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THE EPIDEMIOLOGY OF MALOCCLUSION AND THE NEED FOR ORTHODONTIC CARE IN NORTHERN LABRADOR INUIT YOUTH

by

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

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THE EPIDEMIOLOGY OF MALOCCLUSION AND THE NEED FOR ORTHODONTIC CARE IN NORTHERN LABRADOR INUIT YOUTH

Abstract

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Many previous epidemiologic studies of malocclusion have used molar classification alone to characterize a population group. The present study examined the prevalence of malocclusion in Inuit youth, aged between 5 - 22 years, living in subarctic Labrador, Canada. Psychosocial, dental and skeletal parameters were obtained during a field study in 1991. The two communities examined, Nain (population about 1000) and Hopedale (population about 500) had a total of 445 school children. About 82% (n = 363) of the Inuit youth and 50% (n = 222) of their parents responded to the questionnaires. In total, 78% (n = 348) of the Inuit youth were clinically examined to determine the prevalence of malocclusion and caries. In addition, 23% (n = 100) were selected for radiographic evaluation.

The results of this study indicated that the Labrador Inuit were **aware** of their occlusal disharmonies (16 - 63%), **wanted** to wear orthodontic appliances (65 - 70%) and had a **high prevalence** of malocclusion (95%). Orthodontic care was highly recommended for persons over the age of 12 years provided the individual was adequately educated and motivated

towards treatment, demonstrated good oral hygiene skills and was a regular dental attender. Orthodontics was not recommended for the 5-8 year old age group because they demonstrated a high prevalence of caries in the primary dentition. Data from dental and skeletal evaluations indicated that the orthodontic problems were severe and may prove to be difficult to treat. If the problems of caries in the primary dentition are adequately addressed, early intervention would be beneficial. Native people of Northern Labrador are eligible for dental care at no cost to them. Implementation of an orthodontic service in any northern community depends on the availability of funds and the method of health care delivery. Orthodontic care would have to be closely coordinated with general dental care.

DEDICATED

TO

My parents, whose love, academic initiative and financial support made my education possible.

Ellen, for her love, assistance support and understanding.

All the people of Labrador, for their wonderful resilience and warmth.

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INTRODUCTION

Malposition or "malocclusion" of teeth has been known to exist in the human dentition for many centuries. Weinberger (1926) points out that the father of medicine, Hippocrates [460-377 BC], may have been the first to describe malocclusion and its possible relation to different facial types. Aristotle [384-377 BC] and Celsus [25 BC] were also aware of the unsightly appearance of "crooked teeth". Examination of dentitions of ancient civilizations has revealed that a low prevalence of malocclusion was often present. Attrition or wear of occlusal and interproximal surfaces of the teeth was, however, a common finding. In contrast, the dentition of industrialized populations, demonstrates a much higher prevalence of malocclusion with little or no attrition.

The Inuit, including those of Northern Labrador, are a population in transition. Historically, this population has demonstrated a low prevalence of malocclusion and a high degree of occlusal wear (Costa 1980; Leigh 1925; Waugh 1932). The acculturation process has resulted in dramatic increase in the prevalence of dental diseases, so much so, that Waugh (1932), has stated that "the Eskimo is veritably paying for his civilization with his teeth". The main dental diseases of concern are malocclusion and dental caries. The increase in these two diseases are thought to be linked to dietary changes and the increase in genetic pool that accompanies acculturation.

Many health care models exist to control and treat dental caries in a population of this kind. Malocclusion, on the other hand, is a little more complicated to measure, control and treat. Malocclusion involves dental, skeletal, and soft tissue parameters and is often accompanied by psychosocial factors. Furthermore, all of these factors can vary between population groups. In order to design an effective strategy for correction of malocclusion, the dental, skeletal and psychosocial needs of the population must be determined. At the time data for this thesis was collected, the Labrador Inuit and the Inuit who live in the remainder of the circumpolar region, had received minimal orthodontic evaluation or care.

The purpose of the present epidemiological study was to examine malocclusion using psychosocial, dental and skeletal parameters recorded for Inuit youth living in subarctic Northern Labrador, Canada. Ages ranged from five to twenty two years. The data was collected by the author and two assistants in a field study lasting two and a half weeks during the Spring of 1991. Specific aims included:

(1) To evaluate **psychosocial** aspects related to malocclusion using parent and student questionnaires.

(2) To evaluate the **dental** aspects of malocclusion using clinical epidemiological parameters pertaining to the prevalence of malocclusion in Labrador Inuit school children.

(3) To evaluate the **skeletal** parameters and jaw relationships of malocclusion in this Inuit population using cephalometric radiographs (oriented skull X-rays) of a selected sample.

(4) Analysis of data collected provided insight into the prevalence of dental and skeletal malocclusion as well as actual and perceived need for **orthodontic care** in two Canadian native communities (Nain and Hopedale, Northern Labrador).

1. LITERATURE REVIEW

"Orthodontia" comes from the Greek words "orthos" meaning "correct" and "dons" meaning "tooth". Orthodontics is the art of straightening teeth that are malposed. Today's practitioners evaluate orthodontic problems in patients using dental, skeletal and soft tissue parameters. Epidemiologically, however, the prevalence of malocclusion has traditionally been recorded using Angle's molar classification and subjective evaluation. Few researchers have used objective methods. On the other hand, some clinical methods for the evaluation of patients' orthodontic problems involve the examination of psychosocial parameters as well as dental and skeletal parameters. No epidemiologic studies on malocclusion have attempted to examine this clinical approach by combining dental, skeletal and psychosocial parameters together.

To provide modern orthodontic care to any group of people, the practitioner needs to have a knowledge of facial morphology and of facial characteristics of the race that are unique to that population. In addition, a knowledge of normal development, facial growth patterns, general dental status and dietary habits is also necessary. To individualize orthodontic care, the orthodontist should understand the population's general attitudes as well as their attitudes to dental treatment. Furthermore, delivering efficient health care to remote populations requires a knowledge of the

availability of resources and the methods of health care delivery in that region.

The Northern Labrador Inuit number some 2,000 in a total circumpolar Inuit population of around 95,000. The role of the Labrador Inuit will be discussed in relation to the origin and evolution of the entire Inuit race. The circumpolar Inuit population is distributed throughout the northern regions of **Russia**, **the United States of America**, **Canada**, and **Greenland** (see Appendix B). The Inuit of the circumpolar region share several common genetic and environmental features. This literature review will thus compare research from within the country of origin and also from within the circumpolar regions as a whole.

1.1. Inuit/Eskimos

There is reference throughout the literature to the "Eskimo", an old term referring to the people living in and around the Arctic. This term has been replaced by "Inuit", meaning "real man" or "people", and is the term preferred by the people themselves.

The following will be discussed in this section:

(A) Prehistory and History

(B) Population Distribution

(C) Origins

(D) General Growth Patterns

(E) Nutrition and Culture

(F) Dental Health

(G) Craniofacial Studies

(H) Health-care Delivery and Future Trends

(A) Prehistory and History

North America went through four major glacial stages during the Pleistocene, the last stage of which is known as the Wisconsin Stage (between 90,000 and 10,000 years ago). The sea level during the Wisconsin period fell by some ninety to one hundred meters (300-330 feet). Asia became linked to Alaska and North America via the Bering land bridge. It is believed that animals moved eastwards across the land bridge, closely pursued by man hunting for food (Herbert 1976). Today, the shortest distance in the Bering Straits between Siberia and Alaska is eighty kilometers (50 miles). However, the land bridge was not passable all of the time. It would seem that there were three main periods when man and animal could have made the journey from Asia to America more easily:

(1) 40,000 years ago

(2) 28,000- 23,000 years ago

(3) 13,000-10,000 years ago

Determining when and how the Americas first became peopled is still very controversial. Traditionalists believe that the first Americans arrived from Siberia, across the land bridge, around 12,000 years ago. However, archaeological sites discovered all over North and South America, dating as old as 47,000 years, have cast doubts on this theory. One view questions whether the first American people were technologically capable of

completing the journey over the land bridge earlier than 12,000 years ago, or whether the earth was sufficiently warmed to make travel possible before 14,000 years ago. Another hypothesis suggests an alternative mode of travel - by sea - which would suggest that an earlier migration was possible (Begley 1991). The detailed examination of past and present dentitions of many Asians and Native Americans by some dental anthropologists has further suggested a three or four wave pattern of migration (Turner 1989).

Nevertheless, it is generally believed that the Eskimo is likely to have crossed the land bridge separately from American Indians between, at least, thirteen and ten thousand years ago (Herbert 1976). Evolution of the Eskimo race is likely to have changed from the PROTO-ESKIMO, a race of pure Mongoloids and Northeastern Asians about ten thousand years ago, to the PALEO-ESKIMO, found up to 900 AD, and then to the NEO-ESKIMO, around 1300 AD. The present Eskimo or "INUIT", as the race is known today, evolved from the Neo-Eskimo. A probable sequence of the various Inuit cultures that emerged are listed below:

Proto-Eskimo

(1) Denbigh Flint Complex (5,000 years ago)---the people hunted seal in the summer months while others hunted the interior.

(2) Aleuts in the Aleutian Islands located off Alaska (around 2000 BC).

(3) Pre-Dorset (around 2000 BC)---spread across Canada and northeast Greenland, became known as Independence 1, and were orientated towards life on the coastal waters.

(4) Caribou Eskimo---adapted to living inland and subsequently became trapped in the interior.

Paleo-Eskimo

(1) Norton Sound---occupied this area in Alaska.

(2) Sarqaq (1400 BC)---occupied Canada and Greenland.

(3) Dorset (800 BC to 1300 AD)---settled on the Arctic east coast and developed changes in tool making, also using a range of tools. The oldest skeletal remains found in Canada belong to this group.

Neo-Eskimo

(1) Thule phenomenon---a strong culture that influenced the entire Arctic Coast. By 900 AD, the Thules were on the Arctic west coast; by 1300 AD, they were on the east coast in Canada, Labrador and Greenland.

(2) Inugsuk---occupied the west coast of Greenland and were influenced by the Norsemen until around 1345 AD (Dumond 1965; Herbert 1976).

It would appear that, after several adaptations, the Thule Eskimo are likely to be the direct ancestor of the modern Canadian Eskimo (Milan 1980).

(B) Population Distribution

The Inuit have been known to the European world since 1000 AD. Leif Erikson came across some Inuit on the coast of Labrador who had already been living in the New World for over four thousand years (Laughlin 1963).

Krauss (1973) had estimated the Inuit population at 95,000 (plus or minus 5%), with Greenland having 43,000, Canada 17,000, Alaska 34,000, and Siberia 1,000. Milan (1980) estimated the total at 91,104, with slight variation from Krauss' estimate for each country. On the other hand, a national census for aboriginals living in Canada, completed in 1986,

suggested that there were more Canadian Inuit than previously estimated. The census listed 26,805 Inuit of single origin alone, and an additional 6,170 Inuit of mixed origin. Deciding who was native and who was not, has always been a difficult and politically sensitive task to investigate.

(C) Origins

Today, there are three distinctive Arctic languages spoken by the Inuit. Two of the languages are "Eskimo" (the Yupik language in the west, and the Inuit language in the east). The third is the "Aleut" language (Zegura 1978; Laughlin 1963). These three languages are phonetically and grammatically similar. Linguists, and some anthropologists, have suggested a two-fold division of the Inuit based on language. One group would be the "Aleut", and the other, "Eskimo", with the dividing line being located at Norton Sound (Dumond 1965). Some other anthropologists see the boundary east of Point Barrow (Hrdlicka 1930; Levin 1963). On the other hand, blood group studies of skeletal remains show a similarity between the Aleuts in the west, and Greenland Eskimos in the east. The Aleuts may be genetically similar to the Inuit, but speak a slightly different language. A similarity to the Inuit blood group was also found in Asiatic Mongoloids, but was not found to be similar to that found in American Indian blood groups (Laughlin 1963). American Indians and Inuit are thus not genetically similar, nor are their languages similar. "ABO" blood-typing of ancient skeletal remains has been in use since 1929. Initially, this technique was not considered to be accurate for genetic studies. Considerable improvement of

the technique, using haem-agglutination-inhibition, has made blood-typing of skeletal material more reliable (Micle et al., 1977).

Besides the traditional archaeological and ethnological methods, several other methods of investigation have been employed to shed some light on the origins of the Inuit people. These include genetic studies (Harvald 1974, 1989), similarities in biological morphology (Turner 1989, 1990; Doyle, Johnson 1977; Matis, Zwemer 1971; Perzigian 1977), craniofacial studies (Packard, Zwemer 1971; Yongyi et al., 1991; Ossenberg 1976, 1981), and linguistics based on lexico-statistical descriptions (based on vocabulary) and degree of relatedness of languages (Zegura 1978; Laughlin 1963; Bergsland, Vogt 1962; Harper 1980). Combined approaches, involving many disciplines, have also been investigated. Some of these studies include taxonomic congruence or ranked degree of relation between linguistic and craniofacial parameters (Ossenberg 1977; Zegura 1975).

The accuracy of some of the origin studies such as glotto-chronological estimates of elapsed time (changes in the language pronunciations with time), have been disputed. In this example, the indication of changes within the language stock is considered more important than the exact timing of the event of the change in language (Bergsland, Vogt 1962; Dumond 1965).

Zegura (1975) discussed a method of correlating seventy-four craniometric measurements and twenty-eight subjective cranial observations from Inuit skulls with linguistic parameters of the region in order to estimate biological distances. He later concluded (Zegura 1978) that

discrete biological traits (strong genetically inherited characteristics) may provide valuable comparative information when used in conjunction with other data related to origins of the population. In another study, the Bjork orthodontic analysis was used to analyze tracings of cephalometric radiographs of American Indian and Alaskan Inuit skulls. The researchers were able to classify the natives ethnically with 88% accuracy, and by sex, with 93% accuracy (Packard, Zwemer 1971). Ossenberg (1977) also analyzed biological distances on non-metric skull observations as compared with biological distances based on cranial measurements of Inuit populations. The non-metric distances exhibited stronger agreement than the metric distances when compared with the linguistic or the geographic affinity. Complex statistical analysis were used in many of the calculations.

North American Inuit populations are typically small and geographically isolated. Gene flow has been relatively limited and insulated from change (Harvald 1989). The physical traits which characterize isolated people can either vary continuously (present in a large number of the population), or discontinuously (not present in all the population). Examples of continuous variables include stature, intermembral portions, and the size of the ascending ramus of the mandible. Examples of discontinuous variables include blood groups, fissural patterns of teeth and various cranial foramina and sutures (Laughlin 1963). These measures have been used in many origin studies (Turner 1989).

Genetic distance analysis of Inuit of St. Lawrence Island using forty-four discrete genetic loci, demonstrated that a close relationship existed between the Inuit of St. Lawrence and Inuit from other locations. A strong

similarity to Asiatic populations was also demonstrated (Ferrell et al., 1981). Caucasian admixture in the Inuit population of St. Lawrence Island was estimated to be 2-7% (Ferrell et al., 1981). In Point Hope, Alaska, 35% of the population had non-Eskimo genes. In Wainwright, Alaska, the admixture was 27%, whilst in Igloolik, Central Canada, it was only 6%. According to Milan (1980) the concept of a "pure race" of Inuit is presently considered to be fallacious.

Non-genetic environmental factors may adversely affect dental and skeletal growth and can produce bilateral asymmetry in various skeletal structures. The teeth or jaws on one side of the face may be larger than on the other. If asymmetries are not bilateral, the descriptive term used is "fluctuating asymmetry". Perzigian (1977) postulated that environmentally mediated growth disturbances can be sensitively reflected by dental asymmetry in some populations, such as the Inuit. In another genetic study, Doyle et al., (1977) examined the possibility of inbreeding in small Arctic populations as a cause of fluctuating asymmetry in teeth, but the hypothesis was not found to be statistically significant.

Harvald in 1976, examined some common polymorphisms related to red blood cell and immunoglobulin antigens. He demonstrated that in Caucasians, these polymorphisms had alleles that were closer together than those of the Inuit. The relative "shortage" of alleles found in the Inuit signifies a lower average heterozygotism and a smaller genetic pool. It is not clear whether these results indicate that the Inuit have adapted to the environment for increased probability of survival or lack the genetic adaptation found in Caucasians (Harvald 1989).

There is some reference in the literature to the epidemiological distribution of rare diseases which have unusually high prevalence among native American Indians and Inuit. Focal epithelial hyperplasia or Heck's Disease, for example, is a rare, possibly viral disease, that has been described to effect the oral mucosa of American Indians and Inuit. In American Indians the disease occurs as multiple nodular elevations found on the lower lip, buccal mucosa, commissures and labial mucosa of the upper lip and tongue (Praetorius-Clausen 1972). In the Inuit, the prevalence ranged from 8.6%-12.7% in the Canadian arctic and 7%-35.8% in Greenland (Jarvis, Gorlin 1972). The prevalence among Caucasians has rarely been reported. The prevalence was also found to be higher in areas where the Inuit have had less admixture with Caucasians. Thus, a genetic factor has been suggested to explain the pattern of the distribution of the disease (Praetorius-Clausen 1972). This may suggests that the North American Indians and North American Inuit may have a similar overall genetic make-up that differs from that of Caucasians.

In another study Yongyi et al., (1991) proposed that, at best, there are eight major regional clusters of world populations including Africa, Amerind, Asia-Mainland, Australo-Melanesia, Eskimo-Siberia, India, Europe and Jomon-Pacific. Twenty-four craniofacial dimensions were made from skeletal remains to reach this conclusion. In the past the term "Mongoloid" has been used to describe certain craniofacial characteristics present in Asians. However, "mongoloid" would include a number of these suggested population clusters. The authors of this study recommended that since the

term "Mongoloid" lacks the precision necessary to accurately describe facial morphology in Asian populations, its use should be discontinued.

The precise morphology of human teeth results from patterns of genetic inheritance that remain stable from generation to generation within a given population. The four basic dental features which are considered as stable polygenetic traits (under multiple genetic control with minimal variation in response to environmental influence) are crown shape, root number, types of teeth (incisors, canines, premolars and molars), and number of teeth (32 in the adult, 20 in childhood). Secondary traits (dental characteristics showing discontinuous variation) are less stable in the human race and, therefore, exhibit more variation (Turner 1989). Of the thirty common secondary dental traits, there are eight that have been found to be the most statistically significant in distinguishing types of teeth. They are:

(1) upper incisor shovelling

(2) double shovelling

(3) upper first premolar root number

(4) upper first molar enamel extensions

(5) third molar reduction

(6) lower first molar root number

(7) lower first molar deflecting wrinkle

(8) lower second molar cusp number

From such genetic dental trait analysis, it was hypothesized by Turner (1990) that there are two large branches of people that make up the "mongoloid" population today:

(a) **Sundadonts**---the people who occupied Sundaland such as the Asians from southeast Asia, Indonesia, and Polynesia. Retention of the ancestral qualities of earlier Late-Pleistocene teeth are present. There is also a reduced frequency of the secondary traits mentioned above. Particular findings include general crown reduction and a higher incidence in peg-shaped teeth and congenitally missing third molars.

(b) **Sinodonts**---people who have evolved from Sundadonts including those from Mongolia and China, Japan, Siberia and the New World (Indians and Eskimos). Therefore, native North Americans Indians and Inuit are Sinodonts. Specialization and intensification of several features of root and crown traits is exhibited. This may be due to micro-evolutionary adaptation to life in colder climates. The dental pattern is also more complex with a greater frequency in all the secondary traits listed above.

The center of differentiation of the two types of dentition appears to be in **southeast Asia**. The Sundadonts spread north to China and Mongolia about 20,000 years ago. They developed into Sinodonts who then spread to Siberia. Sundadonts then migrated across the Pacific to reach New Zealand, Australia and Hawaii; an observation also demonstrated in linguistic and archaeological evidence (Turner 1990).

It has been suggested that the ancestors of native Americans that made up the New World, originated in **northeast Asia**. The Sinodonts then spread as far south as southeast Chile about 11,000 years ago. Studies in dental anthropology (Turner 1984) have also suggested that there were three waves of migration of Sinodonts into the Americas (see

Appendix A). This is in contrast with the single wave suggested by Laughlin (1975) and West (1981), the four wave pattern suggested by Irving (1968), or the multiple wave pattern suggested by Voegelin (1958).

The three wave theory (Turner 1984) suggested that the first migrating group of Sinodonts included the Paleo-Indians, whose ancestors may also be from the late Pleistocene north Chinese. These Sinodonts are the ancestors to most North American and to all South American Indians who reached as far south as southeast Chile. This group may have crossed western Beringia via the **Lena-Arctic route**. The second wave contained the group who crossed the Bering land bridge and became the Aleuts and the Eskimos. This group may have crossed via **Amur-Ushki route**. The third wave are considered to be ancestors of the Navaho and Apache Indians, and the Indians of Alaska and parts of British Columbia. This group may have crossed via the **Diuktai route** (see Appendix A).

The use of craniofacial metrics, such as that described by Turner, are comparable to studies that use genetic typing of DNA. These studies are able to utilize data from modern human populations (Yongyi et al., 1991).

Although the reconstruction of the exact origins of the native people in North and South America is by no means complete, dental anthropology seems to be helping answer some of the important puzzling questions. Further study is still needed in this area.

(D) General Growth Pattern

Jamison (1990) examined the growth patterns in Arctic populations. He demonstrated that Inuit children displayed characteristics such as high

weight for height, that are established early in life. Those growth patterns are different from those of European or Continental US children. Earlier, in 1963, Laughlin stated that the Inuit were muscular with heavy bone structure. Little fat was usually present even at advanced ages. The high weight for height found in the Inuit has lead researchers to examine the suggestion that the Inuit are more obese than other Caucasians. Schaefer in 1977, found obesity to be present, especially in Canadian Inuit men. He questioned the reliability and methodology of using skin thickness anthropometric measurements as a means of reaching such a conclusion because it was not a good measure of obesity.

North Alaskan Eskimo stature lies between the tenth and twenty-fifth percentile, while weight falls between the fiftieth and seventy-fifth percentile of US White pre-adolescent standards. During adolescence, both of these variables approached higher percentiles on the white growth standards (Jamison 1976). The peak velocity for Inuit weight and height occurred between fourteen and fifteen years of age. That is approximately one year after the peak velocity for Caucasians. The male Inuit growth spurt in stature lasted for a longer period of time than that recorded for White males. Female Inuit peak height velocity, on the other hand, demonstrated a growth spurt that was similar in duration to that for White females (Jamison 1978). Eskimos of the interior of Northern Alaska and Canada are taller than the Eskimos living along the coast. They also grow over a longer period of time (Laughlin 1963). Rode et al., (1976) forecasted that the size differential that exists today between the white population and the Inuit would disappear over the next few decades once similar life-styles ensued.

A comparative study between circumpolar Lapps, and Alaskan, Foxe Basin, Quebec and Greenland Inuit, discovered that mean stature variation from one to twenty years of age for both sexes was similar for all groups. The slow rate of growth that is established early in life becomes accentuated after ages 7-8 years, suggesting that environmental factors may be responsible for slowing growth (Auger et al., 1980).

Longitudinal studies on many populations of the world have demonstrated two important secular trends. Firstly, statural height is increasing approximately one centimeter (1 cm) per decade. Secondly, sexual maturation is occurring earlier in teenagers, as evidenced by the earlier development of secondary sex characteristics.

Increase in genetic admixture or population hybridization has been postulated as one of the causes of secular increases in stature (Tanner 1986). Some studies question this hypothesis. For example, Inuit populations have had a secular stature increase of 1-2 cm. Lapps, another circumpolar population of different ethnic origin, have also had a 3-4 cm increase in stature in the last decade. Although hybridization has occurred to differing extents in both groups, the Lapps have remained the most genetically isolated of all circumpolar peoples. Yet, the Lapps still exhibited an upward trend in stature with time (Lewin, Hedergard 1971; Jorgensen et al., 1972).

The secular changes in stature for the circumpolar groups seem to have started after 1920. Similar increases started much earlier for American and European populations (Milan 1980). Improvements in the level of health care, hygiene conditions, dietary and life style changes, and possibly

also an increase in hybridization, may have contributed to the general increase in population stature (Johnston et al., 1982; Jamison 1976).

Increase in statural height and earlier sexual maturation are positive indicators of a population's health status. With continued improvement in the environment and better nutrition, more individuals may achieve their genetic potential for body size. Some researchers also predict that with time, the secular trends will level off (Jamison 1990; Rode et al., 1976).

(E) Nutrition and Culture

Inuit obesity has become an increasing concern, and may suggest that the dietary changes that have occurred are not all improvements (Jamison 1976).

By the eighteenth century the process of acculturation and deculturation of the Inuit had started. Contact with the White man during this period caused the Inuit culture to gradually erode and be replaced by the dominant culture of the West (Shedden 1988).

Seltzer (1980) described an acculturation "stress phenomenon" affecting particularly adolescents and young adult Inuit males. The stress manifested itself as a syndrome that included low self-esteem, negative self-image, and feelings of emasculation. Berry (1990) listed the indicators of low mental health status in any population, as exhibiting high patterns of suicide, homicide, alcohol and drug abuse, spousal and child abuse, high infant mortality, low life-expectancy, and low educational achievement. The incidence of all the above indicators was found to be higher than the

national average in Inuit populations of Canada, Alaska and Greenland (Milan 1980).

In 1972, a seven-day diet survey on adult inhabitants of an Inuit settlement in northwest Greenland indicated that protein provided 44% of the dietary calories, fat made up 47% and carbohydrate, 8% of the total (Bang et al., 1976). Bell, Heller (1978), using four-day dietary records from Point Hope, northern Alaska, recorded that indigenous or native foods, supplied 22% of the calories in the adult diet, and only 8% in the children's diet, with modern store foods providing the calories for the rest of the diet.

Bang et al., (1980) analyzed the dietary differences between the levels of fatty acid, carbohydrate, protein and cholesterol present in the traditional fish and seal diet of Greenland Inuit and the typical Danish diet. The Inuit diets were richer in polyunsaturated fatty acids. Hoppner et al., (1978) also sampled the traditional foods of the Inuit living in the Northwest Territories. Caribou, seal and arctic char were found to contain a high level of polyunsaturated fats. These healthy dietary characteristics of the Inuit food were used to explain the rarity of heart disease in the Inuit people in earlier studies. Thouez et al., (1989) postulated that the changing dietary habits towards more purchased store foods with a lessening reliance on hunting and fishing have lead to an increase in heart conditions, hypertension and diabetes.

Condon (1990) in a ten year longitudinal developmental study on Inuit adolescents, emphasized the drastic changes in Inuit family relations that resulted from population increases and concentrations, government housing policies, formal schooling systems, and the availability of social

subsidies. Peer group pressures to acquire western values and practices are expanding. The social structural changes are thus also being reflected in dietary changes (Alton-Mackey 1988). Wildlife foods, however, still remain an important part of the Inuit diet today. Although the eating of such foods is encouraged by all, it causes great concern among health workers because industrial pollutants from the West are presently finding their way into the food chain (Kuhnlein 1990).

Various stages of acculturation amongst native peoples exists and it appears that the further the acculturation, the greater the deterioration in general and nutritional health (Schaefer et al., 1980). Changes in the dental health related to acculturation among the Inuit appear to be more complex (Milan 1980).

(F) Dental Health

Costa (1980) investigated the dental health of 246 pre-white contact Inuit skulls from three sample locations in Alaska. Heavy occlusal wear was found to be present in all three samples. There was a low caries rate noted which was attributable to a traditional diet totally devoid of refined sugars, starches and food additives.

Leigh (1925) examined 395 primitive Inuit skulls and found tooth decay in only 0.1% of the dentitions. Price (1936) noted a prevalence of dental caries of 0.09% in the dentitions of living Inuit from remote areas in Alaska and Canada. Pedersen (1938) also noted that only 0.38% of a sample of primitive Greenland Inuit skulls demonstrated decay.

Waugh in 1932 stated that "the American Eskimo is veritably paying for his civilization with his teeth" in reference to the changes that were occurring in the dentition of the Inuit after contact with the West.

Price (1936) noted that a group of Alaskan Inuit who had recently been exposed to western civilization, demonstrated a prevalence of dental caries of 13%, whereas established settlements living around trading posts showed a prevalence of 30%-50%. Pedersen (1938) showed increases in the incidence of dental caries up to 87.5%, whereas Baarregaard's survey in Greenland in 1945, showed caries to be present in 95.1% of the population sample. Newman's caries prevalence in 1953 was also 94.6% for children and 89.7% for adults of Greenland Inuit origin.

In the last forty to fifty years, the incidence of dental caries in Greenland's Inuit populations has increased at an incredible speed and has become a serious public health problem. The prevalence of dental caries in first and seventh grade children in fourteen Greenland communities was found to be almost twice as high as that in Denmark (Jacobsen, Hansen 1974). Untreated caries was about five times more frequent in Greenland than in Denmark (Dahlberg 1980). The steep increase in consumption of sugar and sweets has often been proposed to be the probable cause of the marked increase in dental caries (Ismail et al., 1984; Sreebny 1982; Waugh 1932).

The traditional indices that have been used to measure the incidence of dental caries are divided into two groups: those related to deciduous teeth and those related to the permanent teeth. The caries index for deciduous teeth records the number of decayed, extracted or missing and filled **teeth**

and is designated as **"deft"**. The one for permanent teeth is **"DMFT".** If one relates the dental disease to **surfaces**, the index is **"defs"** (deciduous), and **"DMFS"** (permanent teeth). Indices related to surface decay are more sensitive than those related to number of decayed teeth. However, surface indices are harder to record clinically. Extraction of teeth is a common mode of treatment in remote areas having sparse dental services. To eliminate experimental bias, caries surface indices which exclude the number of extracted teeth from the final score (**dfs** or **DFS**) are often used in remote areas (Curzon, Curzon 1979).

Johnsen et al., (1984,1986) explored the use of child-oriented caries measures as a supplement to the traditional tooth-oriented measures. The incidence of dental caries patterns in pit and fissures, caries secondary to hypoplastic enamel, nursing bottle caries and rampant caries, are described in studies comparing "low-income head start" children living in various locations around Ohio, USA. Attempts are presently being made to investigate the prevalence of dental caries experience based on etiology (Greenwell et al., 1990).

Dental caries surveys in Alaska revealed that the peak caries involvement occurred at age 21-30 for both sexes, but leveled off in females in the later years. Dental caries progression was much faster in the deciduous teeth than in the permanent teeth. A drop in the prevalence in adult males, was indicative of the reverting back to traditional foods and a decreased exposure to cariogenic material (Mayhall et al., 1970).

The prevalence of dental caries in 766 Baffin Island Inuit was found to be comparable to the levels found elsewhere in the Arctic. The acculturation

changes in the Baffin Zone are more recent and more rapid than other arctic areas (since around 1940). Although fifty percent of the deciduous dentition was found to be severely affected, the permanent dentition was found to exhibit caries levels comparable to those of Canadian Caucasians living further south. The mean deft for 3-5 year olds was 5.27 (range 3.75-8.14), and for 6-9 year olds was 6.85 (range 5.93-11.36). The mean dfs for 3-9 year olds was 6.14, and the defs, was 15.30. In the permanent dentition of 6-9 year olds, the mean DMFT was 1.88, the DMFS was 3.92 and the DFS was 2.75 (Curzon, Curzon 1979).

The caries indices reported for Inuit children living in Northern Quebec were also high. The deft index for six year olds was 11.2 and the DMFT for thirteen year olds was 13. The DMFS for 10-14 year olds increased steadily from 10.8 to 18.4 with increase in age. Treatment levels were still found to be low (Gagnon et al., 1991). In an oral health survey of 708 head start children aged 3-5 years of age, about 70% were Alaskan natives. The caries-free incidence in these natives was 22% while active decay was present in 66%. A further 40% had baby bottle tooth decay (BBTD), while 44% of the defs scores were due to pit and fissure decay (Jones, Schlife 1991). Thus it seems that the caries experience in Inuit people was particularly high at initial contact with people of Western cultures. The incidence is still presently higher than other more developed areas particularly in the primary dentition.

The pattern of eruption of permanent teeth in Inuit children and adolescents was found to be earlier than all Caucasian teeth except for the incisors (Mayhall 1978). The difference was statistically significant. There

was no evidence that the early eruption pattern was the result of premature extractions of the diseased teeth (Mayhall 1978). On the other hand, in a radiographic study of the calcification and eruption of the permanent teeth in Inuit children, it had been suggested that the primary cause of earlier tooth eruption in the Inuit was the premature loss of the deciduous teeth (Trodden 1982). In this study, a distinction was made between the emergence of teeth through the alveolar bone and eruption through the gingivae. The use of an "eruption index" to describe the pattern of tooth emergence through alveolar bone was found to be more accurate in predicting skeletal age than conventional methods.

Mayhall (1972) summarized the features of dental morphology found in American Indians and Inuit. Shovelled incisors, the absence of the cusp of Carabelli, barrel-shaped incisors, occluded tubercles, enamel projections, molar buccal pits lacking enamel lining and third molar agenesis were some of the characteristic features. A number of these dental features may increase plaque retention and provide caries initiation sites. Moorrees (1957) also described these anatomical features as "traits of the Mongoloid master plan".

Reports on periodontal health and oral hygiene of present day Inuit appear to be conflicting. This may be related to early problems in the inaccurate recording of the disease and inter-examiner variability (Mayhall 1976; Dahlberg 1980). Costa (1982) also reported different rates of periodontal disease in prehistoric Eskimo dentitions which originated from two different locations in Alaska.

Waugh (1932) may have been the first to note the changing dental malocclusions that occurred in the dentition of the Inuit following the sudden change to a more western diet. However, researchers like Leigh (1925), noted that 11.4% of a sample of Inuit skulls demonstrated a malocclusion mainly of the Angle Class I variety. Price, in 1936, described the presence of narrowed dental arches, underdeveloped maxillas, incisor crowding, crossbites and buccal eruption of the maxillary canines in his sample of Alaskan Inuit. Newman (1953) reported that 43.6% had normal occlusion, 53.8% had an Angle Class I malocclusion, and 2.6%, had a Class III molar relation. The prevalence of Class II malocclusion was zero in his Greenland sample.

Wood (1971) examined 100 "pure Eskimo" Alaskan children aged 11-20 years. His subjective evaluation of the occlusion revealed that 82% showed some degree of malocclusion. Eighteen percent (18%) had "normal" occlusion, 64% had an Angle Class I malocclusion, 8% had an Angle Class II malocclusion, and 10% had a Class III malocclusion. He also noted that the intercanine and intermolar widths were the same for patients with or without malocclusion. From this he concluded that the increase in malocclusion rate was the result of the change in diet which led to a dramatic increase in the caries rate and increased loss of teeth. Without any diagnostic radiographs he concluded that the predominant interjaw relationship in the examined sample was "Class I", despite the increase in dental malocclusions. A questionnaire given to the children indicated that 23% reported difficulty in chewing as a result of the crooked teeth, and 42% were concerned about the appearance of their crooked teeth (Wood 1971).

(G) Craniofacial Studies

The first detailed ethnological study of the Canadian Inuit was written in 1889 by Dr.Franz Boas in *"The Central Eskimo"*. The first detailed study of Eskimo craniology appeared in Furst and Hansen's *"Crania Groenlandica"* in 1915. However as early as 1722, Winslow described one Eskimo skull using some craniofacial measurements (Colby 1972). Hrdlicka's 1930 report on 1,283 Eskimo skulls was increased to 2,200 skulls in 1942, and is now the largest catalogue of information on Eskimo crania. Other important pioneer work on skeletal material came from Stewart (1959), Debetz (1959), Lester and Shapiro (1963), Cederquist (1975), and Hylander (1977). Collins (1951) described the morphologic pattern of the Eskimo skull as having the following characteristics:

(1) long and narrow vault

(2) high, broad and square face

(3) Prominent cheek bones

(4) high orbits

(5) Narrow nose with slightly developed brow bridges

(6) large and heavy Eskimo lower jaw with wide ascending ramus

(7) thick tympanic plate

(8) maxillary and mandibular tori

The long, narrow high skull is not universal among the Inuit, but has been found to predominate parts of Greenland, Mackenzie Delta, and

Northern Alaska. Facial dimensions, however, remain relatively constant across the geographical distribution of the Inuit. Headform, on the other hand, changes from dolichocephalic (long cranium) in the east to brachicephalic (broad cranium) in the west (Zegura 1978).

Seven circumpolar craniofacial studies were completed for the International Biological Program (IBP), including populations of the Ainu of Japan, the Inuit of the Northern Foxe Basin, Canada, the Inuit of Greenland, the Inuit of Wainwright, Alaska, Alaskan Inuit, the Lapps of Finland, and the Lapps and other Northern population groups of Russia (Dahlberg 1978, 1980). Unfortunately, the guidelines laid down by the IBP Working Party Conference for procedures, equipment, consent and methodology were not followed in all the groups. Thus, cephalometric radiographic comparisons could only be drawn between Wainwright, Alaska, Northern Foxe Basin, Canada and some Eskimo pre-contact skeletal material from northwest Hudson Bay and Port Hope, Alaska.

Generally, the cephalometric studies demonstrated a significant increase in mid-facial flatness with age. The younger pre-contact skulls, show a significantly greater sexual dimorphism than do the adults. A similar cranial base flexure was found to be present in all the living subjects, but was found to be smaller in the skeletal material. A degree of maxillary prognathism was also present. There were conflicting results regarding the size of the mandible, the changes in gonial angle with age, and the incisor inclination. Females however, exhibited more alveolar protrusion than males. Generally, the mesio-distal diameters of Inuit teeth were reported to be larger than those of American whites, whilst male Inuit teeth were larger

than female Inuit teeth (Dahlberg 1978, 1980). Hanson, Owsley (1980) also noted that radiographically, the frontal sinuses were small or even absent.

A high percentage of the entire Inuit population seemed to show an interjaw relationship that was more maxillary prognathic. Many children as early as three years of age, also demonstrate an edge to edge occlusion (Dahlberg 1978, 1980).

Colby (1972) conducted a cephalometric study of 192 Northern Foxe Basin Eskimos aged between 3 and 59 years. Using 24 linear and 13 angular measurements he compared the results to those of 143 Caucasians. He concluded that the craniofacial complex was larger than the control group even at the age of three. The rate and the direction of craniofacial growth was in the same direction as the control group but took longer to develop, peaking in the second decade. Sexual dimorphism in the skull was present in the Eskimo race. Anterior and posterior facial heights were larger in the Eskimo. Posterior cranial depth and cranial base was also larger. The maxilla was shorter and in a more anterior position. The mandibular body length was larger than that for Caucasians, yet the chin point was often recessive. Both maxillary and mandibular incisors were more proclined. The maxilla was often anteriorly positioned. His final conclusions were that soft tissue contours of the face reflected the underlying facial skeletal structures.

Two hypotheses have been postulated to explain the characteristics of the Inuit skull and the related soft tissue. One theory holds that the distinct craniofacial morphology was an adaptation to the cold climate (Coon 1950, 1962). The second hypothesis contends that facial morphology is an

adaptation to functional chewing (Hrdlicka 1910; Collins 1951). The often proposed idea that the protrusive face of the Eskimo is adapted to withstand the cold, does not seem to be borne out by the investigations in the IBP studies (Milan 1980). Further rejection of the hypothesis is also seen in experimental work conducted by Steegman (1967, 1970), Shea (1977), and Hylander (1977). Hylander (1977) advocated a further modification of the second theory in that the Inuit skull was especially modified to generate and dissipate large vertical biting forces. Scott (1967) on the other hand, suggested that the Eskimo has an inherent tendency towards the development of massive bony structures. This adaptation can only be expressed in the primitive environment and cannot be expressed under conditions of modern civilization.

Although there is general agreement that the Inuit craniofacial skeleton is different from that of Caucasians, the exact reason is only speculated to be related to function and diet. With the "soft" nature of the modern diet, it is possible that this functional stimulus is no longer present, and may be the cause of facial degeneration in many populations (Davies 1972; Beecher 1981, 1983). Other researchers have not found a reduction in dental measurements with an increased consumption in soft diet (Tseng 1991). It is speculated that the gnathic evolutionary reduction is ahead of the dental reduction as a result of dietary and genetic changes.

(H) Health-Care Delivery and Future Trends

Christensen (1990) reviewed the health problems presently affecting Alaskan infants and young children. An improvement in health-care delivery

with higher standards of medical care, are now available to the Inuit. Epidemics like tuberculosis and Spanish influenza, that have afflicted the Inuit since contact with white man began, have now been controlled or brought down to manageable levels. However, a number of disturbing problems, such as anemia, otitis media, and meningitis, remain health risks. Three other problems listed by Christensen, have orthodontic implications. Baby Bottle Tooth Decay (BBTD) present in 50-70% of Alaskan infants, can cause long term orthodontic and speech problems. Foetal Alcohol Syndrome (FAS) affects Alaskan natives infants at a rate of 5.1/1000 and Foetal Alcohol Effect (FAE) affects at a rate of 1.7/1000. Both of these alcohol related problems are known to cause malformations in the craniofacial skeleton.

Wenzel (1981) has suggested that differing levels of immunity causes native populations to experience different patterns of disease than those observed in the Western world. Some diseases which would not be considered a problem in the West may become a serious health problem in native communities.

Two types of native health-care delivery have been proposed. One is based on the western medical practice of treating presenting symptoms. A second is based on the acceptance that acculturation and the changing environment are the cause of the symptoms of the disease. Some communities are now finding the second approach to be more effective in combating the health problems of the north (Lynch 1991). Thouez (1990) suggested that to increase positive relationships between health-care personnel and patients, it is essential to have continuity in health-care

delivery. Shedden (1988) further suggested that health-care delivery should change from a passive system, with no community involvement, to a more active interaction that gives natives gradual control over delivery of their own services.

Summary

Anthropological evidence suggests that the Inuit population originated in northeastern China. They arrived in North America by crossing the Bering land bridge from Siberia around 11,000 years ago. The timing of this migration may have been different from that of the American Indian. The Thule culture was the ancestor to the present day Inuit. Thules successfully spread to Alaska in the west and to Greenland in the east by around 1300 AD. Therefore, the Inuit race is basically the same across the arctic except for slight differences noted in the Aleut in the Aleutian Islands. Although there is considerable Caucasian admixture today, a characteristic Inuit growth pattern and facial morphology still exists. A deterioration in dental health has occurred since contact with the Western World. The incidence of dental caries is still presently relatively high. Malocclusion has also increased but has been inadequately reported. The prevalence of occlusal disharmony in the Inuit has increased from 11% in 1925 to 82% in 1971. The Inuit are presently struggling for autonomy and land ownership. A number of social and health problems have resulted that seem to be present in many circumpolar regions. Active health-care delivery, involving more native participation, would be a more effective way to combat present health problems.

1.2. Labrador Inuit

Both North American Indian (Innu) and Inuit populations presently reside in Northern Labrador. Ethnological and archaeological differentiation of artifacts from the two populations have not been as severe a problem as it has been for other northern areas. Labrador Inuit have hugged the coastline, while the Innu demonstrated a migratory pattern inside the interior (Fitzhugh 1977).

Labrador's **Inuit prehistory** seems closely related to other Eskimo developments in the Eastern Arctic, namely:

(1) Independence I era---the Eskimos of the pre-Dorset era in northern Greenland and the high Arctic.

(2) Independence II---the Dorset era.

(3) Thule culture---coastal spreading from eastern Baffin Island (1300-1450 AD)

(4) Labrador Inuit---1450 AD to present.

Archaeological remains of all of the above-listed cultures have been found in Northern Labrador in the locations of Nain and Hopedale. These two particular sites were selected for the present study (see Appendix C).

The Labrador Inuit era can be subclassified as:

(1) Early phase (1450-1700 AD)---pre-contact

(2) Communal House phase (1700-1850 AD)---contact with Europeans.

(3) Recent phase (1850 AD)---where traditional aspects of culture are modified by western economy. A relocation of isolated communities into larger towns, was encouraged, whilst the appearance of German Moravian Missionaries, no doubt, influenced the Inuit leadership and social structure in Northern Labrador (Fitzhugh 1977).

Indian/Inuit feuds, intermarriages with Europeans since 1800, and the spread of several diseases, like tuberculosis and Influenza, reduced the number of Inuit, especially the number of pure Inuit, living in Labrador. Harper (1986) also documented that Inuit from Labrador were taken to Chicago for exhibition and study of ethnic characteristics in 1896. The Labrador Inuit eventually became concentrated largely in Northern Labrador. The present provincial native census (Newfoundland and Labrador) is shown in Table 1 (Statistics Canada 1986). The present Labrador Inuit membership is depicted in Table 2 (LIA Membership 1991).

Table 1.--Population Census for the Province of Newfoundland and Labrador based on ethnic origin for Inuit and North American Indians (1986 Canadian Census)

RACE	ORIGIN	POPULATION
Inuit	Single	1,815
Inuit	Mixed	1,750
N. American Indian	Single	1,740
N. American Indian	Mixed	2,690

Table 2.--Labrador Inuit Association membership for Nain and Hopedale (1991 Labrador Inuit Census)

LOCATION	LIA MEMBERSHIP
Nain	1,079
Hopedale	534

Sir Wilfred Grenfell first arrived in Labrador from the United Kingdom in a missionary ship in 1892, and fell in love with the remoteness of Labrador. He returned in the early 1900 with a hospital ship. He was the first to introduce medical services to Labrador (Kerr 1959; Grenfell 1920). Improvement in the service continued the tradition started by Sir Grenfell and is known today as the **Grenfell Regional Health Services.**

Newfoundland and Labrador were part of the United Kingdom until 1949, after which they together became the last province to join the Confederation of Canada. The economy of Newfoundland and Labrador has been volatile and is presently still dependant on natural resources especially the fishing industry.

General and dental health of the Labrador Inuit follows a similar pattern as that of Inuit in other areas of the circumpolar region. Stewart (1939) may have been the first to report anthropometric observations on the Labrador Inuit. Waugh, as early as 1928, reported that the Labrador Inuit living in isolated areas, had excellent dentitions free from decay. The younger age groups who had ventured into "civilized" settlements such as Hopedale, on the other hand, experienced dental abscesses and periodontal disease as a result of a changed diet. Alton-Mackey in 1988 documented that the effects of eating imported foods instead of the traditional Labrador Inuit diet had contributed to the cultural, social and nutritional change seen in the area. He also expressed concern that educational initiatives were still needed in order to provide nutritional balance in today's Inuit diet.

Dental services to Labrador have also been greatly improved in a very short time (Messer 1979, 1985, 1988, 1990; Dickson 1988). Manpower restrictions and limitations in the delivery of services by travelling dentists to Northern Labrador, necessitate the referral of patients for specialty care (for example, orthodontics and oral surgery) to central locations several hundred miles away (Messer 1984; Baikie 1991).

Messer (1986) showed that the dental caries index scores (DMFT) for fifteen year olds in 1969 and 1984 have remained constant. However, the number of decayed teeth has lessened whilst numbers of treated teeth has increased. "DMFT" for 12 year olds was 4.7, and the "deft" for 7 year olds was 8.0 in 1984. Various attempts to control the high rate of decay have also been initiated with the use of fluoride tablet supplements and fluoride mouth rinses (Messer 1985). Delivering dental care to small communities has always been frustrating and full of challenges (Messer 1988). A list of many of the frustrating problems related to the employment of dentists, patient attendance, equipment limitation, cultural differences, communication difficulties and difficulties in transportation to the area, have been described (Zammit 1991).

A dental health survey conducted by Curson in 1984 established that there were a number of children with irregularities of the teeth in Labrador. A subjective 'WHO' evaluation index was used but no prevalence was noted. He also recommended that only gross orthodontic conditions should be corrected on a referral basis to specialists.

In January of 1989, a **Non-Insured health benefit scheme** was introduced to 4,501 Labrador Inuit Association (LIA) members living in

Northern Labrador and Happy Valley-Goose Bay. Table 2 shows the LIA membership for Nain and Hopedale, the two locations selected for this study. Among other medical related services, dental treatment was made available at no cost to the LIA member and was an immediate success in its first year of operation (Messer 1991; Zammit 1990).

A report on the Labrador Inuit non-insured health benefits prepared by Baikie (1991) demonstrated that 17% of the patients who visited specialists located hundreds of miles away from Labrador were orthodontic referrals and 21% were Ear-Nose-Throat (ENT) referrals for the period 1990-1991. A strong recommendation was made in this report, to attempt to bring an ENT and orthodontic specialist to Labrador on a visiting basis. The revised schedule for dental services to Inuit people limits orthodontics to persons under the age of eighteen years. A review committee would then approve potential orthodontic patients for treatment if they had "a functional occlusal disability" (Health and Welfare, Canada, 1990). However no craniofacial studies, other than dental caries evaluation, have been reported on the Labrador Inuit. No objective assessment on the prevalence of malocclusion or psychosocial evaluation related to dentistry has been completed to date to fully evaluate the possible need for orthodontic care.

Summary

The Labrador Inuit have similar origins, levels of acculturation, and general and dental health problems as the rest of the circumpolar region. Dental services to Labrador have improved over the past twenty years. Few patients for specialty dental care are referred out of Labrador because of the

prohibitive cost. No craniofacial studies to date, other than for the incidence of tooth decay, have been adequately reported in Labrador to evaluate the need for orthodontic care.

1.3. Psychosocial Assessments

In the early days of dentistry and orthodontics, malocclusion was defined by clinical standards alone. Criteria for successful orthodontic results centered mainly on anatomical and functional goals with little emphasis on facial esthetics. Any deviation from the ideal occlusion was termed by Guilford (1889) as a mal-occlusion. Today, major goals in orthodontics aim not only to obtain optimal proximal and occlusal contact of all teeth, but also to produce acceptable dentofacial esthetics and improved self-image (Graber, Swain 1985). Young and Zwemer (1966) suggested that malocclusion was a problem of concern only when recognized as such either by the individual, by the community that surrounds the individual, or by dental health-care professionals. The oral characteristics that constitute a malocclusion are only handicapping to the individual if the condition is seen to be a barrier in achieving particular goals in life, or if the individual or peers recognize the problem (Cohen 1970). Malocclusion may, in fact, not be perceived as a physical handicap to all individuals to the same extent (Sergl 1967; Morris et al., 1976).

Researchers (Richardson 1963; Cohen 1970) have investigated the way children react to peers who are in some way disfigured. A negative social relationship was found to be greatest in facial disfigurement, more so than any other physical handicap tested. The higher the socio-economic

status, the stronger was the negative relationship. Although the facial disharmony seen in orthodontic offices does not relate to the disfigurement tested in these studies, the important point to be drawn is that children are sensitive to facial disharmonies in themselves and in their peers (MacGregor et al., 1953). Man's reaction to facial disfigurement has not been uniform. Some societies like the Pre-Columbian Indians in Mexico, afforded special privileges and even worshipped the facially deformed. Other societies have put deformed newborns to death (Morris et al., 1976). There was also a paradoxical greater negative psychological response to mild deformities than to severe handicaps (MacGregor et al., 1953).

Attractive people are more likely to succeed socially than less attractive individuals. Unattractive people were found to be perceived less liked, less preferred as friends, and less desirable as partners for marriage (Adams 1977; Walster et al., 1966). Research into esthetics and facial esthetics is a hard concept to measure since it may be purely subjective when based on personal feelings that are difficult to isolate and test (Graber, Lucker 1980).

Although facial characteristics vary from culture to culture, the public tends to share a common esthetic standard (Foster 1973). However, it is possible that the esthetic standard changes from time to time, even within the same community. Various different racial traits may become accepted as the norm within that race. Maybe the old saying, "beauty is in the eye of the beholder" is profound when viewing concepts of facial esthetics from a historical or cross-cultural perspective (Morris et al., 1976).

Physically unattractive candidates are routinely discriminated against by interviewers (Dipboyne et al., 1975), although the selection of persons for employment based on good facial appearances may be unintentional (Gustovich 1980).

It had been suggested by Linn (1966) that part of the unattractiveness of an individual was related to dental appearance. Children with normal dental appearance were judged to be better looking, more popular with friends, more intelligent and less likely to exhibit aggressive behavior (Shaw 1981). Even teachers seem to have higher expectations in children with good looking teeth (Adams 1977). It appears that the human face may be the focal point of all communication of the body (Kiyak, Bell 1991).

Edward Angle (1907), the father of modern orthodontics, may be responsible for explaining why orthodontists have become involved with profile correction as well as the straightening of teeth. He felt that ideal dental occlusion required a full complement of teeth "as nature intended". The ideal facial esthetics was considered by Angle to be based on the classic Greek profile of Apollo Belvedere. Angle also believed that the best orthodontic treatment was best achieved by not extracting any teeth. Tweed (1953) on the other hand, advocated the removal of teeth to obtain the "ideal" profile. Presently many orthodontists are still divided on the issue of extraction and non-extraction treatments. Even more diverse opinions exist regarding the "ideal profile" (Peck, Peck 1971). Norms of facial esthetic standards may become culturally determined by the public through education and especially through the mass media and television (Foster 1973).

Artists (using artwork for many centuries), anatomists and physical anthropologists (using anthropometry in the eighteenth and nineteenth century), orthodontists (using cephalometry in the nineteenth century), and presently, plastic surgeons and various professional dentists (using computer visual imaging), have attempted to measure the physical attributes of dentofacial esthetics (Powell, Humphreys 1984; Bowbeer 1985; Sarver et al., 1988). Despite all these efforts, facial esthetics may still be best judged by the subjective reaction of others (Morris et al., 1976).

Orthodontics, malocclusion and esthetics have thereby become the focus of several psychosocial analyses. Two major groups of psychosocial parameters have been examined within the orthodontic profession:

(1) First, the **self-concept, self-worth, self-esteem, body image, and personality factors** related to healthy smiles and good esthetics (Tulloch et al., 1984; Squier, Mew 1981; Fox et al., 1982; O'Regan et al., 1991; Katz 1978; Sahm et al., 1990);

(2) Second, the **motivation, compliance and co-operation factors** involved during orthodontic treatment (Sahm et al., 1990; Albino et al., 1991; Caltabiano 1989; Cucalon 1990; Weiss 1977; Burns 1970; Ngan 1989; Brattstrom et al., 1991; Crawford 1974; Slakter et al., 1980; El-Mangoury 1981).

Occasionally, both groups of psychosocial parameters are discussed together in the literature (Hertrick, Hirschfelder 1990; Cohen 1970; Shaw et al., 1986; Tedesco et al., 1984; Tayer, Burek 1981; Oliver, Knapman 1985). Since the second group of psychosocial parameters related to motivation and compliance is not the subject of this thesis, only the first group of parameters is discussed here in some detail.

Investigations of psychosocial parameters use either self-assessment questionnaires or surveys evaluated by psychologists, parents, teachers and health personnel. Some may use a mixture of both tools. Many scales are used for such evaluation (Evans, Shaw 1987). Two popular scales to assess self-esteem and esthetics are Tedesco's five point dentofacial esthetic scale (1983), and Howells and Shaw's ten point visual analogue scale (1985).

Thouez et al., (1990) questioned the use of the "survey" as a comprehensive indicator of the true cultural meaning of any illness. Interpretation of results from such surveys, however, should be dictated by the social, cultural and economic environment in which the population under study resides.

Stricker (1979) concluded that the literature on the psychological aspects of malocclusion was filled with theoretical speculation based on mostly unsubstantiated psychoanalytical data; data based on sound experimental design was lacking.

Shaw et al., (1986), addressed the "lack of experimental design" issue in psychosocial studies by implementing a detailed strategy for investigation based on longitudinal and cohort data, taken from one thousand 12-year olds. This strategy involved a longitudinal comprehensive social, psychological and multi-disciplinary oral health assessment of the effects of malocclusion.

The study of psychological problems affecting individuals with "handicapping" dental malocclusion according to Morris et al., (1976) can either relate to:

(1) The degree to which one's personal relationships are distorted as a result of **other people's response** to the malocclusion. (The response may vary from "utter horror" to "mild amusement").

(2) The person's **own reaction** to the problem of the malocclusion and subsequent personality changes. (The response may also vary from suicidal attempts to no effect).

Baldwin and Barnes (1965) pointed out that only half of a group of candidates for orthodontic treatment were reported to have been teased about their teeth. Of these, only 10% reported being teased on a frequent basis.

Frazier and Lisonbee (1950) found that only 20% of an adolescent population with malocclusion indicated having a knowledge of their irregular teeth. Of these, 40% showed some concern about the condition, 10% reported having a knowledge of the presence of spaces between their teeth, and less than 10% being concerned about dental appearance. Stricker (1979) inferred that patients were unable to assess the dentition that was present in their own mouths with any degree of accuracy. Persons with acceptable dentition were also likely to take their appearance for granted. Espeland and Stenvik (1991) confirmed that awareness of occlusal traits varied among the persons who considered themselves satisfied with their appearance, even though some of them had a malocclusion. Persons with malocclusion, on the other hand, may over focus on the problem and experience dissatisfaction with their body-image and self-concept. A consequent reduction in psychological function may then result (Weiss 1974). Baldwin and Barnes (1965) in contrast, pointed out that a large group of children with esthetically pleasing dentitions still experienced some

dissatisfaction with their own dental appearance. O'Regan et al., (1991) further concluded that an improvement in dental esthetics does not necessarily imply an increase in the self-esteem. Body-image and self-image are increased as the dentofacial esthetics are improved. However, self-concept may not increase at all (Kiyak, Bell 1991).

Britain and America are two countries whose inhabitants differ in an emphasis on self-worth and on esthetic concepts. In a study comparing British and American orthodontic patients, Tulloch et al., (1984) concluded that the attitudes involved in seeking orthodontic treatment were similar in both countries. However, the availability of orthodontic services and the associated "symbol of beauty" in patients undergoing orthodontic treatment, or the implied "degree of wealth" in the parents of patients, is greater in the USA.

Morris et al., (1976) and Stricker (1979) both make reference to the parent, especially the mother, as being a prime motivator for both the seeking of orthodontic treatment and throughout the duration of orthodontic treatment of their children. Proffit (1991) suggested that a mixture of both internal and external motivation usually produced satisfactory compliance during orthodontic treatment. External motivation, however was considered to be "dangerous". Internal motivation was considered to be more ideal. It is reasonable for patients to expect better alignment and function of their teeth and jaws improved esthetics after undergoing orthodontic treatment. Most children usually fall within this category. Adults, however, demonstrate very specific and more complex expectations which are often unrealistic. The more realistic the expectation of the patient, the less the chance that a

personality disorder would result as a consequence of the original "deformity" (Proffit 1991).

Seltzer (1980) described an acculturation "stress phenomenon" particularly affecting adolescents and young adult Inuit males. The stress was manifest as a syndrome of low self-esteem, negative self-image, and feelings of emasculation. Berry (1990) listed the indicators of low mental health status in any population as high rates of suicide, homicide, alcohol and drug abuse, spousal and child abuse, infant mortality, and low life-expectancy and low educational achievement. The incidence of these indicators was found to be higher than the corresponding national averages for the Inuit populations of Canada, Alaska and Greenland (Milan 1980).

It is unknown whether promoting dental health and healthy smiles with orthodontic care can reduce the psychological stress in young Inuit. However, Shea (1991) reported that appearance, especially facial appearance, was a concern in 42% of the Igloolik Inuit youth interviewed on matters of primary health and well-being. In another questionnaire, Wood (1971) indicated that 42% of Alaskan Inuit youth reported being concerned about their malocclusions, with another 23% indicating difficulty in chewing.

Inuit youth often appear shy, quiet and occasionally content in non-verbal communication, yet they are people-oriented, field-dependant, and subjective. They are able to learn well primarily by observation (Shea 1991). These characteristics of Inuit youth should indicate that they are positively motivated towards orthodontic care. Further investigation is necessary to determine the anticipated and actual motivation during orthodontic treatments in Inuit youth.

Summary

In summary, the face and the teeth may be the focal point of communication, attractiveness and related self-concept. Some people are unaware of their malocclusion while others who undergo orthodontic treatment report positive life changes, improved body image and even increased self-esteem. There is a critical period following orthodontic treatment for patients to gather other people's responses to their new appearance. The long term evaluation of improved self-esteem and self-concept following orthodontic treatment has yet to be determined. It is generally believed that the desire for improved esthetics is one of the motivating factors for people who are aware of a malocclusion to seek orthodontic care. The Inuit, who are presently adopting more western values and practices amidst difficult psychological adjustments, may benefit from the availability of orthodontic services.

1.4. Occlusion and Malocclusion

The following will be discussed in this section:

(A) Normal occlusion

(B) Etiology of Malocclusion

(C) Malocclusion Indices

(D) Epidemiology of Occlusion in World Populations

(A) Normal Occlusion

Teeth are formed in the jaws and then undergo certain movements to reach a position of functional occlusion in the mouth. The movements can be classified as pre-eruptive, pre-functional and functional. The motile cells of the periodontal membrane are believed to be responsible for the predominant forces of eruption of teeth. In addition, blood pressure in the blood vessels, or increased tissue fluid pressure in the region, as well as other known and unknown mechanisms of eruption may also be partly responsible for eruption of teeth into the mouth (Melcher, Beersten 1977).

Garn et al., (1977) indicated that there are major population differences in the largely genetically controlled timing of tooth eruptions into the mouth. The norms that have been used in the past are based on northwestern European means, which show an eruption timing that is earlier than African, Asian, and Amerindian populations.

After the teeth have erupted and reached functional occlusion, they occupy space in a dental arch in each jaw. Each arch is supported by apical bone within the jaw. The dental arches meet at the occlusal plane. If there is excess arch circumference or a deficiency in tooth size, spacing results. If there is a shortage of arch circumference or an excess of tooth material, crowding results (Van der Lindern 1977). In a number of persons (1-35% in the United States), ideal occlusion is achieved (Proffit, Ackerman 1985,1991; Morris et al., 1976; Kelly 1977).

Although the term "occlusion" pertains only to the manner in which the maxillary and mandibular teeth come into contact, **a proper analysis of**

occlusion actually entails the study of the dentofacial skeleton (Moorrees 1957).

Clinical orthodontists and physical anthropologists differ in their interpretation of what is the normal or ideal occlusion (Brace 1977). Primitive man had larger teeth than modern man. However, teeth were subjected to occlusal and interproximal wear. In addition, an edge-to-edge bite, with no centric occlusion (CO) or maximum intercuspation position (MIC) was predominant in those dentitions (Begg 1954; Kesling 1988). Cusps of teeth were flat resulting in a flat occlusal plane. Temporomandibular joint adaptation was found to occur, thus maintaining a healthy dentition after occlusal attrition (Hinton 1981). Food impaction in interproximal dental areas did not seem to be a problem for the periodontal health of the dentition (Brace 1977; Begg 1954). Anthropologists have concluded that the cusps of the teeth in primitive man were not essential for chewing food or for the health of the temporomandibular joint and periodontal membrane. They were considered to be essential, however, in guiding teeth into functional occlusion. Attrition was considered to be a physiological process in primitive man.

On the other hand, researchers in the dental field, including orthodontists, consider incisal overlap between upper and lower teeth of one-third to two-thirds to be the norm in modern populations. This is considered to be important for good esthetics, the scissor-like action of the anterior teeth and for the guidance the anterior teeth provide to the condyles in the temporomandibular joints. The curve of Spee, or curved occlusal plane, would guide the mandibular condylar path during motion of the

mandible (Hunter 1771; Bonwill 1899; Moorrees 1957). Conversely, some authors in the dental profession have considered malocclusion and especially, a deep bite malocclusion, to be responsible for temporomandibular joint dysfunction. There is no evidence to date that such a cause-effect relationship exists (McLaughlan 1988; Greene 1984). Some anterior tooth contact between upper and lower teeth is considered necessary for a stable occlusion (Fox 1982; Vanarsdall, Musich 1985) but the amount necessary for health of the temporomandibular joints is still unknown (Greene 1984; Runge et al., 1989; Just et al., 1991). Attrition of teeth is presently considered to a pathological condition.

The degree of procumbancy of the incisors has some racial significance. In "Mongoloid" races, prognathism is confined largely to the alveolar processes or to the bone supporting the teeth. In the Black race, the prognathism is largely in the jaws themselves. Caucasians tend to have more upright dental and skeletal features (Moorrees 1957). Thus, the norm varies with each race.

A longitudinal study on dental health reported that malocclusion was not the cause of poor periodontal health. Rather, poor periodontal health was found to be the result of unfavorable oral hygiene factors (Helm, Petersen 1989).

After examining Aborigine teeth, Begg (1954) proposed that it was the interproximal tooth wear that lead to minimal or no crowding of teeth in primitive dentitions. However, the absence of interproximal wear was not found to be the primary cause of malocclusion (Corruccini 1990). Varrela (1990) examined the incidence of malocclusion in Finnish skull samples

from the fifteenth and sixteenth century and compared them to present day Finnish dentitions. Ninety seven point seven percent of the older skulls exhibited Angles Class I (one) lateral molar relationships with no evidence of skeletal malocclusions. Angles Class II (two) deep bites occurred with significantly lower frequencies than it did in the present day dentitions The change in diet was proposed as being the probable cause. Brace (1977) and Corruccini (1990) both refereed to the changes in diet, as well as the mode of food preparation and its consistency, as being important factors in the development of malocclusion. Corruccini (1990) however, could not verify some of the major features of the Begg model specifically relating to the amount of interproximal wear seen in Aborigine teeth or other "primitive" populations.

The type of occlusion depicted in primitive man is considered to be the norm in Stone Age, Bronze Age, and Iron Age man. Even some European populations as late as the seventeenth or eighteenth century depicted such an occlusion (Brace 1977). Some present Arab populations still depict various levels of the occlusal wear patterns today similar to those seen in primitive man (Johansson et al., 1991). In the Inuit, some degree of occlusal attrition was often found to be present. This was mainly attributed to cultural habits, such as the chewing of seal-skin boots in order to soften the hide before daily usage (Davies 1972).

Orthodontists continue to base the ideal occlusion on maximum intercuspation with a full complement of teeth (Angle 1907), or with the removal of some teeth (Tweed 1953; Begg 1954). Bonwill (1899) described ideal occlusion based on geometric triangles, mathematical formulas and

theology. Many orthodontists presently observe the "six keys to normal occlusion" as described by Andrews (1972) in terms of molar relationship, crown angulation or tip, crown inclination or torque, absence of rotations, tight interproximal contacts, and flat occlusal plane or very slight curve of Spee. There are differences of opinion within the orthodontic profession about the finer points in occlusion, as depicted by the differences in angulation in bracket prescription in the straight wire technique or the amount of torque that is put into orthodontic wires in other techniques (Alexander 1986; Tweed 1954). There are further differences of opinion in the concept of ideal occlusion between the various disciplines of dentistry, as seen in denture makers, fixed prosthodontists, general dentists, periodontists and oral surgeons. As orthodontics is both an art and a science, it appears that orthodontists will continue to judge ideal occlusion based on esthetics and goodness of fit of teeth.

Many minor deviations from the "ideal" anatomical relationships of teeth fall within the limits of normal variation. Others which fall outside the limits are classified as malocclusions. Occlusal abnormalities can be best classified using the three planes of space: antero-posterior or sagittal, horizontal or transverse, and vertical (Moorrees 1957).

Traditionally, orthodontists have classified occlusal normalities and abnormalities in only the sagittal plane with a classification developed in 1898 by Edward H. Angle, the father of orthodontics. Angle divided malocclusions into three classes based on a molar relationship: a neutro-occlusion was Class I, a disto-occlusion was Class II and a mesio-occlusion was Class III. This classification merely described a dental-relationship and

not a jaw-relationship. However it still is often erroneously used to describe the prevalence of skeletal malocclusions (Staggers et al., 1992).

Moyers (1977) described the three current hypotheses that have been used to explain the relationship between craniofacial development and occlusion. He suggested that the results from univariate statistical analyses, crude cephalometric measurements, inadequate sampling, poor model cast analysis, and the continual use of **Angle's molar classification** are presently considered to be inadequacies in this field of research.

Moyers (1973) described malocclusion as a discrepancy between tooth size and the size of the jaws or a disharmony in the different parts of the facial skeleton. However, Bowbeer (1985) explained that the interpretation of the position of the jaws in relation to the teeth was often misinterpreted by orthodontists. In an Angle Class II relationship, for example, it was often considered that the maxilla was excessively prognathic. Bowbeer (1985) indicated that after closer examination of a sample of such individuals, it was established that 80% of the maxillas were in a neutral or in a retruded position. Enlow et al., (1990) also confirms that often, the mandible is retruded in dental Class II cases, not the maxilla being protruded as was once believed.

There is difference of opinion between orthodontists and anthropologists in describing what is "normal occlusion". There has also been confusion in the interpretation of cephalometric radiographs by orthodontists when evaluating the skeletal disharmonies of malocclusions. There is still further confusion in the orthodontic profession in distinguishing the difference between skeletal and dental malocclusions.

(B) Etiology of Malocclusion

Orthodontic textbooks tend to classify the etiology of malocclusion either as acquired (trauma, congenital, specific local problems and environment factors) or as Genetic (hereditary factors). Moyers (1973) classified malocclusion in the following way.

(1) Hereditary

(2) Developmental defects of unknown origin (congenital)

(3) Trauma (prenatal, during delivery and post-natal)

(4) Physical agents (diet, early loss of teeth)

(5) Habits (lip sucking, digit sucking, posture, nail biting, tongue thrusting.

(6) Systemic and endocrine diseases

(7) Localized problems (dental caries, gingival health, mouth breathing, tumors, disturbance in dental eruption sequence)

(8) Malnutrition

As "normal occlusion" and "malocclusion" share similar traits, the term "degrees of occlusal disharmony" was suggested. Malocclusion should refer specifically to occlusal disharmonies that require orthodontic intervention rather than to every deviation from the ideal. Johnson, as early as 1923, recognized the confusion in terminology, and suggested the terms "specific norms" for the ideal occlusion, and "individual norms" for the variation from the ideal (Proffit, Ackerman 1985).

If malocclusion accompanies disproportions of the face and jaws, the problems are commonly referred to as dentofacial deformities. Little is

known on the initial causes of dentofacial deformity and etiology of malocclusion, and thus the confusion in the orthodontic literature is compounded by the fact that classification is conducted from the point of view of effect rather than cause (Moyers 1973).

One way to classify occlusal disharmony is by the primary site in which malocclusion arises (Moyers 1973; Dockrell 1952; Moore 1969). Dockrell (1952) suggested that it was the frequency and duration of the cause that would eventually produce the effect on the various tissue structures, which include:

(1) Teeth

(2) Bone and cartilage

(3) Soft tissue other than muscles

(4) Neuromuscular system

Certain oral habits (like digit sucking) are known to change developing occlusal relationships if the duration and frequency are of sufficient intensity. Some researchers are now reporting that bottle feeding significantly increases the risk of malocclusion (Davis, Bell 1990). In a group of 588 Scandinavian children, 88% were reported to have had a sucking habit, but only 48% persisted in the habit into the fourth year of age. An increase in the incidence of unilateral crossbite was reported in the children with the retained habit. A recommendation to bring the habit under control by the age of two was made by Modeer et al., (1982).

Heritability or degree of inheritance, in the broadest sense, is the total genotypic (related to genes) contribution to the phenotypic (related to the

environment) variation. The genetic variance can be separated into contributions from individual alleles, and from pairs of homologous alleles at a particular locus or at a combination of non-homologous loci. In contrast, only a small portion of the phenotypic variation can be attributed to individual genetic variance (Harris, Johnson 1991). However, both genotypic and phenotypic variation may be involved in the development of malocclusions (Figure 1).

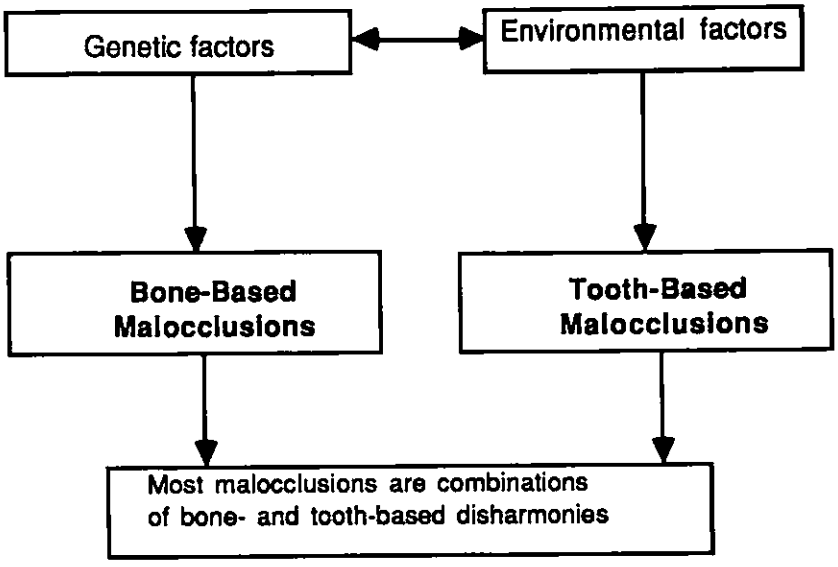


Figure 1. Schematic representation of the inter-relationships between bone- and tooth-based sources of malocclusion (modified from Harris 1991).

When Smith and Bailit (1977) reviewed literature or heritability of occlusal parameters, it was concluded that heredity was far more important than environment in the etiology of malocclusion. Due to the confusion in

the classification of malocclusion with Angle's molar relationship, erroneous conclusions were drawn from twin and sibling analyses. Bias and the fact that bone-based and tooth-based malocclusions were lumped together were the probable sources of confusion (Kang et al., 1977; Haseman, Elston 1970).

Garn (1979) pointed out that family members living and sharing the same environment are more likely to appear alike, especially because of dietary preferences, similar food preparation, socio-economical status, energy expenditure and childhood illness. The common factors would tend to enhance phenotypic correlations and thus bias sibling studies.

In the light of the above considerations, Harris and Johnson (1991) reviewed several studies examining the genetic contributions to craniofacial similarities among family members. He provided an interesting study based on the longitudinal evaluation of 30 sibships taken from the Bolton-Brush growth records in Cleveland, Ohio. Using craniometric measurements from lateral cephalometric x-rays, he concluded that the skeletal structures depicted in the skull had comparatively high heritabilities. Occlusal variables taken from dental casts, on the other hand, had low genetic contributions. The study implied that **craniofacial relations are largely inherited (the genotype)** but **dental malocclusions are acquired conditions (the phenotype).**

Many descriptions of malocclusion fail to account for the high prevalence of occlusal disharmony in industrialized countries. Some authors have suggested that the increase in the prevalence of malocclusion in industrialized countries is due to increased frequency of chronic mouth

breathing. Another factor may be related to the reduced masticatory stress as a result of a "softer" diet consumed in industrialized countries (Harris 1991; Corruccini 1984).

There have been several opinions, first initiated by Moss (1969), concerning the role of "soft tissue matrices" in the development of malocclusions or as a contributing factor to normal facial growth. These envelopes of muscular activity surround the bone and are considered as being the primary driving force for facial growth. The "Functional Matrix theory" has never been fully substantiated because of the limitations in methodology in examining the face two-dimensionally. It is likely that investigations into the etiology of malocclusion may reconsider such a concept when the methods of imaging the face and head will become three-dimensional.

Some researchers were able to demonstrate that short-period induced hyperactivity in the muscles of mastication in experimental animals, produced long-lasting malocclusion symptoms. The same researchers argued that if the muscle activity continued beyond certain limits, an interference with bone remodelling would then result (Woodside et al., 1983).

Oral respiration or mouth breathing, associated with obstruction of the nasal airway is a common finding among patients seeking orthodontic treatment. To test the hypothesis that nasal obstruction is in fact a cause of malocclusion, Harvold et al., (1973, 1981) designed a series of animal experiments using live monkeys. Plugging the monkeys' noses produced mouth breathing habits that resulted in open mouth tendency, caused the

mandible to drop in position, and often caused the tongue to protrude. The experimental animals developed a facial appearance and dental occlusion that differed from the control animals. Not all developed the same type of malocclusions. No one type of malocclusion could thus be associated with oral respiration. The monkeys demonstrated a range of manifestations from a normal appearance to one of severe skeletal and dental irregularity. This seemed to depend on how the surrounding musculature was able to influence its surrounding tissues (Harvold et al., 1981).

A sample of 73 children with enlarged tonsils were found to have significantly different dentitions from those of the control group. Retroclined lower incisors, anteriorly positioned upper incisors, smaller overbite, larger overjet, shorter lower arches, narrower upper dental arches, increased frequency of lateral crossbite, open posture of the mouth, and low position of the hyoid bone were the dominant craniofacial features (Behlfelt et al., 1989).

In a quantitative assessment of breathing patterns on the dentofacial development in a group of growing children, only a weak correlation was found when using objective physiological methods. Subjective analysis on the mouth-breathers demonstrated an increase in anterior face heights and greater mandibular planes. Another clinical study by Woodside et al., (1991) examined orthodontic patients who had had their severe nasal obstruction corrected by adenoidectomy. A greater mandibular growth at the chin point was demonstrated for both sexes when compared to the control group. The association between respiratory patterns and malocclusions are complex

issues that need longitudinal evaluation and a refinement in methodology (Ung et al., 1990).

The presence of dental caries is often included in classifications of the etiology of malocclusion (Moyers 1973). Tipping and drifting of adjacent teeth, premature loss of deciduous teeth and possible changes in eruption patterns may result in dentitions with a high incidence of dental decay. In a longitudinal study of 176 Scandinavian adolescents, however, no relation could be found between malocclusion and caries prevalence (Helm, Petersen 1989). Many American children still seek orthodontic treatment despite or maybe as a result of the fact that about 50% of USA children aged between 5-17 years are caries free (Bowen 1991). Dental caries should be classified as an environmental co-factor in the etiology of malocclusion and not as a direct cause.

Dietary change (a change in food preparation and a reduction in the chewing stress in the jaws due to the "softer" consistency of food) rather than dental caries may be considered to be a cause of malocclusion (Harris 1991). Corruccini (1984) described the changes in occlusion in populations of the world as it relates to pre-industrialized and industrialized components. He suggested that the higher frequency of malocclusion in industrialized areas is proportional to the rate of urbanization.

The "chewing stress stimulation" model has been tested in controlled experiments and seems to indicate that hardness of diet is related to various occlusal and facial measurements on rats and non-human primates (Watt, Williams 1951; Beecher et al., 1981,1983; Corruccini 1982, 1984). Generally, Wolff's law (1885) relating the form of the internal architecture of a

bone to its function and strength was upheld in these studies. Some other studies, however, did not find a correlation between dietary consistency and dental parameters (Tseng 1991).

Oyen and Tsay (1991) cautions that conventional methodology in bite force and bone strain animal experiments can produce misleading results. He advocated the use of growing rather than mature animal models, the recording of bite forces on facial bone strains rather than long bones, and the recording of tensile rather than compressive forces.

Bittner and Pancherz (1990) evaluated malocclusion and facial morphology. He concluded that sagittal and vertical dental skeletal interjaw malrelationships only partly affect the face. Bhat and Enlow (1985) on the other hand, indicated that headform type or even basicranial flexure was related to a certain type of facial morphology and craniomandibular relationship. They postulated that headform may even be related to malocclusion. Thus, a dolichocephalic headform (long cranium) would be more likely to exhibit mandibular retrognathia and an Angle Class II dental relationship. A brachicephalic individual would be more likely to have mandibular prognathia and an Angle Class III molar relationship. The dinaric headform (a partially brachycephalized dolichocephalic) tended to show more mandibular prognathia with facial leptoprosopic (long face) features.

In summary, classification of occlusal disharmonies should be separated into hereditary or environmental factors. Genotype plus environmental factors yield the phenotype (Proffit, Ackerman 1985). Most

malocclusions are a combination of tooth-based and bone-based disharmonies (Harris, Johnson 1991).

(C) Malocclusion Indices

In order to select or construct an index of health, it is important to know the purpose of the proposed index. In his summary to the International Conference on the Epidemiologic Assessment of Dentofacial Anomalies, Green (1970) suggested the following purposes for a malocclusion index:

(1) To determine the magnitude of the problem and thus, to plan its treatment

(2) To identify levels of severity in order to be able to allocate to those in greatest need

(3) To describe conditions for regular assessment of the disease

(4) To predict which children will be at risk for developing handicapping malocclusion

Brook and Shaw (1989) pointed out that since many indices are available it is important to distinguish those that classify malocclusions into types, like Angle (1907), those that record the prevalence of the disease, like Bjork et al., (1964), and those that attempt to record treatment priority, like Draker (1960), Summers (1966), Grainger (1967), Salzman (1968), FDI index (1973), Linder-Aranson (1974), Lundstrom (1977), and Brook (1988). Moyers, Summers (1970) suggested that epidemiology and treatment priority indices should not be interchangeable.

Early attempts by Massler and Frankel (1951) and by Van Kirk and Pennell (1959) to develop a malocclusion index, limited their approach to

occlusion alone. Draker (1960) was the first to introduce the idea of malocclusion as a handicapping condition. The Occlusal Feature Index was developed by the National Dental Research Council in the early 1960's. The index was improved by including the concept of arch form as well as individual tooth position (Poulton, Aaronson 1961).

The World Health Organization (WHO 1962) developed a simple Handicapping Dentofacial Anomalies Index. The assessments on eight parameters were recorded subjectively. The parameters included cleft lip and palate, overjet of maxilla or of mandible, overbite and open bite, crowding and spacing.

The indices that followed attempted to be more objective. However, the point at which any deviation from normal becomes of sufficient magnitude to be considered a malocclusion, still remains a subjective decision. In addition, the decision is influenced by social and psychological roots (Stricker 1979). In 1966, Summers developed the Occlusal Index in an attempt to define normalcy (Summers 1966). This index cannot assess individual components of malocclusion (O'Brian 1992).

The Treatment Priority Index developed by Grainger in 1967 finally introduced a level of sophistication to the recording of malocclusion by utilizing a weighting scale. Data was based on a cross-sectional trial population of 375 twelve year olds with ideal occlusion taken from the Burlington Orthodontic Research Center. A descriptive list of handicapping conditions or seven syndromes was included as an adjunct to the objective recording of the malocclusion. The syndromes included expanded maxillas, overbites, mandibular retrognathisms, mandibular prognathisms, open bites,

maxillary constrictions, and congenitally missing teeth (Grainger 1967). Figure 2 demonstrates the variables examined by the TPI. The difficulty of treatment and severity of malocclusion were based on the following scale:

(1) zero.--virtually classic normal occlusion: no treatment needed

(2) 1 - 3.--minor manifestations: slight treatment needed

(3) 4 - 6.--definite malocclusion: treatment is only elective

(4) 7 - 9.--severe handicap: treatment is highly desirable

(5) 10 and over.--very severe handicap: treatment is mandatory

Examiners may differ by 2.8 points on a ten point scale and thus the judgement of case severity is not absolute (Grainger 1967). Despite the impressiveness of the Treatment Priority Index, the esthetic judgement issue was not fully addressed untill the Eastman Esthetic Index was produced (Howitt, Stricker and Henderson 1967). One year later (1968), the Salzman, or the Handicapping Malocclusion Assessment Record Index, was developed by the American Association of Orthodontists' Council. The index has three advantages; first, it records the need for treatment objectively, second, it can be used by personnel other than dentists or orthodontists, and third, it records six intra-arch and seven inter-arch deviations without the use of a millimeter rule (Salzman 1968). The Federation Dentaire Internationale (FDI) developed an index attempting to obtain the best qualities of the other indices, and combined epidemiological and administrative methods (1973). Robert Little (1975) developed an Irregularity Index solely for the quantitative objective assessment of mandibular anterior irregularity on study models. As an epidemiological tool, this index has limited general usefulness.

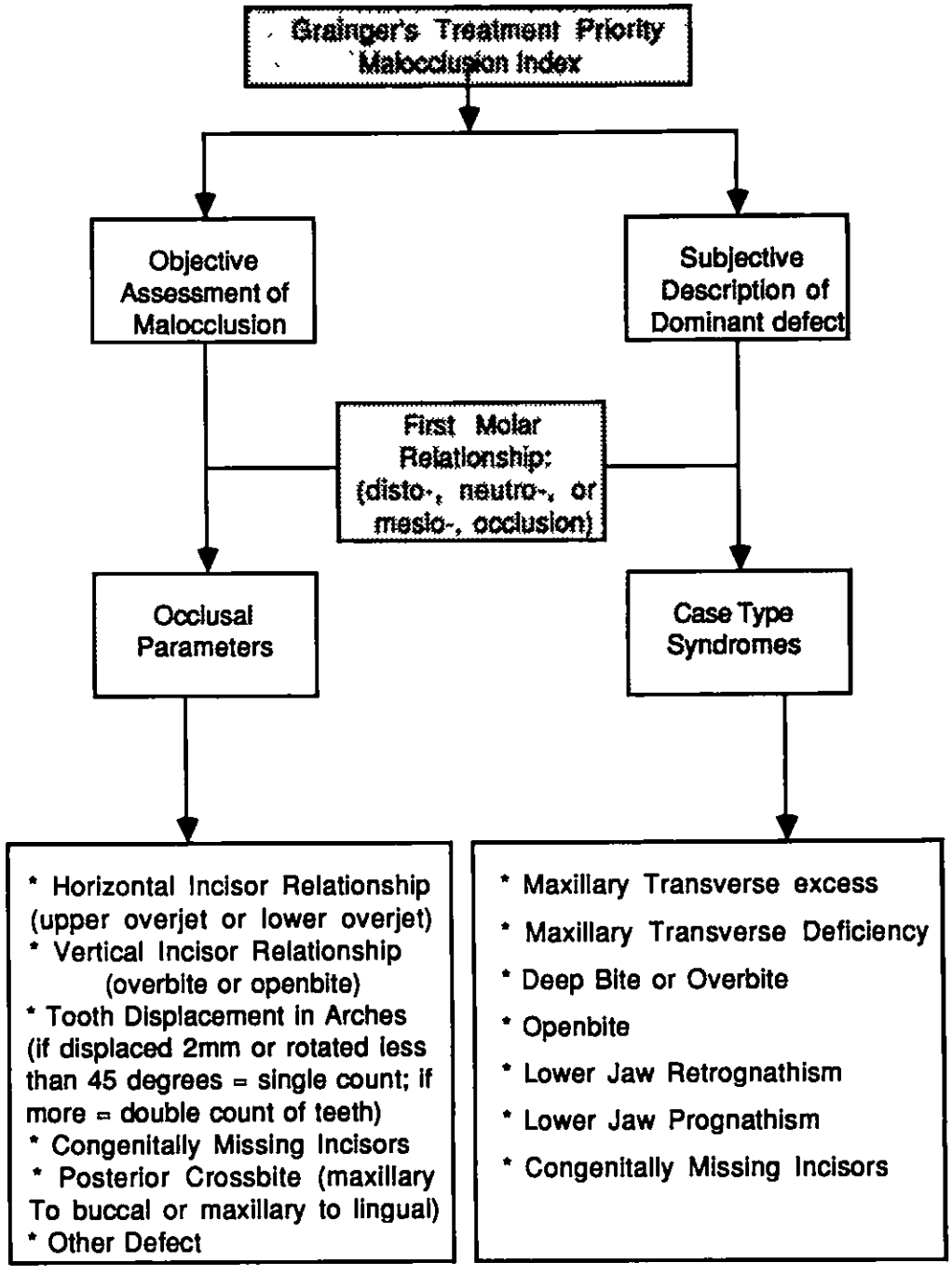


Figure 2. OBJECTIVE AND SUBJECTIVE ASSESSMENT OF MALOCCLUSION USING THE TREATMENT PRIORITY INDEX

A recent index developed by Brook (1988) in Manchester, UK, is called the Index of Orthodontic Treatment Need (IOTN). The index uses study models to record the functional dental health need for orthodontic treatment. It also includes evaluations of esthetic impairment and psychosocial need for orthodontic treatment (Brook, Shaw 1989). The Peer Assessment Rating Index (PAR) is presently being evaluated. It is attempting to measure functional rather than morphological malocclusion (O'Brian 1992). Shaw (1992) explained that the index was developed based on the opinions of 70 "peer" British orthodontists. The assessment is made on the most displaced tooth of the arch rather than the whole arch. This index is presently being used in a number of comparative craniofacial studies in five European countries. This literature is still unpublished.

Morris et al., (1976) described the terms **"seriously handicapping orthodontic conditions"** with respect to physical health and psychosocial aspects. A "seriously handicapping orthodontic condition" is a dentofacial abnormality that compromises a person's physical or emotional health. If the condition affects breathing, speaking or eating, it is considered to be a physical handicap. If the abnormality causes others to react negatively, or if that person is treated different by peers because of the abnormality, or if the abnormality causes an altered self-image and self-esteem or consequent life adjustment, the condition is considered to be an emotional handicappping disability (Morris et al., 1976). The researchers also concluded that there was no scientifically or clinically valid reason for accepting a particular malocclusion index over another. They felt that this was especially true with respect to classifying "seriously handicapping orthodontic conditions".

In a study by Katz (1978), eight orthodontic indices were compared. These included the Malalignment Index by Massler and Frankel (1951), Malalignment Index by Van Kirk and Pennel (1958), Draker's Handicapping Labio-Lingual Deviation Index (1960), the Occlusal Feature Index by Poulton and Aaronson (1961), Grainger's Treatment Priority Index (1967), the Eastman Esthetic Index by Howitt et al., (1967), the Handicapping Malocclusion Index by Salzman (1968), and Angle's classification (1899). All were compared with an oral self-image satisfaction scale. The researchers concluded that none of the above indices measure psychological components well. All were able, although weakly, to distinguish between subjects who were satisfied with their oral appearance, and those who were not. Ironically, Angle's classification seemed to be the best in identifying oral satisfaction.

Allen (1970) evaluated the Handicapping Malocclusion Assessment Record in direct mouth examinations, using 110 patients ranging from age 10-19 years. He concluded that the method of assessment was quick, did not require millimeter measurements, and was valid and practical for examination of large numbers of children for third party orthodontic care programs. Byrne (1968) agreed that the Salzman Index was a most valid index for assessing prepayment programs. There was also a 5% inter-examiner variability when it was used directly with the patient or indirectly with study models.

Carlos (1970) advises that the validity and reliability of an index of malocclusion should be demonstrated before it can be accepted for widespread use. An index should be used for more than one purpose and is

not necessarily limited to its intended use. Attempts to establish validity are often unsuccessful. Solow (1970) suggested the possibility of establishing a computer epidemiological analysis of malocclusion only if there was international agreement on the definition of individual traits of malocclusion.

In a longitudinal comparison of the orthodontic Treatment Priority Index (TPI) developed by Grainger in 1967, with the subjective appraisal by a group of orthodontists, it was concluded that the use of an index to record the severity of malocclusion was much more difficult than the use of an index for recording the prevalence of dental caries or periodontal disease (Popovich, Thompson 1971). The Treatment Priority Index used in the study analyzed children between the ages of 3-16 years, and demonstrated more consistency with identifying the prevalence of malocclusion in the group than did the subjective appraisal. Some modifications in the methods of determining priority weighting scores were suggested.

Grewe and Hagan (1972) assessed three malocclusion indices (the Occlusal Index, Grainger's Treatment Priority Index, and the Handicapping Malocclusion Assessment Record) on 130 plaster casts taken from patients aged between 11-15 years. Intra-examiner, inter-examiner and intra-index variables for all three indices being tested were compared with subjective appraisals of the malocclusion. No one index was found to be better than another, but it was the Occlusal Index that showed the least amount of bias. A high degree of reproducibility was noted for each of the examiners and for each of the indices. With regard to the ranking of the severity of malocclusions, the Occlusal Index showed a correlation factor of 0.742, the

Treatment Priority Index showed a value of 0.551, whilst the Salzman Index showed a correlation of 0.532.

In 1983, Steigman et al., utilized the Handicapping Malocclusion Assessment Record (HMAR) to assess the prevalence and severity of malocclusion in 803 Arab children aged 13-15 years. When comparing subjective measures using Angle's classification with the HMAR scores, it was concluded that a positive correlation between the two methods was only expressed in 12.4% of the children classified under the weighting score of a treatment highly desirable or mandatory. In view of Grewe's work in 1972, a proposal for increasing the sensitivity of the HMAR index was made with certain selected items from the Treatment Priority Index and the Occlusal Index being incorporated into the original index. The adjusted index was found to increase the sensitivity of the HMAR.

Lewis et al. (1982), in assessing the reliability and validity of measuring the degree of malocclusion, chose to compare standard subjective clinical methods with a recognized, reliable objective index of malocclusion (the Treatment Priority Index). They decided to choose the index because of previous successful analytical studies performed by the group, and because several other researchers had recommended the Treatment Priority Index, especially for national surveys. It was concluded that clinical evaluations of the severity of malocclusion were comparable to objective measures of the index, in terms of inter-rater reliability.

In another longitudinal evaluation of the Treatment Priority Index, Ghafari et al., (1989) concluded that the index was a valid epidemiological indicator of malocclusion, but not a predictor of the severity of the problem.

The Treatment Priority Index scores were also found to decrease after orthodontic treatment in the sample of patients chosen.

The Occlusal Index was used to evaluate the effectiveness of removable versus fixed appliances in a study by Tang and Wei (1990). Although the Index was not considered to be a sensitive index for the assessment of a developing malocclusion, it was found to be suitable for measuring basic features of malocclusion.

Payette and Plante (1989) used the Treatment Priority Index to evaluate 1201 Quebec children aged 13-14 years. He reported that 13.7% were found to have mandatory or highly desirable treatment needs. Al-Emran et al., (1990) used a modified Bjork Index to assess treatment needs in Saudi Arabia, and also found it to be adequate.

Longitudinal studies evaluating a particular index, or studies comparing several indices, are lacking. Based on the available data, the **Treatment Priority Index** is considered by some, to be the best index for objective assessment of malocclusion. It may be the only epidemiological index that has been longitudinally tested for reliability and reproducibility. It is the only index that has been used in national surveys in the United States. However, it may not be considered to be the best index for priorizing orthodontic treatments for the purpose of prepayment programs.

(D) Epidemiology of Malocclusion in World Populations

The National Center for Health Statistics of the United States Public Health Service (USPHS) published two studies (1973, 1977) of dental relationships in a sample of about 8,000 US schoolchildren in each of the

studies. The first study involved 7,400 children from across the USA, aged 6-11 years (Kelly et al., 1973), excluding only persons living on Indian reservations. The survey reported that 75% of American children had some degree of occlusal disharmony. Using the Treatment Priority Index, 37% were judged to have a handicapping malocclusion for which treatment was highly desirable. A further 5% of these were actually considered to have severely handicapping malocclusion, for which treatment was considered mandatory. In Descriptive terms, 17% of the children had significant maxillary protrusion, 25% had improper molar relationships, with 20% having an Angle Class II, and 5% having an Angle Class III molar relationship. Open bites were four times more common in blacks than in whites, and also slightly more common in females than males (Kelly et al., 1973).

The second survey (Kelly et al., 1977) examined the occlusal disharmonies present in the age groups of 12-17 years using the Treatment Priority Index. Similar results were obtained as in the younger age group, but the incidence of crowding increased with age, whilst the number of open bites decreased with age.

Morris et al., (1976) reported an incidence of ideal occlusion in 1-2% of American children. Kelly and Harvey (1977) reported a prevalence of ideal occlusion in 9% of their sample while Proffit (1991) reported the prevalence to be 35%. Proffit also indicated that 60% of the population examined in that sample had a malocclusion of unknown origin and 5% had a malocclusion of known cause. A further 5% of all the examined malocclusions were related to a severe dentofacial deformity.

The American data on occlusal disharmonies seem to be more complete when compared with similar studies from other countries. A similar trend in the incidence of malocclusion has however been reported, with more developed nations exhibiting a higher incidence in occlusal disharmony than in pre-industrialized countries.

Angle's classification of molar relationships is excellent for the purposes of description of malocclusion. However, it does not portray the degree of handicapping malocclusion or the urgency for orthodontic treatment (Steigman et al., 1983). Never the less, it continues to be used in epidemiological studies of malocclusion. El-Mangoury and Mostafa (1990) described a panoramic view of malocclusions in many ethnic populations, including the British, Indian, Inuit, Polynesian, Swedish, Black American, White American, Finnish, Kenyan and Egyptian dentitions. The number of persons exhibiting normal occlusion in the reviewed study samples ranged from 66% in Britain to 8% in Sweden. The incidence of an Angle Class I malocclusion ranged from 83% in Sweden to 13.7% in Britain. The incidence of Angle Class II malocclusions ranged from 46.4% in American Whites to 3% in the Swedish population. The incidence in Angle Class III malocclusions was highest in the Kenyan population at 16.8% and lowest for the Danes, British, and Indian populations at around 1-3%. El-Mangoury's review of the surveys reported that the sample sizes ranged from 100 to 19,854 people. The years during which these studies were completed ranged from 1957 to 1990. The variability in such data on occlusal disharmonies in different populations suggests a problem in

methodology. **Researchers are using a discrete classification to record a continuous variable.**

In 1983, Steigman et al., conducted a study to record the prevalence and severity of malocclusion in 803 Israeli Arab urban children aged 13-15 years. Only 0.3% of this population depicted an ideal occlusion, whilst 85% had an Angle Class I, 8.5% had an angle Class II division 1, 1.7% showed an Angle Class II division 2, and 1.3% showed an Angle Class III molar relationship. Some studies seem to indicate that the prevalence of malocclusion in fluoridated areas is less than in non-fluoridated areas (Erickson, Graziano 1966; Ast et al., 1962).

Caucasians are reported to have a higher incidence of Angle Class II molar relationship than non-Caucasians. Whites tend to have more displaced teeth or midline deviations than Blacks, whereas Blacks tend to have more generalized spacing and midline diastemas (Horowitz 1970).

Kerosuo (1991) reaffirmed that although many ethnic studies on malocclusion have been performed, few have been based on the same criteria. Many countries presently have facilities for providing orthodontic treatment. This tends to create a problem in the methodology of data collection. Kerosuo (1991) addressed this problem by adopting similar criteria for data collection in his comparative study between the occlusal characteristics of 642 Tanzanian adolescents aged 11-18 years and 458 Finnish children aged 12-18 years. He accounted for the number of people who had had orthodontic treatment and excluded them from the final analysis.

Woon et al., (1989) analyzed the occlusal traits and norms in Chinese, Indian and Malay samples of people living in Malaysia. He established that a high prevalence of Class III molar relationships (54%) and an edge-to-edge bite was present in 50% of the Chinese and Malay. A normal overjet and overbite was reported in 50% of the Indian sample. Crowding was found to be present in all the three ethnic groups.

In a study of malocclusion traits in 617 schoolchildren aged 10-19 years in Lagos, Nigeria, it was observed that Class I molar relationship was present in 76.8%, Class II in 14.7% and Class III in 8.4%. Crowding, on the other hand, was present in only 15.1% of the cases (Isiekwe 1983).

Malocclusion and orthodontic treatment need for 15-74 year old Dutch adults was analyzed by Burgensdijk et al., (1991). Severe crowding in the mandibular teeth was found to be present in 15% of the population. An Angle Class II molar relationship was seen in 28% of cases and a maxillary overjet of 5 millimeters or more was reported in 23% of the cases.

Another study on the prevalence of malocclusion in Saudi Arabia reported that 62.4% of a group of 500 fourteen year old children were found to have some degree of malocclusion. Sixteen point four percent exhibited an Angle Class II and 3% a Class III molar relationship. Seventeen point two per cent had an overjet of 5 - 8.9 millimeters and 1.2% had an overjet greater than 9 millimeters. Twenty per cent showed a deep bite, 3.6% had an open bite and 20% of the sample demonstrated crowding of their teeth (Al-Emran et al., 1990).

The prevalence of malocclusion and orthodontic treatment needs was also determined for 1201 Quebec children aged 13-14 years (Payette,

Plante 1989). It was determined that 32% of the group had Angle Class II molar relationship, 18% had an overjet greater than 5 millimeters, and 50% had teeth in some sort of occlusal disharmony. Mandatory or highly desirable treatment was found to be present in 13.7% of this sample based on the Treatment Priority Index weighting scale.

Wood (1971) examined one hundred "pure Eskimo" Alaskan children aged 11-20 years. His subjective evaluation of the occlusion revealed that 82% demonstrated some degree of malocclusion. Eighteen percent (18%) had "normal" occlusion, 64% had an Angle Class I, 8% had an Angle Class II, and 10% had an Angle Class III molar relationship.

In comparing the epidemiological transitions in dental occlusion of world populations, Corruccini has suggested that the rapidity of transition of **occlusal disharmonies may be proportional to the rapidity of urbanization of the area**. He makes a distinction between industrialized and pre-industrialized areas in relation to severity of malocclusion (Corruccini 1984).

Summary

The term "occlusion" pertains only to the manner in which the upper and lower teeth come together. A proper analysis of occlusion should however include a detailed study of the dentofacial skeleton. The concept of ideal occlusion has changed over the centuries from one affected by function, cultural habits and diet in "primitive" societies, to one affected largely by esthetic values in modern societies.

The etiology of malocclusion or occlusal disharmony has traditionally been classified and described according to effect but it should be described according to cause. A clear distinction between genotypic and phenotypic factors are essential in determining the cause of malocclusion but further research is necessary in this field. Several indices to record malocclusion have been proposed. Malocclusion encompasses several parameters other than occlusal disharmonies. No one index has been able to address all of these parameters. Clear definitions of terms is essential. Current research is addressing functional rather than morphological malocclusion. The term "handicapping malocclusion" also seems to be a common descriptive term in a number of indices. The Treatment Priority Index may be the only index that has been tested longitudinally, epidemiologically and for reliability and reproducibility. It has also been used in American national surveys on about 16,000 school children. The Peer Assessment Rating index is presently being used in Europe but is only beginning to be evaluated in North America.

Recent epidemiology studies in occlusion in world populations appear to be reporting similar traits, with a large percentage of the population having some degree of occlusal disharmony. The incidence of crowding of teeth seems to be especially high in industrialized areas. Caucasians appear to demonstrate a high prevalence of Angle Class II molar relationship up to 46%, and a Class III relationship up to 5%. On the other hand, Black and Asian populations demonstrate an incidence in Class II molar relationships up to 15% and a higher incidence of Class III relationships up to 20%. Handicapping malocclusion has been reported to

be present in 40%, while severely handicapping malocclusion has been reported to be present in 15% of Caucasian samples. Methodology and type of index used in studies on malocclusion have not been uniform or consistent in a large number of the reviewed studies, making comparisons difficult.

1.5. Cephalometrics in Orthodontics

Radiography has been in use in Medicine and Dentistry as a diagnostic tool for almost a century. Cephalometrics, or the technique involving radiographic imaging of the skull, is still in use in orthodontics. Present techniques are considered to be safe and effective for diagnostic purposes (Tyndall, Turner 1990).

Before the use of x-rays, researchers studying human growth and development, relied on anthropological measurements, comparative anatomy, histological sections, and animal experiments using vital staining, metallic implants, and transplantations. Today, several methods of diagnosis are being utilized as an adjunt to radiography.

Campter in 1792, reported morphological differences in inter-racial characteristics of the face. It was Welcher, however, in 1862 who introduced the use of a facial angle to estimate prognathism of the jaw (Colby 1972). In 1884, Von Hering and Merkel suggested the use of a horizontal reference plane on the skull (Frankfurt Plane) passing through the external acoustic meatus and the lowermost point of the infra-orbital margin. This horizontal plane was also utilized in orienting skull material when radiographic techniques were introduced (Brader 1956). Welcher in 1896 may have

been the first to encourage the use of profile radiographs in the field of physical anthropology (Colby 1972).

Broadbent of the United States and Hofrath of Germany introduced a system of standardizing the radiographic technique for imaging the head of living persons around 1931. Cephalometry, as it became known, is still used today after some minor modification (Mc Gonagle 1956; Colby 1972).

Ricketts (1981) described the changes that cephalometrics have undergone over the past 50-60 years. Broadbent's radiographs eventually came to be known as the Bolton-Brush growth study and are possibly the largest longitudinal collection of radiographs in the world (Behrents 1984). Later clinical applications were introduced after the location and identification of certain points and planes on the skull. After several cephalometric analyses had been developed, the morphological description and typing of clinical conditions, began. Some of the common analyses presently used in orthodontics include that of Tweed in 1946, Bjork's in 1947, Wylie's in 1947, Downs' in 1948, and Steiner's in 1953 (Krogman, Sassouni 1957; Salzman 1961). Recently other analyses have been developed such as that of Rickett's in 1960, Enlow et al., in 1969, Jacobson's "Wits" analysis in 1972 and McNamara's in 1984 (McNamara 1986). The fourth phase in the development of cephalometrics involved facial growth forecasting techniques. This was followed by attempts to try to predict growth in the different planes.

Cephalometric analyses are considered to have four main objectives (the four C's): to characterize and describe the condition that exists, to classify into categories, to compare individuals to one another, and to

communicate all these aspects to other clinicians or researchers or parents (Ricketts 1961).

Cephalometrics is not an exact science. A certain amount of uncertainty is inherent in the technique. Variation occurs during the taking and processing of radiographs. Additional error can occur while tracing the image onto tracing paper or while digitizing the tracing into the computer. Sassouni (1962) recommends that a minimum of a hundred x-ray tracings would have to be completed before the technique is mastered. Selection of landmarks should be validated and double checked. Good lighting, sharp pencils and smooth tracing paper should be used. Magnification of the image should be recorded. Proffit (1991) suggested that the more points on the digital model, the more the computer image of the tracing would resemble the actual tracing. Computerized digital models also provide for an unlimited number of instant calculations. Davis and Mackay (1991) compared manual and interactive computer methods of cephalometric analysis. He concluded that the computer version was statistically more favorable. Research is still being conducted to produce automated computer image interpretation systems and radiographic scanning in order to provide cephalometric data without human operator errors.

Using skulls, Utermohle and Zegura (1982) investigated the error in craniometry. They found that experienced researchers produced less intra-observer repeatability, and even less inter-observer reproducibility than was expected. Houston (1983) made a distinction between systematic error (bias) and random error (instrumentation or landmark identification). Landmark identification, it is argued, is not significantly related to the quality

of the image on the x-ray (Stathopoulos, Poulton 1990). By using rare earth intensifying screens and fast films, a reduction in radiation dosage of 96% of the previous levels is presently possible with only a slight loss of image quality. Experience and calibration should then be sufficient to easily identify landmarks on the x-rays. Houston (1983) concluded that although error analysis is tedious, it should be reported. Radiographs should be digitized directly onto the computer to minimize error and wild values should be remeasured. The randomization of record measurements is the best way to avoid bias. On the other hand, Hatton and Grainger (1958) stated that the best experimental procedure would be to use a sufficient number of subjects rather than try to reduce technical error.

Natural Head Posture (a physiological posture) has been suggested by some workers as a substitute for the Frankfurt horizontal plane (an anatomical posture), when orienting patients in the cephalometer (Moorrees 1958). Although this position is a useful orientation posture in some special instances, its long term reproducibility has not been consistent when compared with patients oriented in the Frankfurt plane (Cooke 1990). Proffit (1991) identified Natural Head Posture as being more useful for obtaining cephalometric orientation for patients with dentofacial deformities.

Several workers have attempted to use longitudinal studies of cephalometric x-rays to describe growth. Broadbent and Broadbent (1975) developed the Bolton Standards from 4,614 persons and about 22,000 recordings. They were able to develop norms or averages for the craniofacial growth of Caucasians from age 1-18 years. These standards are used as diagnostic aids in orthodontics, oral and maxillofacial surgery,

and for analysis of the relationship of the dentition to its supporting skeletal bases. Mean data for cephalometric parameters were incorporated into a set of templates which are the visual equivalent of a table of standard values in analyses. The use of the templates are considered appropriate for any individual as long as that person was representative of the reference group. A list of standards for Caucasians is also available from Alabama, Michigan, Rocky Mountain Data System (all from United States samples), and Burlington in Canada (Proffit 1991). All five sources have been used as a base line for research.

As the Caucasian norms were inappropriate for other racial groups, several researchers have started to study different ethnic groups. Some of these studies include: Suh's study of Koreans in 1967, Drummond's study of Blacks in 1968, Nanda's study of North Indians in 1969, Velarde's study of Mexicans in 1974, Chan's study of Chinese in 1975, Garcia's study of Mexican Americans in 1975, Mitani's study of Japanese in 1980, and Bishara's study of Egyptians in 1990. Thus, different racial groups came to be treated orthodontically according to their own racial characteristics (Park et al., 1989). Other researchers feel that it is better to analyze skeletal patterns of a particular patient on an individualized basis or on "floating norms" (Segner 1989).

Cephalometric x-rays can only provide a static view of a person's craniofacial complex in two dimensions. Attempts are presently being made to develop three-dimensional views of the skull, but reference points are proving hard to equally locate in all planes (Brown, Abbott 1989).

Other methods of craniofacial appraisal that have been used with less success than cephalometry include photography, photogrammetry, laminography, pantography, CT scanning, magnetic resonance imaging, and xeroradiography. Recently, computer visual imaging techniques are being assessed for accuracy, reproducibility, and validity. Low-dose x-ray cephalometry, however, is presently the preferred technique for examining and recording craniofacial morphology.

Summary

Racial characteristics are often manifested in the craniofacial complex. Physical anthropologists have long been interested in studying these characteristics in dried skulls in a laboratory using craniometry. The use of x-rays was also utilized for this purpose. In 1931, Broadbent in Cleveland, Ohio, developed a system for standardizing head and neck radiographs of living persons. Cephalometric radiography is still used today in orthodontics to examine and record the growth of the craniofacial complex before, during and after orthodontic treatment. Some error is associated with cephalometric analysis. Techniques to reduce these errors have been developed. Computerized (digitized) tracings of the radiograph is presently an accepted accurate technique. The use of cephalometrics for epidemiological studies of malocclusion have rarely been adequately reported.

STATEMENT OF THESIS

The purpose of the present epidemiological study was to examine malocclusion using psychosocial, dental and skeletal parameters together, recorded from the Inuit youth living in subarctic Northern Labrador, Canada. The data was collected by the author and two assistants in a field study lasting two and a half weeks during the Spring of 1991. Specific aims included:

(1) To evaluate **psychosocial** aspects related to malocclusion using parent and student questionnaires. The total school population for both Nain and Hopedale schools was 445 but not all were available to participate [parent (n=222) and student (n=363)].

(2) To evaluate the **dental** aspects of malocclusion (n=348) using clinical epidemiological parameters pertaining to the prevalence of malocclusion in Labrador Inuit school children aged between five and twenty-two years.

(3) To evaluate the **skeletal** parameters and jaw relationships of malocclusion in this Inuit population (n=100) using cephalometric radiographs (oriented skull X-rays) of a selected sample taken from the main clinical sample of 348 school children.

Analysis of data collected provided insight into the prevalence of dental and skeletal malocclusion as well as actual and perceived need for **orthodontic care** in two Canadian native communities of Nain and Hopedale, Northern Labrador.

2. METHODS AND MATERIALS

This study examined the dental occlusion of 348 Labrador Inuit school children from the communities of Nain and Hopedale. Psychological profile data was obtained from 363 students and 222 of their parents. Cephalometric radiographs were taken on a sub-sample of 100 subjects selected from the Nain school. This data will be used to determine the prevalence of skeletal and dental malocclusion as well as actual and perceived need for orthodontic care in this group.

2.1. Sample

Nain and Hopedale both had one school each in their communities. The total school population was 445. Ninety seven children were either absent on the day of clinical examination or did not have parental consent, thus, 78.2% of the Inuit youth were examined. Eighty two children were not available to answer the questionnaire, thus, 81.6% of the Inuit were interviewed. One hundred (22.5%), of the Inuit youth were selected for the radiographic sample. The school children ranged in age from 5-22 years.

Figure 3 shows the demographic distribution for the psychosocial, clinical (malocclusion and caries) and radiographic samples. The radiographic sample was subdivided into four age groups to coincide with molar eruptions and pre- or post- puberty growth stages as seen in Table 3.

Table 3.--Radiographic Sample Distribution according to Age and Developmental Stage.

Age (years)	Developmental and Dental Stage	Sample Number (Total N = 100)
5-8	early mixed dentition - pre puberty	23
9-11	late mixed dentition - -pre puberty	31
12-14	early teenage - puberty	23
> 15	late teen/adolescent- -post puberty	23

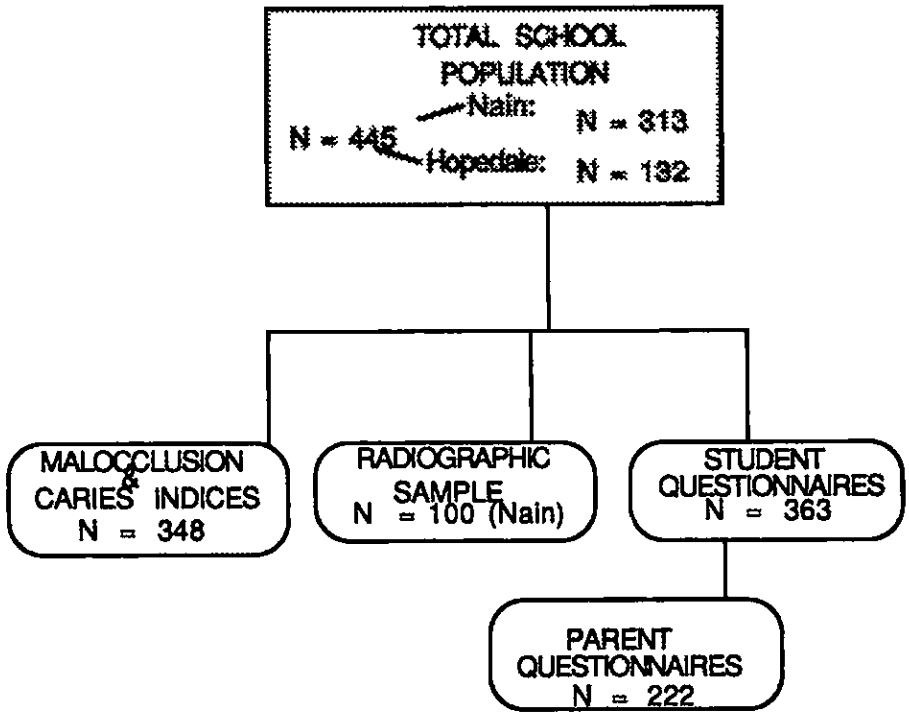


Figure 3. Population Sample Demographics for the three sources of data collection.

2.2. Data Collection

The data was collected by the author and two assistants in a 1991 field study in Northern Labrador lasting two and a half weeks. Appendix D documents the preliminary procedures for acquiring permission to conduct this study, travel and accommodation arrangements, transportation of materials, and methods of collecting consent. Students without consent were removed from the potential exam list. (Appendix H - Consent Forms; Appendix I - Letters granting permission; Appendix J - List of equipment).

(A) Data Collection: School

Disposable gloves, mirrors and examining lights were taken to the school to a room assigned for the dental examinations. A native assistant was hired to help with organization, identification, paper work, and language interpretation.

The assistant brought six students at a time from the class room to the examining room. The assistant then checked and matched the names with the school list and assigned the appropriate identification numbers. Two Inuit judges identified the students of Inuit background, grading each student for esthetic and facial harmony according to Inuit standards. Any temporary residents, or persons who had orthodontic appliances, were excluded from participating in the study.

Two examiners positioned at either end of the examining room, awaited the students. The identification number, age and gender were

double checked verbally with that on the data sheet. The first examiner recorded the malocclusion index. The data sheet was then returned to the student. The student was then examined by the second examiner for a charting of the dentition to determine the caries index. Before leaving the room the first examiner would decide whether to include that student in the radiographic sample based on the following criteria:

(a) a high esthetic index with good facial balance as decided by the two Inuit persons who were assisting with data collection.

(b) being Inuit and a permanent resident of Labrador.

(c) having all or nearly all the dentition with no previous orthodontic treatment.

(d) having no obvious dental pathology or craniofacial defect.

Data collection on each student could last between three to five minutes depending on the efficiency of the team. An efficient system of "musical chairs" was devised so that six students would be in the examining room at one time. The total examining time for all six students would be around fifteen minutes. About 60-80 students a day could be examined in this manner. Approximately 6% of the students were scored twice in order to calculate intra-examiner variability and reliability. It took the two examiners a total of five days to collect all the clinical data on 348 students from the two schools in the two towns.

At the same time that the clinical examinations were being performed a third research assistant collected student questionnaire responses from each classroom. Responses were collected in the classroom in order to:

(1) Standardize the response setting

(2) Minimize outside influences on responses

(3) Minimize disruption to classes

(4) Obtain the largest number of student responses possible

The research assistant was a Labrador Inuit with classroom experience but with minimal orthodontic or dental education. The questionnaires were distributed to each student in the class. Each question was read out loud. Upon request by a student, some carefully worded explanations of terms would be given. Care was taken so as not to bias the responses. The completed questionnaires were then collected. Next, a questionnaire for the parent of the student was distributed around the classroom. Participants took the questionnaires home, had the parent complete it and return it the next day. It took the assistant fifteen to twenty minutes per classroom or a total of four school days to collect 363 student questionnaire responses. For details of the student or parent questionnaires please refer to Appendix E and F.

(B) Data Collection: Dental Office

Only the Nain Nursing Station was used to collect radiographic data. Nain was selected because it was a larger building with dark room and x-ray facilities. The assistant prepared a schedule for the students selected for this sub-sample to attend the clinic over the next few days. The response level was close to 95%.

Since a complete genealogy was not available, and because the level of Caucasian admixture was completely unknown for the Labrador Inuit population at this point in time, no attempt was made to subgroup the population into pure or mixed Inuit. However, obvious hybrids and non-Inuits were eliminated from the sample. Therefore, the selected sample was representative of the Inuit population living in Northern Labrador, Canada in 1991.

Three rooms and a waiting area in the Nain Nursing Station were organized to collect the required data. The waiting area was used to reassign the data sheets to the students according to identification number. The vacant lead-walled x-ray room was set up for taking cephalometric radiographs, photographs as well as recording head measurements. An anthropometric caliper set was used to record the head length and width. Measurements were recorded three times and averaged. Upper and lower dental impressions of the mouth and centric occlusion bites were taken in the dental office. The third room was set up as a small dark room. Safe lights were installed to allow film processing, as well as storing or changing x-ray films. All equipment was supplied by the CWRU orthodontic department, interested alumni, or the Bolton Brush Growth Study Center. It took three days to collect radiographic data on 100 students.

2.3. Cephalometric Technique

One portable cephalometric x-ray machine was utilized in this study in order to take lateral skull and postero-anterior frontal skull radiographs. The machine consisted of:

(1) "Thurow" cephalostat and head holder (courtesy of Dr. N. Pooler).

(2) A Picker 'Meteor' 90KV x-ray head source connected to its own control box (courtesy of Dr. N. Pooler).

(3) A slide-projector stand, consisting of a forty inch-long metal pole (40"), which was one and one half inches (1 1/2") in diameter, mounted on a detachable heavy triangular base (courtesy of the Bolton Brush Growth Study Center).

The whole x-ray apparatus weighed approximately eighty pounds (80lbs) and was thoroughly tested for safety and function before departure. The radiographs taken with this machine were obtained using a technique similar to that described by Broadbent (1931).

The head holder was mounted on a plywood base for standardized orientation of components. The anode x-ray head fit snugly into the metal pole. The triangular base was of sufficient weight to support the x-ray head. The distance between the midsagittal plane of the cephalostat and the x-ray head (Source-Object distance) was set at sixty inches (60"). Two spirit levels were also used to orient the x-ray head source parallel to the floor. It took approximately two hours to set up the portable x-ray machine and a further hour to fine tune the equipment to the required operational level.

For the lateral skull x-ray, the central x-ray beam passed through the ear rods, at right angles to the midsagittal plane of the skull. The x-ray film cassette was brought up to the side of the patient's face until it would go no further. The subject was asked to bite in centric occlusion. A transparent plastic slab six inches (6") long and half an inch (1/2") thick had two lead shots embedded at hundred millimeters (100 mm) apart. The slab was then

scotch-taped to the nasal rest of the machine in the midsagittal plane. The image of the two lead shots on the x-ray film could then be used to calculate the magnification of the machine. The subject held a soft tissue aluminum screen along the contours of the face and chin in order to accentuate the soft tissue profile on the x-ray film image. The patient's head was oriented with the frankfort plane parallel to the floor, such that the eyes also gazed straight ahead into the distance.

For the frontal (PA) film, the ear rods were rotated ninety degrees so that the x-ray beam would now pass through the back of the head and parallel to the midsagittal plane. The subjects were oriented in a similar manner as for the lateral view, but this time facing the film cassette which was brought up to touch the nose of the patient.

Lead identification numbers were taped on to the x-ray cassette for each subject and for each x-ray for easy later identification of the x-ray film image. The exposure time on the x-ray machine for the subject was 1/6th second for the lateral, and 1/2 second for the frontal x-rays.

The x-ray film was then taken to the dark room and manually processed according to Kodak's "T-Mat G" film recommendations (Kodak 1980, 1986). If the waiting room was busy, the films were stored in a lead box, to be developed later.

The following precautions were taken to produce good-quality x-rays, and to minimize radiation exposure (Watson 1982):

(1) The number of x-rays were limited to the intended number and were not repeated.

(2) A high kilovoltage (90KVP) was used for good penetration and lesser contrast.

(3) The milliamperage was kept at 15MA for increased intensity of x-rays.

(4) Ultra high speed film was used (Kodak T-MAT G, Eastman Kodak Co., New York).

(5) Rare-earth intensifying screens (Lanex-fast, Eastman Kodak Co., New York) were used in the film cassettes.

(6) Collimation of the central beam was used to produce a narrow beam by fitting the machine with a collimator.

(7) Lead aprons were used on all patients for protection against scatter and secondary radiation.

(8) All female subjects were asked if there was a possibility that they were pregnant.

(9) Exposure time was carefully controlled according to previous trials.

(10) Fresh chemicals were used for optimal developing time.

(11) Dark room procedures were carefully controlled. Safe light filters were also installed.

(12) Lead barriers to protect the operator and lead-lined walls, to protect other nursing staff working nearby, were present in the x-ray room.

2.4. Analysis and Statistics

Analyses of the psychosocial and clinical data from Nain and Hopedale revealed no differences between the two communities. Thus, the data was pooled and subgrouped into psychosocial, clinical and radiographic data.

(A) Psychosocial Assessment Analysis

A large number of orthodontic questionnaires of varying lengths have been devised. Most questionnaires require that the subject have some background knowledge in orthodontics. Others are designed for people living in more urban rather than rural locations. The questions for this study were designed to be brief and easy to answer. This was done in order to increase compliance and increase communication. The intent was also to encourage honest responses that did not require previous knowledge of orthodontics. To eliminate bias against a rural culture, questions that referenced to life in the city were eliminated (Appendix E and F). The questions used were similar in overall objectives to many previously developed orthodontic questionnaires (Brook, Shaw 1989; Caltabiano et al., 1989; El-Mangoury 1981; Espeland, Stenvik 1991; Kiyak, Bell 1991; Morris et al., 1976; O'Regan et al., 1991; Tedesco et al., 1983; Wood 1971).

The answers to each of the questions were numerically coded. This allowed a total score to be computed for both student and parent responses. Specific responses to individual questions could also be calculated.

The student questionnaire was devised to demonstrate the following factors:

(1) Satisfaction with dental appearance (Question #1)

(2) The frequency of dental attendance (Question #2)

(3) Awareness of occlusal traits present in the child's mouth (Q. #3, #4)

(4) Amount of previous educational knowledge about orthodontics (#5 and #9)

(5) Other people's perception of the child's occlusal traits (Q. #6, #7)

(6) Attitude to orthodontic treatment if it were available(Q. #8, #10)

The parental questionnaires were designed to identify these specific factors:

(1) Parent's awareness of their child's occlusal traits (Question #1)

(2) The degree of psychological handicap in their child as a result of the malocclusion (Q. #2)

(3) The level of concern of their child for good dental health (Q. #3)

(4) Whether the parent wanted their child to have orthodontic treatment (Q. #4)

(5) Whether they thought that their child would comply with orthodontic treatment (Q. #5)

Percentage frequency response was tabulated for each of the questions. Two-tailed significance tests were conducted between the student and parent questionnaire responses and the Treatment Priority Index scores. This was performed to establish correlations between the clinical findings of the severity of malocclusion with the concept of handicapping malocclusion as perceived by the Inuit students and their parents.

(B) Clinical Analysis

The clinical data included:

(1) An objective index for recording occlusal disharmony was used, the Treatment Priority Index (TPI), to determine the prevalence and severity of malocclusion.

(2) Full dental charting for recording decayed, missing or extracted and filled teeth was performed to evaluate the caries prevalence by number of teeth or surfaces affected (def, DMF, def/DMF-S, def/DMF-T).

The Treatment Priority Index developed by Grainger (1967), was selected for use in the present study for a number of reasons:

(1) This index was used in two American surveys on malocclusion by Kelly in 1973 and in 1977, who examined around 16,000 children.

(2) A review of the literature has shown that this index has faired well when compared with other indices (Grewe, Hagan 1972; Katz 1978).

(3) It has shown validity when used epidemiologically (Lewis et al., 1982; Payette, Plante 1989).

(4) It has been tested in longitudinal studies (Popovich, Thompson 1971; Ghafari et al., 1989).

The author found the index to be easy to learn and to teach to other colleagues. However, it was felt that a certain degree of dental and orthodontic knowledge was essential for reliability and reproducibility Thus, it may prove to be difficult to delegate such an index to non-dental personel in the manner some other indices can. In the field, the TPI proved to be very efficient when examining several hundred children. The TPI was found to be less tiring than DMFT dental charting for the purpose of determining dental caries rates. It was felt that this index as a whole did examined occlusal disharmony fairly objectively. However, the method of measuring the degree of crowding suggested by Grainger was still subjective. The overall

score was easy to compute if the child had symmetrical molar relationships, but was a little more complex when asymmetry was present. This method, as described by Grainger, demonstrated only morphologic malocclusion. Unfortunately, no valid or reliable indices exists to examine the concept of handicapping or functional malocclusion. Thus, Grainger's Index may still be the best index available. The Peer Assessment Review index (PAR) may become the index of choice in the future once more literature becomes available.

A Treatment Priority Index data sheet, prepared by the National Center for Health Statistics and by the University of Toronto (Appendix G), was used in its original format to record seven parameters related to malocclusion. Six of the seven parameters (that is, all except the molar relationship), relate a score or "weight" according to the magnitude of the defect. The appropriate column of the score chosen is determined by the choice of molar relationship as indicated by the first parameter.

The seven parameters were:

(1) First molar relationship: disto-, neutro-, or mesio- occlusion.

(2) Horizontal incisor relationship: upper or lower overjet (a measurement in millimeters)

(3) Vertical incisor relationship: overbite or openbite (a measurement in millimeters)

(4) Tooth displacement (a count of the number of teeth displaced or rotated 45 degrees or less than two millimeters (2mm). If rotated or displaced more than 45 degrees or two millimeters, a double score was taken).

(5) Congenitally missing incisors (a count of teeth).

(6) Posterior crossbite (a count of teeth)

(7) An arbitrary weight was given for any other defect.

The clinical time to record the seven parameters was approximately two minutes. The remaining computations on the data sheet were completed during the data analysis stage. An arbitrary weight was included for factors that are known to be related to the prolongation or complication of orthodontic treatment and care. Some of these factors included spacing due to multiple missing teeth, very large diastemas, temporomandibular joint symptoms, retained deciduous teeth, active habits, large midline discrepancies and unusual dental anatomy.

The Grainger data sheet was also used to describe the specific dominant defect of the dental malocclusion as a list of seven "syndromes":

(1) Syndrome I: maxillary expansion (transverse excess).

(2) Syndrome II: overbite (vertical discrepancy).

(3) Syndrome III: retrognathia (mandibular sagittal discrepancy).

(4) Syndrome IV: openbite (vertical excess).

(5) Syndrome V: prognathism (mandibular sagittal excess).

(6) Syndrome VI: maxillary collapse (transverse discrepancy).

(7) Syndrome VII: congenitally missing incisors.

The scoring was graded in the final analysis according to Grainger's original classification as seen in Table 4. This type of scoring has some limitations in that discrete intervals are being used to describe continuous variables. Furthermore, the score changes between the intervals may not show same changes in treatment need.

Table 4.--Interpretation of the Treatment Priority Malocclusion Index Scores for Orthodontic Treatment Need based on Grainger's original format (1969).

0 - 0.9	classic normal occlusion--no treatment required
1 - 3.9	minor disharmony--slight treatment may be needed
4 - 6.9	definite malocclusion--treatment only elective
7 - 9.9	severe handicap--treatment highly desirable
> 10	very severe handicap--treatment mandatory

The number of decayed, missing or extracted and filled teeth were then calculated from the dental charting for the "tooth number" and "tooth surface" indices for both deciduous and permanent dentition. Each of these scores were then added to obtain one score for all deciduous and permanent teeth present in the mouth.

Means and standard deviations were tabulated for the malocclusion and caries indices according to gender and for the four age groups already described. Percentage prevalence for each of the specific parameters that make up the malocclusion index (molar relationship, degree of crowding, overjet, overbite, and posterior crossbite) were also tabulated. Fourteen of the children were scored twice for malocclusion and caries indices at different times in order to calculate the reliability of the operator. These persons were randomly selected during data collection. Previous scores were not examined before the second examination in order to eliminate bias.

(C) Radiographic Analysis

The portable cephalometer proved to be similar in set-up and operational procedures to office cephalometers. However, the room used had non-rigid floors and walls that were not perpendicular. Hence, the face was not always symmetrically placed in the radiographic field. This provided a source of variability when averaging of bilateral structures. Artwork was used in these situations on the tracings of the radiographs. Amperage settings occasionally fluctuated from one radiograph to the next.

The radiographs were placed on a variable intensity illuminator for identification of anatomical landmarks and traced with a 0.3 mm lead pencil on a 0.001 mm acetate. Bilateral structures were traced individually and averaged. The tracings were securely fastened to an illuminated translucent digitizer (Numonics 2210 Chart Digitizer). Sixty eight anatomical points (Standard 68 Cephalometric Digitizing Regimen) were digitized from each tracing using commercially available software (Dentofacial Planner, Dentofacial Software Inc., 1990) and a microcomputer (AST-286).

Selected angular and linear measurements were computed using the same computer software. A subset of measurements was cross checked using manual methods. A total of 17 (9 linear and 8 angular) measurements selected from established cephalometric analyses such as Downs, McNamara, Steiner, Wits, Cogs and Jarabak (Krogman, Sassouni 1957; Mcnamara 1986), were recorded and statistically analyzed using means and standard deviations (Dentofacial Planner, Dentofacial Software Inc., 1990).

Harris and Johnson (1991) lists several of the popular measurements used in orthodontics that have been tested for heritability. All the craniofacial measurements used for this section of the present study are known to have a high degree of heritability.

The following linear and angular measurements were used to asses the morphological relationships of the craniofacial complex of the Northern Labrador Inuit Youth in the three planes of sagittal, transverse and vertical:

(1) Sagittal Relationships

(1) **Sella/Nasion/A-Point (SNA)** - a traditional angular measurement that relates the upper jaw to the cranial base of the skull. (Reidel and Steiner's Analysis).

(2) **Sella/Nasion/B-Point (SNB)** - a traditional angular measurement that relates the lower jaw to the cranial base of the skull. (Reidel and Steiner's Analysis).

(3) **A-Point/Nasion/B-Point (ANB)** - angular measurement relating the upper and lower jaws to each other in relation to the cranial base. (Reidel and Steiner's Analysis).

(4) **Wits Appraisal (AO-BO)** - a linear measurement that relates the upper and lower jaws to the occlusal plane. (Wits).

(5) **Condylion to Gnathion (CO-GN)** - a linear measurement of the relative length of the lower jaw. (McNamara's Analysis).

(6) **Conylion to A-point (CO-A)** - a linear measure of the length of the upper jaw in relation to the mandible. (McNamara's Analysis).

(7) **Maxillary-mandibular difference (CO-GN minus CO-A)** - a linear measure of the difference between the two jaws. (McNamara's Analysis).

(8) **Inter-incisal Angle** - an angular measurement of the relationship between the upper and lower incisor teeth. Also an indication of the relationship of the supporting bone between the upper and lower incisor teeth. (Downs Analysis).

(9) **Lower Incisor to Mandibular Plane Angle (IMPA)** - an angular measurement of the lower incisor tooth to the mandibular plane. (Downs Analysis).

(10) **Upper Incisor to the Palatal Plane (IPP)** - an angular measurement of the upper incisor to the maxilla or palatal plane. (Downs Analysis).

(2) Transverse Relationships

(11) **Bitemporal Widths (BT 1 - BT 2)** - a linear measurement between the right and left temporal bones of the skull.

(12) **Bimaxillary Widths (BM 1 - BM 2)** - a linear measurement of the width of the maxilla.

(13) **Bigonial Widths (BG 1 - BG 2)** - a linear measurement of the width of the mandible at the gonial angles.

(3) Vertical Relationships

(14) **Anterior Facial Height Ratio (UAFH/LAFH x 100)** - a percentage ratio between the upper and lower anterior facial height (Cogs Analysis).

(15) **Lower Anterior Facial Height (LAFH)** - a linear measurement between the anterior nasal spine and menton (McNamara's.Analysis).

(16) **Mandibular Plane Angle (FMA)** - an angular measurement between the Frankfurt horizontal and the mandibular plane. Also an indication of the degree of difficulty in treatment of the orthodontic case (Downs and McNamara's Analysis).

(17) **Gonial Angle (Go)** - an angular measurement between the ramus and the body of the mandible. Also a descriptive measurement of the degree of squareness of the lower jaw (Jarabak's Analysis).

Means and standard deviations for each measurement were tabulated for the different age groups and for gender. Caucasian means were taken from the Bolton template standards or from established

Caucasian averages of each of the cephalometric analyses. Fourteen radiographs were retraced and re-digitized. Six measurements were randomly selected and compared with the recordings for time one and time two in order to calculate reliability coefficients from the differences in the means.

3. RESULTS

The epidemiology of malocclusion and the need for orthodontic care in the Inuit youth of Northern Labrador was evaluated using data from three sources. The demographics of these three sources are shown in Table 5. First, the prevalence of dental malocclusion and dental caries was evaluated from intra-oral examination of 348 individuals. Second, some of the psychosocial parameters concerned with the concept of "handicapping malocclusion" were evaluated from questionnaire responses from 363 students and 222 of the students' parents. Third, headform types and the skeletal relationships of the teeth and jaws were evaluated from frontal and lateral cephalometric radiographs from a 100 individuals. The data were analyzed according to age (four age groups: 5-8 years, 9-11 years, 12-14 years, and over 15 years) and gender.

3.1. Psychosocial Questionnaires

Ten psychosocial-related questions were addressed to the Inuit youth in the form of a questionnaire in order to establish a psychological profile. About 19% of the Inuit in the two communities that were chosen for evaluation (Nain and Hopedale) were not able to respond to this questionnaire while 81% responded **(See Table 6)**.

Fifty eight per cent of the Inuit youth reported satisfaction with their dental appearance and 42% were dissatisfied. Only 11% reported regular

Table 5.--Demographics by Age and Gender of Sample Sizes and Types (Malocclusion and Caries, Psychosocial Student and Parent Questionnaires, and Radiographic Samples).

	Age (Years)				Gender		
Sample Type	**5-8**	**9-11**	**12-14**	**>15**	**Male**	**Female**	**Total Sample**
Malocclusion & DMF	n = 111	n = 95	n = 77	n = 65	n = 176	n = 172	**n = 348**
Student Questionnaire	n = 120	n = 98	n = 81	n = 64	n = 190	n = 173	**n = 363**
Parent Questionnaire	-	-	-	-	-	-	**n = 222**
Radiographic	n = 21	n = 30	n = 26	n = 23	n = 42	n = 58	**n = 100**

attendance at the dental office, 18% never attended, while the majority reported infrequent attendance. About 10-16% were very aware of their occlusal disharmonies, 26-34% were not aware of having any malocclusions, while the rest were not sure. A positive correlation between the students' perceived awareness of occlusal disharmony and the actual clinical assessment of malocclusion severity was significant at the 0.001 level. Similarly, 17% of the Inuit youth reported that they perceived others (friends and relatives) to also be aware of their occlusal disharmony. This was also significantly related ($p < 0.001$) to the severity of malocclusion assessed using the Treatment Priority Index (TPI). About 5% reported being teased a great deal by others because of the malocclusion present in their mouths, while 17% were only occasionally teased. About 65% reported that they would like their teeth straightened if they were found to need orthodontic treatment (13% said they would not), while 55% reported willingness to comply with orthodontic treatment (19% said they did not). Interestingly, only 6% reported having any previous knowledge about orthodontics. (See Table 6).

Five questions were posed to the parents of the Inuit school children in the form of a parent questionnaire. Approximately 50% of the parents living in the two locations under study responded to the questionnaire (Table 7). Of these, 63% replied that they were aware of the occlusal disharmonies in their child's teeth (27% said they were not). This was significantly related ($p < 0.01$ level) to the severity of malocclusion as determined by the TPI. About 23% of the parents thought that their child was affected in some way by his or her malocclusion, while 49% replied that their child was not

Table 6.--Percentage Response to each of the Student Questions and Correlations with the Treatment Priority Malocclusion Index (TPI).

Student Questionnaire *	Response			
	Never /No	Sometimes /A Little /May Be	Often /Yes /A Lot	Correlations with TPI
Satisfied with dental appearance?	41.9	--	57.9	-
How often visits dentist?	18.2	70.0	11.0	-
Awareness of "crooked teeth"?	25.9	57.3	16.3	Yes * *
Awareness of spaces between teeth?	33.8	54.0	10.5	-
Others aware of student's crooked teeth?	23.1	58.1	17.1	Yes * *
Teased by others?	74.7	17.4	5.23	-
Would they like teeth straightened?	12.9	22.3	64.7	-
Would they wear braces?	19.6	25.9	54.5	-
Aware that dentist can straighten teeth?	47.9	--	51.5	-
Knowledge about orthodontics?	66.4	27.5	5.5	-

* 81.6% of the Inuit school children responded to the Questionnaires.
* * Correlation to the malocclusion index was significant to the 0.001 level.

Table 7.--Percentage Response for each of the Parent Questions and Correlations with the Treatment Priority Malocclusion Index (TPI).

Parent Questionnaire *	Response			Correlations with TPI
	No	Sometimes /Don't Know	Yes	
Parent's awareness of child's crooked or spaced teeth?	27.0	10.4	62.6	Yes * *
Was child affected in any way by his or her crooked teeth?	49.1	25.7	23.4	-
Would parent wish child to wear braces if they were needed?	13.5	15.8	69.8	-
Does parent think child would wear braces?	18.9	21.2	59.0	-
Does child look after his or her teeth?	6.3	55.4	37.8	-

* 49.9% of the parents of the Inuit school children responded to the Questionnaires.
* * Correlation to the malocclusion index was significant to the 0.01 level.

affected. About 70% of the parents wished their children to wear braces if the service were available (14% did not), and 60% said that they thought that their child would comply with orthodontic treatment (19% thought that they would not comply). About 38% of the parents thought that their child looked after his or her teeth well, while 6% said that they did not **(Table 7).**

3.2. Malocclusion and Caries Rates

The Treatment Priority Index (TPI) was used in the present study to evaluate the prevalence of malocclusion in Northern Labrador Inuit youth. **Table 4** demonstrates the interpretation of the scores according to Grainger's original recommendations for the need for orthodontic treatment. Approximately 5% of the total sample had "normal" or "ideal" occlusion, while 95% had some degree of occlusal disharmony. About 24% had minor occlusal disharmonies, 34% had a definite malocclusion, 18% had severely handicapping malocclusion and 20% had very severely handicapping malocclusion **(Table 8 and Figure 4)**. The overall mean TPI score for the whole sample was 6.71 (SD = 4.24) indicating that "definite malocclusion" was present but that treatment was only "elective". There was no difference between the prevalence of malocclusion in either gender. However, there was a difference in the prevalence of malocclusion among the four age groups **(Table 12)**.

Table 4.--Interpretation of the Treatment Priority Malocclusion Index Scores for Orthodontic Treatment Need based on Grainger's original format (1969).

0 - 0.9	classic normal occlusion -- no treatment required
1 - 3.9	minor disharmony -- slight treatment may be needed
4 - 6.9	definite malocclusion -- treatment only elective
7 - 9.9	severe handicap -- treatment highly desirable
> 10	very severe handicap -- treatment mandatory

The prevalence of ideal occlusion decreased from 6 % in the young age group to 3 % in the older age group. The mean score for the TPI in the young age group was 5.25 (SD = 3.52) while that for the older age group increased to 8.06 (SD = 4.54) as seen in **Table 12 and Figure 7.** The prevalence of minor disharmonies changed from 33 % in the younger age group to 15 % in the older age group. The prevalence of severe and very severe handicapping malocclusion was more evident, at 20 - 30 %, after the age of 12 years. The highest prevalence of very severe handicapping malocclusion was present in the over 15 year-age-group at a rate about 34%, **(Table 8 and Figure 4)**. Orthodontic treatment for these older age groups was deemed to be highly desirable or mandatory.The specific occlusal variables that make up the malocclusion index (TPI) were also examined separately. The differences in molar relationship and degree of crowding between the four age groups and between the two genders were tabulated in Table 9. The differences in posterior crossbites, overjet and overbite between age groups were tabulated in Table 10, while the same variables for gender were tabulated in Table 11.

Table 8.--Percentage Distribution of Malocclusion Index Scores with Age and Gender.

	Age (Years)				Gender		
Score	5-8	9-11	12-14	>15	Male	Female	Total Sample
0 - 0.9	6.3	4.2	3.9	3.1	4.5	4.7	**4.6**
1 - 3.9	33.3	26.3	15.6	15.4	25.0	23.3	**24.1**
4 - 6.9	39.6	34.7	27.3	29.2	34.1	33.1	**33.6**
7 - 9.9	11.7	14.7	31.2	18.5	17.6	18.6	**18.1**
> 10	9.0	20.0	22.1	33.8	18.8	20.3	**19.5**

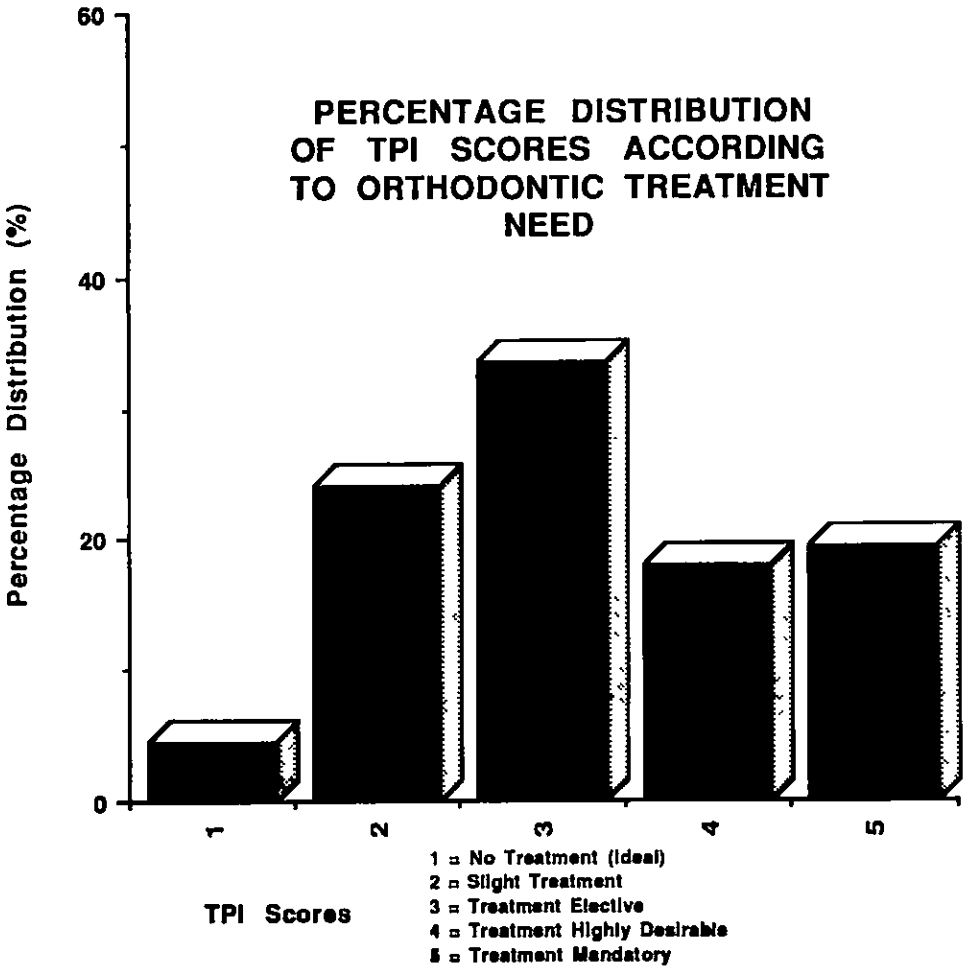


Figure 4. Graphic representation of Table 4 and 8. In about 5% of the total sample no treatment was needed, in about 20%, treatment was deemed mandatory, and in about 34%, treatment was deemed elective.

Table 9.--Percentage Distribution of Molar Relationship and Degree of Crowding with Age and Gender.

	Age (Years)				Gender		
	5-8	9-11	12-14	>15	Male	Female	Total Sample
A. Molar Relationship							
Neutro-occlusion (Angle Class I)	34.2	36.8	36.4	29.2	38.6	30.2	**34.5**
Disto-occlusion (Angle Class II)	53.2	51.6	50.6	38.5	46.6	52.3	**49.4**
Mesio-occlusion (Angle Class III)	12.6	11.6	13.0	32.3	14.0	17.4	**16.1**
B. Crowding							
1. Nil	34.2	9.5	7.8	7.7	18.2	15.1	**16.7**
2. Mild	49.5	43.2	27.3	38.5	40.9	40.7	**40.8**
3. Moderate	15.3	31.6	39.0	36.9	27.8	30.2	**29.0**
4. Severe	0.9	15.8	26.0	16.9	13.1	14.0	**13.5**

An **Angle Class I** molar relationship was seen in 35% of the sample, an **Angle Class II** in 49%, and an **Angle Class III** was present in 16% of the sample. Females tended to have a higher prevalence of Angle Class II and Class III molar relationships than males. A higher prevalence of Angle Class III was also seen in the over 15 year age group. **(See Table 9).**

About 17% of the total sample had no crowding at all, while 41% had mild crowding, 29% had moderate crowding, and 14% had severe crowding. The degree of crowding was found to be the same for both males and females. However, the prevalence of no crowding decreased from 34% in the young age group to 8% in the older age group. The prevalence of severe crowding increased from 0.9% in the younger age group to 17-26% in the older age groups. **(See Table 9 and Figure 5).**

In the transverse plane, about 44% of the total sample had an upper lingual posterior crossbite on at least one side, while only 2% had a buccal posterior crossbite. More females had lingual posterior crossbites than males. A high prevalence of crossbites was evident in all age groups (32-52%). **(See Table 10 and 11 and Figure 6).**

In the sagittal plane, about 39% of the total population had a positive overjet while 10% had a negative overjet (anterior crossbite). The highest prevalence of negative overjet, including edge to edge bite, was seen in the older age group (up to 19%). The prevalence of positive overjet ranged from 32-46% among the various age groups. There was equal distribution of sagittal problems in males and females **(See Table 10 and 11 and Figure 6).**

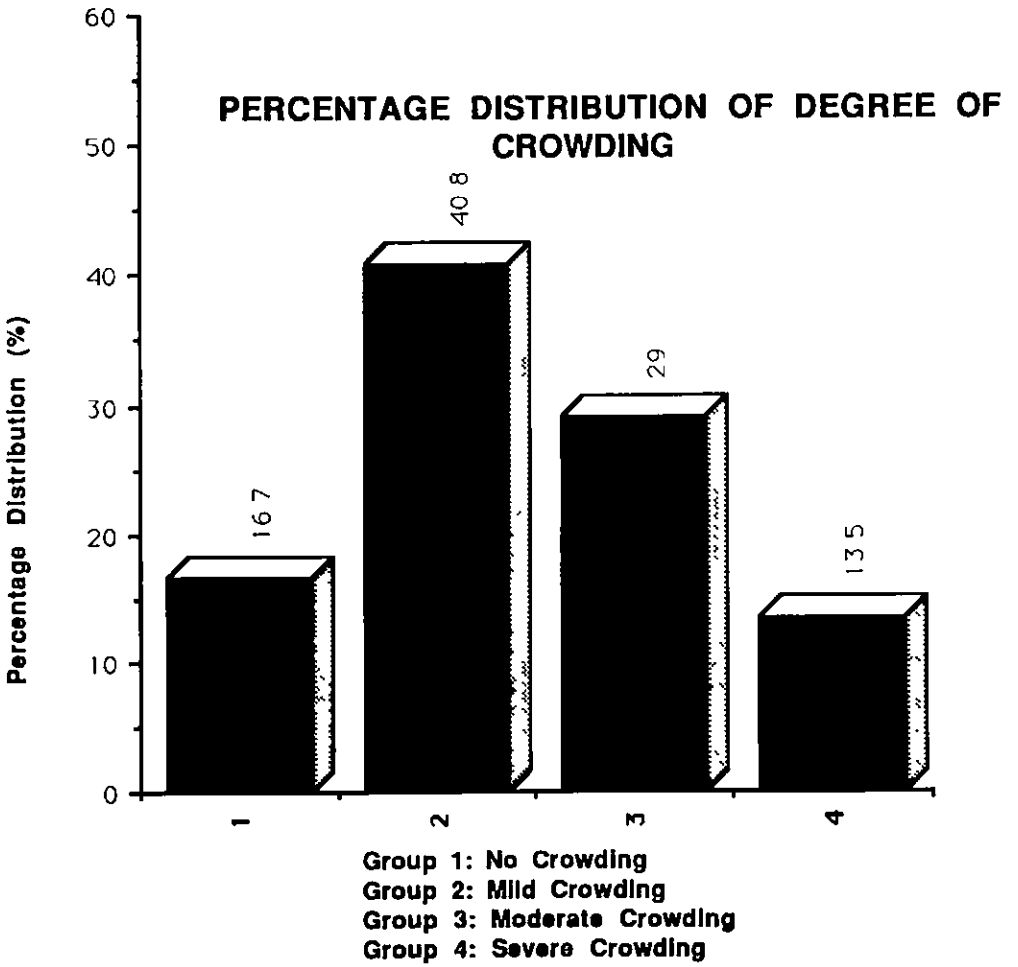


Figure 5. Graphic representation of the percentage distribution of the degree of crowding in the whole sample (Table 9). About 41% had mild crowding, 14% had severe crowding and 17% had no dental crowding at all.

Table 10.--Percentage Distribution of Specific Dental Malocclusion Variables with Age in the Three Planes of Space (Transverse, Sagittal, Vertical).

	Age (Years)			
Variable (Dental Malocclusion)	**5-8**	**9-11**	**12-14**	**>15**
A. Transverse (Posterior Crossbite)				
1. Normal	67.6	45.3	50.6	46.2
2. Excess	0.9	3.2	2.6	1.5
3. Deficiency	31.5	51.6	46.8	52.3
B. Sagittal (Anterior Crossbite or Overjet)				
1. Normal	58.6	48.4	46.8	49.2
2. Positive Overjet (Retrognathic)	32.4	46.3	44.2	32.3
3. Negative Overjet (Prognathic)	9.0	5.3	9.1	18.5
C. Vertical (Anterior Bite)				
1. Normal Incisor Bite	73.0	81.1	75.3	70.8
2. Deep Bite	8.1	7.4	14.3	13.8
3. Open Bite	18.9	11.6	10.4	15.4

Table 11.--Percentage Distribution of Specific Dental Malocclusion Variables with Gender in the Three Planes of Space (Transverse, Sagittal, Vertical).

	Gender		
Variable (Dental Malocclusion)	**Male**	**Female**	**Total Sample**
A. Transverse (Posterior Crossbite)			
1. Normal	58.5	48.8	**53.7**
2. Excess	2.3	1.7	**2.0**
3. Deficiency	39.2	49.4	**44.3**
B. Sagittal (Anterior Crossbite or Overjet)			
1. Normal	52.3	50.6	**51.4**
2. Positive Overjet (Retrognathic)	37.5	40.1	**38.8**
3. Negative Overjet (Prognathic)	10.2	9.3	**9.8**
C. Vertical (Anterior Bite)			
1. Normal Incisor Bite	73.9	76.7	**75.3**
2. Deep Bite	13.1	7.6	**10.3**
3. Open Bite	13.1	15.7	**14.4**

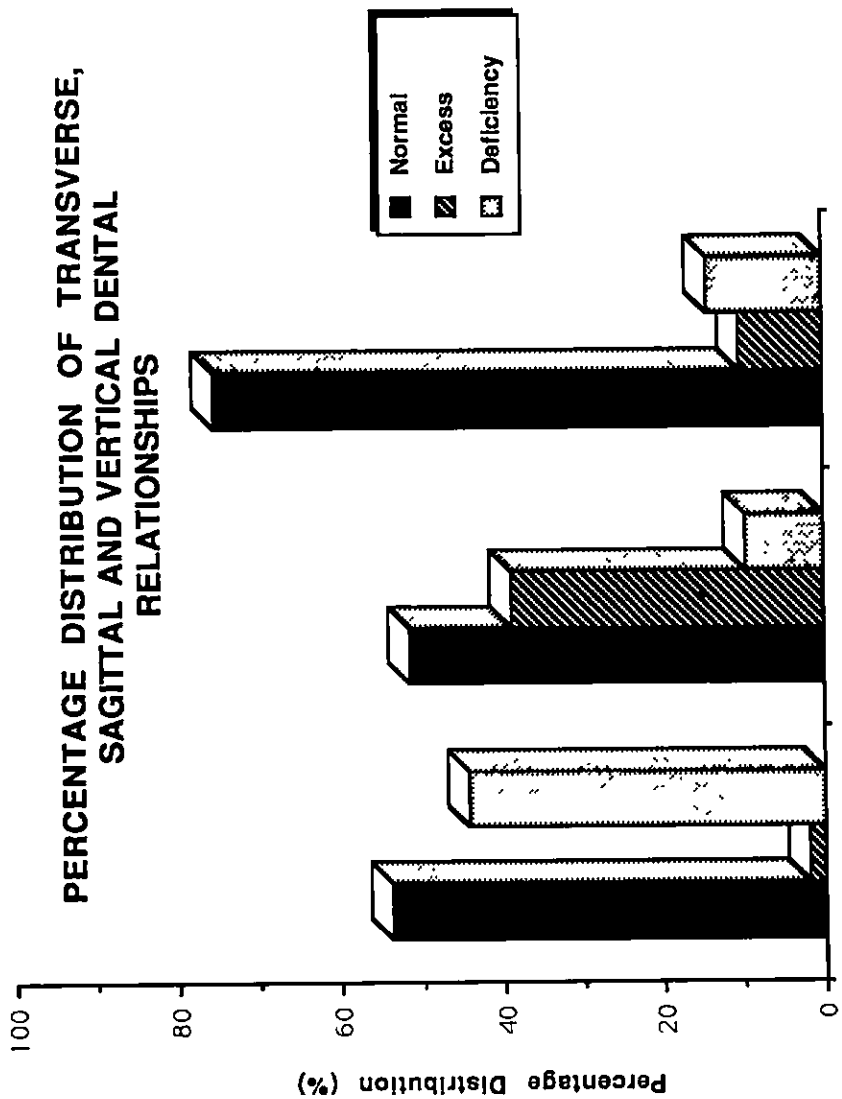


Figure 6. Graphic representation of Table 11. About 44% had a posterior upper lingual crossbite (Group 1), 39% had an overjet greater than 4mm, 10% had a reverse overjet (Group 2), 10% had an overbite greater than 3mm, and 14% had an open bite .

In the vertical plane, 10 % of the total population had a deep bite while 14 % had an open bite. More females had open bites than males, while more males had deep or large overbites. Deep bites were present in higher proportions in the age groups over 12 years of age. The prevalence of open bites tended to increase in the older age group. **(See Table 10 and 11 and Figure 6).**

The incidence of dental caries was calculated using traditional indices involving tooth numbers and tooth surfaces of decayed, missing and filled teeth. On average males had a higher caries index than females. The mean index for deciduous tooth surfaces (defs) was the highest (23.7), in the young age group (age 5-8 years). The mean defs for the whole sample was 8.8 (SD = 14.2). The mean caries index for permanent tooth surfaces (DMFS) was the highest (15.6) in the older group (> 15 years). The mean DMFS for the whole sample was 6.8 (SD = 8.4). The mean of the sum of the caries indices for primary and permanent tooth surfaces for the whole sample was 15.7 (SD = 13.6). The mean of the sum of the caries indices for the number of primary and permanent teeth affected in the whole sample was 6.9 (SD = 4.0). For 5-8 year old Inuit children this figure was 9.3 (SD =3.9), and for the over 15 year age group, it was 7.8 (SD = 4.0). **(Table 12 and Figure 7).**

Table 12.--Means and Standard Deviations for Caries, Malocclusion and Cranial Indices with Age and Gender.

	Age (Years)				Gender		
	5-8	9-11	12-14	>15	Male	Female	Total Sample
Variable	**Means (SD)**	**Means (SD)**	**Means (SD)**	**Means (SD)**	**Means (SD)**	**Means (SD)**	**Means (SD)**
Caries Index							
1. defs (Deciduous)	23.65 (15.45)	4.39 (8.24)	0.27 (1.26)	0.02 (0.12)	10.23 (15.03)	7.24 (13.04)	8.76 (14.15)
2. DMFS (Permanent)	1.52 (2.54)	4.55 (3.82)	9.84 (8.41)	15.63 (10.82)	6.71 (8.87)	6.98 (7.86)	6.84 (8.38)
3. (surface) def.DMF(S)	25.46 (16.01)	8.92 (8.13)	10.29 (8.19)	15.63 (10.84)	17.02 (14.41)	14.37 (12.58)	15.72 (13.59)
4. (Tooth) def.DMF(T)	9.29 (3.86)	4.39 (2.64)	5.65 (3.47)	7.75 (3.98)	7.02 (4.01)	6.68 (4.04)	6.85 (4.02)
Malocclusion Index (TPI)	5.25 (3.52)	6.76 (4.44)	7.6 (4.14)	8.06 (4.54)	6.59 (4.17)	6.83 (4.33)	6.71 (4.24)
Cranial Index (CI)	76.22 (3.91)	76.81 (4.12)	76.46 (4.32)	77.92 (3.77)	77.13 (3.85)	76.66 (4.19)	76.86 (4.04)

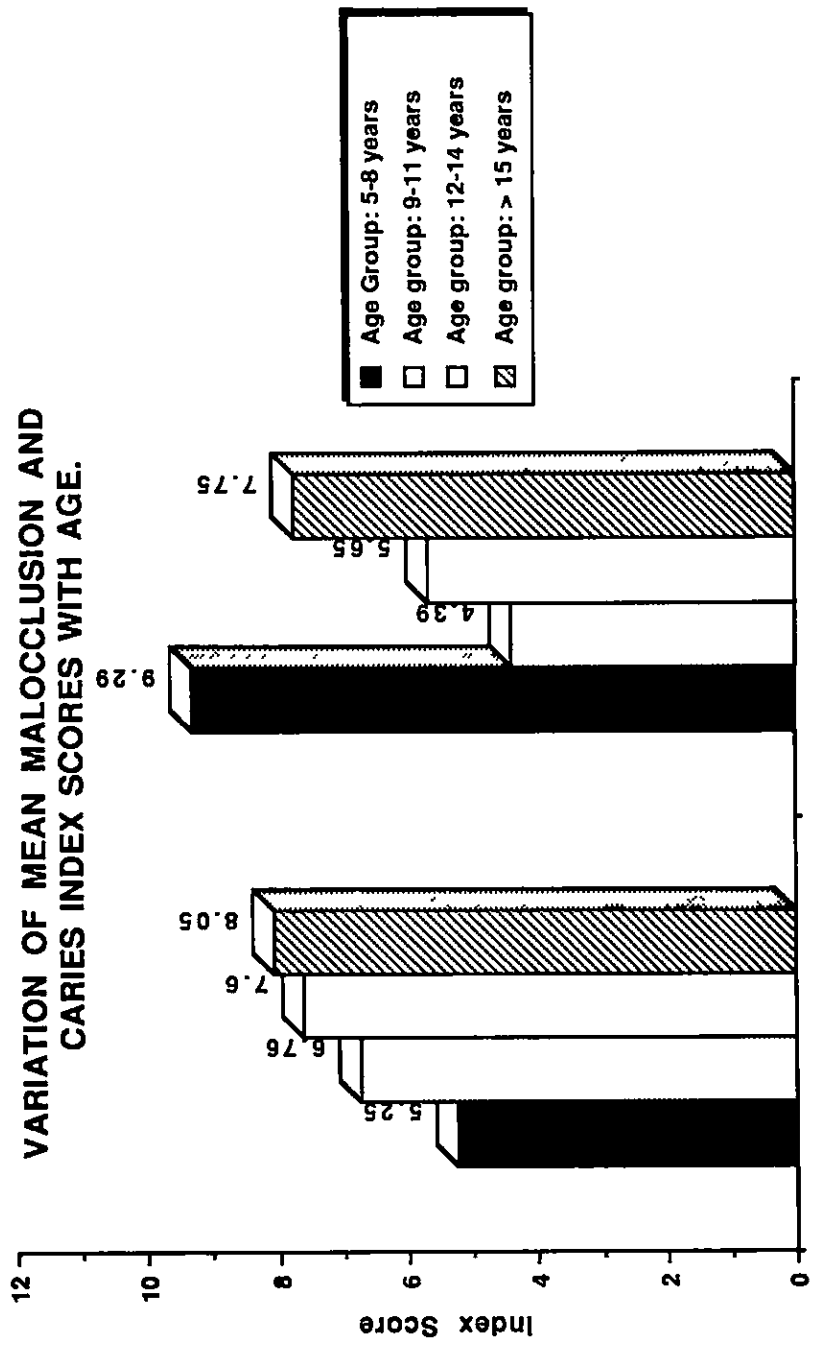


Figure 7. Graphic representation of Table 12. The prevalence of malocclusion (TPI) increased with age increase (Variable 1). The mean caries index scores were highest for the 5-8 year age group and lowest for the 9-11 year age group (Variable 2).

3.3. Cephalometric Values

Cephalometric measurements are considered to be manifestations of the genetic pool of the race being investigated. The mean Cranial Index (skull width divided by skull length times one hundred) for the selected sample was 76.86 (SD = 4.04). The mean measurement was similar for all ages and gender indicating that the mean headform type was a Mesocephalic type. **(See Table 12)**. The percentage distribution of headform types for the selected sample was 33% for Dolichocephalics, 39% for Mesocephalics, 25% for Brachycephalics and 2% for hyper-brachycephalics **(Table 13)**.

Table 13.--Percentage Distribution of Headform Type in the Radiographic Sample.

Head-Form Type	Dolicho-cephalic < 74.9	Meso-Cephalic 75 - 79.9	Brachy-cephalic 80 - 84.9	Hyperbrachy-cephalic 85 - 89.9
% of Sample	33	39	25	2

All mean linear cephalometric measurements for males were larger than those for females. The measurements increased with increasing age. The mean magnification factor for the frontal radiographs was 5.7%, while that for the lateral cephalogram was 6.7%.

In the transverse plane, the mean bizygomatic width for the total radiographic sample was 125.49 mm (SD = 8.76). This value increased from 116.56 mm (SD = 4.98) in the young age group to 135.23 mm (SD = 7.43) in the older age group. The mean bimaxillary width for the sample was 63.99 mm (SD = 3.89). The mean bigonial width for the whole sample was 98.25 mm (SD = 8.06). **(See Table 14 and 15).**

In the sagittal plane, the mean angular measurement for the total sample for the relationship of the maxilla to the cranial base or the SNA angle was 86.51 (SD = 4.25). The relationship of the mandible to the cranial base was assessed using the angle SNB. The mean SNB angle for the selected sample was 81.79 (SD = 3.68). The overall relationship of the maxilla to the mandible in relation to the cranial base (ANB angle) indicated that the maxilla was prognathic (mean ANB angle for the sample was 4.66). The ANB angle tended to decrease with increasing age in this sample. On the other hand, the relationship between the maxilla to the mandible in relation to the occlusal plane (Wits) was found to indicate a slightly prognathic mandible. The mean Wits for the selected Labrador sample was -2.01 millimeters (SD = 3.07). **(See Table 14 and 15 and Figure 8).**

The relative length of the mandible of the Labrador Inuit was 110.47 mm (SD = 9.53) and the mean relative maxillary length was 84.77 mm (SD = 6.16). The mean difference in length was 25.68 mm (SD = 5.28). **(See Table 14 and 15).**

In the vertical plane, the mean anterior face height ratio was 72.60 (SD = 7.23), indicating that either the lower face height was increased or the upper face height was reduced. The mean lower anterior face height for the

Table 14.--Means and Standard Deviations for Cephalometric Skeletal Measurements with Age in the Three Planes of Space (Transverse, Sagittal, Vertical).

	Age (Years)			
Variables (Skeletal)	**5-8**	**9-11**	**12-14**	**>15**
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
A. Transverse *				
1. Bizygomatic (mm)	116.56 (4.98)	123.69 (4.85)	126.18 (7.05)	135.23 (7.43)
2. Bimaxillary (mm)	60.24 (2.71)	63.69 (3.48)	65.26 (3.62)	66.42 (2.97)
3. Bigonial (mm)	89.71 (5.25)	95.71 (4.36)	100.95 (4.95)	106.41 (7.49)
B. Sagittal * *				
1. SNA (degrees)	86.18 (4.89)	86.77 (5.07)	86.87 (3.68)	86.16 (3.13)
2. SNB (degrees)	79.85 (3.77)	82.11 (4.04)	82.35 (2.97)	82.60 (3.43)
3. ANB (degrees)	6.18 (2.89)	4.47 (2.44)	4.53 (2.53)	3.65 (2.39)
4. "Wits" (mm)	-1.36 (2.80)	-2.54 (2.97)	-1.80 (3.08)	-1.95 (3.42)
5. Mand. Length (mm)	100.82 (4.08)	106.82 (6.48)	112.71 (6.04)	122.42 (6.09)
6. Max. Length (mm)	81.15 (3.28)	81.93 (5.46)	85.38 (5.36)	91.67 (4.04)
7. Mand-Max Difference	19.69 (3.48)	24.82 (3.63)	27.35 (3.61)	30.74 (4.21)
C. Vertical * *				
1. AFH Ratio	73.21 (6.76)	72.27 (8.14)	72.29 (7.19)	72.63 (6.97)
2. LAFH (mm)	63.11 (4.07)	65.62 (4.91)	70.68 (3.78)	74.77 (3.76)
3. FMA (degrees)	31.23 (5.39)	31.40 (5.84)	32.12 (4.01)	30.39 (4.35)
4. Gonial (degrees)	133.52 (6.49)	135.30 (5.62)	130.89 (6.86)	129.44 (5.99)

* Mean Magnification of the Frontal Radiographs was 5.66 % (SD was 0.57).
* * Mean Magnification of the Lateral Radiographs was 6.67 % (SD was 0.89).

Table 15.--Means and Standard Deviations for Cephalometric Skeletal Measurements with Gender in the Three Planes of Space (Transverse, Sagittal, Vertical).

	Gender		
Variables (Skeletal)	**Male**	**Female**	**Total Sample**
	Mean (SD)	Mean (SD)	Mean (SD)
A. Transverse *	[mm or Degrees]	[mm or Degrees]	[mm or Degrees]
1. Bizygomatic (mm)	127.22 (9.73)	124.24 (7.83)	**125.49 (8.76)**
2. Bimaxillary (mm)	65.17 (4.17)	63.12 (3.44)	**63.99 (3.89)**
3. Bigonial (mm)	100.46 (8.46)	96.62 (7.41)	**98.25 (8.06)**
B. Sagittal * *			
1. SNA (degrees)	86.49 (4.69)	86.52 (3.97)	**86.51 (4.25)**
2. SNB (degrees)	81.93 (4.23)	81.68 (3.28)	**81.79 (3.68)**
3. ANB (degrees)	4.54 (2.56)	4.74 (2.52)	**4.66 (2.52)**
4. "Wits" (mm)	-1.88 (3.38)	-2.10 (2.86)	**-2.01 (3.07)**
5. Mand. Length (mm)	112.32 (10.89)	109.19 (8.33)	**110.47 (9.53)**
6. Max. Length (mm)	86.32 (6.72)	83.70 (5.56)	**84.77 (6.16)**
7. Mand-Max Difference	25.93 (6.0)	25.51 (4.77)	**25.68 (5.28)**
C. Vertical * *			
1. AFH Ratio	70.39 (8.25)	74.12 (6.05)	**72.60 (7.23)**
2. LAFH (mm)	69.95 (6.15)	67.23 (5.73)	**68.34 (6.03)**
3. FMA (degrees)	31.06 (5.09)	31.43 (4.91)	**31.27 (4.96)**
4. Gonial (degrees)	133.40 (6.9)	131.90 (6.23)	**132.51 (6.52)**

* Mean Magnification of the Frontal Radiographs was 5.66 % (SD was 0.57).
* * Mean Magnification of the Lateral Radiographs was 6.67 % (SD was 0.89).

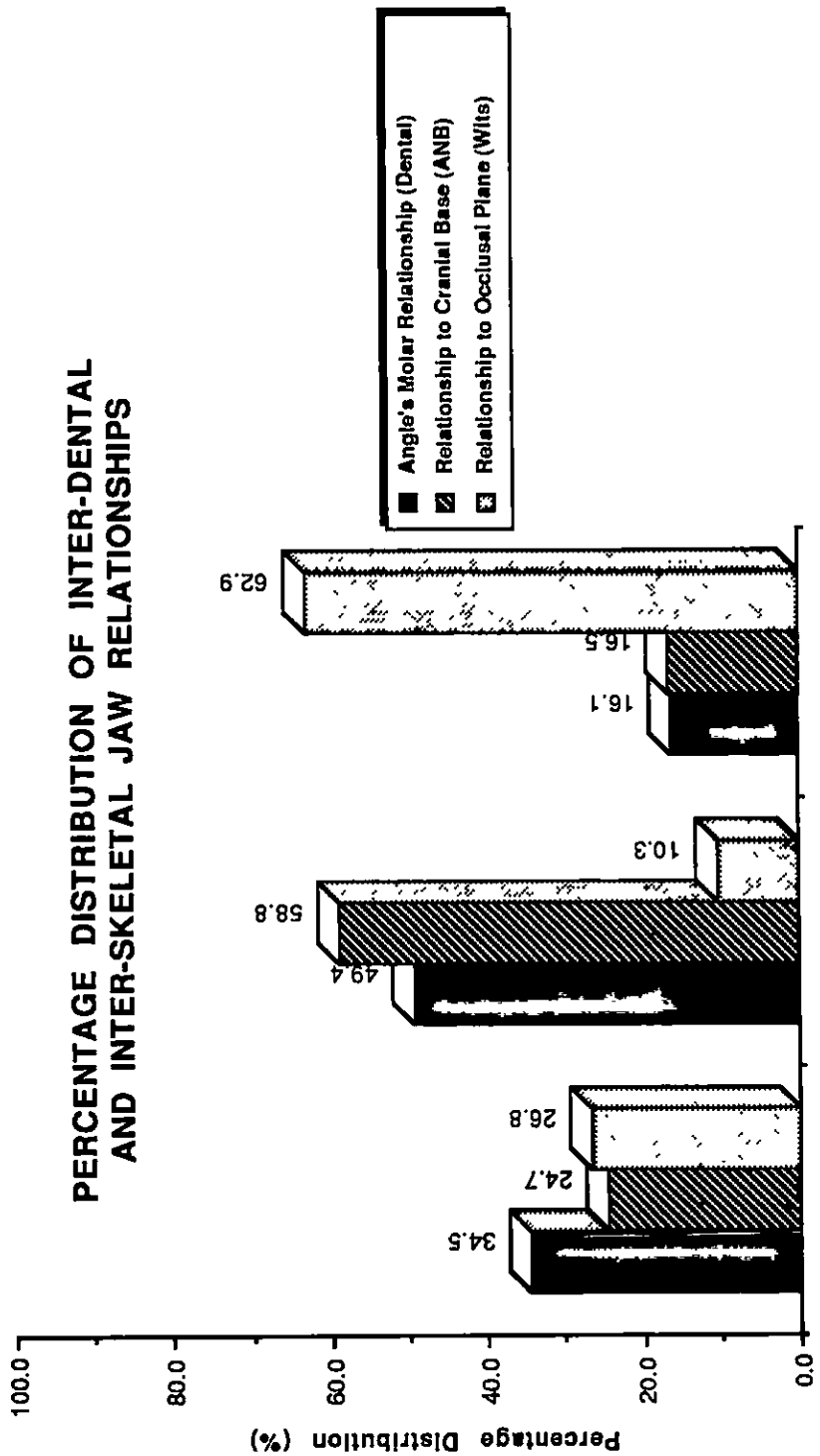


Figure 8. Comparison of three different methods of relating the upper jaw to the lower jaw. Angle's molar dental relationship and the ANB angle recorded similar results, but the Wits analysis provided opposing results for describing protrusive jaws.

Inuit sample was 68.34 mm (SD = 6.03) indicating that it was a longer lower face height that was responsible for the decrease in the anterior face height ratio. The mean mandibular plane angle was 31.27 (SD = 4.96). The large-sized mandible present in the Inuit and the large mandibular plane angle with a consequent longer lower face height indicated a strong vertical component to the growth of the face of the Inuit. The mean Gonial angle or the angle of the jaw was 132.51 (SD = 6.52). **(See Tables 14 and 15).**

The dento-alveolar measurements **(Table 16)** in the sagittal plane for the Inuit indicated that the lower incisor was placed within the basal bone of the mandible, however, the upper incisor was slightly proclined. The mean interincisal angle was 124.97 (SD = 10.57). The mean lower incisor angle to the mandibular plane was 91.96 (SD = 6.71). The mean upper incisor angle to palatal plane angle was 114.38 (SD = 4.44).

Reliability coefficients were calculated for the malocclusion and caries indices and six randomly selected cephalometric variables from the lateral radiograph. The reliability coefficient for the malocclusion index was 0.978, and for the caries index (def/DMF-S) it was 0.998. The reliability coefficients for the cephalometric values were calculated by retracing 14 radiographs. The coefficients for the cephalometric linear values was 0.886 for the Wits measurement and 0.986 for the lower anterior face height. The coefficient for the angular measurements was 0.936 for the ANB angle, 0.973 for the interincisal angle, 0.940 for the lower incisor to mandibular plane angle and 0.918 for the frankfort/mandibular plane angle. **(Table 17).**

Table 16.--Means and Standard Deviations for Cephalometric Dento-Alveolar Measurements with Age and Gender in the Sagittal Plane.

	Age (Years)				Gender		
Variables (Skeletal)	**5-8**	**9-11**	**12-14**	**>15**	**Male**	**Female**	**Total Sample**
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Sagittal * *	[Degrees]	[Degrees]	[Degrees]	[Degrees]	[Degrees]	[Degrees]	[Degrees]
1. Inter-incisal Angle	133.39 (14.45)	120.06 (6.35)	122.88 (8.77)	126.58 (7.34)	126.74 (10.82)	123.75 (10.31)	**124.97 (10.57)**
2. Lower Incisor to Mand. Plane	89.64 (7.36)	92.43 (5.38)	93.33 (7.41)	91.50 (6.44)	91.83 (7.15)	92.04 (6.44)	**91.96 (6.71)**
3. Upper Incisor to Palatal Plane	105.10 (9.76)	115.90 (4.89)	114.29 (4.54)	114.38 (4.44)	111.23 (8.29)	113.91 (6.44)	**112.84 (7.32)**

* * Mean Magnification of the Lateral Radiograph was 6.67 % (SD was 0.89).

Table 17.--Reliability Coefficients for Malocclusion and Caries Indices and Six Cephalometric Values.

	VARIABLE							
	Malocclusion Index	Caries Index	ANB (angle)	Wits (mm)	Interincisal (angle)	IMPA (angle)	LAFH (mm)	FMA (angle)
Means (SD) for Time 1	7.81 (2.42)	11.93 (13.62)	5.04 (2.19)	-1.53 (1.87)	126.59 (8.75)	90.02 (4.65)	68.33 (6.47)	31.20 (4.42)
Means (SD) for Time 2	8.07 (2.81)	12.50 (13.66)	4.96 (1.78)	-1.39 (1.82)	127.11 (7.83)	91.02 (5.20)	69.04 (6.10)	31.91 (4.10)
Reliability Coefficient	**0.978**	**0.998**	**0.936**	**0.886**	**0.973**	**0.940**	**0.986**	**0.918**

4. DISCUSSION

Many theories as to the benefits of orthodontic treatment have been postulated but few have been verified by prospective clinical trials. Orthodontics has been reported to be helpful in improving facial appearance, psychological well-being, dental chewing function, periodontal health, temporomandibular joint health, smiles and dental appearance. Although many of these factors are improved with good orthodontic care, the degree to which an individual can be expected to benefit is still unknown. There is agreement, however, that orthodontics is of positive value in improving dental esthetics and self image.

Patients generally consider orthodontic treatment to be costly, however, insurance coverage may reduce this cost and influence some patients to seek orthodontic treatment. In the United States, orthodontic care is generally available to any person who is able to afford the cost of treatment. In addition, up to fifty percent of the orthodontic patients in any practice may be covered under dental or medical insurance plans. In contrast, the National Health Service in the United Kingdom provides orthodontic treatment to all persons at no cost to the patient. Private insurance coverage does not play a significant role in the patient's decision to seek orthodontic care. However, the method of delivery of orthodontic care, and types of orthodontic appliances used differ between the United States and the United Kingdom. For example, in the US, the majority of

patients are treated with fixed appliances. In the UK, on the other hand, the majority of the appliances used are removable. In other countries, delivery of orthodontic care may be a variation of the methods of delivery in these two countries.

In Northern Labrador, "Non-insured Health Benefit Schemes" are presently available and provide dental care at no cost to persons of **native origin.** Funding for such schemes is derived from a limited pool of federal funds. While the demand for general dental care was known to be high, the demand or need for orthodontic care in Northern Labrador has not been extensively studied. Orthodontic treatment to Canadian native people is presently limited to persons under the age of eighteen and must have preliminary approval by a review board at Health and Welfare branch offices. Thus, cost of orthodontic treatment is not an inhibiting factor in motivating Labrador Inuit youth to seek care. However, this health care policy may limit the number or type of orthodontic care that may be available to Labrador Inuit.

Previous studies have shown that the Inuit youth of today are seeking to acquire western values and practices. However, other studies have reported that the effects of acculturation on native populations has created complex psychological problems particularly on young adolescents. Orthodontic care and good dental esthetics has been considered by some, to be a cultural by-product of the West, and therefor not "essential" for native populations. Attitudes and environments in northern arctic areas are, however, rapidly changing, despite the geographic isolation that exists in these areas. Some studies have shown that different cultures may value

improved esthetics (as a motive for seeking orthodontic care) with varying importance (Kiyak, Bell 1991). Personal appearance and being in good-health are becoming issues of daily concern for the Inuit. In fact, Canadian Inuit from Igloolik have reported that general and facial appearance was a concern to them (Shea 1991). Wood (1971) reported that Alaskan Inuit were particularly concerned about their malocclusions. The results from the Labrador Inuit student and parent questionnaires support these earlier findings and indicated a want for orthodontic treatment and a desire for improvement in dental appearance. About 42% of the Labrador Inuit youth reported being dissatisfied with their dental appearance, 65% wished to have their teeth staightened and 55% would wear braces if they were found to need them. Although 58% reported that they were satisfied with their dental appearance, only 13% reported not wanting their teeth staightened. Television and cable programming have been known to influence people's cultural and behavioral attitudes. It may be that by being exposed to similar media, the Inuit youth are becoming similar in their expectations and attitudes to those of western youth. Hence, personal appearance may also be as important a factor in motivating native people towards orthodontic care as it is for others.

The prevalence of indicators of low mental health status in the Inuit population of Canada, Alaska and Greenland are particularly high (Milan 1980). The indicators include high suicide rates, homicide, alcohol and drug abuse, spousal and child abuse, high infant mortality, low life-expectancy and low educational achievement (Berry 1990). The incidence of similar indicators in Northern Labrador are reported to be particularly high. Seltzer

(1980) described the affects of acculturation and deculturation on Inuit populations as a syndrome that manifests itself as low self-esteem, negative self-image and feelings of emasculation especially affecting young adolescent males. Orthodontic care is reported to help improve self-esteem, and self-worth, although quantification of benefit has not been adequately reported. The introduction of orthodontic care for Inuit people may be considered by some, to be a way of deepening the acculturation process and an imposition of western standards. Arguments can be made, however, in favor of the positive benefits that an orthodontic service would provide in any culture. The increase in self-esteem or self-image after orthodontic treatment has been well documented (Kiyak, Bell 1991; O'Regan et al., 1991).

Orthodontic treatment has been reported to reduce psychological stress to varying degrees in patients who are teased because of their malocclusions (Baldwin, Barnes 1965). About 5% of the Labrador Inuit youth reported being teased a great deal because of the appearance of their teeth and 17% were occasionally teased. Baldwin and Barnes (1965) also reported that 10% of their Caucasian sample were teased on a frequent basis because of abnormal malocclusions. Furthermore, 23% of Labrador parents reported that their children were affected in some way by their malocclusions. Many studies have reported that the parent may be the prime motivators for orthodontic treatment for up to 50% of all teenage children (Morris et al., 1976; Stricker 1979). Thus, it is possible that between 5 - 23% of the Labrador Inuit youth may have social benefits from

orthodontic care based on their own and their parents' perception of the social impact of malocclusion.

Studies that have looked at comparisons between communities which had different education backgrounds regarding orthodontic care, have suggested that increased familiarity with orthodontic treatment did not lead to more critical judgement of dental esthetics or treatment need (Tulloch et al., 1984). Thus, although only 6% of the Labrador Inuit reported being well educated about techniques of orthodontic treatment, their interpretation of treatment need may have been realistic based on their own perspective. Parents of the Inuit youth also expressed enthusiastic written comments about wanting to become better educated in orthodontic knowledge and wanted their children to have orthodontic care. It would seem that although education on orthodontic-related matters was clearly lacking, demand for treatment was high among Labrador Inuit.

Questionnaires and surveys rely on good will and honest responses. Thouez et al., (1990) questioned the use of the "survey" in native populations as a comprehensive indicator of the true cultural meaning of any illness. The student and patent questionnaires for Labrador were based on other similar pyschosocial studies, but were modified to be simple, direct, and with close-ended responses. However, some difficulty was encountered during the collection of responses in the Labrador study, particularly from the younger age groups (5-8 years). This age group was found to be difficult to interview because of a lack of language skills or maybe because of the nature of the content of the questionnaires. The class setting in which the responses were collected helped minimize adult

influences on the students' responses. This was considered to be a better method of extracting "honest" information than by the use of open-ended questions which could have been answered privately. On the other hand, peer pressures were also found to be strong influential factors within the class room setting. In some instances, this was noted to be of sufficient magnitude in the young age group to influence an individual's response to questions. Furthermore, although the parent questions were designed to be independent of each other, the student questions were not, since some questions were related to each other. Perhaps, a visual analogue scale (VAS) of graded responses or a preliminary talk, could have helped reduce the variability. Thus, although care was taken to customize questionnaires, not all ages may have interpreted the questions to the same degree of significance.

Other studies have reported that not all persons interviewed were equally aware of the occlusal traits in their mouths (Espeland, Stenvik 1991). In the Labrador study, the clinical **need** for treatment was positively correlated to the **awareness** of the presence of the condition. A positive correlation ($p < 0.001$) was found to exist between the severity of dental malocclusion in Labrador Inuit youth, their awareness, and the awareness of their friends and relatives to their presenting malocclusions. Parents were also significantly aware ($p < 0.01$) of their child's occlusal traits. The results show that the Inuit youth and their parents may already be focusing on the problems of malocclusion.

Frequency of attendance for Inuit people at dental clinics has been largely influenced by the method of health care delivery. Dentists are

usually flown into a community for a brief period lasting from a couple of days to a few weeks. Few northern communities have dentists who reside permanently in a community. Regular attendance at the dental clinic as well as excellent oral health are essential factors when considering orthodontic treatment for any group of persons. Only 11% of the Labrador Inuit youth reported high attendance at the dental clinic and 18% reported no visits to the office. The majority, however, were regular attenders. These results were not surprizing considering the difficulties in delivery of dental services to Northern Labrador. Due to inclement weather and the itinerant nature of the dental service, attendance at the dentist is often beyond the control of health care providers or even the patients themselves (Zammit 1991). The younger age groups expressed verbal opinions during data collection regarding the difficulty in obtaining regular appointments to see the dentist. In spite of these apparent difficulties, attendance patterns for the younger age groups have been reported to be high in Northern Labrador (Zammit 1989, 1990). Because of the high cost of delivering dental services to a remote location, delivery of orthodontic services to Labrador may have to be closely co-ordinated with the delivery of general dental services.

Waugh, as early as 1932, reported that "the North American Eskimo is veritably paying for his civilization with his teeth". Dental caries rates in Inuit people have been reported to be very high when compared with the Western world. Similarly, the caries index rates recorded in this study (mean def/DMF-S = 15.72, and a mean def/DMF-T = 6.85) were high and agree with those previously recorded for specific ages in Labrador (Messer 1986). These relatively high caries rates may also be related to the method of

health care delivery and the large consumption of cariogenic food and drink in Labrador. Unfortunately, the high adult unemployment rate leading to dependance on social assistance, along with acculturation stress, may increase the consumption of unhealthy foods. The lack of a readily accessible fresh water supply was a significant local problem in the immediate past and occasional annual freeze-ups of water lines in the winter months, may still play a role. Nevertheless, Messer (1984, 1985, 1988) has reported significant improvements in dental health in Labrador during the past decade. With better health care services available in the 1990's, one would expect the improvement in dental health to continue. The Labrador study identified the younger age group (5-8 years), however, as experiencing the highest caries rates in the two communities of Hopedale and Nain.

Interestingly, the prevalence of caries and malocclusion in the Labrador Inuit seem to follow similar patterns in that both tended to increase with age at the same rate. The etiology of malocclusion is multifactorial. It is dependant on a combination of environmental and genetic parameters (Harris, Johnson 1991). Dental based discrepancies are considered to be under stronger environmental influence while skeletal discrepancies are considered to be more influenced by genetic factors. Dental caries, an environmental disease, probably influences the prevalence of dental malocclusions. Decayed or lost teeth can cause drifting, crowding or spacing, and changes in molar relationships. It would seem that malocclusion is increased by untreated dental caries rather than dental caries being a cause of malocclusion. It may be that, in the Inuit, as Waugh

noted earlier, dental caries may be effecting malocclusion in a more significant way than noted in other populations. Better dental education and oral hygiene would greatly reduce the incidence of caries, which, in turn, would reduce the incidence of malocclusion.

In general, the Labrador caries rates seemed to be higher than for those recorded in Inuit youth living in Baffin Island (Curzon, Curzon 1979) yet not as high as those for Inuit people in northern Quebec (Gagnon et al., 1991). The drop in the caries index noted in the young ages from ages 5-8 years to ages 9-11 years in the Labrador Inuit, may be due to the early loss or extraction of deciduous teeth. There is a gradual increase in the dental caries again with age increase (Figure 7). It is paramount to control dental decay before starting orthodontic treatment. Fixed appliances routinely accumulate food debris and in the absence of good brushing, this can be disastrous for the dental health of the individual. Removable appliances may also increase the risk of dental caries and gingivitis. In addition, other oral opportunistic infections will ensue. In such circumstances, orthodontic care is contra-indicated. Thus, orthodontic care should only be made available to individuals who demonstrate good oral hygiene skills, low dental caries rates, controlled and inactive carious sites, and adequate internal motivation.

Few studies on the epidemiology of malocclusion in the Inuit race have been published to date. Most previous studies have used Angle's molar classification to describe malocclusion. In 1925, Leigh reported that 11.4% of the Inuit in his sample demonstrated a malocclusion of the Angle Class I variety. Waugh in 1932 noted a connection between the increase in

the incidence of malocclusion and dental caries with the changing dietary habits in a number of Inuit communities that he examined. Price in 1936 described the malocclusion present in his sample of Inuit and reported his findings subjectively. A predominance of narrow dental arches, incisor crowding, small maxillas, crossbites and buccally placed canines were reported. Newman, in 1953, may have been the first to attempt to quantify the prevalence of malocclusion. He reported that 44% had normal occlusion, while 54% had an Angle Class 1 molar relationship. No Class II molar relationships were noted. A prevalence of 3% of Class III molar relationships was reported. Wood (1971) reported the prevalence of malocclusion in Alaskan Inuit to be high. Only 18% had normal occlusion. About 64% had an Angle Class I molar relationship, 8% had a Class II relationship, and 10% had a Class III relationship.

The results from Northern Labrador Inuit reported higher prevalences of molar relationships that differed from the norm. About 95% were reported to have some degree of malocclusion, 5% had normal occlusion, 35% had Class I, 49% had a Class II, and 16% had Class III molar relationships. The present study also found that the prevalence of Angle Class III was double the sample mean for the Inuit youth over 15 years of age (32% compared to 16%). The prevalence of Class III molar relationships was not, however, found to be as high as other Asian populations such as Chinese Malaysians (54%). The high prevalence of Class III molar relationships, in any population, may be related to dental parameters such as early loss of lower primary molars or upper first permanent molars. In addition, skeletal parameters such as prognathic mandibles or retrognathic maxillas, may also

contribute. In the Labrador Inuit, the etiology of the increased prevalence of Class III molar relationships with age, was not fully evaluated and may be a an area for future study.

The use of Angle's molar classification to describe malocclusion has been popular in many epidemiological studies. Both Newman (1953) and Wood (1971) used Angle molar relationships alone to describe the incidence of malocclusion in the Inuit race. Others (El-Mangoury, Mostafa 1990; Corruccini 1984) used molar relationships as a basis for comparisons of the different levels of malocclusion in various ethnic populations. If molar relationships were genetically inherited traits, then similar prevalences would be seen in many Asian populations. A review of literature has shown that this is not the case. In descriptive terms, knowledge of molar relationships is most helpful to orthodontists. However, molar relationships only describe a part of the malocclusion. A more detailed description of malocclusion should include variation from the norm in all the three planes of space (transverse or horizontal, sagittal or antero-posterior and vertical). Few studies on malocclusion in ethnic populations have been based on the same criteria (Kerosuo et al., 1991). Many countries presently have facilities for providing orthodontic treatment and thus are treating malocclusions. This tends to create a problem in the methodology of data collection when epidemiology of actual prevalence of malocclusion is being investigated in a population. Many other researchers are attempting to include more than just molar relationships when describing the epidemiology of malocclusions in a population. The condition is still, however, being reported in a subjective manner (Isiekwe 1983; Woon et al., 1989; Burgensdijk et al., 1990; Kerosuo

et al., 1991). A few researchers have used a malocclusion index to record malocclusion objectively on an epidemiological level (Popovich, Thompson 1971; Kelly et al., 1973, 1977; Steigman et al., 1983; Payette, Plante 1989; Al-Emran et al., 1990). Thus, it was decided that a popular and valid index would be used in the present study to supplement Angle's molar relationships.

Clinical orthodontists and physical anthropologists differ in their interpretation of what is normal or ideal occlusion (Brace 1977). Anthropologists who examined "primitive man's" teeth, reported that their teeth were larger than those of modern man. However, primitive teeth were subjected to occlusal and interproximal wear. In addition, an edge-to-edge bite, with no centric occlusion (CO) or maximum intercuspation position (MIC) was predominant in those dentitions (Begg 1954; Kesling 1988). Cusps of teeth were flat resulting in a flat occlusal plane. Minimal malocclusion was also reported. Anthropologists have concluded that the cusps of the teeth in primitive man were not essential for chewing food or for the health of the temporomandibular joint or periodontal membrane. Cusps were considered to be essential, however, in guiding teeth into functional occlusion. Some present Arab populations still have occlusal wear patterns similar to those seen in primitive man (Johansson et al., 1991). Previous studies on Inuit teeth have reported some degree of occlusal attrition. This was mainly attributed to cultural habits, such as the chewing of seal-skin boots in order to soften the hide before daily usage (Davies 1972).

Orthodontists, on the other hand, do not consider the dentition of primitive man to be normal. Many orthodontists presently base their

definition of normal occlusion on the "six keys to normal occlusion" as described by Andrews (1972) (molar relationship, crown angulation or tip, crown inclination or torque, absence of rotations, tight interproximal contacts, and flat occlusal plane or very slight curve of Spee). The dentitions, thus have incisal overlap, curve of Spee or curved occlusal plane, and maximum intercuspation. As orthodontics is both an art and a science, it appears that orthodontists will continue to judge ideal occlusion based on esthetics and goodness of fit of teeth of the population being treated. The norm varies with each race. For example, Caucasians have more upright dental and skeletal features. Blacks have prognathic jaws. "Mongoloids" have prognathism largely confined to the alveolar processes or to the bone supporting the teeth. This is the reason for selecting native Labrador people to judge their own esthetically pleasing faces based on their own perspective of normal rather than on a clinician's view of what the orthodontic profession considers to be normal.

There are several malocclusion indices presently available for the objective evaluation of the different aspects that constitute a malocclusion (Massler and Frankel 1951; Van Kirk and Pennell 1958; Draker 1960; Poulton and Aaronson 1961; WHO 1962; Bjork 1964; Summer 1966; Grainger 1967; Howitt, Stricker and Henderson 1967; Salzman 1968; FDI 1973; Little 1973; Linder-Aranson 1974; Lundstom 1977; Brook 1988; O'Brian 1992). Each attempted to improve the previous index. Few studies, however, have compared these indices to each other (Katz 1978; Grewe, Hagan 1972; Steigman et al., 1983). The Treatment Priority Index by Grainger (1967) although reported to demonstrate validity, reliability, and

usefulness in longitudinal epidemiological studies, was found to be difficult to use when asymmetric molar relationships were encountered. Inter-examiner scoring was found to differ by up to 2 points in Grainger's original study. Despite this, the reliability coefficient was found to be fairly high in the Labrador study (0.978). Like any index, the TPI has limitations to its use. The TPI was designed to record malocclusion on an epidemiological level and to equate the scores to describe treatment need. Individualized scores do not depict the clinical severity of the problem. For example, a Class III molar relationship may be harder to treat than a Class II. The index, however, does not distinguish clinical severity, but scores them as both needing treatment with equal priority. Because of the high prevalence of the Class III malocclusions, the TPI may have underestimated the degree of difficulty that will be encountered in treating Inuit malocclusions.

Various studies have shown that the prevalence of malocclusion in populations has increased over the past hundred years. The prevalence of malocclusion in Inuit has reported similar findings. Occlusal disharmony was reported to be prevalent in 11% of Alaskan Inuit by Leigh in 1925. In 1991, this study found about 95% of the Labrador Inuit youth to have some degree of occlusal disharmony. Kelly et al., (1973) found 75% of American children to have some degree of occlusal disharmony. Payette and Plante (1989) reported 50% of the Quebec children aged 13-14 years to have a malocclusion. The Labrador survey also identified the prevalence of malocclusion to be particularly high in persons over 12 years of age and even higher in persons over 15 years of age. Other studies have shown that objective need for orthodontic care is between 30 - 50% of the teenage

population. The overall need for Dutch youth was found to be 39%. For the American public, it was considered to be 20 - 30%. In comparison, the objective overall need for orthodontic care was 38% for the Labrador youth. This would imply that the Labrador Inuit demonstrated a need for orthodontic care that was similar to other industrialized countries. This is in agreement with Corruccini's hypothesis that the higher frequency in industrialized areas is proportional to the rate of urbanization (Corruccini 1984).

Crowding of teeth was present in 82% of the Labrador Inuit population. This is not unusual as some degree of crowding of teeth has been reported to be present in many ethnic populations. In Blacks, for example, the prevalence is low (about 15%), while in other Caucasian samples, the prevalence has been recorded at 31 - 47%. Mild to moderate crowding was predominant in the Labrador study and this was reported to be highest in the younger age groups. Only 14% had very severe crowding of teeth while 18% had no crowding at all. It is possible that the younger age groups who have a high caries experience, tended to lose their deciduous teeth prematurely. This would result in loss of space for the permanent teeth to erupt and possibly explain the higher prevalence of crowding. Occlusal and interproximal attrition, which was very evident in primitive populations, no longer plays a role in reducing tooth mass. The jaws have decreased in size as an evolutionary process in many populations. Bone size reduction presently seems to be ahead of tooth size reduction. Blacks still have prognathic jaws with bi-alveolar protrusion. The arch length gain as a result of this anatomical characteristic in this race provides additional space to accommodate all the teeth. The reason for increased crowding in Labrador

Inuit is not known, but it could be due to a number of factors. Untreated caries, premature extractions, mouth breathing, bone size reduction ahead of tooth size reduction and the fact that the alveolar protrusion is not a "true" bi-alveolar protrusion are all possible factors.

The prevalence of posterior lingual upper crossbites in the Labrador study was found to be as high as 44%. In contrast, studies have shown that between 8-10% of the American population have a posterior crossbite of at least one upper premolar or molar. It was recorded by Price in 1936 that a feature of the Inuit dentition was a narrow upper arch. It may be possible that other soft tissue factors, such as nasal obstruction, may be contributing factors towards posterior crossbites. In experimental animal studies, posterior crossbites, narrowing of upper arch, tongue posture, and increased lower face height, were produced by blocking nasal airways in monkeys. Chronic nasal airway obstruction, large adenoids and tonsils, chronic respiratory diseases, and habitual mouth breathing due to cold weather, could all cause posterior crossbites. Further investigation of the Labrador Inuit is needed to determine the cause of such a high prevalence of posterior crossbites.

The prevalence of open bites was 14% in the Labrador Inuit. Anterior open bite or overbite is hard to record in the young age group because of the variation in eruption times of the incisors. The prevalence of open bites tended to increase with increasing age in the Labrador Inuit and was more prevalent in females. In contrast, Kelly et al., (1973, 1977), had reported that the number of open bites tended to decrease with age in the American sample. The prevalence of open bites in Caucasians is reported to be about

3-6%. In Blacks it is slightly higher at 10%. In the vertical plane, on the other hand, the prevalence of large overbites greater than 3 millimeters was 10% in the Labrador Inuit. The prevalence of overbites in Caucasians is estimated at around 40-50%. The high prevalence of open bites and low prevalence of deep bites is consistent with the increased lower face height found for the Inuit compared to Caucasian standards.

The findings in the Labrador Inuit demonstrated a mean headform type that was mesocephalic. Previous reports on headform type of the Inuit have revealed that in the West (Alaska), the predominant headform type was brachycephalic, while this changed to a dolichocephalic in the East (Greenland). Although headform has some genetic significance, there are many environmental factors that can influence its outcome. Furthermore, it is unclear at present if the mesocephalic headform found for the Labrador Inuit was due to greater admixture with other races. Studies have shown that although the Inuit race is relatively homogeneous, the concept of a pure race is presently considered to be fallacious. Some researchers (Enlow 1990) have suggested that certain headform types predispose individuals to certain skeletal and dental malocclusions. However, no specific relationship was found between headform type and malocclusion for this population. Headform type, however, remains useful in descriptive terms.

Researchers continue to describe the epidemiology of malocclusion in terms of dental relationships alone. Furthermore, dental and skeletal terminology are sometimes erroneously used synonymously. Although the term "occlusion" pertains only to the manner in which the maxillary and mandibular teeth come into contact, a proper analysis of occlusion actually

entails the study of the dentofacial skeleton (Moorrees 1957). There may be a practical reason why researchers do not examine malocclusion from both a dental and skeletal point of view. It is hard to record skeletal relationships accurately on an epidemiological level without the use of cephalometric radiographs. Besides being more time consuming, radiographs substantially raise the cost of field studies. Safety precautions would also need to be strictly enforced. For these reasons, the epidemiology of craniofacial morphology in populations is seldom reported in the literature. In addition, many different cephalometric analyses are used for assessment of skeletal parameters. At the present time, no epidemiologic standard for cephalometrics has been adopted. For the present study, it was decided to include a morphologic description of the skeletal parameters of malocclusion to complement the dental parameters. However, further research is necessary to develop an index for recording skeletal malocclusions.

Cephalometric skeletal values are a reflection of the genetic pool. Harris and Johnson (1991) suggested that skeletal parameters in malocclusion were inherited and under genotypic variation. Dental or tooth-based malocclusions, however, were subject to phenotypic variation. Every effort should be made to examine both parameters when describing ethnic variation even if racial admixture is present. Caucasian admixture in the Inuit population of St. Lawrence Island was estimated to be 2-7% (Ferrell et al., 1981). In Point Hope, Alaska, 35% of the population had non-Eskimo genes. In Wainwright, Alaska, the admixture was 27%, whilst in Igloolik, Central Canada, it was only 6%. According to Milan (1980) the concept of a

"pure race" of Inuit is presently considered to be fallacious. The level of Caucasian admixture in Labrador is presently unknown. It is believed to be between 6-35% based on other studies and because of the geographic location, history of interaction with other races, and physical characteristics (phenotype).

Similar magnifications were noted in the Labrador radiographs as in the Bolton Standards, thus making comparisons possible. **Linear** transverse measurements from other Inuit cephalometric studies from Wainwright, Alaska (Cederquist 1975) and from Igloolik, Canada (Colby 1972) could not be directly compared because the magnification was not recorded. **Angular** measurements, however, could be compared. The present study used traditional cephalometric measurements for recording skeletal parameters in the three planes of space. All linear measurements in the transverse plane were larger in the Inuit population than in Caucasians (Bolton Standards).

In the sagittal plane, the ANB angle or the skeletal relationship of the upper to the lower jaw based on the cranial base, demonstrated that the Labrador Inuit had a prognathic maxilla. This is consistent with previous studies on Inuit craniofacial structures. The mean ANB angle for the Labrador population was 4.7 degrees, while for Igloolik, it was 4.4. For Japanese, this value was reported as being 4.0, for American Blacks it was 6.0, while for Caucasians it was 2.0 (Profitt 1991). The greater the angle, the greater is the difference in the position of the upper and lower jaw with respect to the cranial base. Comparisons of ANB angles are not considered to be valid unless the geometry of the faces are similar. When the jaws were

compared to each other using the occlusal plane as a reference (Wits), the mandible was forward of the maxilla in the Labrador study (Figure 8). McNamara's analysis of relative jaw lengths demonstrated maxillary retrusion when compared with similar jaw lengths in Caucasians. This would indicate that the relationship between the Sella-Nasion plane and the occlusal plane was very steep. The nose in the Inuit race is positioned relatively further back in the face compared to Caucasians because the Inuit have a short anterior cranial base. Thus, the shape of the face is different as result of genetically inherited racial characteristics. Researchers have postulated these differences to be an adaptation to cold weather or to increased facial muscular function. It is difficult to suggest which of the measurements (ANB, Mcnamara or Wits) are more valid for orthodontic treatment planning. No Inuit cephalometric standards are presently available for such comparisons. The reliability coefficient for the measurement of Wits analysis was 0.886. This number was less accurate than others because of the difficulty involved in the averaging of bilateral dental structures. Further research is necessary to develop craniofacial cephalometric standards for this race.

In the vertical plane, the mean FMA angle and lower anterior face height were both increased when compared to the Bolton Standards. The mean FMA angle for the Labrador Inuit was 31.3 degrees while that for Caucasians was 21.3. This may indicate that the Inuit show a pattern of growth that is more vertical than Caucasians. The gonial angle or the angle formed by the junction of the ramus to the corpus of the mandible, was similar for both races. This could indicate that the mandible was rotating

down and back in the Labrador Inuit. The reliability coefficient for the measurement of the FMA angle was 0.918. Some difficulty was encountered locating anatomical porion because of the large size of the ear rods of the portable cephalometer. The reliability coefficient for the measurement of the Lower anterior face height was more accurate at 0.986.

Studies of mean dento-alveolar measurements for the upper and lower incisors have indicated that bi-alveolar protrusion was present in the Inuit race. The lower incisor demonstrated similar proclinations (IMPA) in the Labrador Inuit (91.9 degrees), in Igloolik Inuit (89.3), and in Caucasians (91.4). The interincisal angle, however, did not demonstrate the strong prevalence of a bi-alveolar protrusion as seen in other races. The mean interincisal angle for Labrador Inuit was 125, for Caucasians it was 131, for Blacks it was 114, and for Japanese it was 120. Blacks demonstrate the greatest tendency for bi-alveolar protrusion. It would seem, therefor, that the Inuit do not demonstrate a true bi-alveolar protrusion. The bi-alveolar "look" is created by the short anterior cranial base, small nose, normal upper jaw, steep mandibular plane angle (FMA) and obtuse gonial angle. The Labrador Inuit radiographic examination revealed a short anterior cranial base and steep occlusal plane. Absence of true bi-alveolar protrusion may partially explain the observed increase in prevalence of crowded dentitions.

Other studies have shown that the Inuit face develops in a similar pattern as that for Caucasians. The Labrador face, however, demonstrated a strong vertical component in the recorded skeletal and dental data. The Labrador Inuit face demonstrated maxillary jaw prognathia with some maxillary incisor protrusion in relation to the cranial base. In relation to the

occlusal plane, the lower jaw was found to be prognathic. The lower teeth were minimally protruded. The mean lower face height was long and demonstrated a high mandibular plane angle. This may explain the high prevalence of open bites in this race.

The degree of difficulty in treating some of the reported skeletal problems orthodontically is considered to be high. No analysis of soft tissue parameters were included in this study, but should not be forgotten. An association of large tonsilar, excess adenoid tissues or chronic nasal blockage and large-sized tongues have been implicated in the kind of skeletal malocclusions that are present in the Labrador Inuit race. Further research is necessary to examine some possible causes of the unusual distribution of malocclusions in this race.

A variety of orthodontic appliances and techniques may be needed to treat the variety of malocclusions found for the Labrador Inuit. In the US, the predominant type of orthodontic appliances used are "fixed". In the UK, the principle type of appliances used are "removable". There are advantages and disadvantages to using both types of appliances. For example, fixed appliances take longer to put on, cases take longer to treat, yet the finishing and amount of correction of malocclusion achieved can be close to ideal. Although minimal compliance is necessary, perfect oral hygiene is mandatory. Removable appliances, on the other hand, require increased compliance, require minimal chair-side time to insert and can be prefabricated in laboratories. Patients can still clean their teeth once the appliances are removed from the mouth. However, removable appliances do not provide the precise control of tooth movement needed for consistently

excellent orthodontic results. Given these factors, a combination treatment approach may be more appropriate for isolated communities such as those under study. For example, "orthopedic" or "functional" appliances, which are removable, could be used as part of the initial treatment. The fixed appliance stage could then be kept to a minimum. Removable or fixed "expanders" may be used to address the high prevalence of posterior crossbites. Removable "bite block" appliances could be used to aid in controling vertical facial relationships. As a form of prevention, "space-maintainers" could be inserted to save the "E" space following premature extractions of second deciduous molars. The "Tip-Edge" technique (TP Orthodontics, Inc.), may be beneficial for Labrador because appliances need adjustment only once every six to eight weeks. This 6-8 week adjustment schedule could be integrated into the itinerant dental care program currently being used in Labrador.

In addition to the need for treatment, the cost, treatment time, the availability of resources and the supportive general dental services should also be carefully evaluated. Motivation and oral hygiene factors are of paramount importance when recommending fixed orthodontic treatment. It is possible that better dental education and oral hygiene would greatly reduce the incidence of caries, which in turn, would reduce the incidence of malocclusion.

This study has attempted to combine various points of view in anthropology, psychology, cephalometrics and epidemiology to determine the need and the possible benefits of providing orthodontic services to this population. The results indicated that the Labrador Inuit youth were aware

of their malocclusions, wanted to improve their dental appearance with orthodontic care and wanted to become educated in orthodontic techniques. Thirty-eight percent of this population demonstrated a need for care. Examination of the data collected demonstrated a high prevalence of posterior buccal crossbites, crowding, open bites, vertically long faces and high mandibular plane angles. Many of these orthodontic problems respond well to early intervention. However, the presence of high dental caries rates along with poor oral hygiene may contra-indicate orthodontic treatment in some individuals.

Health care planners and providers of the north are faced with many difficult decisions. In order to make informed choices, dental health problems must be priorized. It is hoped that this study will provide meaningful insight and will convince policy makers of the importance of providing orthodontic care to the Labrador Inuit.

5. SUMMARY AND CONCLUSIONS

This study examined malocclusion in Inuit youth living in subarctic Northern Labrador, Canada. Psychosocial, dental and skeletal parameters were evaluated. This study was a cross-sectional population study. Data were collected by the author and two assistants in a field study lasting two and a half weeks during the Spring of 1991. Specific aims included:

(1) To evaluate **psychosocial** aspects related to malocclusion using parent (n = 222) and student (n = 363) questionnaires.

(2) To evaluate the **dental** aspects of malocclusion (n = 348) using clinical epidemiological parameters pertaining to the prevalence of malocclusion in Labrador Inuit school children aged between five and twenty-two years.

(3) To evaluate the **skeletal** parameters and jaw relationships of malocclusion in this Inuit population (n = 100) using cephalometric radiographs (oriented skull X-rays) of a selected sample taken from the main clinical sample of 348 school children.

Analysis of data collected provided insight into the prevalence of dental and skeletal malocclusions as well as actual and perceived **need for orthodontic care in two Canadian native communities** (Nain and Hopedale, Northern Labrador).

A proper analysis of occlusion actually entails the study of the dentofacial skeleton. The decision at which an occlusion is considered a malocclusion has social and psychological roots. Psychological profiles have helped identify malocclusion in terms of a "handicapping" condition. It

is not uncommon for orthodontists to evaluate their patients using psychosocial profiles as well as dental and skeletal analyses. However, few studies have examined the epidemiology of malocclusion using all three of these factors.

Epidemiology of occlusion in world populations has traditionally used Angle's molar classification. The use of a discrete classification to record a continuous variable necessarily limits the investigator's ability to detect subtle differences between individuals or groups. In this study, indices were used to examine the clinical and psychosocial aspects of malocclusion. Specifically, the **Treatment Priority Index** (TPI) was used to record dental malocclusion. The TPI has been tested for validity in longitudinal and epidemiologic studies in relation to treatment need. This index was also compared to other indices and was chosen for use in national surveys involving around 16,000 American children. Its use for clinical severity, however, is limited.

From the analysis of the three sets of data, the following results were obtained:

(1) Psychological profiles of 363 Labrador Inuit youth aged between 5 to 22 years, revealed that **awareness** of occlusal disharmonies was correlated ($p < 0.001$) with the severity of malocclusion. A **want** for treatment was expressed by 65% of the sample but only 6% expressed a knowledge of orthodontic procedures. About 5% were teased "a great deal" because of their malocclusions.

(2) Psychological profiles of 222 Inuit parents demonstrated an **awareness** of the occlusal disharmonies in their child's mouth. This was correlated with the severity of malocclusion ($p < 0.01$). About 70% **wanted** their child to wear orthodontic appliances if they were needed. About 23% of the parents considered their child to be **affected** in some way by malocclusion.

(3) About 95% of the 348 Inuit youth examined had some degree of **occlusal disharmony**. 20% of the sample had a "very severely handicapping malocclusion", for which treatment was deemed **mandatory**. 18% of the sample had a **severely handicapping** malocclusion for which treatment was deemed **highly desirable**. For 34% of the sample, treatment was deemed **elective**.

(4) The prevalence of malocclusion **increased with age**. About 31-34% of the persons over the age of twelve had a malocclusion for which treatment was deemed highly desirable or mandatory.

(5) Dental **crowding** was present in 82% of the sample with 14% having severe crowding. An **Angle Class I** molar relationship was present in 35%, **Class II** in 49% and **Class III** in 16% of the sample. About 44% had a **lingual crossbite** which was present at an early age, 39% had an **overjet** greater than 4 mm, 10% had a **reverse overjet**, 10% had a **deep bite**, and 14 .% had an **open bite**.

(6) The mean **headform type** was mesocephalic. The relationship of the maxilla to the mandible based on the cranial base demonstrated a **maxillary prognathism** (mean ANB = 4.7), while when based on the occlusal plane there was **mandibular prognathism** (Wits = -2 mm). Vertically, the Inuit lower face was **long** and had a **high mandibular plane angle** (FMA = 31). The upper incisor was **proclined** within the maxillary bone, and the lower incisor was near normal.

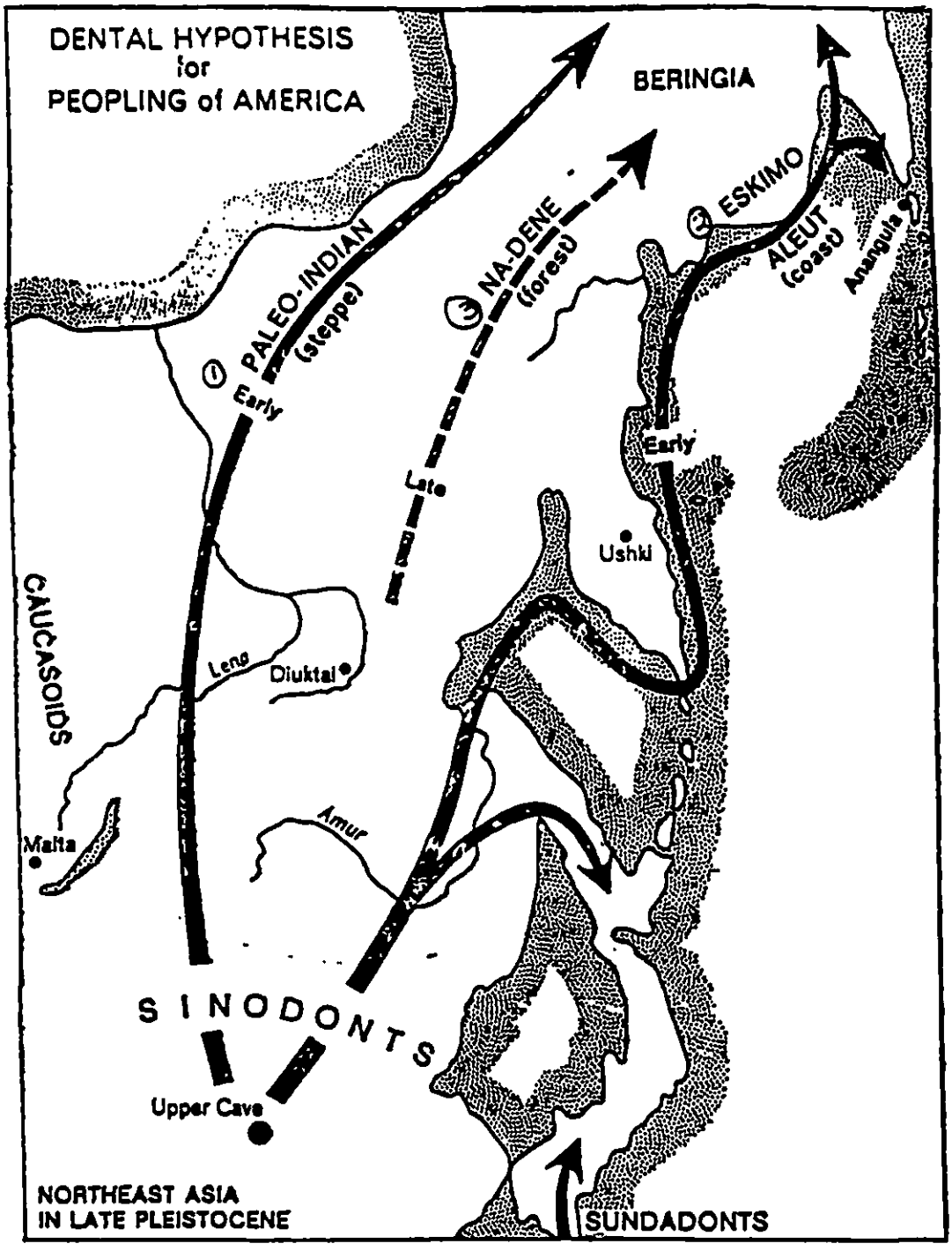
(7) Based on the above results, it seems that the Labrador Inuit were **aware** of their occlusal disharmonies, **wanted** to wear orthodontic appliances and had a **high prevalence** of malocclusion. Orthodontic care was highly recommended for persons over the age of 12 years, provided the individual was adequately educated and motivated towards treatment. The ideal patient must demonstrate good oral hygiene skills and be a regular dental attender. Orthodontics is not recommended for the 5-8 year old age group because they demonstrated a high prevalence of caries involvement in the primary teeth. The orthodontic problems described by the dental and skeletal parameters measured may prove to be difficult to treat. Therefor, if caries can be controlled, it may be beneficial to treat these problems at an earlier age.

In conclusion, it seems that the Labrador Inuit youth who were examined, were aware of their malocclusions, wanted to improve their dental appearances with orthodontic care, wanted to become educated in orthodontic techniques, and 38% of this population demonstrated a need for care. The results demonstrated a high prevalence of posterior buccal crossbites, crowding, open bites, vertical long faces and high mandibular plane angles. Correction of malocclusions of this severity may require early intervention to achieve optimal results.

Several significant health care issues face the Inuit population and its health care providers. Alcoholism, poor self esteem, poor nutrition and housing are amongst the most damaging. This study has shown that malocclusion and dental health are also concerns of this population group. The commitment of health care planners to improve dental health is evidenced by existing services. Thus, because of the limited funding available for health care, planners will have to weigh the benefits of providing orthodontic treatment against other socioeconomic problems affecting this underserved group. It is hoped that the results of this study will provide meaningful insight and support the decision to plan for orthodontic care to the Labrador Inuit.

APPENDIX A

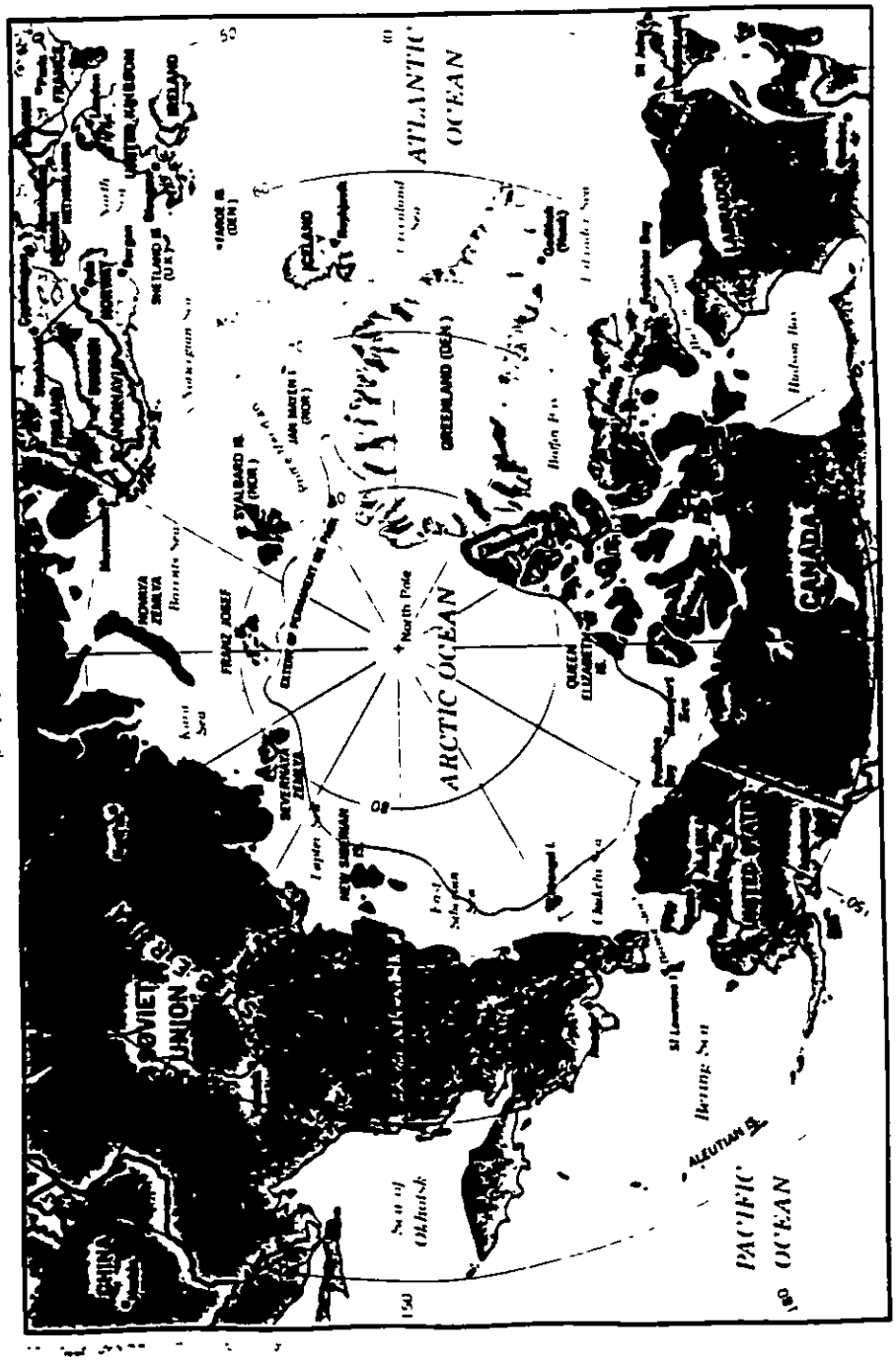
Map of Dental Hypothesis for the peopling of America.
(Taken from Turner CG II, 1984)


DENTAL HYPOTHESIS
for
PEOPLING of AMERICA
BERINGIA
① PALEO-INDIAN (steppe)
Early
Late
② NA-DENE (forest)
③ ESKIMO ALEUT (coast)
Anangula
Early
Ushki
CAUCASOIDS
Lena
Diuktai
Malta
Amur
SINODONTS
Upper Cave
NORTHEAST ASIA
IN LATE PLEISTOCENE
SUNDADONTS

APPENDIX B

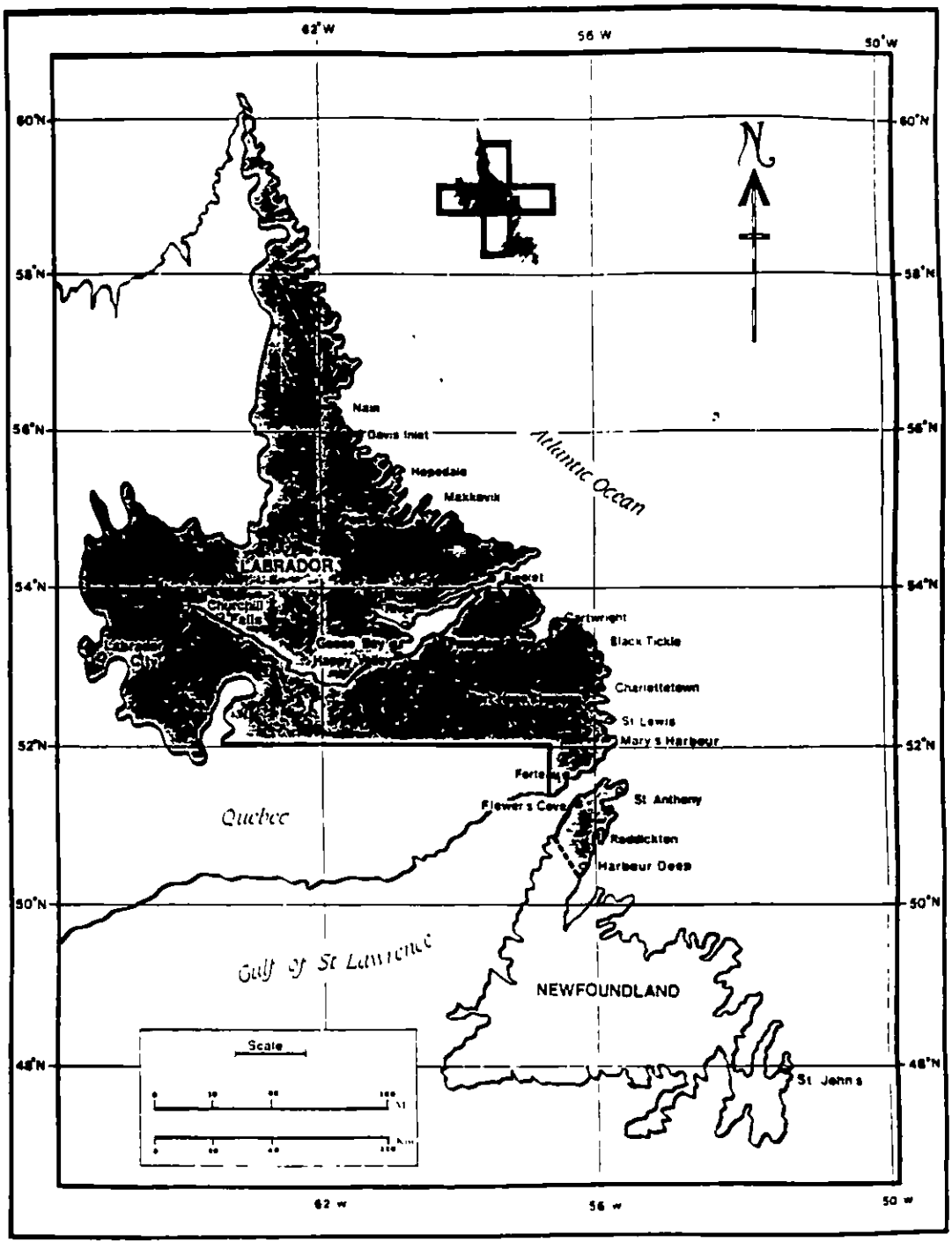
Map of Northern Circumpolar Region.
(Taken from American Express Calendar 1988)

POLAR REGIONS



APPENDIX C

Map of Labrador.
(Taken from Grenfell Clinical Quarterly)


62°W
56 W
50°W
60°N
58°N
56°N
54°N
52°N
50°N
48°N
N
Nain
Davis Inlet
Hopedale
Makkovik
LABRADOR
Rigolet
Churchill Falls
Goose Bay
Happy Valley
Cartwright
Black Tickle
Charlottetown
St Lewis
Mary's Harbour
Forteau
Flower's Cove
St Anthony
Roddickton
Harbour Deep
Atlantic Ocean
Quebec
Gulf of St Lawrence
NEWFOUNDLAND
St John's
Scale
62 w
56 w
50 w

APPENDIX D

Preliminary Preparation for Materials and Methods.

Preliminary preparation for materials and methods.

After Case Western Reserve University orthodontic department approved the subject material for the present thesis, it was necessary to communicate with various Labrador organizations in order to obtain the required written permissions.

Several months of communication were necessary before final approval could be obtained from: the Grenfell Regional Health Services Research Review Committee; the Grenfell Regional Health Services Executive Director and the Chief of Dental Services; the Health Advisor to the Labrador Inuit Health Commission; and the Labrador Inuit Association. It was then necessary to inform the local communities about the proposed study.

Two towns were to be used: Nain (population - 1079) and Hopedale (population - 534). The town councils, the Labrador School Board, the local school principals, the nurse-in-charge for each nursing station, the dentists working in the area, and the native people who would be employed by the author during data collection, all had to be contacted and informed about the nature of the study. Accommodations were also arranged prior to departure into the field.

Travel arrangements for the principal investigator and two research assistants travelling from Cleveland, Ohio to Goose Bay, Labrador, were made through Air Canada. Local transportation for the final journey from

made through Air Canada. Local transportation for the final journey from Goose Bay to the two isolated towns was made through the Melville Hospital administrator in Goose Bay. The only form of transport at that particular time of the year was by "Twin Otter" plane. The plane was designated only for hospital staff and patient transport. Thus, the travel arrangement could not be confirmed until one or two days before arrival.

Dental materials, radiographic and photographic equipment were packed into a sturdy trunk (45"X27"X22"), weighing approximately 375 pounds. The contents of the trunk had to be registered with US Customs. It was also necessary to make pre-arrangements with the airlines in order to ensure that the equipment would travel with the investigators on the day of departure.

About three weeks before data collection, it was necessary to mail consent forms to the two schools. Instructions were given to the school principals to distribute the material to each classroom. Each respective teacher of that classroom would then distribute the forms to the students to take home, with instruction to collect the completed forms the following day.

APPENDIX E

The Student Questionnaire

Student Questionnaire (SQ)

NAME_____ LOCATION_____

IDENTIFICATION NUMBER_____ AGE____ SEX_____

1. Do you like the way your teeth are?
   (0) No____ (1) Yes____

2. How often do you see the dentist?
   (0) Never___ (1) Sometimes___ (2) Often____

3. Do you think you have crooked teeth?
   (0) No_____ (1) A Little_____ (2) A Lot____

4. Do you have spaces between your teeth?
   (0) No_____ (1) A Little_____ (2) A Lot____

5. Do you know that specially trained dentists can straighten teeth that are crooked or spaced?
   (0) No____ (1) Yes____

6. Do your relatives or friends think you have crooked or spaced teeth?
   (0) No_____ (1) A Little_____ (2) A Lot____

7. Do your friends make fun of you because of your crooked or spaced teeth?
   (0) No_____ (1) A Little_____ (2) A Lot____

8. If you have crooked or spaced teeth, do you think you would like your teeth straightened?
   (0) No_____ (1) Maybe_____ (2) Yes_____

9. Do you know anything about how the dentist can straighten your teeth?
   (0) No_____ (1) A Little_____ (2) A Lot____

10. Do you think you would wear braces if you had crooked or spaced teeth?
    (0) No_____ (1) Maybe_____ (2) Yes_____

APPENDIX F

The Parent Questionnaire

Parent Questionnaire (PQ)

NAME OF CHILD_____ LOCATION_____

IDENTIFICATION NUMBER_____ AGE____ SEX_____

1. In your opinion, does your child have crooked or spaced teeth?
   (0) No____ (1) Don't Know____ (2) Yes_____

2. Is your child affected in any way by having crooked or spaced teeth?
   (0) No____ (1) Don't Know____ (2) Yes_____

3. Does your child look after his or her teeth?
   (0) No_____ (1) Sometimes_____ (2) Yes____

4. If the dental service to have braces for straightening teeth were available in your community, would you wish your child to have braces?
   (0) No____ (1) Don't Know____ (2) Yes_____

5. Do you think your child would wear braces to straighten his or her teeth?
   (0) No____ (1) Don't Know____ (2) Yes_____

APPENDIX G

The Treatment Priority Index Data Sheet

NAME .....
.....
DATE.....
EXAMINER.....

AGE.....
SEX.....
CASE NO. .....
COMMUNITY.....

TREATMENT PRIORITY INDEX
National Center for Health Statistics
and
University of Toronto

FIRST MOLAR RELATION — Choose appropriate column	(6) Distoclusion: 2 sides full	(6) Distoclusion: 1 side + to + and 1 side full	(6) Distoclusion: 2 sides + to + or 1 side full	(6) Distoclusion: 1 side + to +	Mesiocclusion	(7) Mesiocclusion: 1 side + to +	(7) Mesiocclusion: 2 sides + to + or 1 side full	(7) Mesiocclusion: 1 side + to + and 1 side full	(7) Mesiocclusion: 2 sides + to +	Weights	CASE TYPE IS INDICATED BY THE DOMINANT SYMPTOM
HORIZONTAL INCISOR RELATION — (1) Upper Overjet	9+	2.0	3.4	5.4	9.3	10+	9.3	5.4	3.4	2.0	SYMPTOM III MISMORPHOLOGY
	8	1.4	2.5	4.0	6.9	10+	6.9	4.0	2.5	1.4	
	7	1.0	1.8	2.8	4.8	8.0	4.8	2.8	1.8	1.0	
	6	.6	1.1	1.8	3.0	5.1	3.0	1.8	1.1	.6	
	5	.4	.6	1.0	1.7	2.9	1.7	1.0	.6	.4	
	4	.2	.3	.4	.8	1.3	.8	.4	.3	.2	
Point SCORE 0	3	.2	.3	.4	.8	1.3	.8	.4	.3	.2	SYMPTOM V PRESENTATION
	2	.4	.6	1.0	1.7	2.9	1.7	1.0	.6	.4	
	1	.6	1.1	1.8	3.0	5.1	3.0	1.8	1.1	.6	
	0	1.0	1.8	2.8	4.8	8.0	4.8	2.8	1.8	1.0	
(2) Lower Overjet	1	1.4	2.5	4.0	6.9	10+	6.9	4.0	2.5	1.4	
	2+	2.0	3.4	5.4	9.3	10+	9.3	5.4	3.4	2.0	
VERTICAL INCISOR RELATION — (3) Overbite in crown units 0-2/3 — SCORE 0	Bite 3/3+ 2/3-3/3	2.2	3.8	4.6	6.2	8.0	6.2	4.6	3.4	2.2	SYMPTOM II OVERBITE
		1.5	2.8	3.4	5.2	6.1	5.2	3.4	2.6	1.5	
		.5	.7	.8	1.1	1.5	1.1	.8	.7	.5	
(4) Openbite in mm.	0	.5	.7	.8	1.1	1.5	1.1	.8	.7	.5	SYMPTOM IV OPENBITE
	< 2	1.5	2.0	2.4	3.2	4.1	3.2	2.4	2.0	1.5	
	2-4	2.9	3.8	4.6	6.2	8.0	6.2	4.6	3.8	2.9	
	4+	4.9	6.3	7.9	10+	10+	10+	7.9	6.3	4.9	
(10) TOOTH DISPLACEMENT SCORE — Count teeth rotated about ≤45° or displaced about 2mm. ☐	0	.1	.1	.2	.3	.4	.3	.2	.1	.1	IS MESIOCCLUSION AND/OR POSTERIOR CROSSBITE MAX. TO BUCCAL PRESENT? YES: Sympt. I Max. Expansion Syndrome; NO: Sympt. VI Max. Collapse Syndrome
	1	.2	.3	.4	.7	1.1	.7	.4	.3	.2	
	2	.5	.8	1.2	1.8	2.9	1.8	1.2	.8	.5	
Count teeth rotated >45° or displaced more than 2mm: 1 ☐	3	.7	1.1	1.6	2.6	4.3	2.6	1.6	1.1	.7	
	4	1.0	1.5	2.4	3.9	5.9	3.9	2.4	1.5	1.0	
	5	1.3	1.9	3.1	4.9	7.7	4.9	3.1	1.9	1.3	
	6	1.7	2.5	4.1	6.2	9.7	6.2	4.1	2.5	1.7	
Total (0, 1 or more): ☐	7+	2.0	3.0	4.9	7.7	10+	7.7	4.9	3.0	2.0	
CONSTANT		3.1*	3.95	2.72	1.50	0.27*	1.50	2.72	3.95	3.1*	

SYNDROME VII

(5) ORIENTALLY MESIODENS INCISORS

No.	0	1	2	3+
Weight	0	7	9	9

(8) Posterior Crossbite Count No. of Teeth

	No.	0	1	2	3	4	5	6	7	8	more
MAX. TO BUCCAL	Weight	0	.1	.6	1.3	2.2	3.3	5.0	6.9	9.0	10
MAX. TO LINGUAL	No.	0	1	2	3	4	5	6	more		
	Weight	0	.3	1.0	2.3	4.2	6.5	9.4	10		

OTHER DEFECT _____ Arbitrary Weight _____

SUM OF WEIGHTS IS TREATMENT PRIORITY INDEX

Manual examination and calculating form for deriving the Treatment Priority Index.

APPENDIX H

Consent Forms in English and Inuktitut

CONSENT FORM

I, _____, wish / do not wish, my child, _____, to have his/her teeth checked for crookedness at the school.

I understand that my child may be selected for furthur evaluation at the Dental Clinic in the Nursing Station, for the taking of some photographs and X-rays of the head and face. This proceedure will be provided free of charge , will take about half an hour, and will be done during school hours.

_____ _____

(signature) (Date)

Principal Investigator:
Dr. MARK ZAMMIT.,
CWRU., CLEVELAND, OHIO, USA.

ANGIUTIK ALAKKASÂJAK

Uvanga,_____,angivunga/anginngilanga,sugusiga,_____,kigutingit kamagijaukKujakka kamagijaukKungitakka sittungatsiamangatta Illniavimmi KimikKutausongugajaktut.

Tukisivunga kamagijaugiallalânnunganik Anniasiugvimi Kigutiligijiup Illugusigani, atjiliuttauluni x-ray-taulunilu, kenammigut, niaKommigullu.

Tanna akiuâlunnigituk, sitontiup agvangani pijagettauluni,ilinniavimmeguni kissiani kamagijaulluni.

_____ _____

(sugusik) uvlunga

AngajukKak kamagi tatsuminga:

Dr. MARK ZAMMIT.,

CWRU.,CLEVELAND,OHOI.USA.

APPENDIX I

Letters Granting Permission to Conduct Study



GRENFELL REGIONAL HEALTH SERVICES

Division of Community Health
St. Anthony, Newfoundland
A0K 4S0
1991 07 18

Dr. Mark Zammit
School of Dentistry
Department of Orthodontics
2123 Abington Road
Cleveland, Ohio
44106

Dear Mark:

The complete Research Review Committee met to review your proposal: 91-5 "Epidemiology Of Malocclusion And The Need For Orthodontic Treatment In Northern Labrador Inuit Youth".

Full approval was granted, thus having previously received approval for completion of the research, you may now proceed with publishing the research as per the terms of approval on your submitted request form.

On behalf of the Committee, I wish you well with your future publication and look forward to receiving a copy.

Sincerely yours,

Sue Webb

Sue Webb, Chairperson
Research Review Committee

I

Dr. Maureen Baikie
Health Advisor
LABRADOR INUIT ASSOCIATION
P.O. Box 117
Northwest River, Labrador
A0P 1M0

Wed, Apr 10, 1991

Dr. Mark Zammit
Resident Orthodontist
School of Dentistry
Dept of Orthodontics
2123 Abington Rd
Cleveland, Ohio
USA 44106

CONFIRMATION OF TELECOPIER

Dear Mark:

Thank you for sending me a copy of your research proposal and a reply to my concerns. Both Iris Allen, Executive Director of LIHC and myself have reviewed your proposal and feel that your research would be of benefit to the membership of LIA. As you are well aware, the lack of an appropriate and readily accessible orthodontics program has been of concern to us for sometime. We are also well aware of the need to develop norms or average measurements based on our population rather than on people eslewhere.

I trust that you have corresponded with the communities of Nain and Hopedale. I have taken the liberty of copying this letter and your proposal to them.

It is unclear to me whether or not you will be submitting your proposal to the GRHS Research Review Committee. Since you will be using GRHS facilities, this may be necessary. However, I urge you to consult with Sue Webb, Public Health, GRHS, St. Anthony who is the Chair of the committee.

Good Luck with your research and I hope to see you when you are in the area.

Regards

Maureen

Dr. Maureen Baikie

cc
Iris Allen
Community Council, Hopedale
Community Council, Nain
Sue Webb
Carol Flynn, LIA

APPENDIX J

List of Equipment for Field Study in Labrador

CASE WESTERN RESERVE UNIVERSITY · CLEVELAND, OHIO 44106

May 9, 1991

TO WHOM IT MAY CONCERN:

The contents of this trunk are for collecting **ORTHODONTIC DATA** in Northern Labrador, Canada. The purpose of this research is for evaluating the level of orthodontic need in the Inuit population of Labrador. This study has the support of the local Inuit Government and the Grenfell Regional Health Services.

The following is a list of contents and their estimated value. All of this material and equipment, which was made in the U.S.A., will be returning to Cleveland, Ohio, U.S.A. with Dr. Mark Zammit.

	Quantity	Description	Estimated Value
1.	200	impression trays	U.S. $ 80.00
2.	1	lead letter holder	50.00
3.	5 packets	x-ray film	300.00
4.	14 rolls	Kodak slide photography film	100.00
5.	2 twin pks	developing solution	40.00
6.	6 tubes	impression material	80.00
7.	1	camera	300.00
8.	1	cephalometer (Serial #134) and	)
9.	1	control box and head unit (Model 571, Serial #375)	700.00)
10.	250	Zip-Lock plastic baggies	15.00
11.	4	Rubbermaid plastic containers	20.00
12.	800	questionnaires and record forms	20.00
13.	7	x-ray cassettes & screens (8"x10")	400.00
14.	1	filtration bulb box	30.00
15.	1	supporting stand	30.00
16.	1	tissue screen	20.00
17.	3	tubs for developing	40.00
18.	6	x-ray developing holders	40.00
19.	1	spreading caliper	200.00
20.	1 box	wax wafers	30.00
		TOTAL U.S.	**$2,495.00**

Varun Kalra, B.D.S., M.D.S., D.Orth., M.S.D., D.D.S.
Clinic Director

School of Dentistry
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