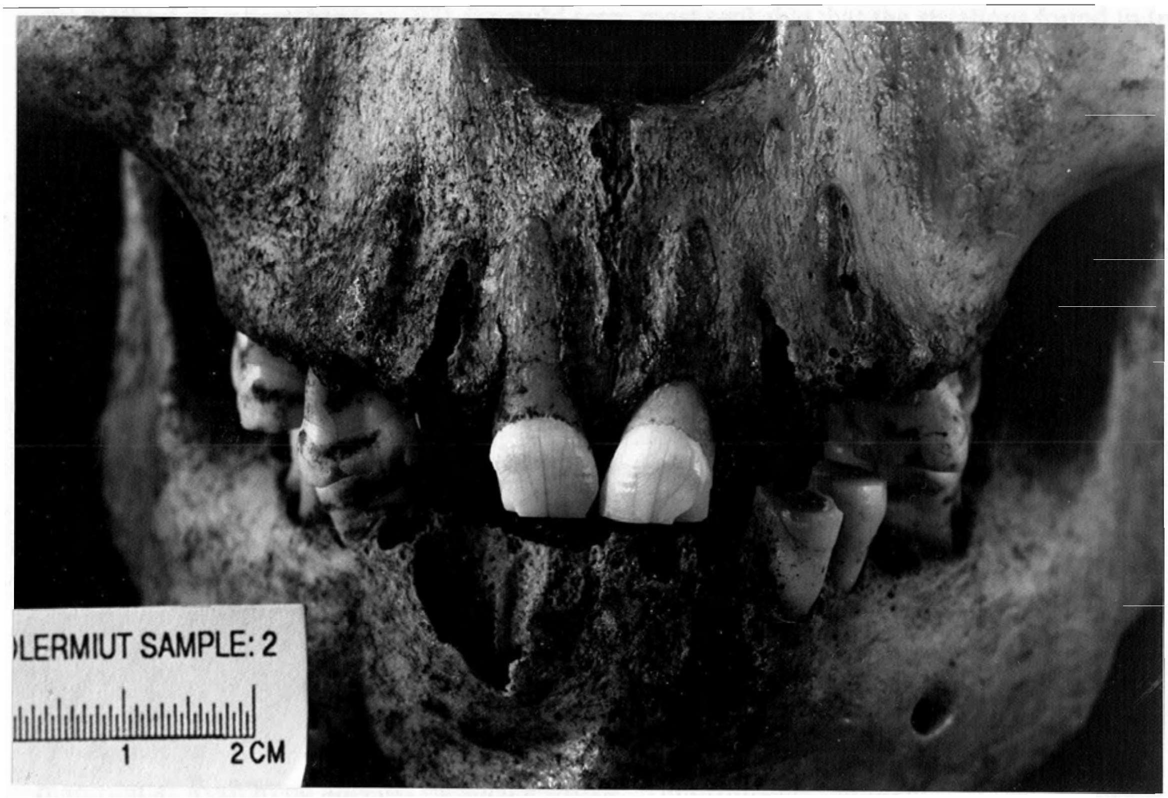


Figure 14: Buccal Striations on the Upper Central Incisors

As in this study, such cutmarks were clearly visible to the naked eye, were not found in the post-canine region, and were mainly located in the central area of the buccal face. In general, these striations ran obliquely across the tooth surfaces. Taphonomic processes were ruled out, as a careful examination revealed the lack of these striations on any of the post-canine teeth. If these striations were created after death, all teeth should have been equally affected. As well, taphonomic processes were considered unlikely to produce such a homogeneity of orientation in the marks. Bermudez de Castro et al. also rejected Martin's suggestion (1923 as cited in Bermudez de Castro et al. 1988:408) that these striation were the result of the mastication of silica impregnated objects such as bones or roots . Again, they felt such an action would not have left so large or homogeneously arranged striations.

Experimental work indicated that the cutmarks were antemortem as the location, orientation, and microscopic features of the experimental work and the fossil teeth were comparable. The striation orientation was also more compatible with a right handed action. Bermudez de Castro et al. (1988) concluded with Brace (1975) that the striations had been produced by a sharp flint held in the right hand during a stuff-and-cut method of eating.

With this evidence in mind, and with the known ethnographic accounts of the Inuit stuff-and cut method of eating (Merbs 1983), it would seem most probable that the striations found in this sample are the result of this action. Although not a tool use of the teeth per se., other objects held in the same manner and also being cut with an ulo would leave the same marks. While the possibility of the cutmarks being the result of a bow-drill mouthpiece slippage remain, both for the women and the men, it seems less likely. Such a slippage would not be expected to leave the homogeniety of marks, both in location and orientation.

Summary. Roughly one third of this sample exhibits the presence of diagonal buccal striations in their anterior teeth, most notably in their incisors, although this does occur to a lesser extent in the canines and premolars. More women than men exhibit this trait, although the difference is not significant. The direction of the striae indicates that in most cases the object drawn across the teeth had been held in the right hand.

The differences discerned in a comparison between the upper and lower and left and right mouth parts might also be the result of the postulated handedness of this action. The movement of the ulo from the left down to the right (or up from the right up to the left, see Marsh 1987) would make it more likely for upper left maxillary teeth and lower right mandibular teeth to be affected by such a stroke. Unfortunately, an investigation of individuals with this phenomenon to see if this was the case was hindered by tooth loss.

Buccal striations were also observed in two of the immature individuals, indicating that the causal activity began early in life.

Notches or Unusual Surface Forms

Notches and unusual surface forms that could not be easily explained as the result of occlusal patterning were also observed in a number of teeth. The occurrence of such dental surface forms is important as they are less likely to be the result of paramasticatory activity. In this analysis, only those forms that occurred in the anterior dentition have been compared. An examination of the posterior dentition revealed the presence of only a very few teeth with notches or unusual surface forms. Posterior teeth exhibiting such features were most often the fourth premolars.

Thirty-six individuals exhibited this type of wear in the anterior portions of their mouths, 16 women (53.3%) and 20 men (62.5%). Using nested anova, no significant differences were found between females and males, or between mouth parts. Women did, however, exhibit a higher proportion of teeth with unusual surface forms, particularly in the maxilla.

Oblique Lingual-Buccal Wear (Labial Rounding)

Many investigators (see for example Pedersen 1952; Pedersen and Jakobsen 1989; Ryan 1980, 1989) have commented on the occurrence of lingual-buccal wear on the anterior teeth of Inuit groups. Generally this has been attributed to the practice of drawing objects through the anterior dentition or to the softening of the skins by rubbing them over the anterior teeth. This results in a rounded appearance in the wear in a lingual buccal direction, also referred to as labial rounding. Fifty percent of the sample, both female and male exhibited this wear.

The posterior dentition was not closely examined for the presence of this wear pattern. This was partly because the wear in this area is complicated by the fact that the lower molars often exhibited lingual-buccal wear. This wear was related more to the maxillary overjet, and the lingual slant of the erupting molars (resulting in the formation of the helicoidal plane) than to a tool use pattern.

A significant difference did occur for the sample as a whole between the upper and lower jaws (Table 50).

Table 50: Labial Rounding Comparison - UL

Dependent variable: labial rounding

Source	D.F.	Type III SS	Mean Square	F Value	Probability(2-t)
UL	1	0.804	0.804	17.81	0.0001

where:

Mouth Section	Count	Mean	Std. Dev.
Upper	83	0.039	0.142
Lower	94	0.198	0.325

Labial rounding occurs far more often in the mandible than in the maxilla. This would indicate an action in which some object is being drawn down through the teeth.

I had earlier hypothesized that women would exhibit more incidences of labial rounding due to the softening of skins. It could also be proposed that this task would be unlikely to show a side difference as, in all pictorial examples I have seen (see for example Lous 1970), the skins are pulled through the center of the mouth. This directional hypothesis resulted in one comparison that neared statistical significance. This comparison was that between women and men and the right and left sides of the anterior half of the dentition (Table 51).

Table 51: Labial Rounding Comparison - FM*LR

Dependent variable: labial rounding

Source	D.F.	Type III SS	Mean Square	F Value	Probability
FM*RL	1	0.109	0.109	2.41	0.0619

where:

		Mouth Part					
		Right			Left		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Sex	F	42	0.123	0.230	42	0.121	0.274
	M	44	0.074	0.155	49	0.170	0.309

There is a greater difference in the the right and left sides of the male mouths for anterior rounding, while the female exhibit a more even occurrence of this phenomenon. The almost equal occurrence of this phenomenon on the left and right sides could be a reflection of female tasks using a greater area of the mouth. The more localized occurrence of this pattern in the male could reflect some vice-grip task.

Summary. Labial rounding occurs commonly in this sample. About 50% of the women and the men exhibit it. It is found more in the mandible for the sample as a whole, and more evenly in the female dentition. This is in accordance to what could be expected by rubbing skins over the lower teeth for softening purposes.

Grooving

Grooving occurred quite infrequently in this sample, and only in the anterior portion of the dentition. For the most part these grooves were not well defined. This may be due in part to the fact that few people in this group lived past forty. Five women, or 16.7%, and five men, or 15.6% displayed grooves. The only significant difference in grooving is that between the anterior and posterior sections of the mouth (Table 52).

Table 52: Grooving Comparison - AP

Dependent variable: grooving

Source	D.F.	Type III SS	Mean Square	F Value	Probability(2-t)
AP	1	0.076	0.076	8.39	0.0041

where:

Mouth Section	Count	Mean	Std. Dev.
Anterior	177	0.039	0.154
Posterior	176	0.000	0.000

Only one individual (XIV-C:739, a female of uncertain age with an extremely pathological dentition), had evidence for interproximal grooving - and this could be explained as a result of occlusion rather than the pulling of sinews through the teeth or the use of palliative toothpicks (Figure 15). The upper dentition slides down along the two canines pictures here, and this activity is possibly creating the grooving. Grooving, or at least a scooping out of the dentine can also be observed on the occlusal surfaces of these teeth. Again this may have more to do with occlusion than sinew processing. The upper anterior dentition also exhibited the occlusal and approximal grooving. The occlusal grooves interlock or slide by each other as if in a left and right grinding motion. A great many of the posterior teeth are missing in this individual. This may possibly relate to the cupping observed by Hinton (1981a) and Molnar (1972) on anterior dentition forced into a grinding function by the antemortem loss of the posterior teeth. However, this was not seen on other dentitions with an antemortem loss of most of the posterior teeth.

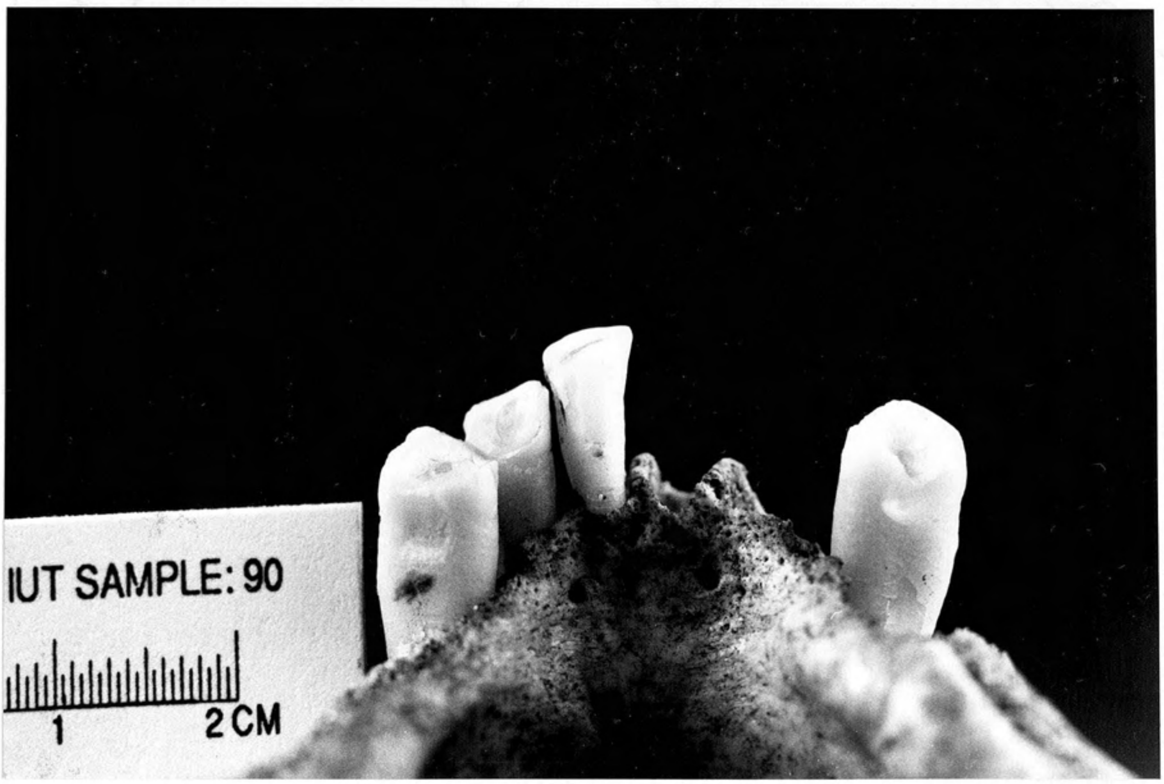


Figure 15: Occlusal and Approximal Grooving on XIV-C:739

Figure 16 illustrating male and female grooving patterns, tentatively reveals some differences between the sexes. Male grooves are clustered very closely together in the anterior dentition, primarily on the incisors. They run solely in a buccal-lingual direction. Women's grooving patterns tend to extend a little further down the anterior tooth row. There is also more of a mesial-distal orientation in the grooving directions. This may in part be misleading, as some of the mesial-distal grooves belong to individual XIV-C 739, and may be more a reflection of a pathological occlusion. At least one mesial-distal groove along a lower lateral incisor, does not. Grooving was not found in immature dentitions.

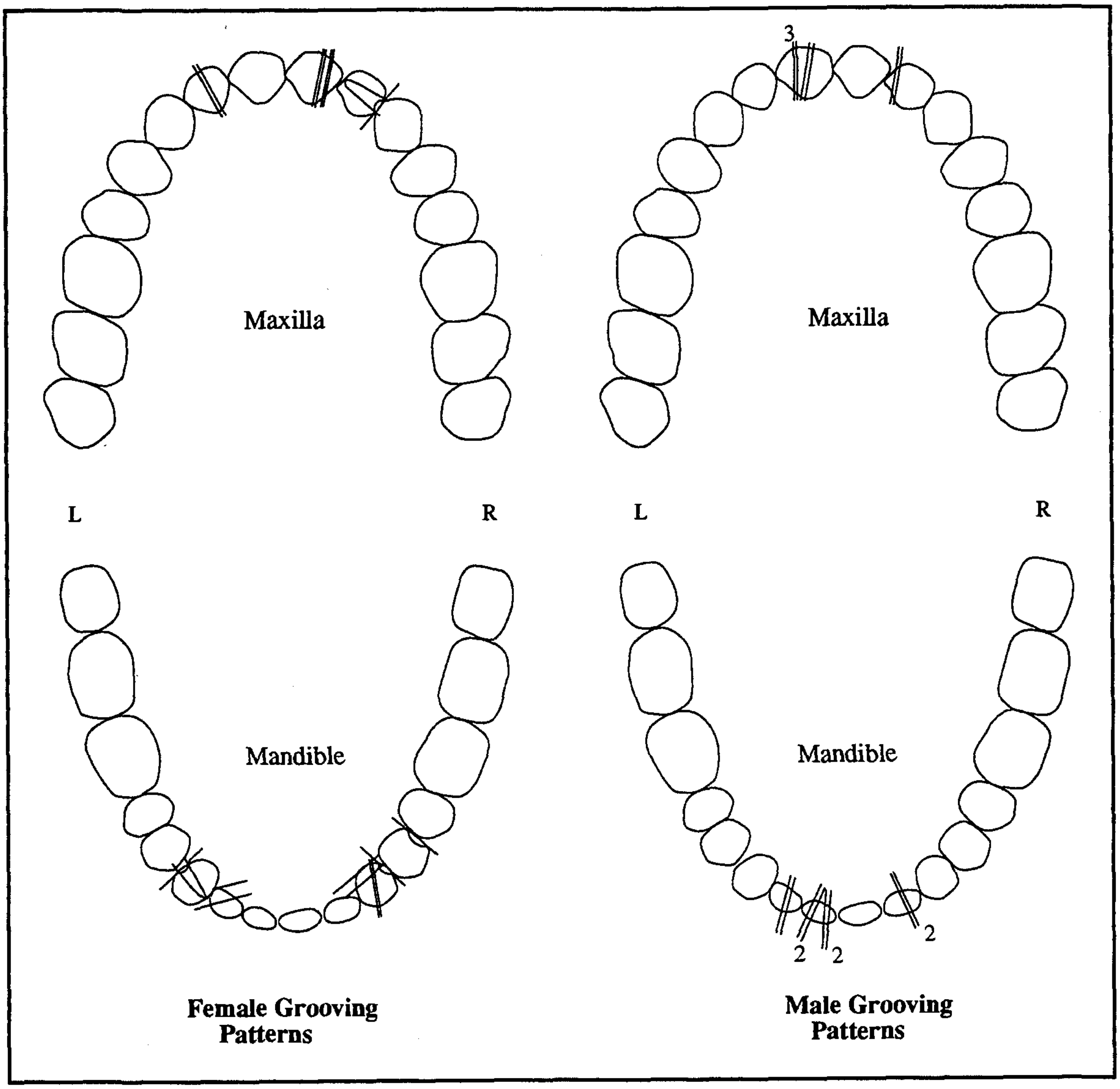


Figure 16: Female/Male Grooving Patterns

Summary. Grooving was not a common occurrence. That which occurred was situated primarily on the occlusal surfaces of the anterior teeth in a buccal-lingual direction. Only in the females were grooves found running in a mesial-distal direction. Grooves in females also extended further down the tooth row. Female-male differences were insignificant. Although women are exhibiting higher proportions of grooved teeth on their maxillas rather than their mandibles, the exact opposite is happening in males.

Antemortem Tooth Loss

Table 53: Percentage of Teeth Lost Antemortem

Maxilla	Female	Male	p
R. M3	13.8%	24.1%	N.S.
M2	17.2%	34.5%	N.S.
M1	13.8%	24.1%	N.S.
P4	6.9%	24.0%	N.S
P3	10.3%	20.7%	–
C	0.0%	17.2%	–
I2	20.7%	24.1%	N.S.
I1	34.5%	31.0%	N.S.
L. I1	34.5%	27.6%	N.S.
I2	23.3%	24.1%	N.S.
C	8.3%	17.2%	N.S.
P3	10.3%	13.2%	–
P4	10.3%	24.1%	N.S.
M1	10.3%	31.0%	N.S.*
M2	17.2%	31.0%	N.S.
M3	13.8%	34.5%	N.S.
Mandible	**Female**	**Male**	**p**
R. M3	32.0%	21.4%	N.S.
M2	44.0%	34.5%	–
M1	28.0%	27.6%	–
P4	16.0%	13.8%	–
P3	4.0%	3.4%	–
C	4.0%	0.0%	–
I2	4.0%	0.0%	–
I1	20.0%	10.3%	–
L. I1	20.0%	10.3%	–
I2	0.0%	3.4%	–
C	0.0%	0.0%	–
P3	8.0%	0.0%	–
P4	12.0%	0.0%	–
M1	20.0%	3.4%	N.S.
M2	40.0%	24.1%	N.S.
M3	24.0%	20.7%	N.S.

Antemortem tooth loss was investigated down the tooth row, in an attempt to see if Mayhall's (1977) findings in tooth loss patterns might be duplicated. They were not, nor were those of Merbs' (1968, 1983). Chi squares between females and males could not be performed for the maxillary third premolars and right canines, and the mandibular premolars, canines, incisors and right first and second molars. Expected values are less than five. No significant differences in antemortem loss had occurred on those teeth for whom the comparison could be performed, . The only value that neared significance occurred in the maxillary left first molar (Table 53).

Teeth least affected by antemortem loss included the canines and the third premolars. Lateral incisors and fourth premolars were lost antemortem slightly more frequently. Antemortem loss occurred to a greater extent in the posterior teeth of the mandible, and in females, the anterior teeth of the maxilla. Loss in the male maxillae was more evenly distributed.

In the nested anova comparisons for antemortem loss, postmortem loss and abscessing I was not restricted to the scoreable teeth. Unless the mandibular or maxillary arch were broken or a third molar was unerupted, all proportions were out of four for each section of the tooth mouth. In one way, there was less lost information for these three traits. However, as the prerequisite for the selection of the material under study was scoreable teeth, and not scoreable sockets, the sample may be inadvertently skewed.

A nested anova comparison of antemortem loss revealed several statistically significant differences. For the sample as a whole, differences were found between the upper and lower jaws (Table 54), the anterior and posterior halves of the mouth (Table 55), and the interaction between the upper and lower and anterior and posterior portions of the mouth (Table 56).

Table 54: Antemortem Tooth Loss Comparison - UL

Dependent variable: antemortem loss

Source	D.F.	Type III SS	Mean Square	F Value	Probability
UL	1	0.570	0.570	13.10	0.0003

where:

Mouth Section	Count	Mean	Std. Dev.
Upper	231	0.213	0.324
Lower	216	0.147	0.267

More teeth are lost antemortem in the maxilla than in the mandible.

Table 55: Antemortem Tooth Loss Comparison - AP

Dependent variable: antemortem loss

Source	D.F.	Type III SS	Mean Square	F Value	Probability
AP	1	1.216	1.216	27.93	0.0001

where:

Mouth Section	Count	Mean	Std. Dev.
Anterior	224	0.131	0.245
Posterior	223	0.231	0.338

More teeth are lost antemortem in the posterior half of the mouth than in the anterior half. This would agree with Pedersen's (1947) findings.

Table 56: Antemortem Tooth Loss Comparison - UL*AP

Dependent variable: antemortem tooth loss

Source	D.F.	Type III SS	Mean Square	F Value	Probability
UL*AP	1	0.784	0.784	17.99	0.0001

where:

		Mouth Part					
		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Jaw	Upper	116	0.203	0.306	115	0.222	0.342
	Lower	108	0.053	0.114	108	0.241	0.335

Teeth are lost to about the same extent in the posterior portion of the mouth, with slightly more teeth being lost in the mandible. By contrast, there is a large difference between the tooth loss antemortem in the anterior portion of the mouth, with many more teeth being lost from the maxilla than the mandible. Again the similarities in the posterior section of the mouth might reflect the dietary demands on the teeth, while the antemortem loss of the anterior teeth could be indicating some tool use.

A significant difference between the women and the men occurred in the interaction between antemortem loss in the upper and lower jaws (Table 57).

Table 57: Antemortem Tooth Loss Comparison - FM*UL

Dependent variable: antemortem tooth loss

Source	D.F.	Type III SS	Mean Square	F Value	Probability
FM*UL	1	0.535	0.535	12.29	0.0005

where:

		Jaw					
		Upper			Lower		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Sex	F	115	0.159	0.262	100	0.176	0.278
	M	116	0.266	0.369	108	0.122	0.255

Women are losing teeth almost equally in the mandible and the maxilla. The men, on the other hand, are losing a considerably greater proportion of teeth antemortem in the maxilla than in the mandible. Overall, men seem to be experiencing a greater proportion of antemortem tooth loss than are women.

Using a directional hypothesis which proposes that given Merbs (1968, 1983) findings, women would be losing more teeth in the anterior portion of the mouth than the males while loss should be about equal in the posterior section of the mouth, a significance difference was found in the interaction between women and men and the upper/lower and anterior/posterior sections of the mouth (Table 58).

Table 58: Antemortem Tooth Loss Comparison - FM*UL*AP

Dependent variable: antemortem loss

Source	D.F.	Type III SS	Mean Square	F Value	Probability
FM*UL*AP	1	0.126	0.126	2.89	0.0450

where:

Female

		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Jaw	Upper	58	0.178	0.266	57	0.140	0.259
	Lower	50	0.075	0.126	50	0.277	0.345

Male

		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Jaw	Upper	58	0.228	0.342	58	0.303	0.394
	Lower	58	0.034	0.099	58	0.210	0.326

The differences between the mouth parts in women are greater (.240) than the differences between the mouth parts in men (.101). In women, more teeth are being lost in the posterior half of the mandible than in the anterior half of the mandible. In the maxilla, teeth are being lost to about the same degree, although slightly more teeth are being lost antemortem in the anterior portion. Men are also undergoing a greater antemortem loss of teeth in the posterior half of the mandible. However, they are also losing more teeth antemortem in the posterior section of the maxilla. Overall men are losing more teeth than women in the maxilla while, to a lesser extent females are losing slightly more teeth in the mandible.

Antemortem loss of teeth in the posterior section of the mouth is more likely to be related to masticatory demands. Tooth loss occurs most frequently in the men and in the mandibular portion of the female mouths. The greater relative loss in the anterior portions of the women's dental arcade may reflect the effect of some tool use.

Summary. There was no significant difference in antemortem tooth loss in the tooth-to-tooth comparisons between the sexes, although there was some indication that men were losing their teeth more evenly down the tooth row. Overall, more teeth were lost antemortem in the maxilla than in the mandible, and in the posterior rather than in the anterior sections of the mouth. Posterior antemortem loss occurred in about the same proportions between the maxilla and the mandible, but anteriorly, more teeth were lost antemortem in the maxilla.

Seventeen, or 56.7% of the women exhibited antemortem tooth loss, and 19, or 59.4% of the men. Men were losing proportionately more teeth antemortem than women, especially in the maxilla. However, relatively speaking, women were losing more teeth in the anterior maxilla than in the posterior portions of the mouth, although they were experiencing about equal proportions of antemortem loss in the maxilla and mandible as a whole.

Postmortem Tooth Loss

An examination of postmortem loss revealed some interesting differences. For the sample as a whole, more teeth are lost postmortem in the anterior half of the mouth as compared to the posterior half (Table 59). This is likely due to the single-rootedness of the anterior teeth, and multi-rootedness of the posterior half (Pedersen 1947).

Table 59: Postmortem Tooth Loss Comparison - AP

Dependent variable: postmortem loss

Source	D.F.	Type III SS	Mean Square	F Value	Probability
AP	1	2.074	2.074	36.71	0.0001

where:

Mouth Section	Count	Mean	Std. Dev.
Anterior	224	0.371	0.313
Posterior	223	0.237	0.258

While a straight right/left comparison of the mouth indicated that relatively the same proportions were being lost postmortem on each side, a further difference that nears statistical significance in the sample as a whole is that found in the interaction between the right and left and upper and lower mouth parts (Table 60).

Table 60: Postmortem Tooth Loss Comparison - RL*UL

Dependent variable: postmortem tooth loss

Source	D.F.	Type III SS	Mean Square	F Value	Probability
RL*UL	1	0.195	0.195	3.45	0.0640

where:

		Jaw					
		Upper			Lower		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Side	Right	116	0.348	0.310	108	0.260	0.281
	Left	115	0.305	0.297	108	0.301	0.285

On the left side of the mouth, proportions of teeth are being lost at about the same extent in the maxilla and the mandible. On the right side of the mouth, however, a much greater proportion of teeth are being lost in the right maxilla as compared to the right mandible.

In comparisons between the men and the women, a significant difference was found in the interaction between the anterior and posterior sections of the mouth (Table 61).

Table 61: Postmortem Tooth Loss Comparison - FM*AP

Dependent variable: postmortem tooth loss

Source	D.F.	Type III SS	Mean Square	F Value	Probability(1-t)
FM*AP	1	0.350	0.350	6.19	0.0133

where:

		Mouthpart					
		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Sex	F	108	0.443	0.306	107	0.252	0.269
	M	116	0.304	0.305	108	0.223	0.249

Postmortem tooth loss is occurring at about the same extent in the posterior sections of the male and female mouths, but there is a much greater difference in the loss in the anterior sections of the mouth. Here, women are losing a higher proportion of teeth postmortem in the anterior sections of their mouths than are men. Overall, women are losing a higher proportion of teeth postmortem.

Two explanations might account for this. Possibly, differential burial practices could be resulting in greater proportions of postmortem tooth loss among women. The rather limited information I have on the burials, however, does not support this hypothesis. The skeletal material was recovered from stone graves, vaults, enclosures, in one case from a stone ring, and in two cases from what appears to have been an interment in the ground. Other material was scattered across the site and its environs. Chi-square comparisons of burial mode for women and men did not reveal statistically significant differences. This was the case both when the burial types were compared separately (Table 62); and when the burials that were in some manner encased in stone were lumped together and compared to the scattered materials (Table 63).

Table 62: Burial Type

Burial Type	Female	Male
Stone vault	5	6
Stone grave	3	5
Stone enclosure	1	1
Ground interment	1	1
Stone ring	1	0
Scattered	9	5
House	0	1

Chi square p = 0.7155

Table 63: Burial Type - Stone Versus Scatter

Burial Type	Female	Male
Stone interment	12	14
Scattered	9	5
Other	1	2

Chi square p = 0.4476

A further comparison was made on the basis of information indicating whether or not the burial had been disturbed. A difference in frequency of disturbance could account for differences in tooth loss (Table 64).

Table 64: Incidence of Disturbance

Status	Females	Males
Disturbed	16	11
Undisturbed	6	10

Chi square p = 0.1677

Corrected p = 0.2873

However, no statistical difference in incidence of burial disturbance between women and men was found. The alternate explanation could be that women's tooth roots experienced greater amounts of shortening in the anterior portions of the mouth from to the tasks to which they were put, although again it should be noted that other factors could cause this root shortening. Consequently their teeth could slip out of the sockets more easily. Unfortunately, no measurement of either tooth root length, or socket depth was taken in this sample, although the presence of shortened roots was noted. Such measurements could not be consistently taken as no X rays were taken of the individuals. Figure 17 (page 130) illustrates the magnitude to which these roots can shorten. The tooth on the left belongs to a young male, that one the right to an old female.

Summary. Postmortem tooth loss is occurring in higher proportions in the maxilla than in the mandible, and there is a greater difference in loss between the right upper and lower sides. Part of this may relate to burial practices, and part may relate to a possible further shortening of the roots of the anterior teeth in women. All but two individuals, a man and a women suffered from postmortem loss.

Figure 17: Root Length Comparison

Abscessing

In a comparison of the frequency of abscessing in the sample as a whole, significant differences were found in the upper and lower parts of the mouth (Table 65) as well as the anterior and posterior portions of the mouth (Table 66).

Table 65: Abscessing Comparison - UL

Dependent variable: abscessing

Source	D.F.	Type III SS	Mean Square	F Value	Probability
UL	1	0.036	0.036	14.83	0.0001

where:

Mouth Section	Count	Mean	Std. Dev.
Upper	231	0.119	0.207
Lower	216	0.068	0.144

More abscesses are found in the maxilla than in the mandible.

Table 66: Abscessing Comparison - AP

Dependent variable: abscessing

Source	D.F.	Type III SS	Mean Square	F Value	Probability
AP	1	1.086	1.086	44.45	0.0001

where:

Mouth Section	Count	Mean	Std. Dev.
Anterior	224	0.045	0.131
Posterior	223	0.145	0.209

More teeth are abscessed in the posterior portion of the mouth than in the anterior portion.

A possible explanation for the greater occurrence of abscessing in the posterior maxilla may be due to its location next to Stensen's duct of the parotid salivary gland (Lindhe 1989). A fair amount of calculus was observed on the Sadlermiut dentition, although this is a general impression. Calculus was not systematically scored. It has been theorized that calculus, calcified plaque, forms as a result of the differing carbon dioxide tensions in saliva and in the oral cavity, from 69 mm Hg to 29 - 0.3 mm Hg. As a result, carbon dioxide escapes from the saliva, thereby increasing its pH. The higher pH in the saliva leads to the possible precipitation of calcium and phosphates. Once seeded by these crystals, the conditions are ripe for a physiological superstaturation and growth of calculus (Lindhe 1989). Large amounts of calculus hinder effective oral cleansing, which in this case of the Sadlermiut was unlikely to have been habitual, accelerating plaque formation and periodontal disease. Additionally, the calculus itself, "may contain products toxic to soft tissue ... [and] ... may be considered to be slowly delivering pathologenic products to the adjacent soft tissues" (Lindhe 1989:121). Therefore the greater occurrence of abscessing in the upper posterior maxilla could be linked to the presence of the Stensen's duct.

However, this does not explain why the same thing is not occurring around the other major salivary ducts, Warton's duct of the submandibular and Bartholin's duct of the sublingual salivary glands. These are located near the lower incisors (Lindhe 1989). Perhaps the use of these teeth in tool use functions and their contact with abrasives, serves to "clean" them, disallowing the formation of plaque and calculus and leaving this area relatively free from disease.

A difference nearing significance in the sample as a whole is found in the interaction between the right and left and posterior and anterior parts of the mouth (Table 67).

Table 67: Abscessing Comparison - RL*AP

Dependent variable: abscessing

Source	D.F.	Type III SS	Mean Square	F Value	Probability
RL*AP	1	0.086	0.086	3.51	0.0619

where:

		Mouthpart					
		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Side	Right	112	0.056	0.153	112	0.127	0.188
	Left	112	0.033	0.103	111	0.162	0.227

There is a greater difference in abscessing between the left anterior and posterior halves of the mouth than on the right side. Although on both sides, a greater proportion of abscessed teeth is occurring in the posterior half, the difference is more marked on the left side.

In a comparison between the sexes and the whole mouth, a difference nearing significance has been reached (Table 68).

Table 68: Abscessing Comparison - FM

Dependent variable: abscessing

Source	D.F.	Type III SS	Mean Square	F Value	Probability
MF	1	0.206	0.206	3.48	0.0670

where:

Mouth Section	Count	Mean	Std. Dev.
Female	215	0.074	0.165
Male	232	0.113	0.193

Men are experiencing more abscessing than women. This difference reaches significance in a comparison of the proportions of abscesses in the interaction between the sexes and the anterior and posterior portions of the mouth (Table 69).

Table 69: Abscessing Comparison - FM*AP

Dependent variable: abscessing

Source	D.F.	Type III SS	Mean Square	F Value	Probability
FM*AP	1	0.190	0.190	7.77	0.0056

where:

		Mouthpart					
		Anterior			Posterior		
		Count	Mean	Std. Dev.	Count	Mean	Std. Dev.
Sex	F	108	0.046	0.141	107	0.103	0.182
	M	116	0.043	0.120	116	0.183	0.225

There is a greater variation between the difference between women and men in the posterior portions of the mouth, than in the anterior half. In the anterior section, proportions of abscessed teeth were almost equal. In the posterior half, however, males were experiencing the greater incidence of abscessing.

Summary. In the sample as a whole, more abscessing is occurring in the maxilla, and in the posterior sections of the mouth. This is possibly related to the positioning of the salivary ducts and the formation of calculus. Sixteen or 53.3% of the women exhibit abscessing, as compared to 28 or 87.5 % of the men. Men are also experiencing a higher proportion of abscessed teeth within their mouths. This difference reaches statistical significance in a comparison of the interaction between the sexes and anterior and posterior mouthparts, in which men are experiencing a much higher incidence of abscessing in the posterior section of their mouths than are women.

Tooth Dimensions

Buccal-Lingual Width. Buccal-lingual width is much less affected by wear than mesial-distal length. Consequently, in this respect it is a more accurate estimation of differences in size between groups. Sexual dimorphism has been demonstrated in Inuit populations (Turner 1967; Mayhall 1979). In the case of the Sadlermiut, most of the significant sexual dimorphism occurred in the molars (Table 70), although in general the male teeth were slightly larger than the female teeth. The only exception to this are the upper fourth premolars. In the anterior dentition, the only tooth showing a significant difference in size was the lower right canine.

Table 70: Buccal-Lingual Width

	Female			Male			
Maxilla	n	X	s.d	n	X	s.d	p.
R. M3	11	1.048	.099	8	1.147	.065	.0243*
M2	12	1.163	.054	14	1.231	.063	.0068*
M1	20	1.144	.055	14	1.199	.062	.0109*
P4	15	0.877	.062	15	0.89	.052	.8939
P3	11	0.916	.070	12	0.948	.039	.1778
C	14	0.831	.050	15	0.851	.063	.3484
I2	5	0.664	.061	7	0.700	.025	.1905
I1	6	0.701	.027	10	0.730	.037	.1155
L. I1	8	0.685	.055	12	0.681	.053	.8882
C	14	0.826	.055	17	0.857	.058	.1424
P3	9	0.941	.043	18	0.940	.058	.9920
P4	11	0.910	.044	11	0.931	.049	.2891
M1	17	1.151	.058	15	1.170	.143	.6209
M2	15	1.140	.061	11	1.221	.059	.0025*
M3	8	1.050	.099	10	1.124	.087	.1062
Mandible							
R. M3	8	1.024	.090	11	1.119	.098	.0464*
M2	12	1.067	.080	11	1.131	.055	.0388*
M1	16	1.108	.058	16	1.171	.08	.0158*
P4	14	0.794	.131	17	0.862	.107	.1201
P3	15	0.769	.139	19	0.821	.04	.1270
C	15	0.737	.124	21	0.821	.059	.0109*
I2	10	0.653	.022	16	0.679	.046	.1009
I1	8	0.587	.028	10	0.615	.034	.0831
L. I1	7	0.599	.033	14	0.617	.039	.3064
I2	11	0.644	.027	16	0.666	.035	.0940
C	14	0.784	.046	16	0.817	.049	.0704
P3	18	0.801	.044	20	0.810	.051	.5525
P4	12	0.819	.063	16	0.844	.063	.3121
M1	16	1.084	.046	16	1.154	.048	.00002*
M2	12	1.049	.070	16	1.103	.070	.0532
M3	7	1.021	.077	12	1.065	.076	.2419

Interestingly, significant differences in the molars occurred more often on the right than left sides (M1, M2, M3 as opposed to M1). An investigation of antimere differences revealed no significant differences except for the upper fourth premolars. This may be simple variation.

Mesio-Distal Length. Comparisons of mesio-distal length results in significant differences between females and males at the upper right second molars, the upper left fourth premolars and first molars, and the lower right canine, fourth premolar and first and second molars and the lower left first molar. In all cases, the male dimensions are larger than the female dimension. In teeth for which no significant difference was found, the male teeth are again larger than the female teeth, with the exception of the upper right central incisor, the lower left lateral incisor, and the lower left premolars (Table 71).

Table 71: Mesio-Distal Length

	Female			Male			
Maxilla	n	X	s.d	n	X	s.d	p.
R. M3	11	0.885	.043	8	0.894	.034	.6188
M2	15	0.969	.063	10	1.037	.038	.0053*
M1	20	1.043	.059	15	1.077	.070	.1323
P4	14	0.653	.043	14	0.667	.058	.4733
P3	11	0.679	.060	12	0.719	.052	.0970
C	12	0.768	.046	13	0.807	.089	.1916
I2	4	0.718	.054	6	0.753	.051	.3324
I1	4	0.870	.044	7	0.865	.059	.8873
L. I1	3	0.812	.040	9	0.865	.042	.1609
I2	8	0.701	.062	11	0.738	.049	.0801
C	14	0.772	.058	16	0.811	.050	.0587
P3	10	0.676	.074	18	0.711	.076	.2490
P4	14	0.634	.047	13	0.686	.049	.0099*
M1	17	1.047	.066	14	1.047	.124	.0330*
M2	13	0.978	.183	14	1.023	.077	.4017
M3	9	0.853	.113	10	0.920	.065	.1266
Mandible							
R. M3	8	1.107	.091	12	1.127	.095	.6343
M2	12	1.089	.061	13	1.163	.052	.0033*
M1	15	1.142	.065	16	1.189	.049	.0300*
P4	13	0.609	.169	18	0.746	.121	.0129*
P3	15	0.653	.146	20	0.710	.052	.1193
C	13	0.642	.140	17	0.732	.051	.0133*
I2	7	0.573	.131	11	0.642	.085	.1927
I1	7	0.479	.088	9	0.494	.020	.6837
L. I1	8	0.440	.099	12	0.450	.082	.8038
I2	9	0.601	.095	14	0.574	.114	.5563
C	13	0.671	.087	15	0.733	.085	.0673
P3	18	0.713	.127	19	0.710	.061	.9307
P4	12	0.717	.139	16	0.711	.071	.8862
M1	17	1.113	.129	15	1.214	.053	.0082*
M2	12	1.107	.072	16	1.146	.078	.1894
M3	8	1.102	.105	12	1.120	.087	.6762

Summary. There was not a great deal of significant difference in tooth size between the women and men, although in most cases the men had the larger teeth. Significant differences occurred primarily in the molars, those teeth that were worn to a greater extent in the males than the females. As the teeth in this sample are not very worn overall, all differences in size are indicating is sexual dimorphism in innate tooth size. There is no real significance in term of wear, although one could infer that there was very little interproximal wear.

Unusual Wear Patterns

In the investigation of the Sadlermiut dentition, several unusual wear patterns were observed. Although they may not reflect gender based differences in tool use, they are nonetheless of interest.

In a number of individuals the extreme lingual orientation of the erupting lower molars resulted in the wearing away of the enamel on the buccal sides of the mandibular molars, before dentin was exposed on the cusps. This was especially apparent on XIV-C:Sad 1 (Figure 18, page 137), an individual of unknown age and sex, and XIV-C:750, a young female of 20. Related to this was the commonly found wear pattern on the mandibular molars (3.1, see Chapter Four, Table 4) in which the buccal cusps could be worn almost to the exposure of dentin, but the lingual cusps would exhibit only slight blunting.

In several cases in which the maxillary dentition had been lost antemortem for some time (e.g. the sockets were largely resorbed), the mandibular anterior dentition was worn in an undulating fashion. The central or lateral lower incisors were the least worn, at least in terms of loss of crown height with a progressive loss of crown height on the teeth on the left and right sides of the mandible. All such examples of this occurred in the older adult males, already exhibiting extremely pathological dentitions.

In another older adult male (XIV-C:217), the lower molars exhibited a markedly cupped wear, mesially-distally. The dentin seemed literally to be scooped out. The opposing maxillary molars were rounded, and still retained much of their enamel (Figure 19, page 137).

Interesting wear occurred in the dentin of the anterior lower teeth of two individuals. Contact with the opposing teeth, or in one case exhibiting antemortem loss, the upper alveolar ridge resulted in shallow linear dentin depressions .

The canines, third premolars, and to an extent the fourth premolars are often worn almost to points, or a sort of chisel shape due to the interaction of the opposing dentition shearing along the mesial and distal sides. Tendency toward such wear can be seen in the many teeth with the surface form 6.1 (in which the tooth is worn to a point, see Chapter Four, Table 5). However, in these cases the 'sharpening' is extreme. This wear is seen in old and young females and males.

The final unusual wear pattern concerns the formation of a ring of wear or trauma on the lower molars, principally along the buccal, distal and lingual sides (Figure 20, page 138). Again, dentin is being exposed here, either instead of or along with the loss of enamel on the cusp tips, and to a greater extent. This pattern was seen in only three individuals, two of which lacked the opposing maxillae. One of these was a young male of 27. The third individual, an old female of 38 with a moderately pathological dentition, exhibits lingual cupping in the maxillary molars. In occlusion, the mesial edge of the upper second molar just comes into contact

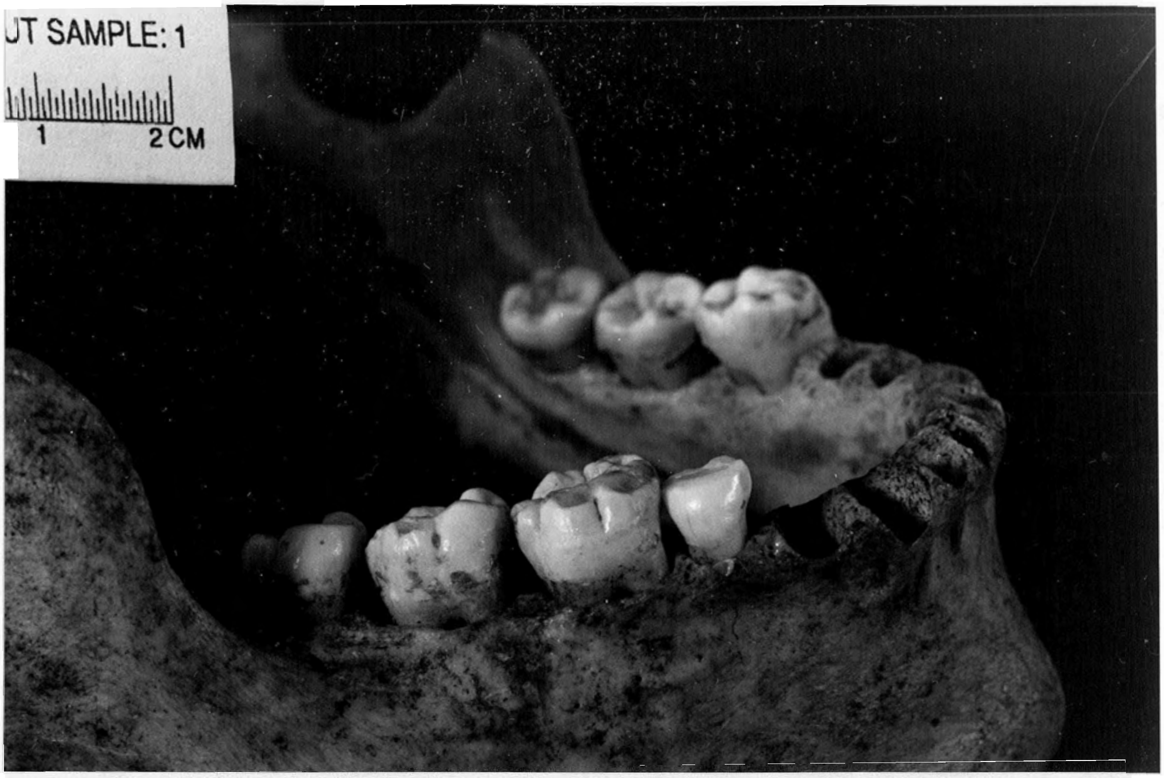


Figure 18: Wear on the Buccal Side of the Molars of XIV-C:Sad 1.

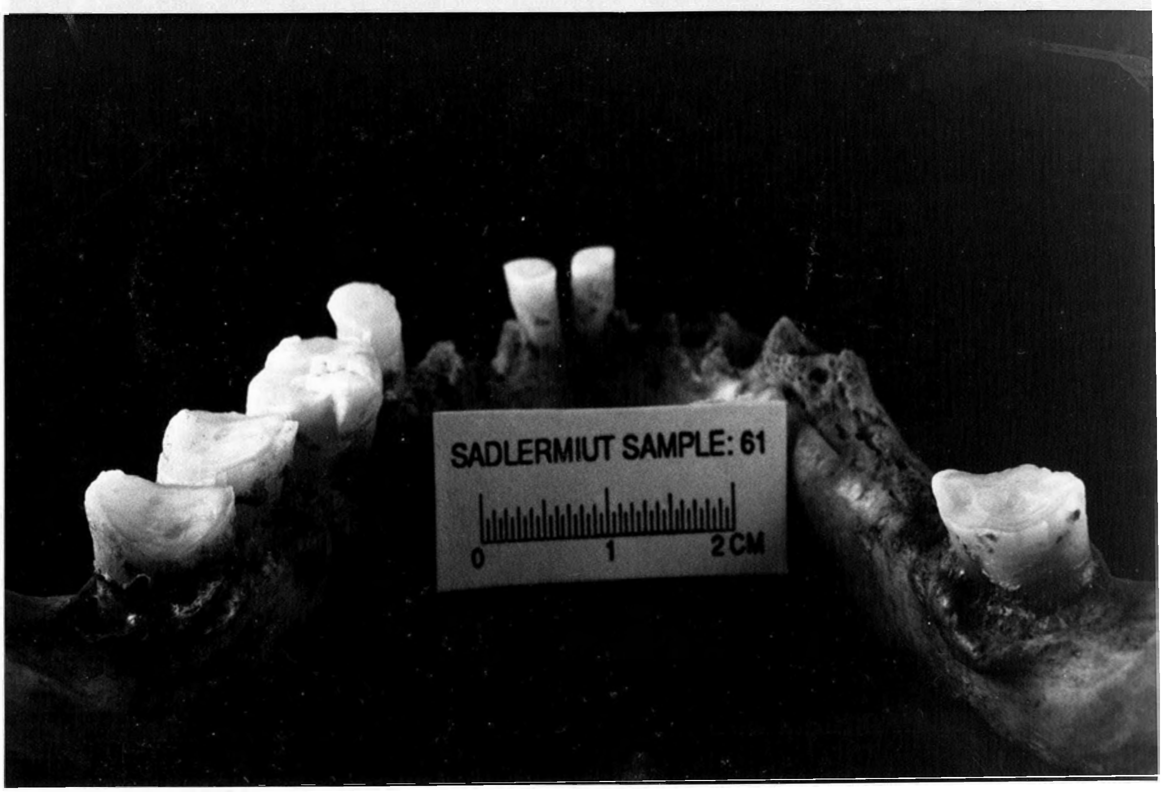


Figure 19: Scooped Dentin in the Mandible of XIV-C:217

with the distal edge of the lower first molar. This is undoubtedly with some force producing the exposed dentin. The lateral buccal and lingual extensions of this distal dentin exposure are less easily explained, but are possibly due to an extensive lateral movement of the mandible during mastication.

Figure 20: Ring of Trauma

CHAPTER SIX: CONCLUSIONS

Introduction

Difficulties in differentiating the effects of masticatory and paramasticatory movements are inescapable. Women's use of teeth in tasks such as the softening of skins may be more likely to mimic or duplicate the activities performed in the mastication of food. Obviously, paramasticatory tasks that simply involve a more prolonged masticatory action are not going to leave any distinctive marker on the teeth with the possible exception of more tooth tissue loss. The Inuit practice of eating with the stuff-and-cut method could also obscure other uses of the teeth as tools. Finally, the extremely demanding Inuit diet, involving the consumption of bone and frozen meats could work to obliterate any differences accruing on the teeth as a result of gender based differences in tooth use.

Regardless, some differences have been discerned in female/male tooth wear patterning. For the most part, these were subtle in nature, found in the comparisons between mouthparts and sex rather than between the overall occurrence of a phenomenon in the mouth as a whole between the sexes. Of the hypotheses put forth in Chapters One and Five, none were unequivocally supported, although in some cases there were indications that they were on the right track. The small sample size dictates that these results and interpretations should be treated cautiously.

DISCUSSION

Cultural Factors Influencing the Wear on Sadlermiut Teeth

Diet. Obviously the very nature of the Sadlermiut diet has contributed to the wear found on their teeth. As dealt with in Chapter Three, the Sadlermiut diet was meat-based, there being little of a vegetable nature to consume. In particular they relied on marine mammals, seals, walruses and whales, as well as caribou and fish (Lyons 1971; Marsh 1976; Mathiassen 1927 a). On the site of Tunirmiut, from which this sample derives, identified faunal material indicate a heavy reliance on seal, followed by caribou, walrus and bearded seal (Collins 1956a, 1956c, Taylor 1960). This meat was eaten boiled, roasted, raw and frozen (Mathiassen 1927a). Abrasives may have entered the diet during the process of drying the meat on the ground, or while it was hung in the cairns or houses. The meat storage house described by Marsh (1976) with its covering of moss, peat and sand, may have been particularly likely to add grit to the diet. Another contributing factor may have been the sand used to clean the houses (Mathiassen 1927 Part One).

The only evidence for a dietary difference between the women and men are the restrictions placed on menstruating women, who were only allowed to consume boiled meat (Mathiassen 1927 Part One). This might possibly contribute to lower posterior wear in the women's teeth.

Turner and Cadien (1969) associated the consumption of a meat based diet with the presence of antemortem trauma (pressure-chipping). They further related the high frequency of antemortem trauma in the Sadlermiut as being due to their demanding environment.

> Because of the greater threat of starvation in the high arctic, all nourishment possible was probably gleaned from a carcass and this would have included extracting marrow from bone. Because this is more commonly attributed to high arctic Eskimo than to Aleuts, we feel that pressure-chipping results in part from the act of chewing bone from several varieties of game, including fish, birds, and sea and land mammals [Turner and Cadien 1969:307].

In short, the Sadlermiut would be regularly cracking open bone and possibly, due to difficulties in obtaining fuel, frequently consuming frozen foods. The physical properties of such a diet, as well as the thermal fatigue induced by its temperature would likely result in a great deal of antemortem trauma (Journal of Dentistry for Children 1971). It is likely that, in common with many arctic people, the specter of starvation was a realistic fear (Birket-Smith 1940), perhaps even more so in an island bound people (Turner 1979). Although not systematically investigated in this study, enamel hypoplasia could be seen clearly on many of the teeth indicating that life for the Sadlermiut was precarious at times (Beynon 1986).

Tool Use of the Teeth. Evidence for the Sadlermiut use of their teeth as tools is indirect but convincing. Ethnographic analogy and the generally homogeneous 'arctic' culture suggest that for all the Sadlermiut uniqueness, it is likely that they used their teeth in a wide variety of tasks. Merbs' (1983) assumption, that the Sadlermiut shared many customs in common with the Central Eskimo, including that tasks to which the teeth were put, is one shared in this thesis. Furthermore, the Sadlermiut isolation forestalled marked European acculturation and resulted in a retention of their traditional lifestyle and sexual division of labour until their demise. Collins' (1957) work indicates that throughout the Sadlermiut occupation of Tunirmiut, cultural habits changed little. Finally, Merbs (1983) analysis of the intensity and distribution of arthritic temporomandibular joints and the pattern of antemortem loss in the anterior teeth points to a differing use of the dentition by females and males in this sample.

Thus, Sadlermiut women most likely utilized their teeth in the maintenance and preparation of skins for tents, kayaks and clothing, removing the fat and connective tissues and chewing the skins soft. Although Sadlermiut women may not have been as skilled as some of their counterparts on the mainland in the manufacture of clothing, the effects of the climate on the skins would still demand that they be softened. It might even be the case that in light of the fact that the Sadlermiut did not use urine to tan the clothing, more chewing was required. In addition, this inability to treat skins may well be exaggerated (see Manning 1942) as Ferguson (1979) was very impressed by the tailoring of the Sadlermiut clothing.

Women would also use their teeth in cutting activities, and to process sinews into thread. Vise-grip activities cannot be ruled out, but it is likely that the men performed more of such activities (Merbs 1983).

Male use of their teeth, in particular their use of the bow drill, can be inferred on the basis of the archaeological findings of an astragalus mouthpiece, artifacts exhibiting drilled holes and the ethnographic descriptions of fire-boring (Boas 1901; Mathiassen 1927 Part Two). However, the male use of the anterior teeth to hold objects or to clamp them between the teeth is thought to result more in antemortem tooth loss than in wear.

Merbs' (1968, 1983) investigation focused on the antemortem tooth loss in the anterior teeth, and the extent and distribution of the temporomandibular joint arthritis. But what is the effect of the use of the teeth as tools, and the sexual division of labour, on those teeth remaining?

Tooth Wear

Tooth wear was less than was expected for the sample as a whole. This finding is in agreement with Hylander's work (1972, 1977). A high rate and degree of wear may not necessarily be a marker for a heavy use of the dentition. The overall average of wear for the women was 3.18, and for the men was 3.30. This corresponds roughly to the blunting of the cusps of the post-canine teeth and at the most moderate dentine exposure for the dental arcade as a whole. It would seem that despite claims for the generally unsanitary living conditions of the Sadlermiut, their food was not being contaminated with much grit.

Turner and Cadien's (1969) study of wear on the Sadlermiut teeth used a fairly broad wear scale applied to the dentition as a whole (Table 72). Wear stage was then averaged for the maxillae and mandibles (Table 73).

Table 72: Wear Stages Used by Turner and Cadien (1969)

0:	No wear
1:	Dentine visible
2:	Cusps gone
3:	Pulp exposes
4:	Roots functional

Table 73: Average Wear Female/Male Jaws

Jaw	Female	Male
Maxilla	1.3	1.5
Mandible	1.3	1.5

To an extent, this thesis has similar findings. Male was heavier than female wear. However, as illustrated, to simply sum the wear for the mouth as a whole is an insufficient means to extract female/male differences within a population. Such a methodology obscures the differences between the anterior and posterior portions of the mouth. Goldstein noted a similar problem in the conflicting findings of his study as compared to Leigh (1925a):

> [this] higher incidence of wear in the teeth of the Eskimo males is at variance with the research of Leigh ('25b), who found the female dentitions somewhat more subject to wear than the male. The latter finding is what might be expected, if this condition is attributed wholly to the chewing of hides, which duty falls entirely upon the women. The front, rather than the back teeth, would probably be used in skin chewing, and this is likewise in agreement with the fact that Leigh observed the entire dentition [Goldstein 1932:429].

Unsurprisingly, in light of all that is known of Inuit paramasticatory activities, the anterior wear is greater than the posterior wear. This follows the patterns observed by Smith (1983) and Hinton (1981a) in which hunter-gatherers in general have more wear on their anterior than posterior teeth, the result of the uses to which the former are put. There is also an indication that mandibular teeth are being worn to a greater degree than are the maxillary teeth.

There is a further gender difference in the relationship of wear between the anterior and posterior teeth: women's anterior teeth are worn to a greater degree over their posterior teeth than are men's. This suggests that women were in fact using their anterior teeth to a greater extent than were males, probably in the processing of skins. There is also an indication that women are utilizing their lower right dentition for some purpose that is not affecting the rest of the mouth. However, sexing this material on the basis of an overall greater degree of wear in the women, as has been suggested by a number of researchers (Bessels as cited in Furst and

Hansen 1915:451, Grant 1922, Jorgensen 1953, Pedersen 1952) would be inappropriate in this sample.

The higher posterior wear in the men could possibly be attributed to a dietary difference, not so much in nature, as in degree. The dietary restriction on the menstruating women might not only have them chewing the relatively softer boiled meat but, in the absence of fuel, no meat at all. Men while hunting also have greater access to food, and do not necessarily bring all animals captured back to the settlements to share with the women. Certainly parts that are considered delicacies were often eaten just after an animal had been killed (de Poncins 1941, 1949). Women may be eating proportionately less food than men. However, the difference in diet is not as marked as the difference in the use of the teeth as tools and so while it is doubtless as factor, it may be concluded to be of lesser strength. Bite force may also be a factor, with the greater bite forces generated by the men adding to wear on their teeth.

Tomenchuk and Mayhall (1979) also found more loss in cusp height in the male as opposed to female maxillary molars in the sample they studied. They attributed this to bruxism. Davies and Pedersen (1955), who noted that the men often clenched their teeth during their tasks and probably ground them, also felt this could create differences in wear. However, the universal nature of this phenomenon (Clarke et al. 1984; Clarke and Townsend 1984) weakens this explanation.

Tooth eruption times are also unlikely to be a factor here. Trodden (1982) and Mayhall et al. (1978) found that not only did the Inuit as a whole erupt their permanent teeth sooner than most other groups, but that girls tended to erupt their teeth earlier than boys. Furthermore, Mayhall et al. (1978) found that the first molars and the maxillary central incisors, the first permanent teeth to erupt, erupted at about the same time in girls and boys.

Trauma

Trauma, in form of chipping, flaking, pitting and/or fracturing, was observed in all individuals in this sample. Both chipping and flaking were found in greater proportions in the maxilla rather than the mandible. Pitting was found in higher proportions in the anterior maxilla, and posterior mandible. This might possibly relate to the suggestion of higher wear in the mandibular teeth in which greater wear has erased antemortem trauma. Thus the relationship suggested between wear and chipping as stated by Milner and Larsen (1991) needs to be modified. Although there is a direct relationship between the amount of chipping and wear, such that the greater the wear, the greater the chipping; at some point, greater wear obscures chipping.

Additionally or alternatively, forces involved in snapping objects off between the anterior teeth with a hand-held vector might create more antemortem trauma in the maxillary teeth.

Both Laughlin et al. (1968) and Turner and Cadien (1969) found a greater incidence of chipping in males than females. Again, both fail to distinguish between different areas of the mouth and their interactions. While greater proportions of chipping and pitting are found in men, this difference is much more marked in the anterior mouth portion. This would suggest mastication of a similar diet in the posterior region, and a different use of the anterior teeth. The men's use of their teeth in a greater incidence and variety of vise-grip tasks may explain this.

The greater proportion of flaked teeth in the women could be related to bite force, as well as to nature of the tasks involving the teeth. Softening skins does not necessarily involve a sharp, high bite force. Rather, a lower, although relatively high, steady force could be used. Further, the description of Lous (1970) and Pedersen and Jakobsen (1979) in which the skins are 'rubbed' over the teeth would also suggest that an extremely high bite force is not being used in this case.

Milner and Larsen (1991) have suggested that in most populations trauma is located most commonly and to a greater degree in the posterior dental region. In the case of the Sadlermiut, the females do exhibit a greater proportion of chipped and pitted teeth in the posterior half of their mouths, but the men exhibit a greater proportion of chipped and pitted teeth in the anterior half.

Buccal Striations

Buccal striations occurred in roughly thirty percent of this sample. They are also observed in some of the immature dentitions. Likely, they relate to the stuff-and-cut method of Inuit eating (see Bermudez de Castro et al. 1988) and not, as suggested (Lukacs and Pastor 1988) to the use of the bow drill. The orientation of the striations also indicates that the Sadlermiut were predominantly right handed. This agrees with the conclusion reached by Merbs (1983).

Notches and Grooves

Notches and grooves, more definite markers of the use of teeth as tools, did not exhibit significant differences between the sexes. Notches and grooves were found predominantly in the anterior portions of the dentition, and, in the case of the grooving, there was only one individual exhibiting grooving interproximally. More men than women exhibited notches, but women had a higher proportion of teeth affected in this manner, particularly in the anterior maxilla. The most notable differences between the two sexes regarding grooving was the fact that mesio-distal grooves were more likely to occur in the women. This could relate to the manufacture of thread from sinew in the women. The buccal-lingual grooves and striations may be a result of a clenching of items between the teeth; in the women, needles, in the men, sinew lines. Notched teeth were seen in some of the immature dentitions but none displayed grooves.

As far as a localized nature for this phenomenon, most of the notches and all of the grooves were found in the anterior section of the mouth as opposed to the posterior section. This also held true for the buccal striations.

Labial Rounding

In direct contrast to trauma, labial rounding occurred in higher proportions in the anterior mandible than the maxilla. This would suggest a downwardly-directed hand-held vector, not the up-and-out snapping motion that may be responsible for some of the trauma. Labial rounding occurred in about half the adult women and men in this sample, but it occurred more evenly on the right and left sides in the women's mouths. Again, this could be related to the softening of skins, and I suspect that the Sadlermiut women softened skins in the manner suggested by Lous (1970) and Pedersen and Jakobsen (1989) in which the skins were rubbed over the anterior dentition, and not that suggested by Merbs (1983) in which skins were softened by chewing them on one side of the mouth and down along the tooth row.

Antemortem Loss, Postmortem Loss, and Abscessing

The results of the tooth-to-tooth comparisons of antemortem tooth loss differ from those of Merbs (1983). I did not find significant differences between the women and the men. This might relate to the fact that we are looking at slightly different samples. Merbs for example included all individuals with undiseased and undamaged sockets while this sample was restricted to those individuals who had at least some teeth. Furthermore, individuals with diseased sockets were not excluded. Loss due to disease may be masking the Merbs' discoveries in this sample.

For the sample as a whole, more teeth were lost antemortem in the maxilla than in the mandible, and in the posterior portion of the mouth. Although there was more antemortem loss in men than women, the difference between female loss in the anterior maxillary portion of the mouth was greater than that found in the rest of the mouth, possibly linking it to some tool use function. The greater overall antemortem tooth loss in the men could be a factor of their use of the teeth as well, with the vice-grip activities resulting in a sudden loss of their teeth.

To an extent, proportions of abscessed teeth follow that of antemortem loss with higher incidence in the maxilla and in the posterior portion of the mouth. This may relate to calculus formation (Lindhe 1989). However, more men have abscessed teeth than women, especially in the posterior portion of the mouth where differences in proportions near significance. Reasons for this are unknown. Possibly it may relate to the higher wear in men's teeth, although wear exposing the pulp cavity was rare in this sample.

The greater loss of teeth postmortem in the female anterior maxillary dentition might be related to the greater shortening of the roots in this area. Assuming that high bite forces are responsible for the root shortening (Hylander 1972, 1977), although women may not have been placing as high bite forces on the teeth as do men, the forces they do place are more constant and may have a higher cumulative effect. Unfortunately, the relative shortness of roots between and within women and men was not systematically measured.

It was beyond the scope of this study to control for most of the biological variables. This inability to control for differences in genders in terms of enamel thickness and hardness, and how these could affect wear dictate that some caution be used in the acceptance of these interpretations.

Tooth Dimensions

Differences in tooth size were slight, and indicate, if anything ,that there was little interproximal wear in this population. Tooth dimensions are merely reflecting sexual dimorphism in innate size.

CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

The purpose of this thesis was to distinguish patterns of wear that could be attributed to the use of teeth as tools in gender specific ways. While this goal was only partially attained, some of the results are encouraging. Female/male differences were found, although attributing a specific wear pattern to a specific task remained out of reach. It is clear that the teeth are being used as tools , and are being affected differently by this use in the women and in men probably from the practice of certain tasks. However, a one-to-one correlation between task and wear phenomena could not be made. It is unlikely it ever will be.

What this study clearly illustrates is the need to differentiate between areas of the mouth in order to extract female/male differences, and to distinguish very finely between phenomena such as wear stage or trauma type. Coarser comparisons fail to distinguish or obscure trends and future studies in this area will require robust methods and large samples. Differences between women and men in this sample are fairly subtle, mainly between wear and trauma. Surprisingly, notches and grooves,which can be attributed with more confidence to task activities are not the phenomena that exhibit the female/male differences. This may partially be due to the small sample size. Very likely it is due to a common problem in physical anthropology, different etiologies result in similar symptoms. The fact remains that a woman's habit of clenching needles between her teeth, and a man's habit of holding a line likewise, may result in the same notch or grooving patterns. The shared demanding diet, and common use of the stuff-and-cut eating method probably also serve to obscure differences between the women and men in the use of their tools in gender specific way.

There is a definite need for standardized methods and reporting in the study of tooth tissue loss due to tool use, particularly that due to antemortem trauma. There is a further need for better criteria to distinguish between antemortem and postmortem wear. It may be that as Ryan (1980) has suggested, that microscopic investigations should be used to help distinguish antemortem or postmortem trauma. Molds and casts were made of all the teeth examined in this study, in anticipation of future work in this area. More studies of gender-related differences in tooth wear both within and between populations are needed, and it would be useful to compare the findings of this thesis to a group in which teeth were not used as tools to see if similar gender differences occurred.

Appendix A: Material Studied

Catologue Number	Elements Present	Age	Sex	Source
XIV-C: Sad 1	Skull	Adult	?	
XIV-C: Sad 2	Skull	Adolescent	?	Taylor 1960
XIV-C: Sad 3	Skull	Adult	?	Taylor 1960
XIV-C: Sad 4	Skull	Child	?	Taylor 1960
XIV-C: Sad 5	Skull	Adult	?	
XIV-C: Sad 6	Mandible	Adult	?	
XIV-C: 76	Skull	Child	?	Merbs 1990
XIV-C: 104	Skull	36	F	Merbs 1990
XIV-C: 111	Skull	25	M	Merbs 1990
XIV-C: 112	Skull	26	F	Merbs 1990
XIV-C: 117	Skull	24	M	Merbs 1990
XIV-C: 126	Skull	25	M	Merbs 1990
XIV-C: 136	Skull	45	M	Merbs 1990
XIV-C: 150	Skull	4	?	Merbs 1990
XIV-C: 151	Skull	12	?	Merbs 1990
XIV-C: 153	Skull	32	F	Merbs 1990
XIV-C: 156	Skull	37	M	Merbs 1990
XIV-C: 157	Skull	26	F	Merbs 1990
XIV-C: 158	Skull	14	F?	Merbs 1990
XIV-C: 169	Mandible	27	M	Merbs 1990
XIV-C: 173	Mandible	29	F	Merbs 1990
XIV-C: 174	Mandible	30	M	Merbs 1990
XIV-C: 175	Cranium	24	F	Merbs 1990
XIV-C: 178	Skull	40	F	Merbs 1990
XIV-C: 179	Skull	36	M	Merbs 1990
XIV-C: 181	Mandible	37	M	Merbs 1990
XIV-C: 182	Skull	29	M	Merbs 1990
XIV-C: 183	Cranium	43	F	Merbs 1990
XIV-C: 190	Mandible	30	M	Merbs 1990
XIV-C: 193	Skull	18	M	Merbs 1990
XIV-C: 198	Skull	15	M?	Merbs 1990
XIV-C: 202	Mandible	<4	?	Merbs 1990
XIV-C: 216	Skull	29	M	Merbs 1990
XIV-C: 217	Skull	36	M	Merbs 1990
XIV-C: 219	Skull	28	F	Merbs 1990
XIV-C: 220	Skull	13	F?	Merbs 1990
XIV-C: 221	Skull	36	F	Merbs 1990
XIV-C: 231	Skull	Subadult	F?	Merbs 1990
XIV-C: 232	Mandible	<4	?	Merbs 1990
XIV-C: 234	Skull	37	F	Merbs 1990
XIV-C: 239	Cranium	18	M	Merbs 1990
XIV-C: 243	Skull	30	M	Merbs 1990
XIV-C: 244	Skull	38	F	Merbs 1990
XIV-C: 246	Skull	27	M	Merbs 1990
XIV-C: 248	Skull	40	F	Merbs 1990
XIV-C: 259	Cranium	32	F	Merbs 1990
XIV-C: 287	Skull	43	M	Merbs 1990
XIV-C: 293	Cranium	36-55	F	Turner 1967
XIV-C: 736	Skull	26	M	Merbs 1990
XIV-C: 737	Skull	19	M	Merbs 1990

Appendix A: Material Studied (Continued)

Catologue Number	Elements Present	Age	Sex	Source
XIV-C: 739	Skull	24	F	Merbs 1990
XIV-C: 741	Skull	25	F	Merbs 1990
XIV-C: 742	Skull	20	M	Merbs 1990
XIV-C: 743	Skull	32	F	Merbs 1990
XIV-C: 744	Skull	25	F	Merbs 1990
XIV-C: 745	Skull	19	M	Merbs 1990
XIV-C: 746	Skull	38	F	Merbs 1990
XIV-C: 747	Skull	25	F	Merbs 1990
XIV-C: 748	Skull	28	M	Merbs 1990
XIV-C: 749	Skull	28	F	Merbs 1990
XIV-C: 750	Skull	20	F	Merbs 1990
XIV-C: 752	Skull	23	F	Merbs 1990
XIV-C: 753	Skull	35	M	Merbs 1990
XIV-C: 755	Skull	32	M	Merbs 1990
XIV-C: 756	Skull	20	M	Merbs 1990
XIV-C: 757	Skull	34	M	Merbs 1990
XIV-C: 758	Skull	34	F	Merbs 1990
XIV-C: 760	Skull	25	F	Merbs 1990
XIV-C: 761	Skull	36	F	Merbs 1990
XIV-C: 762	Skull	26	F	Merbs 1990
XIV-C: 764	Skull	36	?	Merbs 1990
XIV-C: 765	Cranium	Adolescent	?	Museum List
XIV-C: 768	Skull	Adolescent	?	Museum List
XIV-C: 769	Cranium	Adult	F	Museum List
XIV-C: 772	Skull	Adult	M	Museum List
XIV-C: 773	Cranium	Adult	M	Museum List
XIV-C: 774	Skull	Adult	M	Museum List
XIV-C: 776	Cranium	Adult	M	Museum List
XIV-C: 782	Cranium	Young Adult	F	Museum List
XIV-C: 784	Skull	Adult	M	Museum List
XIV-C: 801	Skull	Adult	?	Museum List

Sources: Merbs 1990: list sent by Merbs (December 1990) of the ages and sexes of the specimens he studied

Museum List: Acc 2470, Acc 2530: obtained from the Canadian Museum of Civilizations (December 1990)

Turner 1967

Taylor 1960

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