A SURVEY OF THE OCCLUSAL TRAITS IN AN ADOLESCENT POPULATION IN UGANDA

BY

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ABSTRACT

Epidemiological studies on malocclusion have been primarily concerned with its aetiology and distribution. However, due to the varied and often subjective methods of assessment, many of these studies provide conflicting data related to malocclusions (Solow, 1970). To address this, the Fédération Dentaire Internationale (FDI) in close collaboration with the World Health Organisation (WHO) developed an objective method for measuring occlusal traits (Baume *et al.,* 1973). This method was used to obtain the epidemiological data on occlusal traits for 14-year-old children Kampala in order to provide baseline data related to malocclusion. A total of 402 subjects were examined. Of these 65% were female and 35% were male. Thirty percent of the sample had at least one dental anomaly. The most commonly extracted teeth were mandibular first molars (43.6%) and maxillary canines (17.3%). The high frequency of extracted permanent canines in this sample is unique. By and large, many of the occlusal traits related to the canine are attributable to the practice of *ebinyo*, a form of dental mutilation, which still seem to be rife in many communities in Uganda. Similar to other studies (Massler and Frankel, 1951; de Muňiz, 1986; Ferguson, 1988; Kaka, 1993), mandibular first molars were five times more likely to be missing than maxillary first molars while the ratio of missing maxillary to mandibular canines was found to be 2.5:1. Crowding was most frequently observed in the mandibular incisal segment while spacing was mostly in the maxillary incisal region, thus supporting the view of Brunelle *et al.,* (1996) that although prevalence may vary from study to study, more people have malaligned mandibular incisors than maxillary incisors concurs with these studies. Of the subjects studied, 6.8% had a diastema of 3mm and more. Regarding space measurements, 17.9% of the sample population had at least one segment with crowding, 18.2% had at least one segment with spacing while 33.6% had

some degree of incisor malalignment and 54.2% of the sample population had some form of space anomaly. About 70% of the subjects had symmetric molar relationships of which 54.2% were Class I, 9.2% Class II and 3.2% Class III similar to the universal distributional pattern. Crossbites were not a major finding, and were present in only 7% of the sample. The distribution of overjet was relatively symmetrical on the left and right. Negative overjet (anterior open bite) was a rare occurrence in an average of 2.4% of the population. In 77.6% of the population, the overjet ranged from 1 to 4mm, and in 22.4%, the overjet was either edge-to-edge, reverse or 5mm and over. About 7.3% had an overjet of 5-6mm while only 2.1% had an overjet greater than 6mm. Approximately 53.7% of the population had an overbite of 1-3mm. Edge-to-edge and open bite incisor relationships were found in less than 10% of the sample. Although ideal occlusion as described by Angle (1907) in the Ugandan sample is very rare, using the data derived from this study, normal occlusion as defined by statistical distribution can be described.

DECLARATION

I Aisha Bataringaya declare that *A Survey of Occlusal Traits in an Adolescent Population in Uganda* is my own work, that it has not been submitted for any other degree or examination in any other university, and that all the sources I have used have been duly acknowledged as complete references.

SIGNED: …………………………………………

DATE: …………………………………………...

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DEDICATION

This thesis is dedicated to Aga, Ray, Isaac and Imran who made the ultimate

sacrifice and held the door open for me to enter this great world of orthodontic

opportunity. I thank you.

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CHAPTER ONE:

INTRODUCTION

A review of the literature related to the recording and measuring of malocclusion found that most of the investigations were published between the 1940s and the 1970s. Later publications have focused more on determination of treatment needs and treatment outcomes. (Brook and Shaw, 1989; Shaw *et al.,* 1991; Daniels and Richmond 2000). This shift in interest could be explained by the fact that once the information on occlusal traits was obtained in developed countries, the scope of this kind of research became limited, funding dried up and with the advent of global epidemics like HIV/AIDS, their relevance became questionable. That notwithstanding, epidemiological surveys on occlusal traits do still have relevance particularly in developing countries where baseline data on the occlusal traits is unavailable.

Uganda is a developing country in the Great Lakes region of East Africa. It has a population of 24.5 million people, a life expectancy of 43.8 years, a birth rate of 47 per 1,000 people, a death rate of 18 per 1,000 people, an infant mortality rate of 89 deaths per 1,000 live births, a population of 25,000 people per physician and 1,091 people per hospital bed. With all these primary health care problems, malocclusion and orthodontics have not been regarded as a priority. Since the prevalence of malocclusion in Uganda is not known, it is important to have the relevant epidemiological data on occlusal traits for a country that is embarking on a specialist orthodontic program. Knowledge of occlusion disharmonies is not only important from an academic viewpoint, but is essential for determining the treatment needs of the population, the planning of orthodontic services, assessing the resources required and for establishing orthodontic training programmes.

CHAPTER TWO:

LITERATURE REVIEW

INTRODUCTION

Epidemiological studies on malocclusion have been primarily concerned with its aetiology and distribution. Entrenched in these studies is the typological concept that suggests that all variants from a specified normal are abnormal (Smith and Bailit, 1977). The major flaw in this concept is that it is not easy to define normality, due to the fact that there always exists degrees of natural variation among individuals of a population (Baume, 1970).

In addition, most studies have considered the definition of malocclusion to be largely synonymous with that of the Angle's classification (Smith and Bailit, 1977; Tang and Wei, 1993). Difficulties, therefore, arise when a continuous variable such as the molar relationship is divided into a small number of ordinal categories (Class I, Class II and Class II), which are then treated as a series of independent variables (Gravely and Johnson, 1974; Smith and Bailit, 1977). Angle's classification, though clinically useful, is inadequate for epidemiological studies and as such, indices have had to evolve to focus on means of uniformly evaluating malocclusion.

To determine how much variation in occlusion exists in any given population a basic descriptive study of overjet, overbite, molar relationship, crossbites, crowding and spacing, malalignment and other occlusal variables (defined in an objective and replicable manner) is required such that statistical analyses can be performed. The role of epidemiological factors such as age, sex, geography and diet can be examined to establish their relationship to the observed variation. After the variation within the population is described and understood, populations can be compared and the cause for the observed differences evaluated (Smith and Bailit, 1977).

Many attempts have been made over the years to create an ideal index (Massler and Frankel, 1951; Van Kirk and Pennel, 1959; Draker, 1960; Poulton and Aaronson, 1961; Björk *et al.,* 1964; Grainger, 1967; Salzmann, 1968; Summers, 1971; Baume *et al.,* 1973; Bezroukov *et al.,* 1979; Kinaan and Burke, 1981; Cons *et al.,* 1986; Brook and Shaw, 1989; Shaw et al., 1991; Daniel and Richmond, 2000). Variations in terminology, concepts and methodology have been cited as major reasons for the lack of a universally acceptable index of occlusion (Summers, 1971). However, studies show that occlusal status in a given population can be assessed by the objective measurement of individual occlusal characteristics or traits (Brunelle *et al.,* 1996).

However, due to the varied and often subjective methods of assessment, many epidemiological studies provide conflicting data related to malocclusions (Solow, 1970).

For its part, the Fédération Dentaire Internationale (FDI) in close collaboration with the World Health Organisation (WHO) contributed to the solution of the dental epidemiologic problem by assigning a commission on classification and statistics for oral conditions (F.D.I. COCSTOC). It is from the research by this working group that Baume *et al.* (1973) developed an objective method for measuring occlusal traits (See Appendix I). However, objective measurement of the need for orthodontic treatment still eludes epidemiologists since it depends largely on clinical judgement (World Health Organisation, 1985).

OCCLUSION

Occlusion has been defined as the interdigitation of maxillary and mandibular teeth (Fletcher, 1987). This description is misleading in that it implies that

occlusion is a static contact relationship or arrangement of teeth. The practical concept of occlusion is to recognize the interplay between the teeth, temporomandibular joint and neuromuscular system (Timm *et al.,* 1976; Roth, 1981; Fletcher, 1987).

Angle's description of occlusion is based on the relationship of the maxillary first permanent molar to the mandibular first permanent molar. He noted that in normal occlusion, the mesio-buccal cusp of the upper first molar articulates in the buccal groove of the lower first permanent molar (Angle, 1907). Although his concept of occlusion places primary emphasis on the static relationship of the first permanent molars, he did say that:"…the sizes, forms, interdigitating surfaces, and positions of the teeth in the arches are such as to give one another, singly and collectively, the greatest possible support in all directions…" implying that the functional aspect of occlusion is just as important as the static relationship of the teeth to each other. However, later authors (Dewey, 1915; Dewey and Anderson, 1935; Andrews, 1972) still tended to emphasise the arrangement and alignment of teeth by anatomic standards without specific functional considerations for occlusion.

The definition of occlusion in terms of alignment of teeth is not adequate to describe its functional aspect. Instead, other factors should also be considered, such as excursive movements, contacts, condylar activity and jaw relationships during function to impart the view that occlusion is a dynamic process (Isaacson *et al.,* 1975). It was on this basis that Roth (1981) advanced his concept of "gnathology" which incorporated centric relation, cusp-fossa relationships and canine guidance. According to this concept, the occlusal anatomy is designed to guide the mandible to centric relation upon closure. However, its practical application in orthodontics is rarely feasible because of the difficulty of positioning the posterior teeth so that every supporting cusp occludes in a fossa (Timm *et al.,* 1976). This concept is

further complicated by and the controversy surrounding the definition of centric relation (Keshvad and Winstanley, 2000).

IDEAL AND NORMAL OCCLUSION DEFINED

Within the distribution of occlusal forms are the conditions somewhat arbitrarily designated as *ideal, normal* and *malocclusion,* the precise differences of which are difficult to identify.

Angle (1907) on ideal occlusion stated that, "…each dental arch describes a graceful curve and that the teeth are so arranged as to be in greatest harmony with their fellows in the same arch, as well as with those in the opposite arch." From a functional point of view, an ideal occlusion needs to be in complete harmony with the neuromuscular system and temporomandibular articulation (Timm *et al.,* 1976). According to Burdi and Moyers (1988) "ideal" denotes a hypothetical concept or treatment goal rarely seen in nature. Jago (1974) suggested that a rigid adherence to this concept would mean that only 3% of the population does not have a malocclusion.

In a series of publications, Johnson (1923) pondered with the philosophical implications of the concepts of normal and ideal occlusion. He asked," What is normal occlusion? Does it [normal] mean an ideal, a goal to be sought after but never found?"

In the literature, there has been a tendency to use the word "normal" to describe only ideal occlusions (Andrews, 1972), thus all deviations from perfection are labelled malocclusions. The definition of normal occlusion is problematic. Katz, Sinkford and Sanders, (1990) argued, "If normal is synonymous with typical or average, can normal be taken as a standard because of the high frequency of its occurrence?"

The usual definition where normal occlusion is presumed synonymous with ideal occlusion is based on typologic concepts that require precisely defined ideal "types" which are static and unchanging. Deviations from the ideal are viewed as anomalies or degenerations. Typology is a prestatistical way of thinking that does not recognize the variation that describes natural phenomena. When typology is applied to the dentition, hardly anyone has a normal occlusion (Jago, 1974; Lombardi, 1982). The term "normal occlusion" is thus a broad and vague concept, the boundaries of which are unclear (Vlachos, 1995).

Normal cannot be synonymous with ideal. A biologically valid concept of normal occlusion includes a range of occlusal traits that is compatible with health and unimpaired function (Lombardi, 1982). It allows for minor deviation from the ideal that is aesthetically satisfactory and functionally acceptable and implies variations around an average or mean value (Burdi and Moyers, 1988; Vlachos, 1995). The most rigorous definition of normal occlusion would therefore be a statistical one with stated probabilities (Lombardi, 1982).

Normal occlusion is generally accepted to be a Class I molar relationship with good alignment of all the teeth. This represents a situation that occurs in only 30-40% of the population (Mossey, 1999).

Summers in 1971 postulated that in epidemiology, *normal occlusion* is confusing and thus the term *occlusion* is preferred, because it encompasses all variations from an ideal occlusion to a malocclusion and implies a continuous variability rather than just the invariable state.

THE CONCEPT OF MALOCCLUSION

Malocclusion has been described as any deviation from the normal relation of the teeth in the same arch to each other and to the teeth in the opposite arch (Anderson, 1948).

The World Health Organisation (1962) defined malocclusion as a dentofacial anomaly. A handicapping dentofacial anomaly is one which causes disfigurement or which impedes function and requires treatment if it is or is likely to be an obstacle to the patient's physical or emotional well-being. Salzmann (1968) defined a handicapping malocclusion as one that adversely affects aesthetics, function or speech. However, measuring disability or handicap associated with malocclusion is challenging because the emotional impact of the malocclusion on the individual does not always seem to be directly related to the degree of disfigurement (Baume, 1970; MacGregor, 1973).

The term *malocclusion* is an imprecise and ambiguous concept in that it can only be defined in reference to normal occlusion. The definition of malocclusion originated within the realm of corrective treatment and is thus biased (Moorrees *et al.,* 1971). This approach directs attention away from the variation normally found among individuals thus suggesting that all variants from a specified normal are abnormal (Smith and Bailit, 1977). The determination of the point at which normal variation becomes abnormal is difficult (Lombardi, 1982) and has been cited as the main contributory factor in the variation of the prevalence of malocclusion seen in epidemiological studies (Summers, 1971).

A logical consequence of these flawed attempts at defining malocclusion is that occlusal deviations are then regarded as disease. However, disease

presumes a specific cause, even if it is unknown, and it follows a more or less predictable clinical course resulting in tissue injury, impaired function, and a definable probability of recovery.

Malocclusion fits this definition only approximately, and it seems better to be considered as a condition that can lead to or promote disease in certain circumstances. Periodontal disease, dental caries, and temporomandibular joint dysfunction are the most commonly accepted consequences of untreated malocclusion. This cause-effect relationship, while it appears compelling, is based largely on clinical observation and has not been proved conclusively with experimental or epidemiological evidence (Lombardi, 1982). This cause-effect relationship would be justified if it could be shown that individuals with an ideal occlusion have a better dental health than those with malocclusions, but this has not been so (Prahl-Andersen, 1978). In essence, malocclusion bears a relationship to disease but is not a disease itself.

In order to clear the ambiguity, Moyers and Summers (1970) proposed the term "occlusal disorders" instead of "dentofacial anomalies" or "malocclusion" to describe any variation in occlusion that is unacceptable aesthetically or functionally, to either the individual or the examining dentist. Although in their view, this term, which is neither precise nor better than the term malocclusion, conveys variability rather than an invariable state.

A clearer concept of malocclusion would be obtained if the occlusal variables that it comprises are brought into consideration (Lombardi, 1982). Since malocclusion is described as tooth malpositions and/or malrelationships between arches, it represents a range of deviation from the ideal (Vlachos, 1995), and therefore the developing trend has been to speak of "occlusal variation" or "occlusal traits" in order to avoid the handicapping connotation of the word malocclusion.

MALOCCLUSION IN THE SOCIAL CONTEXT

Malocclusion has been defined as a community problem in contrast to one that is solely a problem of the individual (Young and Zwemer, 1966). It is a problem that must first occur as a biological phenomenon, representing some deviation from a generally accepted norm, and next there must be a personal recognition by the individual and then of the community that there is a problem created by this deviation (Cohen, 1970).

There is general agreement that a public health definition of malocclusion should include consideration of the psychological, social and cultural handicaps to the individual, their families and peers (Cohen, 1970; Baume *et al.,* 1973). Since malocclusion as distinguished from normal variation is difficult to define, the extent to which an individual is labelled or labels themself as having a malocclusion involves clinical judgment and introduces a degree of subjectivity (Mooreees *et al.,* 1971).

It must be remembered that not every child with a malocclusion is self-conscious about it. There is considerable variability of adjustment to the irregularity, from total unawareness to deep concern (Shaw *et al.,* 1975). A malocclusion may therefore become handicapping not because of the functional disability, but because it may adversely affect social relationships (Prahl-Andersen, 1978).

Conversely, it is implied in the literature that for the majority of patients, the primary psychological impact of malocclusion does not result from the response of others to the defect, but from the individual's own reaction to the anomaly (Gosney, 1986). Shaw *et al.* (1975) suggested that the popularity, personality and general appearance of the individual has considerable bearing on how much of a handicap any malocclusion actually is.

Furthermore the scientific approach to the assessment of malocclusion may not be meaningful to the patient.

Stricker (1970) emphasized that the point at which any deviation is of sufficient magnitude to become a malocclusion remains a subjective decision with social and psychological roots. Malocclusion should therefore be assessed in its social context in that it may be regarded as a handicap if it fails to meet society's standards of acceptability (Prahl-Andersen, 1978). Physically handicapping malocclusion would be one which severely compromises a person's oral health, such as clefts of the lip and palate (Corruccini, 1984). However Carlos (1974), at an international conference on *"Who needs and Wants Orthodontic Treatment"*, noted that from a public health standpoint, malocclusions which interfere with mastication, speech or jaw movement constitute a negligible problem.

Public orthodontic programmes are primarily aimed at addressing social handicap. Therefore, cut-off points for treatment should be established along a scale of social acceptability that represents the aesthetic norms and standards of the public at large, rather than on the individual's perceived need or desire for treatment (Jenny *et al.,* 1980).

PREVALENCE AND DISTRIBUTION OF OCCLUSAL TRAITS

The prevalence of malocclusion varies widely among different populations and countries and ranges from as low as 5% to 10% (Baume, 1974), 31% to 40% (Kapila; 1983), 41% to 50% (Kerosuo *et al.,* 1988), 51% to 60% (Tschill *et al.,* 1997), 61% to 70% (Al-Emran *et al.,* 1990; El-Mangoury and Mostafa, 1990), 71% to 80% (Helm, 1968; Cons *et al.,* 1978; Zietsman, 1979 Garner and Butt, 1985; Ng'ang'a *et al.*, 1996) and over 80% (Altemus, 1959;

Horowitz, 1970; Steigman *et al.,* 1983; Garner and Butt, 1985; Dacosta, 1999).

This wide variation in incidence, prevalence and severity must be interpreted carefully because of diagnostic subjectivity, the utilisation of different evaluation systems and vastly different sample sizes. These and other factors affecting the prevalence and distribution of occlusal traits are discussed below:

Definition Of Malocclusion

The wide variability in prevalence reported highlights the subjective definition of malocclusion. There is a lack of uniformity in the definitions of ideal (Angle, 1907; Andrews, 1972; Timm *et al.,* 1976; Vlachos, 1995) and normal occlusion (Johnson, 1923; Lombardi, 1982; Burdi and Moyers, 1988; Vlachos, 1995; Mossey, 1999). Therefore the measurement of malocclusion, which often is defined as any deviation from these, becomes difficult, since judgment on what constitutes a malocclusion is highly subjective (Baume, 1970; Künzel, 1987; Brunelle *et al.,* 1996). Moyers and Summers (1970) go as far as to suggest that different reports should not be compared with each other because of the differences in the definitions of the occlusal characteristics.

Methods of Assessment

The contrasting results in the prevalence of malocclusions that have been reported have been attributed to the differences in the diagnostic standards of the numerous indices used (Solow, 1970; Gravely and Johnson, 1974; Stricker *et al.,* 1979). In 1985, the World Health Organisation conducted a comprehensive study of occlusal traits in Australia, Canada, the Federal Republic of Germany and the German Democratic Republic, Ireland, Japan, New Zealand, Norway, Poland and the USA (Appendix II). Their results are of

significance as the occlusal traits recorded were by examiners calibrated to uniform standards (Künzel, 1987).

Occlusal Traits Being Measured

According to Thilander *et al.* (2001), the differences in the criteria for the recording of occlusal traits is probably the most important factor in explaining the differences in prevalence of malocclusion reported in the literature.

Although indices may differ in purpose and approach, most measure occlusal traits by looking at molar relationships, overjet and overbite, crowding and spacing, crossbites and malalignment. Of these traits, the molar relationship, overjet and overbite are the most emphasized.

One of the first recorded studies of the frequency of distribution of molar relationship was that of Angle (1899). He examined several thousand cases of malocclusion and found that 69.2% had Class I, 26.6% had Class II and 4.2% had Class III molar relationships. However the sample in Angle's study was not random but was restricted to individuals presenting with a malocclusion.

Urbanisation

Malocclusion has often been referred to as a "disease of civilization", signifying that it is found (or at least reported) primarily in developed, urbanised populations and uncommon in primitive groups (Lombardi, 1982; Corruccini, 1984).

With the rigors of a primitive diet, tooth surface is lost due to interproximal attrition. Mesial migration of the posterior teeth provides the functional maintenance of the occlusal table. In modern man there is little attrition of the

teeth because of a soft, processed diet and this has been implicated in the aetiology of dental crowding and impaction of the third molars. It is postulated that the tooth-jaw size discrepancy apparent in modern man was a survival mechanism in primitive man. Large jaws and teeth were a crucial biologic adaptation to maintain sufficient chewing surface area for long-term survival. Selection pressures for teeth large enough to withstand a rigorous diet have been relaxed only recently and the slow pace of evolutionary change has not yet brought the teeth and jaws into harmonious relationship (Lombardi, 1982).

It is suggested in the literature that the prevalence of malocclusion is lower in people living in rural areas when compared with those confined to an urban environment (Begg, 1954; Corruccini and Whitely, 1981; Corruccini, 1984; Otuyemi and Abidoye, 1993). Frequently mentioned influences on the oral environment related to urbanisation include caries, respiratory infection, nutritional and growth differences, premature deciduous tooth loss, and a change in dietary consistency and sugar content. Corruccini (1984) postulated that this may represent an epidemiologic transition in occlusal health, but data comparison has been hampered by inadequate controls and by lack of standardisation of the term malocclusion.

Genetics And Malocclusion

Contradicting views regarding the role of genetics and the environment in the aetiology of malocclusions are found in the literature (Corruccini and Whitley, 1981; Corruccini, 1984).

In craniometric and cephalometric studies of familial similarities, evidence supports the contention that facial form is largely a product of the person's genotype (Saunders *et al.,* 1980; Devor, 1987). However, it does not necessarily follow that tooth-based malocclusions are also inherited. Indeed, there is confusion in the literature between the causes of bone- and tooth-based malocclusion (Ackerman and Proffit, 1969). While many types of

malocclusions involve skeletal and/or dental disharmony, few studies investigating the role of heredity and the environment in their aetiology have taken this into account.

It is implied in anthropological literature that population groups that are genetically homogenous tend to have normal occlusion. According to Lombardi (1982), the observation that urbanised populations seemingly have a higher occurrence of malocclusion than do technologically primitive peoples has led to a widely held concept that the latter represent "pure" races, that they are genetically homogeneous and thus have close concordance between tooth and jaw size, whereas the high incidence of crowding in advanced populations is attributable to the intermarriage of individuals who differ widely in tooth and jaw size. In pure racial stocks, such as Melanesians of the Philippine islands, malocclusion is almost nonexistent. However in heterogeneous populations, the incidence of jaw discrepancy and occlusal disharmonies is significantly greater (Mossey, 1999).
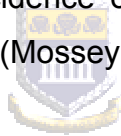
That malocclusion appears rapidly (within one generation) in some aboriginal peoples, once they are in contact with Western technology and food products, calls this "pure race" explanation into question (Hunt, 1961). The concept would be valid only if tooth and jaw size were simple Mendelian monogenic traits or were controlled by a small number of genes. If this were the case, dental spacing should occur about as frequently as crowding, but spacing is comparatively infrequent (Corruccini and Whitley, 1981).

Townsend and Brown (1978) noted that tooth and jaw size are polygenic traits, that is, they are controlled by the additive effect of at least a moderate number of genes and also that tooth and jaw size are not entirely independent of each other.

In a review of the literature, Smith and Bailit (1977) concluded that heredity played a far greater role than the environment in the development of malocclusions. However, Harris and Smith (1980) found that while genetic variation has a major effect on such features as arch width and arch length, environmental factors are more important for occlusal variables such as overjet, overbite, molar relationship, crowding, and rotations. Perhaps foremost in the controversy is the clarification of the source of error in twin and sibling studies. Sibling correlations tend to overestimate the additive genetic component because they incorporate any dominance effect and all acquired similarities that result from shared environments. Malocclusion, defined in the strict sense as tooth malpositions, is essentially an acquired condition (Harris and Johnson, 1991).

There is also evidence of a secular trend towards deeper, longer and narrower faces (Smith *et al.,* 1986) and an increased prevalence of malocclusion (Dixon, 1970; Weiland *et al.,* 1996; Brin *et al.,* 1998). Mossey in 1999 claimed that the trend towards narrower maxillary arches and greater crowding is compatible with a gene/environment interaction, where certain genetically determined craniofacial types tend to show a greater susceptibility to certain environmental factors. It is argued that this is proof of an environmental determination of certain types of malocclusion, but this is undoubtedly an over-simplification.

Diet

A common finding in most of the societies with little crowding is a high degree of interproximal and occlusal attrition. The frequent references to good Aboriginal occlusion have motivated theories to explain Western occlusal deterioration.

Begg (1954) thought that elimination of a gritty diet and the resultant interstitial attrition causes crowding in modern man. He determined that among Australian aborigines consuming a primitive diet nearly 11 mm of arch length could be lost to interproximal wear. Wolpoff (1971) claimed that the wear among Australian aborigines could exceed 21 mm of arch length and also found considerable interproximal wear in Eskimo and American Indian populations and in chimpanzees.

Begg's analysis indicated that interproximal wear is highly correlated with the chewing force required by the diet. A diet consisting largely of tough foods requires high chewing forces that cause lateral movement of the teeth relative to each other. This rubbing of adjacent teeth is the cause of interproximal wear. The amount of particulate matter or grit in the diet is a secondary factor, although it accounts for most of the occlusal wear. Advanced populations that consume a diet composed of cooked or processed foods, do not require the large chewing forces that lead to lateral movement of the teeth and interproximal wear. The low incidence of crowding in primitive populations seemingly results from the high degree of interproximal attrition and not from a more harmonious concordance of tooth and jaw size (Lombardi, 1982).

Although Begg correctly asserted that insufficient jaw to tooth size is the fundamental basis of malocclusion, it now seems that some human groups with reduced attrition show no increase in crowding (Lombardi, 1982) and that smaller jaws, not larger teeth underlie crowding. Howe *et al.* (1983) found that dental crowding in European ancestry appears to be related to a deficiency in arch perimeter than to teeth that are too large. Furthermore, the Begg model has always been deficient in explaining early incisor crowding (Lombardi, 1982), and other occlusal factors such as posterior crossbite and buccal segment relationships.

Age

The age groups of the subjects studied have never been standardised thus making comparisons between them difficult. Baume (1970) noted that the relations and proportions of dentofacial structures undergo continuous change during individual development. The age of the population studied may affect the prevalence since the degree and incidence of crowding tend to increase with age, at least through the first two decades of life (Lombardi and Bailit, 1972; Künzel, 1987; Tod and Tavern, 1997). The prevalence of certain occlusal traits, particularly anterior irregularity, posterior mandibular crowding, posterior rotations and posterior crossbite, has been found to increase with age (Tod and Taverne, 1997; Hong *et al.,* 2001).

Thilander *et al.* (2001), however, felt that malocclusions are a manifestation of morphological variations that are related to the development of the dentition, rather than to chronological age per se.

EPIDEMIOLOGICAL SURVEYS

Epidemiology was originally concerned with the study of the mass outbreak of communicable diseases. Now it defines the study of any disease or disability under the natural conditions of its occurrence, with control of the disease or disability as the ultimate objective (Moyers and Summers, 1970).

The epidemiology of occlusal conditions dates back to Hippocrates who, over twenty-four centuries ago, included the condition of crooked teeth in his sixth book on epidemics. Although great strides have since been made in the field of classification and treatment of malocclusion, it is a fact that the epidemiologic assessment of these conditions still remains little explored (Baume, 1970). In an international collaborative study of dental manpower systems, the World Health Organisation in 1985 published epidemiological

data from various industrialised nations that did not indicate any change in the prevalence of dentofacial anomalies. They underlined the fact that more attention should be paid to the problem of orthodontic treatment and that the approach needs to differ from country to country (Künzel, 1987).

A review of the literature found that most of the investigations were published between the 1940s and the 1970s. In the past three decades, there have been few publications discussing this topic (Tang and Wei, 1993). Recent publications (Brook and Shaw 1989; Shaw *et al.,* 1991; Daniels and Richmond, 2000) have focused more on determination of treatment needs and treatment outcomes as opposed to documenting the malocclusion in a given population. There has been some renewed interest in measuring malocclusion because there is a need for data that establish a reliable basis for predicting the health risks associated with different occlusal traits (Geiger, 2002).

According to Baume (1970), the collection of epidemiological data is usually through the use of descriptive surveys that establish the geographic pathology of the disease, administrative surveys that are employed in planning the treatment and collective prevention of a disease as well as evaluation of the services provided, or constructive surveys that look at aetiological and ecological aspects of a disease and compare cohorts that have or have not been exposed to certain factors. In addition, they are also useful in comparing populations and screening groups for orthodontic treatment need (Foster, 1980).

For each of these purposes, one requires a standard technique that is simple, precise, valid and reproducible. This should cover sampling, collection of data by reference to suitable indices and criteria and standardisation of statistical analysis and the interpretation of results (Baume, 1970). Although indices are

used as registration tools, many of the occlusal surveys in the literature may be of little value for comparative purposes since they lack standardised assessment methods (Foster, 1980).

CRITERIA FOR AN IDEAL INDEX

The accurate assessment of malocclusion is problematic, both for investigators involved in epidemiologic research and for those concerned with establishing priorities in selecting cases for orthodontic treatment. As with any diagnostic test, the most important criteria for any index used in this manner are its reliability and validity, the evaluation of which involves logical and statistical rather than clinical considerations (Carlos, 1970). Although a number of scoring systems have been developed for the standardised assessment of malocclusion, there continues to be concern about the validity of such measures, particularly in terms of the degree to which scores reflect the clinical judgments made by orthodontists (Carlos, 1970; Lewis *et al.,* 1982).

Reliability of an Index

Reliability (precision or reproducibility) of an occlusal index requires that repeated measures by the same or different raters yield the same result (Carlos, 1970; Beglin *et al.,* 2001). Massler and Frankel (1951) reported that in order to get reliable information on the prevalence of malocclusion, the technique of investigation and registration should be simple, reproducible, and it must yield quantitative information that will lend itself to statistical analysis. Carlos (1970) emphasised the need for a method of measurement that would have a high reliability across examiners as well as be precise in the description of occlusion.

The bias, or systemic error, of an index or measurement is the magnitude and direction of its tendency to measure something other than for what it was intended. The score of an unbiased index should be an accurate reflection of the characteristics measured. An index could be precise but biased. In such a case, the score will be reproducible but not an accurate portrayal of the occlusion (Tang and Wei, 1993).

Validity of an Index

The validity of an index is its ability to accurately measure what it set out to measure (Carlos, 1970; Tang and Wei, 1993; Shaw *et al.,* 1995; Beglin *et al.*, 2001).

Carlos (1970) stated that epidemiological surveys would be valid if, in describing its use, an investigator provides a clear statement of what is measured and how it should be measured. This constitutes a working definition of the condition being studied. The data collected and comparisons made on this basis are valid, even though another investigator may not completely agree with the variables included or the methods of measurement.

According to Moyers and Summers (1970) a basic defect is defined as a constant occlusal dysfunction that exists before, during and after the development of the occlusion. Occlusal disorders may consist of either a basic defect or a symptom of developmental change, and for an index to be valid during time, it must concentrate on, and be sensitive to the basic defect and not the symptom. Furthermore, they added that double scoring should be eliminated and there must be agreement in defining and choosing the characteristics as well as the methods for scoring.

Summers (1971) suggested that an index should be "valid over time" and should also consider the normal development of occlusion. For this, the

scoring for the occlusal disorder should either remain the same or increase with time, indicating that the disorder is the same or getting worse. The score should not decrease with time, as this would indicate that the occlusal disorder is self-correcting. Although there is frequent mention in the literature of the self-correction of malocclusion, there actually are few instances whereby they spontaneously resolve (Bishara, 2001).

Attempts to establish the validity of an index intended for administrative purposes is often unsuccessful since the reference criteria used, for example, clinical judgement, is difficult to standardise (Baume and Maréchaux, 1974). Recently, using the opinion of panel orthodontists as the "gold standard" has become an accepted technique in establishing and validating occlusal indices (Brook and Shaw, 1989; Richmond *et al.,* 1992; Beglin *et al.*, 2001). However, there is evidence to suggest that the location where an orthodontic specialist practices has an effect on their evaluation of the need for treatment (Younis *et al.,* 1997; Richmond and Daniels, 1998). Therefore, the decision threshold of an index may require adjustment for different national standards before application in a new setting (Beglin *et al.,* 2001).

OCCLUSAL INDICES

Several indices have been developed to measure malocclusion of which there are five broad categories of indices, each for a distinct purpose (Shaw *et al.,* 1995). Indeed, it is the purpose rather than the content of an index that distinguishes it.

Diagnostic Classifications

The classification of static, morphologic occlusion has been of interest to dentistry for at least a century. Arguably, Angle's classification is the most widely used and accepted occlusal classification system, for instance, it was

adopted by the American Board of Orthodontics in its Phase III examination (Du *et al.,* 1998).

Criticism of Angle's classification has come from several sources. Firstly, there are those who have challenged this classification by developing their own systems (Dewey, 1915; Simon, 1932; Dewey and Anderson, 1935; Ballard and Wayman, 1964; Ackerman and Proffit, 1969; El-Mangoury and Mostafa, 1990; and Katz, 1990, 1992a, 1992b). Dewey (1915) noted that because the first maxillary molar is just as liable as any other tooth to assume an abnormal position, classification should be based on the antero-posterior relation of the arches as a whole rather than only the first molars. He introduced three types of sub-classifications to Class I malocclusion. Anderson later added two more (Dewey and Anderson; 1935) and recently, El-Mangoury and Mostafa (1990) added yet another two.

Simon (1932) developed his gnathostatic system which related the dentition to the cranium in the three dimensions of space. While this was advanced for his time, acceptance of his method was hampered by the complexity of the equipment and the high degree of precision required. This concept of three-dimensional orientation of the dentition to the cranium is the forerunner to modern day gnathology. In addition to describing malocclusion in three planes of space, Ackerman and Proffit (1969) included occlusal alignment, profile and soft tissue in their classification scheme.

In 1964, Ballard and Wayman introduced the British Standard Classification of Malocclusion that described incisal relationship. It has however been found to have poor reliability and gives no indication of treatment need (Williams and Stephens, 1992; Du *et al.,* 1998).

Secondly, there are those authors who have criticised Angle's classification, without having proposed alternatives. Case (1963) slated the Angle's classification for its total disregard of the relationship of the teeth to the face. Horowitz and Hixon (1966) argued that Angle's classification ignores the dentoalveolar and skeletal contributions to the malocclusion. Other authors criticise its failure to recognise that malocclusion is a three-dimensional problem by only taking into account antero-posterior deviations in the sagittal plane (Ackerman and Proffit, 1969; Isaacson *et al.,* 1975; Rinchuse & Rinchuse, 1988; Graber and Vanarsdall, 2000). Rinchuse and Rinchuse (1988) noted that the Angle classification is a system of discrete classes measuring a continuous variable. And furthermore, that the description and definition of his classes was not clear, and that his writings were equivocal leading to the possibility of one class overlapping another; this despite Angle (himself) having admitted that his classification system does not address all possible malocclusion types, such as the case where one side is Class II and the other is Class III. Graber and Vanarsdall (2000) point out that the classification fails to distinguish the malocclusions with analogous anteroposterior relationships, which would require different treatment plans.

Although Angle's classification was originally devised as a diagnostic tool, it has been widely used for epidemiological purposes. Questions have been raised regarding its reliability (Gravely and Johnson, 1974; Jago, 1974; Katz, 1992). Angle's classification was demonstrated to be the least reliable when compared with the Katz and the British Incisor Classifications. All these limit its use as a tool for epidemiologic research (Du *et al.,* 1998).

Indices Of Malocclusion Severity, Treatment Priority, Treatment Need And Treatment Outcome

Indices developed for categorising malocclusion severity and treatment need summarise sets of data about the malocclusion and assigns a numerical

value and categorising the need for treatment. (Massler and Frankel, 1951; Van Kirk and Pennel, 1959; Draker, 1960; Poulton and Aaronson, 1961; Grainger, 1967; Salzmann, 1968; Summers, 1971; Brook and Shaw, 1989). For each index, there is a cut-off point below which there is no need for treatment, and all values above that point for which treatment is indicated.

Generally the goal of these indices is to assign limited state resources to the most severe malocclusion, or as guidelines in orthodontic risk/benefit analysis (Otuyemi and Jones, 1995). However, these indices may be of limited use because traditional orthodontic practice is qualitative in nature (Beglin *et al.,* 2001).

An Index of Tooth Position

Massler and Frankel (1951) made the initial attempt to develop a quantitative method of assessing malocclusion. In this "Index of Tooth Position", the total number of displaced or rotated teeth was the basis for the evaluation of prevalence and incidence of malocclusion in population groups. Assessment was based on individual teeth as units of occlusion rather than on arch segments. Tooth displacement, rotation, infra-occlusion and supra-occlusion were recorded. The number of maloccluded teeth was summed up to give an overall measure of malocclusion.

Unfortunately, this was not reliable because of the difficulty in judging the conformity of each tooth to an ideal position in all planes of space. Furthermore, because each tooth was recorded in an all or none manner - maloccluded or aligned, it gave no relative indication of severity (Otuyemi and Jones, 1995).

The Malalignment Index

Van Kirk and Pennell (1959) proposed the Malalignment Index (MI), which involved the grading of tooth displacement and rotation. This index examined the arches in isolation, with each arch divided into three segments. They quantitatively defined two malocclusion traits: tooth displacement and rotation, the scores of which were summed up to give a full-mouth index.

This method of scoring did not reflect the true severity of the malocclusion because no account was taken of the relationship between the upper and lower teeth in occlusion (Otuyemi and Jones, 1995).

The Handicapping Labio-Lingual Deviations Index

The Handicapping Labio-Lingual Deviations (HLD) Index was developed by Draker in 1960. The index was composed of twelve features that were weighted and then summed up to provide a score. This index was proposed to complement, and perhaps substitute clinical judgement when screening subjects with handicapping anomalies.

Carlos and Ast in 1966 tested the ability of the HLD Index to distinguish "handicapping" and "non-handicapping" malocclusions. Clinical judgement made by orthodontists was used as the gold standard. The major flaw observed with this index was that the scores were found to be largely overlapping, indicating that the HLD Index was unable to distinguish the so-called handicapping malocclusion. Gray and Demirjian (1977) also noted that the HLD Index tended to identify only the very worst cases and was therefore deemed unacceptable for overall field use. One advantage, though, is that special equipment was unnecessary when compared with earlier indices (Otuyemi and Jones, 1995).

The Occlusal Feature Index

The Occlusal Feature Index (OFI) proposed by Poulton and Aaronson in 1961 was developed to measure malocclusion in population studies. The index was based on four primary features of occlusion considered to be of importance in orthodontic examination, namely, lower anterior crowding, cuspal interdigitation, overbite, and overjet. Scores were allocated for specific deviations from normal for each criterion and summed to give an overall index within the range 0-9, with zero denoting normal occlusion. Although this index was considered incomplete since only four features of occlusion were measured and scored (Tang and Wei, 1993), it has been found to have reasonable inter-examiner reliability and good correlation with treatment need (Otuyemi and Jones, 1995).

Malocclusion Severity Estimate

The malocclusion severity estimate (MSE) was developed by Grainger in 1960. The MSE score was that of the syndrome with the largest value, regardless of the scores of the other syndromes. When the validity of the MSE was tested according to aesthetics, function, and treatment difficulty, it was found to be highly reproducible. However, there are possible shortcomings to this index, namely:

(1) The index was derived from data of 12 year-old patients and therefore might not be valid for earlier stages of dental development in the deciduous and mixed dentitions;

(2) The MSE score did not reflect all the measurements that were made and

(3) The absence of any occlusal disorder was not scored as zero (Tang and Wei, 1993).

Treatment Priority Index

Grainger (1967) later revised the MSE and called it the Treatment Priority Index (TPI). He described the TPI as a method of assessing the severity of the most common types of malocclusion, and hence, providing a means of ranking patients according to the severity of malocclusion, the degree of handicap, or their priority of treatment. This index defined seven natural groupings of malocclusions which tended to occur jointly and which were referred to as "syndromes". These included unacceptable aesthetics, significant reduction in masticatory function, traumatic condition predisposing to tissue destruction, speech impairment, unstable occlusion and gross or traumatic defects. Subjects were scored according to the syndrome observed with normalities scored as zero (Grainger, 1967).

Although the TPI was highly reproducible, it needed very close and careful examination. Subjective decisions were required, for example, when deciding whether the molar relationship was distal or mesial by half a cusp or more than half a cusp on each side, or in determining whether some teeth were rotated by 35° to 45° or more than 45°, and in determining displacement by 1.5 to 2mm or more than 2mm (Gray and Demirjian, 1977).

Ghafari *et al.* (1989) did a longitudinal evaluation of the TPI and found that it was a valid epidemiologic indicator of malocclusion. However, the values recorded in the transitional dentition did not predict the future severity of malocclusion in the permanent dentition. In an attempt to revise the MSE, the TPI was corrected for scoring normalities as zero but the "mixed dentition analysis", which measured potential tooth displacement, was deleted. This rendered it inadequate for assessing the occlusion of the deciduous or mixed dentitions (Tang and Wei, 1993).

Handicapping Malocclusion Assessment Record

In 1968, Salzmann developed the Handicapping Malocclusion Assessment Record (HMAR). The purpose of this was to provide a means for establishing priority for treatment of handicapping malocclusions. He defined handicapping malocclusion and handicapping dentofacial deformity as conditions that constitute a hazard to the maintenance of oral health and interfere with the well-being of the patient by adversely affecting dentofacial aesthetics, mandibular function, or speech. A cut-off point was set according to the gold standard established by orthodontists from various parts of the United States.

One important aspect of the HMAR is that it recorded and weighted functional problems, which no other index at the time had addressed. Also, subjective decisions were not as critical as with the TPI or Occlusal Index (OI) (Summers, 1971), because only full-cusp discrepancies were noted. If errors were made, they were not usually serious because the weighting system applied was only to the anterior segment and mostly for aesthetics. The recording and calculation of the index was also simpler and required less time (Tang and Wei, 1993). An added advantage of the HMAR system is the ability to record data without the need for a millimetre gauge, thereby reducing the likelihood of clerical errors (Otuyemi and Jones, 1995).

However, the HMAR was found to have less precision and more bias when tested against the OI and the TPI (Hermanson and Grewe, 1970; Grewe and Hagan, 1972).

The Occlusal Index

The Occlusal Index (OI), presented by Summers in 1971, scores nine characteristics at different stages of dental development. These characteristics include dental age, molar relationship, overjet, overbite,

posterior crossbite, posterior open bite, actual and potential tooth displacement, midline deviations and missing permanent maxillary incisors. Like the TPI, this index is adjusted for normality, so that the absence of any occlusal disorder is scored as zero.

However, Gray and Demirjian (1977) observed that unlike the TPI, the OI may be difficult to compute in field studies as it is expressed as a decimal instead of an integer value. So and Tang (1993) criticised it for failing to score missing teeth other than upper incisors where pre-restorative orthodontics might be needed hence suggesting that this tended to underestimate treatment need. The OI is also time consuming and cumbersome to use, involving a long complex procedure of scoring, thereby making research and audit difficult. It would therefore require more calculations and clerical time (Otuyemi and Jones, 1995).

Despite the criticisms of the OI, it has been shown to be one of the more valid and reliable indices of treatment need (Hermanson and Grewe, 1970; Summers, 1972; Grewe and Hagan, 1972; Pickering and Vig, 1975; Gray and Demirjian, 1977) and has even been used by some investigators to assess orthodontic treatment outcomes (Tang and Wei, 1990).

The Dental Aesthetic Index

The Dental Aesthetic Index (DAI) is an assessment of treatment need based on the evaluation of aesthetics (Cons *et al.,* 1986). It holds to the premise that a dental appearance which deviates from social norms may have a negative impact on the social and psychological aspects of the individual. Cons *et al.* (1986) developed an index that concentrated on the correlation between occlusal morphology and socio-psychological handicaps. The DAI evaluates ten occlusal features: overjet, underjet, missing teeth, diastema, anterior open bite, anterior crowding, anterior spacing, mandibular protrusion, largest

anterior irregularity (maxilla and mandible), and anteroposterior molar relationship. One of the notable features of this index is its ease of measurement. An added advantage is that this index provides good sensitivity, but at the cost of over-estimation of the number of subjects requiring treatment (Keay *et al.,* 1993).

The DAI is limited by its failure to assess treatment need during the mixed dentition effectively. It also cannot distinguish features that constitute aesthetic impairment like dental midline discrepancy, traumatic deep bite, posterior crossbite and open bite, which, although of limited aesthetic importance, can undoubtedly, affect the need for orthodontic treatment (Otuyemi and Jones, 1995).

Index of Orthodontic Treatment Need

Brook and Shaw in 1989 formulated the Index of Orthodontic Treatment Priority. This was later named the Index of Orthodontic Treatment Need (IOTN). The IOTN has two discrete components namely a clinical (the dental health component and an aesthetic component). The dental health component has five grades ranging from grade one, "no need" for treatment, to grade five, "very great need." A grade is allocated according to the severity of the worst single trait that describes the priority for treatment. The aesthetic component consists of a series of numbered photographs that are rated for attractiveness on a 10-point scale. The purpose of the IOTN was to rank malocclusion based on the significance of various occlusal traits for dental health and aesthetic impairment, with the intention of identifying those who would be most likely to benefit from orthodontic treatment (Otuyemi and Jones, 1995).

Cooper *et al.* (2000) found the IOTN to be reliable over time when taking into account the occlusal changes that take place during the 11-19-year age

range. Their study provided some reassurance to clinicians that an IOTN grading at eleven years was unlikely to change by the age of nineteen.

One setback that Evans and Shaw (1987) observed was that the aesthetic scale had a poor ability to represent dentofacial imbalance in the anteroposterior plane. Ghafari *et al.* (1989) stated that although epidemiologic indices are helpful in describing the general need for treatment in a given population, they should not be applied to the individual patient. At the population level, problems that are functionally handicapping are ranked first, while those involving a single tooth or minimally affecting an individual's well being are ranked last. However, on an individual level, even minor displacement of a single tooth could well be the cause of complaint. The IOTN weights tooth displacements heavily; this may be oversensitive, especially when the index is being used as an epidemiological tool (So and Tang, 1993).

When looking at the predictive, specificity and sensitivity values for the DAI, HLD and IOTN, Beglin *et al.* (2001) found that these indices have cut-off points that underscore and are set to exclude many malocclusions that the orthodontist panel would have treated.

Peer Assessment Rating Index

The Peer Assessment Rating Index (PAR) was developed as an index of treatment standards. The subject is scored both at the start and at the end of treatment and the change in total score reflects the success of treatment in achieving overall alignment and occlusion (Shaw *et al.,* 1991).

The Index of Complexity, Outcome and Need

The Index of Complexity, Outcome and Need (ICON) was developed as a single index for assessing treatment inputs and outputs. The aesthetic

component of the IOTN as well as crossbites, upper arch crowding/spacing, buccal segment anteroposterior and anterior vertical relationships are scored on study casts and used to predict treatment need, outcome and complexity (Daniels and Richmond, 2000).

Fox, Daniels and Gilgrass (2002) when comparing the ICON with the PAR and IOTN found that it showed significant correlations with these two indices and concluded that the ICON as a single index may effectively replace them as a means of determining treatment need and outcome.

Epidemiological Indices

Method For Epidemiological Registration Of Malocclusion

Björk *et al.* (1964) introduced a system of registration of malocclusion for epidemiological purposes. This system defined symptoms based on three main features, namely; anomalies in the dentition, occlusion and space conditions which were objectively recorded thus facilitating direct computer analysis of the data.

The advantage of this principle of registration is that any malocclusion may be described in terms of a combination of well-defined single symptoms within these three groups. Although an indication of the need for treatment is included in this registration, Björk *et al.* (1964) acknowledged that this item cannot be recorded objectively in the same way as that of the occlusal traits and would therefore have to be based on individual estimates.

Another shortcoming of this method is that because it was designed with a view to electronically analyse the data, it is rather detailed with a total number of 567 features recorded on the score sheet and as such, simplification of the examination procedure becomes necessary. A specially designed instrument

is required to register the occlusal traits, making it impractical for field studies (Otuyemi and Jones, 1995).

<u>The FDI Commission on Classification and Statistics for Oral Conditions Method for Measuring Occlusal Traits</u>

At the International Conference on the Epidemiologic Assessment of Dentofacial Anomalies, held in New York in 1969, the Fédération Dentaire Internationale (FDI) Commission on Classification and Statistics for Oral Conditions (COCSTOC) was assigned the task of evaluating the problem of assessing the occlusal status and developing a system which could be widely applied. It was emphasized that before methods for estimating treatment need and demand could be developed agreement on the recording of the individual traits of malocclusion was essential (Solow, 1970; Baume *et al.,* 1973). A simplified method was developed during the years 1969-1972 by the Working Group 2 (WG2) of the FDI COCSTOC to record individual traits of malocclusion. This method was field tested and modified by Baume *et al.* (1973).

The FDI method provided a means to assess, and measure pertinent morphologic traits of malocclusion so that the incidence of each trait either separately or in combination, and their interrelationships could be subjected to statistical analysis.

This method was not designed for subjects who are still in the mixed dentition but was based on those with a full complement of the permanent dentition (not including the third molars). Although this index also takes into account the presence of supernumerary teeth and is the only method that indicates gingival trauma through excessive overbite, it offers no information on combinations of occlusal traits that are responsible for total appearance.

Bezroukov and co-workers in 1979 presented the results of collaboration between the World Health Organisation (WHO) and the FDI and proposed the WHO/FDI method of recording occlusal traits. The primary objective of the index was to determine prevalence of malocclusion and dental irregularities as well as to estimate the treatment needs of a population, as a basis for the planning of orthodontic services. The indications for treatment were scored in four categories: treatment not necessary, doubtful, necessary and urgent. This addition to the FDI method undermines its objectivity and introduces a high degree of clinical judgement.

Kinaan and Burke (1981)

Kinaan and Burke (1981) proposed a method whereby five features were assessed namely; overjet, overbite, posterior crossbite, buccal segment crowding and incisal alignment. Each dental arch was divided into three segments, an incisal segment and two buccal segments. The segments rather than individual teeth were then assessed in terms of intra-arch alignment and inter-arch relationships. However, this method requires four registration instruments for direct intra-oral assessment which makes it rather impractical for epidemiological purposes.

SELECTION OF AN INDEX

The selection of an index for measuring any condition is dependent on the aims of the investigation in which the index is to be used. This selection is informed by the nature of the information required as well as the ability of the examiner to reproduce the measurements, on which the scale is based, consistently (Barmes, 1981).

The requirements for an ideal index of occlusion are similar to those of any dental index, and were summarized in a World Health Organisation Report in

1966. This report urged that an index should be equally sensitive along its scale. The index value should closely correspond to the clinical importance of the stage of the disease it represents and should be amenable to statistical analysis. The equipment and instrumentation required should be practical for field situations and the examination procedure should eliminate subjective judgement. The index should also allow for the cost effective study of large populations.

The development of a uniform method of assessment and grading of malocclusion has eluded epidemiologists for several decades. Researchers have highlighted that the inability to develop a universally accepted index is due to the multiplicity of measurement methods, variations in terminology and concepts as well as the difficulty in standardizing the criteria (Summers, 1971; Baume *et al.,* 1973; Jago, 1974). Baume and co-workers (1973) emphasized the difficulty to establish meaningful cut-off points when looking at occlusal traits so as to distinguish those who require treatment from those who do not. As McLain and Proffit (1985) asked, at which point along the continuum of variation for every occlusal feature does the need for treatment begin? The measure of treatment need in itself is subjective and probably the only objective way to judge treatment need is on the basis that every deviation from the ideal needs correction. When any other type of assessment is used, then reliability is reduced (Foster, 1980).

A fundamental flaw in all indices that measure treatment need, treatment priority or malocclusion severity is the subjective nature of assessment. Ultimately it would be desirable to have a method of assessing the need for orthodontic treatment within the framework of varying cultural, social and economic standards, but this goal is unachievable as long as methods for measuring the social-psychological factors too remain subjective (Baume *et al.,* 1973).

The Fédération Dentaire Internationale Commission on Classification and Statistics for Oral Conditions method of measuring occlusal traits (MOT) was developed as an objective method of registration. This index is neither intended to measure the severity of malocclusion or the treatment needs, nor is it meant to define handicapping dentofacial anomaly or malocclusion. It is the attempt at excluding the subjectivity of clinical judgement seen in the other indices that makes the method for measuring occlusal traits proposed by Baume *et al.* (1973) ideal for epidemiological surveys of malocclusion.

CHAPTER THREE:

AIM, OBJECTIVES AND

METHODOLOGY

AIM

To determine the prevalence of occlusal traits in an adolescent population in Kampala, Uganda.

OBJECTIVES

1. To determine the incidence of anomalies of development of the dentition, missing teeth and retained primary teeth.
2. To assess arch space discrepancies and anterior irregularities.
3. To evaluate the lateral and incisal anteroposterior, vertical and transverse inter-arch relationships.

METHODOLOGY

Study Design

This is a descriptive study documenting the occlusal traits of the sample population.

The Population Sample

Uganda has a total area of 241,038 sq km. The country measures 625 km east to west and 638 km north to south. Kampala is the capital city of Uganda. The National Population Census Report of 2002 revealed that the population of Uganda was 24.55 million and that of Kampala was 1,208,544. In Kampala, 20% of the population was under five years and 52% was under fifteen years.

Sample Size Calculation

The sample was drawn from the 135 secondary schools in Kampala. In selecting the sample, the following assumptions had to be made:

1. The number of 14-year old children is evenly distributed among the 135 secondary schools in Kampala.

2. There is an even distribution within the 5-15 year group.

   52% x 1,208,544 = 628,443 under 15 years

   20% x 1,208,544 = 241,709 under 5 years

   The difference: 386734 are in the 5-15 year age group.

3. Therefore the number of 14-year-old children would be one-tenth of the total i.e., 38,673. The sample size was thus calculated using EPI 2000 statcalc for population surveys at the 95th confidence level and arrived at a sample of 400 subjects.

Sampling Method

A multistage sampling method was adopted, the first stage being the selection of schools. Every tenth school was selected from an alphabetical list of the 135 secondary schools in Kampala. A total of thirteen schools were visited. The secondary sampling unit involved selecting the subjects. A selection of thirty-one 14-year-olds from an alphabetical register of Senior One students was examined from each school. A total of 402 children were examined, which is about 2% of the total 14-year-old population in Kampala District.

Inclusion Criteria

The subjects had to be fourteen years old as at their last birthday. This age group was selected because the full complement of the adult dentition is expected in the mouth, without the attendant perio-prosthodontic problems associated with adults (Baume *et al.*, 1973). Investigators argue that values recorded in the transitional dentition do not predict the future severity of malocclusion in the permanent dentition (Ghafari *et al.,* 1989; el-Mangoury and Mostafa, 1990).

Unlike Björk's method for epidemiological registration of malocclusion, the COCSTOC-MOT does not exclude subjects of the basis of previous extractions. All subjects with previous extractions were therefore included.

However, all subjects who had prior orthodontic treatment were excluded.

Intra- Examiner Reliability

A pilot study on ten randomly selected dental students at the University of the Western Cape was done and the intra-examiner reliability was found to be 85%. Since the COCSTOC-MOT does not state a level of agreement for intra-examiner reliability, this was considered acceptable. During the study itself, intra-examiner reliability was assessed by the random re-examination of 10% of the sample population.

Ethical Statement

Ethical clearance was obtained from the research committees of the University of the Western Cape and Makerere University. Permission was sought from the school authorities and consent forms were circulated to the parents or guardians of the selected subjects prior to examination (Appendix III and IV). Those without consent were excluded and replaced by other subjects selected in the same school. The data collected was serialized in order to maintain anonymity of the subjects. All children found to need dental care were referred to the Mulago Hospital Dental Clinic for further attention.

Data Analysis

The data were captured on Microsoft Excel worksheets and analysed using the SPSS 11.0 package.

MATERIALS

The materials used included the following (figure 1):

- A mouth mirror
- A periodontal probe
- Disposable gloves
- A sharp HB pencil
- An orthodontic ruler
- A Nikon 995 Coolpix Digital Camera
- The FDI Commission on Classification and Statistics for Oral Conditions (COCSTOC-MOT) examination form by Baume *et al.* 1973 (Appendix I).

Instruments

Figure 1

METHOD OF EXAMINATION

Examination Procedure

The subjects were made to sit on a chair directly facing the examiner under natural light.

The occlusal traits were recorded on the COCSTOC-MOT examination form (Appendix I) by one clinical examiner and one recorder.

Dental Measurements

According to the FDI method, a tooth is considered impacted if there is no history of previous extraction(s), and if the contour of the underlying ridge indicates the presence of a tooth. It is considered missing due to extraction when there is reduction in alveolar bone in the extraction site. If the subject has no history of previous extraction(s), and if the contour of the underlying ridge does not indicate an impacted tooth, the examiner can assume the tooth to be congenitally missing.

Measurement of Incisor Alignment

The scoring involved measuring, in millimetres, the linear displacement of anatomic contact points, as distinguished from the clinical contact points, of each maxillary and mandibular incisor from the adjacent tooth anatomic point. The sum of these five displacements represents the degree of irregularity in the alignment of incisors in each jaw. Perfect alignment from the mesial aspect of the left canine to the mesial aspect of the right canine would have a score of zero, with increased crowding represented by greater displacement and, therefore, a higher index score. Using an orthodontic ruler, contact points were scored to the nearest whole millimetre. Missing or broken were entered as unrecordable as shown in figure 2.
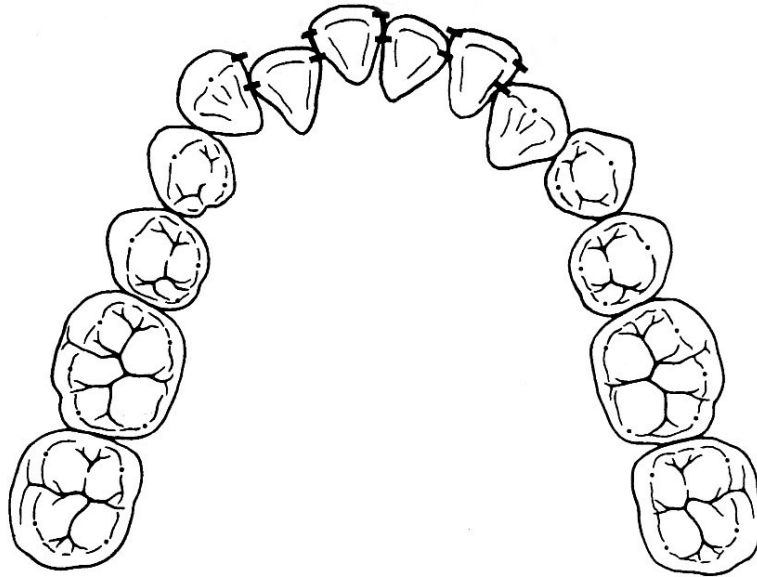
Figure 2

Measurement of Maxillary Midline Diastema

The millimetric measurement of the space between the maxillary central incisors was recorded (figure 3). If one or more teeth were missing, no assessment was made and it was thus regarded as "unrecordable".

Figure 3

Measurement of Molar Relationship

The anteroposterior relationship of the first permanent molars was recorded as illustrated in figure 4:
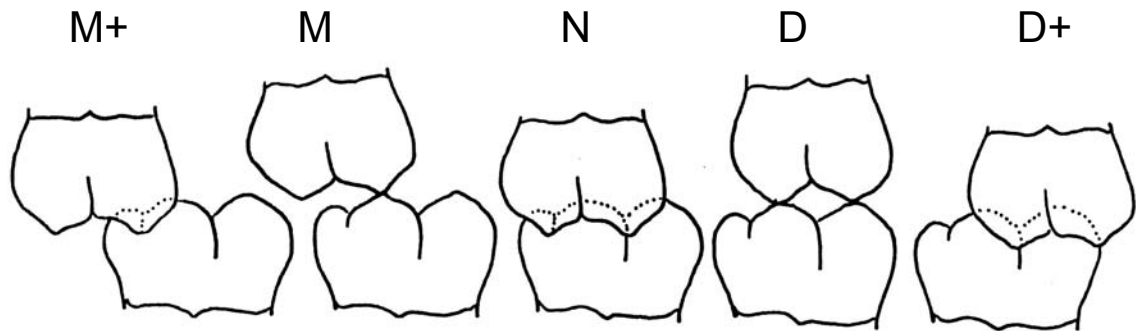
Figure 4:

M+: The mesiobuccal cusp of the upper first molar articulates with the distobuccal groove of the lower first molar or the interproximal space between the lower first and second molars.

M: An end-to-end relationship exists whereby the tip of the mesiobuccal cusp of the upper first molar articulates with the tip of the distobuccal cusp of the lower first molar.

N: A normal relationship exists whereby the mesiobuccal cusp of the upper first molar articulates with the buccal groove of the lower first molar.

D: An end-to-end relationship exists whereby the tip of the mesiobuccal cusp of the upper first molar articulates with the tip of the mesiobuccal cusp of the lower first molar.

D+: The distobuccal cusp of the upper first maxillary molar articulates with the buccal groove of the lower first molar.

Measurement of Posterior Openbite

Visual assessment from the canine to the second molar was done. Posterior openbite was recorded as the absence of vertical overlap of the posterior teeth when the subject is in centric occlusion.

Measurement of Posterior Crossbite

Visual assessment from the canine to the second molar was done. Posterior crossbite was recorded as "normal" if the buccal cusps of the mandibular teeth articulated between the maximum heights of the buccal and lingual cusps of the opposing maxillary teeth. It was recorded as "buccal" (B) if the buccal cusp of a mandibular tooth lies lingual to the maximum height of a lingual cusp of an opposing maxillary tooth. It was recorded as "lingual" (L) if the buccal cusp of a mandibular tooth lies buccal to the maximum height of a buccal cusp of an opposing maxillary tooth (figure 5).
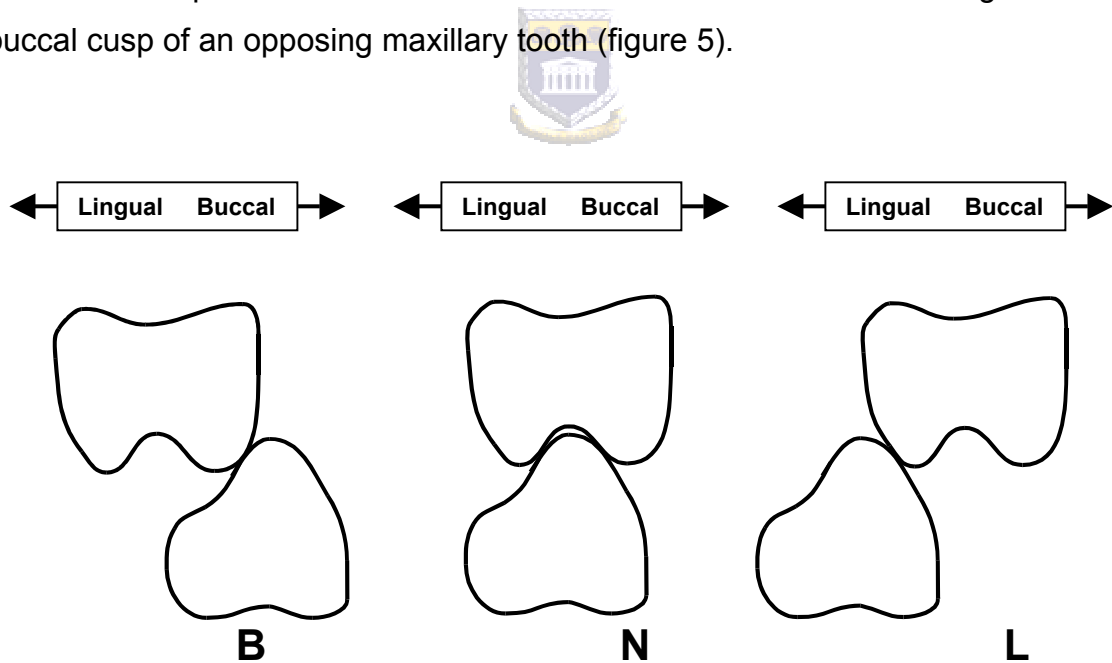
Figure 5

Measurement of Overjet

Overjet was defined as the horizontal overlap of the incisor teeth in centric occlusion (figures 6 and 7). It was measured to the nearest whole millimeter from the midpoint of the labial surface of each upper incisor to that of the lower incisor parallel to the occlusal plane with the patient in centric occlusion. A negative sign denoted a reverse overjet.
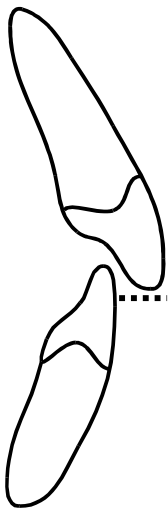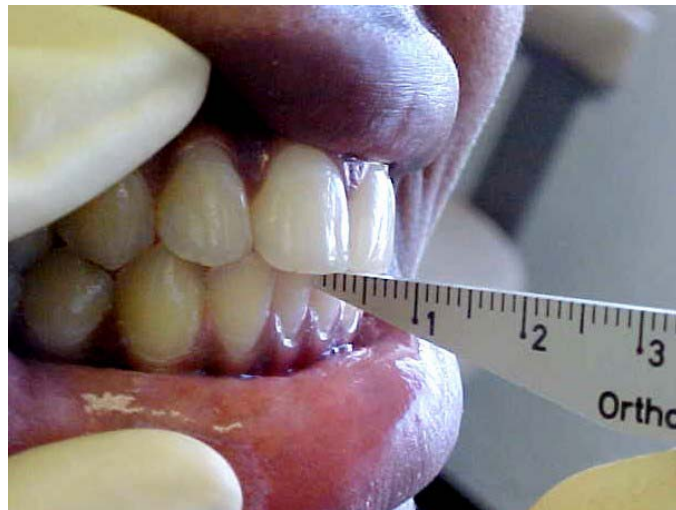
Figure 6   Figure 7

Measurement of Overbite

Overbite was defined as the vertical overlap of the incisor teeth in centric occlusion. With the subject in centric occlusion, a pencil mark was made perpendicular to the occlusal plane from the midpoint of the upper incisor to the corresponding lower incisor (as shown in figure 8 and 9). This was then measured to the nearest whole millimetre as the overbite. The overbite was positive if the incisors overlapped vertically (+), zero if they were edge-to-edge (0), and negative if an openbite was present (-).
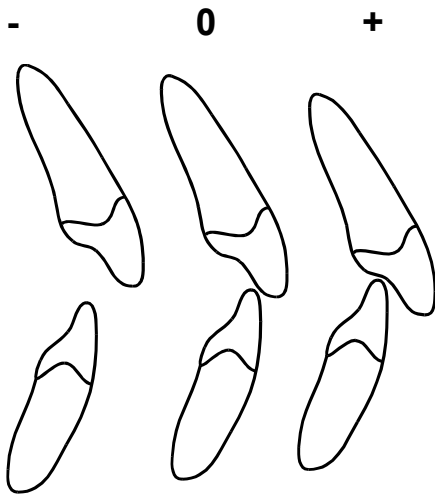
Figure 8   Figure 9

Measurement of Midline Deviations

With the subject in centric occlusion, an assessment of the midlines was done relative to the mid-sagittal plane. Measurements were to the nearest whole millimeter.

CHAPTER FOUR:

RESULTS

INTRODUCTION

A total of 402 subjects were examined. Of these 65% were female and 35% were male. Dental Measurements (anomalies of dental development, missing teeth and retained primary teeth), intra-arch measurements (crowding, spacing, anterior irregularity and diastema), inter-arch measurements (lateral and anterior segments in the anteroposterior, vertical and transverse dimensions) were recorded and their frequencies tabulated in the subsequent tables and graphs.

In the subsequent tables, the central incisor will be abbreviated as CI, lateral incisor as LI, canine as C, first premolar as 1PM, second premolar as 2PM, first molar as 1M and the second molar as 2M, while X will denote any measurement that was unrecordable.

DENTAL MEASUREMENTS

Table 1: Distribution of Anomalies

Developmental Anomalies	Number	Percent
Congenitally Absent Teeth	1	0.5
Supernumerary Teeth	2	1.0
Malformed Teeth	40	19.6
Impacted Teeth	14	6.9
Transposed Teeth	2	1.0
Missing Due to Extraction or Trauma	108	52.9
Retained Primary Teeth	37	18.1
TOTAL	**204**	**100.0**

As shown in table 1, the majority of anomalies found were teeth missing due to extraction or trauma (52.9%), malformed teeth (19.6%) and retained primary teeth (18.1%). Transposition of teeth, supernumerary and

congenitally missing teeth were rare occurrences (0.5 to 1%) in the population sample.

Table 2: Numerical distribution of Tooth Anomalies by Arch

		CI	LI	C	1PM	2PM	1M	2M
MAXILLA	Congenitally absent		1					
	Supernumerary		1			1		
	Malformed	1	23	1		2		2
	Impacted		1	5		1		
	Transposed		1	1				
	Missing (Extraction/Trauma)	3	4	17	3	2	8	1
	Retained primary teeth		1	8		9		
MANDIBLE	Congenitally absent							
	Supernumerary							
	Malformed		1	3		5		2
	Impacted			1		6		
	Transposed							
	Missing (Extraction/Trauma)			7	2	6	49	6
	Retained primary teeth	1	2	5		11		

TOOTH AFFECTED

Table 2 shows that the most common dental anomalies in the maxilla were peg shaped laterals and canines missing due to extraction or trauma. In the mandible, first molars missing due to extraction or trauma and retained primary teeth had the highest frequencies.

Table 3: Distribution of Extractions

TOOTH	MAXILLA	MANDIBLE	TOTAL (%)
CI	0.9	0.0	0.9
LI	4.6	0.0	4.6
C	17.3	7.2	24.5
1PM	2.8	1.8	4.6
2PM	2.7	4.5	7.2
1M	8.2	43.6	51.8
2M	0.9	5.5	6.4

Table 3 shows that the most common teeth missing due to extraction or trauma were mandibular first molars (43.6%) and maxillary canines (17.3%). Mandibular first molars were five times more likely to be missing than maxillary first molars, while the ratio of missing maxillary to mandibular canines was 2.5:1. The tooth least likely to be missing was the central incisor.

Table 4: Comparisons Of Extractions

	MAXILLA			MANDIBLE		
	Ferguson ('88)	Kaka ('93)	This study	Ferguson ('88)	Kaka ('93)	This study
CI	11.6	1.1	0.9	0.7	1.1	0.0
LI	12.0	3.3	4.6	0.4	2.2	0.0
C	4.7	7.6	17.3	0.4	1.1	7.2
1PM	5.4	6.5	2.8	0.7	4.3	1.8
2PM	1.8	5.4	2.7	8.0	10.9	4.5
1M	18.2	20.6	8.2	34.2	30.4	43.6
2M	1.5	3.3	0.9	0.4	2.2	5.5

The method of measuring occlusal traits proposed by Baume *et al.* (1973) has been previously used in two thesis studies in the Orthodontics department, Faculty of Dentistry at the University of the Western Cape. The

research was undertaken by Ferguson (1988) on a Coloured sample and Kaka (1993) on an Indian sample. As shown in table 4, when the pattern of extractions in these two studies is compared with the results obtained from the Ugandan sample, striking differences can be observed:

- o Maxillary incisor extraction was observed in up to 12% of the Coloured population of the Western Cape sample as compared to the Indian (1.1-3.3%) and Ugandan (0.9-4.6%) samples.

- o Extraction of canines in the Ugandan sample was reported to be 17.3% in the maxilla compared to the 4.7% and 7.6% in the Coloured and Indian populations respectively. The differences were even greater in the mandible with 7.2% being reported in the Ugandan sample in contrast to the 0.4% and 1.1% observed in the Coloured and Indian Western Cape samples respectively.

- o Mandibular first molars were the most commonly extracted teeth in all three studies, however, the frequency of maxillary first molar extractions in this study (8.2%) was less than half that observed by Ferguson in 1988 (18.2%) or Kaka in 1993 (20.6%).

Summary of Number of Anomalies per Subject
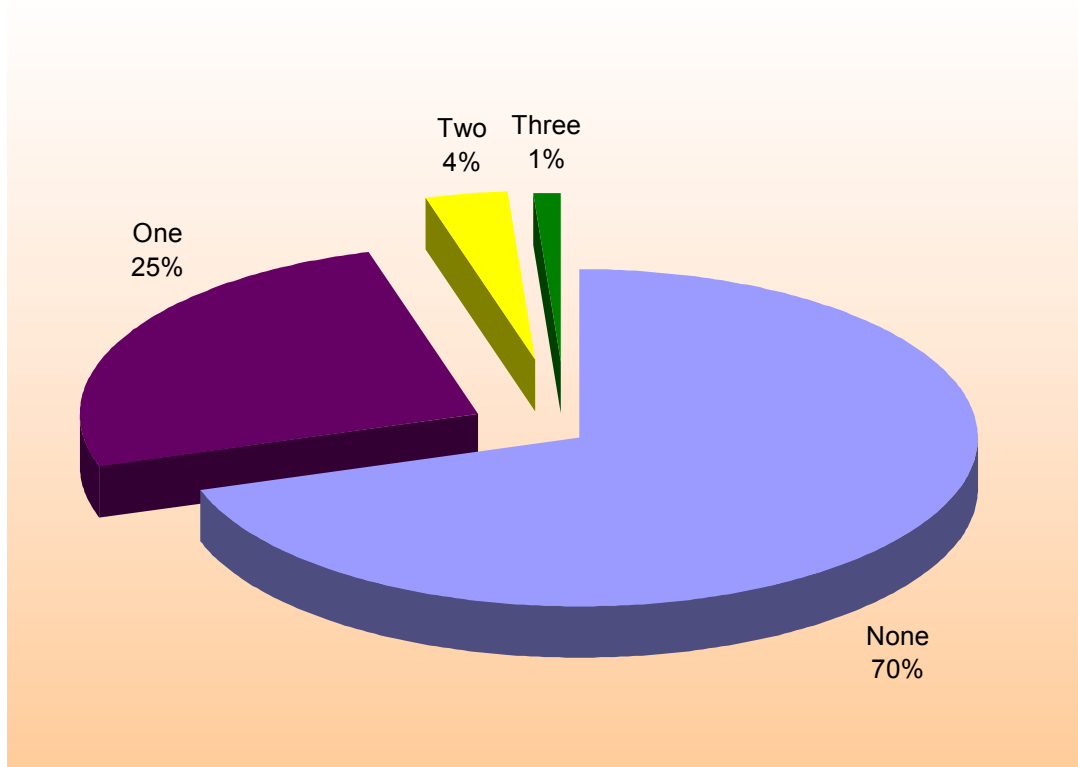
Figure 10

As shown in figure 10, thirty percent of the sample had at least one dental anomaly.

INTRA-ARCH MEASUREMENTS

Table 4: Space Conditions (Percentage)

	ARCH SEGMENT	Normal	Crowded	Spaced	X
MAXILLA	Incisal	77.6	5.7	13.2	3.5
	Right Lateral	89.1	2.2	2.0	6.7
	Left Lateral	89.3	3.2	1.5	6.0
MANDIBLE	Incisal	83.8	8.2	6.7	1.2
	Right Lateral	83.8	4.7	2.0	9.5
	Left Lateral	83.8	5.2	4.2	11.4

Table 5 shows that the majority of the arch segments were normal, ranging from 77.6% to 89.3% in both arches. It is also evident that in the left and right lateral segments of both jaws, there was more crowding than spacing problems. Crowding was most in the mandibular incisal segment while spacing was most frequent in the maxillary incisal region. There were several segments that were unmeasurable (16.2% in the maxilla and 22.1% in the mandible) due to the high frequency of extracted teeth.

Table 6: Anterior Irregularities (Percentage)

	(mm)	A	B	C	D	E
MAXILLA	0	65.7	49.0	74.9	64.2	68.7
	1	13.2	22.1	17.7	18.7	9.5
	2-3	11.9	21.9	4.2	11.9	12.7
	4-5	2.2	3.2	0.7	1.4	1.4
	6-7	0.4	0.0	0.0	0.0	0.0
	>7	0.2	0.0	0.0	0.0	0.5
	X	6.2	3.7	2.5	3.7	7.2
MANDIBLE	0	66.4	64.7	79.9	60.9	66.9
	1	13.9	22.4	15.4	23.1	16.4
	2-3	14.4	12.0	4.7	15.4	13.7
	4-5	1.9	0.2	0.0	0.2	1.7
	6-7	0.2	0.0	0.0	0.0	0.0
	>7	0.0	0.2	0.0	0.0	0.2
	X	2.0	0.5	0.0	0.2	1.0

A = Labiolingual measurement (mm) from the mesial contact point of the right canine to the distal contact point of the right lateral incisor

B = Labiolingual measurement (mm) from the mesial contact point of the right lateral incisor to the distal contact point of the right central incisor

C = Labiolingual measurement (mm) from the mesial contact point of the right and left central incisors

D = Labiolingual measurement (mm) from the distal contact point of the left central incisor to the mesial contact point of the left lateral incisor

E = Labiolingual measurement (mm) from the distal contact point of the left lateral incisor to the mesial contact point of the left canine

Table 6 demonstrates that the majority of segments were normal and the percentage of individual teeth with no displacement ranged from 49% to 75% in the maxilla and 61% to 80% in the mandible. In the maxilla, displacement was more common between the right canine and lateral incisor while in the mandible, it was more between the left central and lateral incisors.

Table 7: Midline Diastema According to Gender

DIASTEMA	BOYS (n)	GIRLS (n)	TOTAL (n)	Freq (%)
None	112	216	328	81.6
1-2mm	17	28	45	11.2
3-4mm	7	14	21	5.2
>5mm	3	4	7	1.6
X	0	1	1	0.2

Table 7 shows that of the majority of subjects studied had no diastemata (81.6%). The mean measurement was 0.49±1.2. A few had a diastema of 1-2mm (11.2%), which is clinically referred to as normal. Only 6.8% had a diastema of 3mm and more.

Summary of Space Conditions per Subject

Regarding space measurements, 17.9% of the sample population had at least one segment with crowding, 18.2% had at least one segment with spacing while 33.6% had some degree of incisor malalignment and 54.2% of the sample population had some form of space anomaly (See Kampala statistics in Appendix II).

INTER-ARCH MEASUREMENTS

Table 8: Numerical Distribution of Molar Relationships

		D+	D	N	M+	M	X	Total
LEFT across top								
RIGHT	**D+**		1	1	1		1	4
	D	2	34	29			2	67
	N	3	24	218	4	13	14	276
	M			8	2	1	1	12
	M+			4	7	3	1	15
	X		5	6	3	2	12	28
	Total	5	64	266	17	19	31	402

Table 8 shows that a bilateral Class I molar relationships was found in 218 of the subjects, bilateral full cusp Class II (M+) was in 7 of the subjects while the more extreme form of Class II relationship (Bilateral D+) was non-existent in the sample. A total of 59 buccal segments were unrecordable (X) due to missing molars while the asymmetric Class II/Class III relationship was found in only one subject.

59

Summary of Molar Relationships (Percentage)
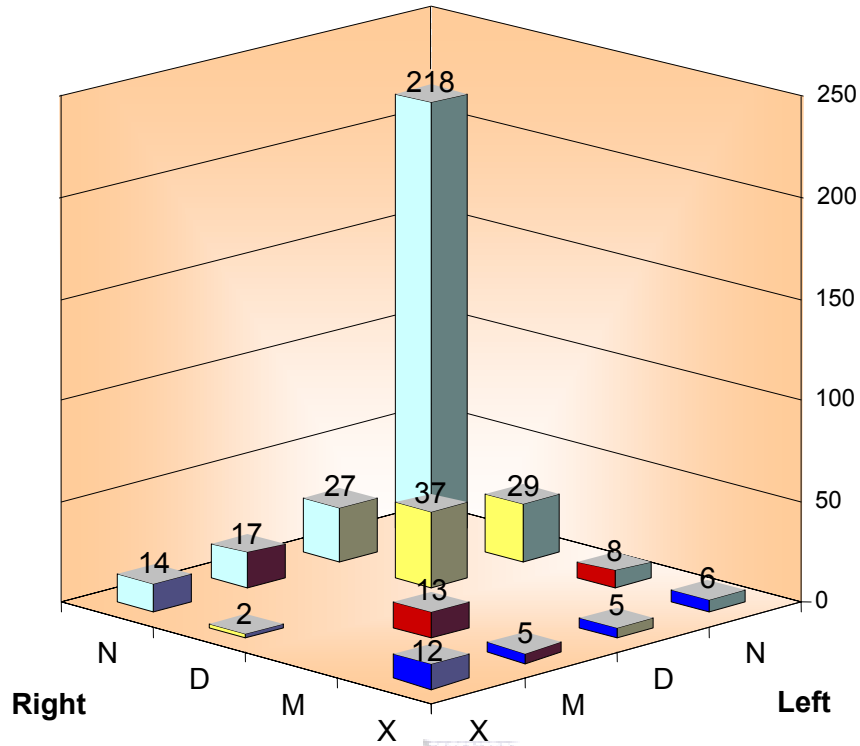
Figure 11

The above figure shows that about 70% (218) of the subjects had symmetric molar relationships:

Bilateral normo-occlusion (Class I molar relationship):	54.2%
Bilateral Disto-occlusion (Class II molar relationship):	9.2%
Bilateral Mesio-occlusion (Class III molar relationship):	3.2%
Bilateral Unrecordable:	3.0%

A number of subjects had asymmetric molar relationships:

Class II/Class I:	14.2%	Class I/Class III:	7.2%
Class II/Class III:	0.3%	Unrecordable/Class I:	5.0%
Unrecordable/Class II:	2.0%	Unrecordable/Class III:	1.7%

Table 9: Posterior Open Bites (Percentage)

TOOTH AFFECTED	RIGHT			LEFT		
	Normal	Openbite	X	Normal	Openbite	X
C	87.8	9.8	2.4	86.1	11.9	2.0
1PM	96.8	2.5	0.7	95.8	3.2	1.0
2PM	96.3	0.5	3.2	96.8	1.0	2.2
1M	94.8	0.5	4.7	94.0	0.0	6.0
2M	97.0	0.8	2.2	97.0	0.8	2.2

The majority of subjects had normal buccal relationships. Open bites were most common in the left and right canine regions (11.9% and 9.8% respectively). 18.9% of the subjects had an open bite involving two or more antagonistic teeth.

Table 10: Posterior Crossbites (Percentage)

TOOTH AFFECTED	RIGHT				LEFT			
	Normal	Buccal	Lingual	X	Normal	Buccal	Lingual	X
C	93.0	1.0	4.0	2.0	93.5	1.0	3.5	2.0
1PM	93.8	3.0	2.5	0.7	94.0	3.2	2.0	0.8
2PM	92.2	1.5	4.0	2.5	90.0	2.2	5.8	2.0
1M	93.8	0.5	1.2	4.5	91.0	0.7	2.0	6.2
2M	96.0	1.0	1.3	1.7	94.5	1.5	0.5	3.5

Table 10 shows that more than 90% of the subjects had a normal buccal segment relationship. Where crossbites were observed, the second premolars and canines were the teeth most frequently in a lingual crossbite both for the left and right buccal segments.

Table 11: Frequency Of Overjet

OVERJET	RIGHT		LEFT	
(mm)	LI	CI	CI	LI
-1 to -4	4.0	1.2	1.2	3.5
0	10.4	3.2	4.0	13.4
1-2	59.0	42.5	36.0	50.0
3-4	22.7	40.6	44.3	27.9
5-6	3.2	9.7	11.7	4.7
7-8	0.7	2.4	2.5	0.4
>9		0.2	0.2	
Mean (±SD)	1.81±1.45	2.76±1.63	2.83±1.66	1.95±1.55

Table 11 shows that edge-to-edge and reverse overjet was observed more on the central than the lateral incisors (14.4% and 16.9% as compared to 4.4% and 5.2%, both for the right and lest sides). However, overjet greater than 3mm was more frequently noted on the central incisors than the lateral incisors.

Summary of Overjet
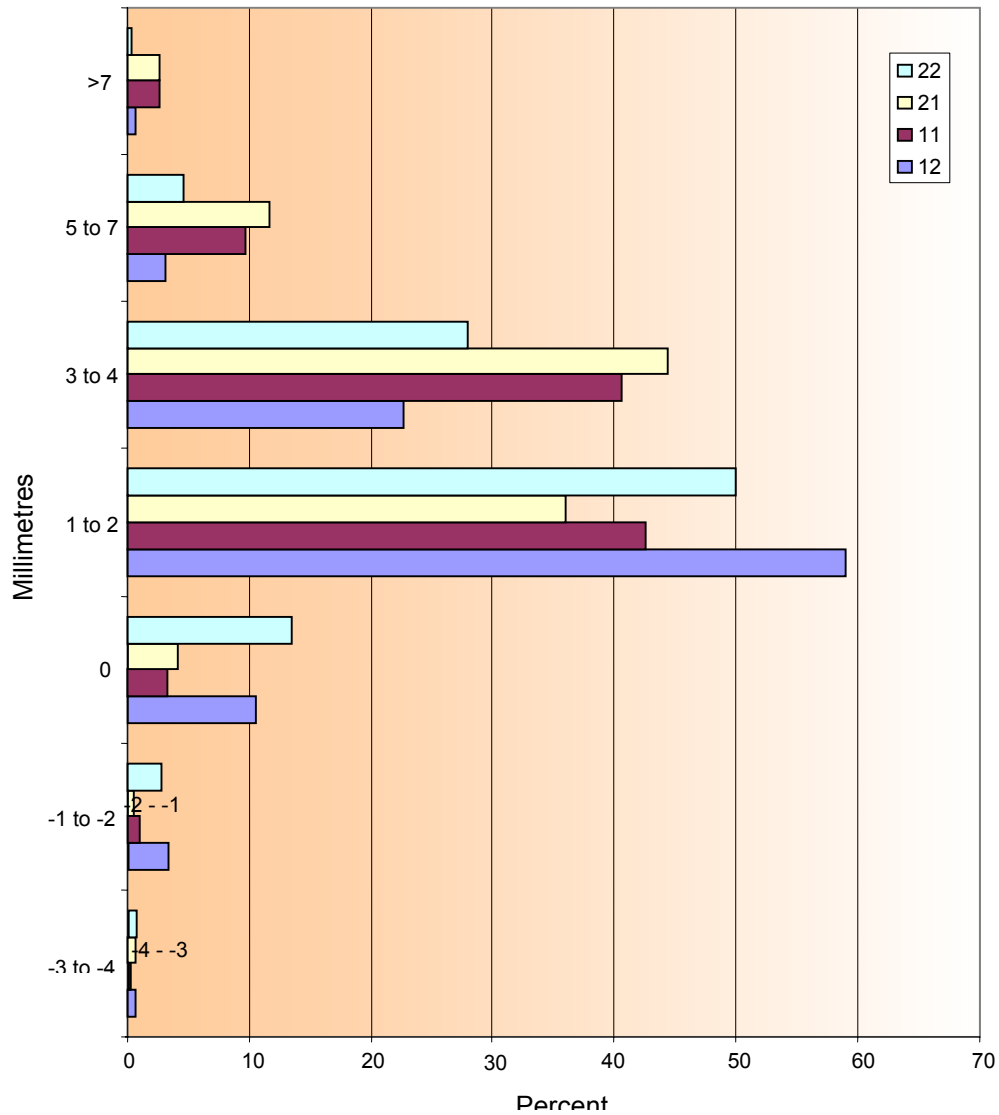
Figure 12

Figure 12 shows that the distribution of overjet was relatively symmetrical on the left and right. Negative overjet (anterior open bite) was a rare occurrence in an average of 2.4% of the population. In 77.6% of the population, the overjet ranged from 1 to 4mm, and in 22.4%, the overjet was either edge-to-edge, reverse or 5mm and over. About 7.3% had an overjet of 5-6mm while only 2.1% had an overjet greater than 6mm.

Table 12: Frequency of Overbite

OVERBITE	RIGHT		LEFT	
(mm)	LI	CI	CI	LI
-6 to -10	0.4	0.9	0.6	0.6
-5 to-4	0.7	1.0	0.9	0.9
-3 to -2	4.7	4.7	5.0	5.4
-1	7.2	2.7	3.0	10.4
0	17.2	9.2	10.2	15.9
1-2	43.5	47.0	44.0	43.6
3-4	23.9	30.4	32.3	21.6
5-6	2.2	4.0	3.7	1.2
Mean	1.34±1.85	1.70±1.95	1.71±1.96	1.16±1.92

Over 40% of the subjects had an overbite of 1-2mm (table 12). However, overbite deeper than 3mm was more frequently noted on the central incisors than the lateral incisors.
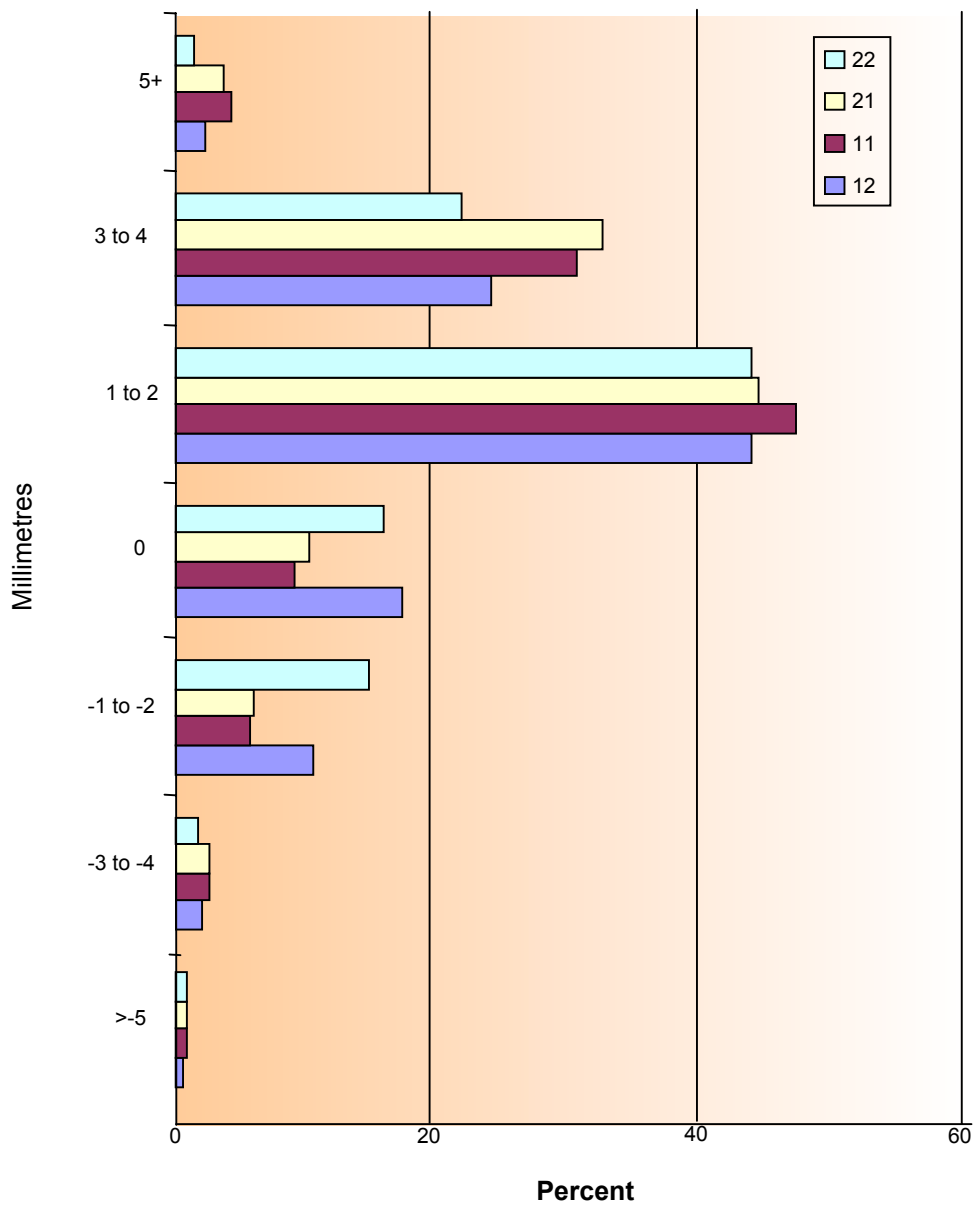
Summary of Overbite (Percentage)

Figure 13

Figure 13 shows that the distribution of overbite was relatively symmetrical when the left and right sides were compared. About 53.7% of the population had an overbite of 1-3mm. Edge-to-edge and open bite incisor relationships were found in less than 10% of the sample.

Table 13: Midline Deviations

Deviation	Number	Percent
Coincident	182	45.3
Maxillary	65	16.2
Mandibular	128	31.8
Both	2	0.5
X	23	5.7
Total	**402**	**100.0**

Table 13 shows in 45% of the cases, the midlines are coincident. However, when a deviation is present, it is twice as likely that the mandibular midline is deviated than the maxilla (31.8% as compared to 16.2%).

Table 14: Types of Midline Deviations

Deviation	Percent	
(mm)	RIGHT	LEFT
0	47.8	65.7
1	4.0	11.2
2	7.5	11.7
3	3.2	9.7
4	3.7	1.5
5	0.2	0.2
Mean (±SD)	**1.79±1.86**	**0.71±1.12**

Table 14 shows that the deviations of a millimetre and above were more frequently to the left than to the right.
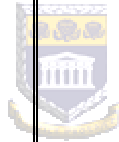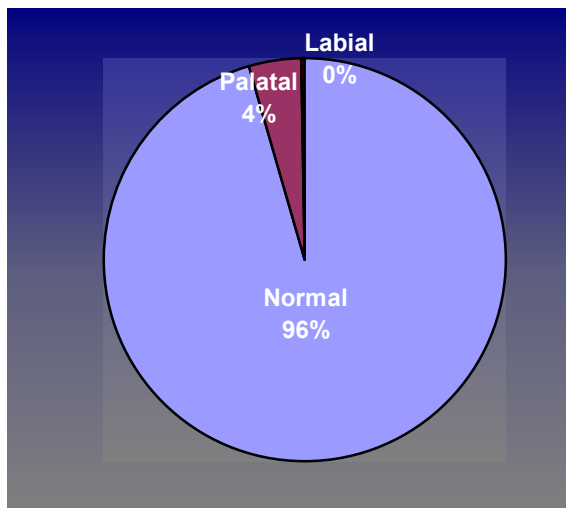
Figure 14: Soft Tissue Impingement (Percentage)

The majority of subjects did not have any soft tissue impingement (figure 14). When present, the soft tissue impingement was palatal. Only one case of labial impingement was noted.

CHAPTER FIVE:

DISCUSSION

DENTAL MEASUREMENTS

It is interesting to note that the percentage of congenitally absent teeth in this study was low when compared to the International Collaborative Study of Dental Manpower Systems (ICS-I) sample in Alberta (0.49% and 0.7% respectively). The presence of retained primary teeth was more common in this sample (18.14%) compared to the highest of the WHO sample in Dublin of 11.8%. However, the presence of supernumerary, impacted and transposed teeth was comparable to those reported in the same study (World Health Organisation, 1985, Appendix II)

Extracted teeth were the most commonly observed of the dental anomalies. These results were higher than those reported in any of the countries involved in the ICS-I (World Health Organisation, 1985). The frequency of mandibular extractions reported by de Muňiz (1986) was five times that of the maxillary first molar and the results of this study reflected a similar ratio (Table 3). The pattern of tooth loss reported in the literature ranks from the mandibular first molar being the highest, followed by the maxillary first molar, the second molars (Massler and Frankel, 1951; de Muňiz, 1986; Ferguson, 1988; Kaka, 1993). By comparison, the Ugandan sample showed a markedly different tooth loss pattern (table 4). The high frequency of maxillary anterior extractions reported in Cape Coloured populations (Ferguson, 1988) was not observed in this study or in South Africans of Indian descent (Kaka, 1993).

Ebinyo

The high frequency of extracted permanent canines (24.5%) in this sample is unique. It is unlikely that permanent canine at the age of fourteen would be missing as a result of caries due to its morphology and relatively short duration in the oral cavity. By and large, many of the occlusal traits related to the canine that have been illustrated (Figures 14, 15 and 16; Appendix V) are

attributable to the practice of *ebinyo*, which still seems to be rife in many communities in Uganda. Mutilation of teeth has long been a tradition in many civilizations for health, religious, ceremonial and aesthetic reasons. Depending on the traditional practitioner, *ebinyo* ranges from rubbing of herbs on the gums to the gouging out of the canines (Morgensen 2000). It is the more extreme form of this practice that would have impact on the occlusal status as observed in this study.

The prevalence of missing canines in our sample was comparable to earlier studies in the region. Pindborg (1969) found that 16% of a sample of 322 members of the Acholi tribe in Northern Uganda had been affected by *ebinyo.* Welbury *et al.* (1993), found that 15% of primary canines and 7% of permanent canines were mutilated in a sample of 300 families in Addis Ababa. They suggested that hypoplastic canines should be included when calculating the prevalence. Thus in this sample, the combined effect of malformed and missing canines would elevate the number of dental anomalies recorded that are attributable to *ebinyo*.

Higher frequencies have been reported ranging from 22% (Rasmussen *et al.,* 1992), 37.4% (Hiza and Kikwilu, 1992), to 100% (Baba and Kay, 1989). Hassanali *et al.* (1995) noted a prevalence of 87% in the six months to two-year age group and 72% in the three to seven-year-olds as evidenced by one or more missing deciduous canines.

Contrary to earlier reports (Pindborg, 1969; Matee and van Palenstein, 1991; Hiza and Kikwilu, 1992; Welbury *et al.,* 1993; Holan and Mamber, 1994), the prevalence of missing canines was higher in the maxilla than the mandible. However, many of the children examined in these studies had a deciduous dentition and therefore, as noted by Holan and Mamber (1994), any inference

concerning the long-term effect of this practice on the permanent dentition could not be made.

The belief in ritualistic extractions is so deeply rooted that the practice is not only confined to communities in Sub-Saharan Africa. Holan and Mamber (1994) reported a prevalence of traditional extraction of primary canines as 59% in a group of Ethiopian Jewish children living in Israel. Cases have been reported in Ethiopians living in Sweden (Erlandsson and Backman, 1999), Somali children living in the United States (Graham *et al.,* 2000) and the United Kingdom (Rodd and Davidson, 2000; Dewhurst and Mason 2001).

In addition to tooth loss and malformations, ritualistic extractions has been shown to affect arch widths. Hassanali and Amwayi (1993) documented a significant reduction of the mandibular arch size in Maasai children who had undergone traditional extraction of mandibular permanent central incisors when compared to the non-extraction group.

INTRA-ARCH MEASUREMENTS

The majority of arch segments had no crowding or spacing. The frequency of crowding ranged from 2.2% to 8.2% in the different arch segments which are lower than the Caucasian samples of Lavelle (1976). The ICS-I study (World Health Organisation, 1985) reported Hannover as having the lowest frequency of crowding (9.9%) and Dublin the highest (48.9%). The anterior arch discrepancies observed in this study (maxilla - 18.9%; mandible - 14.9%) contrasted starkly with that found by Makoni *et al.* (1997) in 14-year-old Zimbabwean students (maxilla - 67.5%; mandible - 60.5%).

Similar to other studies (Künzel and Blüthner, 1981; World Health Organisation, 1985; Al-Emran *et al.,* 1990), anterior irregularities were the most common space condition recorded. The anterior crowding was more in the mandible (8.2%) than the maxilla (5.7%) comparable to the 8% mandibular crowding found by Otuyemi and Abidoye (1993) in a suburban Nigerian adolescent population. Dacosta (1999) on the other hand found in his sample of Nigerian adolescents a mandibular crowding of 36.3%. The view of Brunelle *et al.* (1996) that although prevalence may vary from study to study, more people have malaligned mandibular incisors than maxillary incisors concurs with these studies. Contrary to the aforementioned, Künzel and Blüthner (1981) reported more anterior crowding in the maxilla.

Similar to the observations by Corruccini and Whitely (1981), spacing occurred less frequently when compared to crowding. In this study, spacing was more common in the maxilla with midline diastema being the major contributory factor. The literature is replete with widely ranging prevalence of midline diastema (Cons *et al.,* 1978; Künzel and Blüthner, 1981; WORLD HEALTH ORGANISATION, 1985; de Muñiz, 1986; Al-Emran *et al.,* 1990; Brunelle *et al.,* 1996; Ng'ang'a *et al.,* 1996; Makoni *et al.,* 1997). Of the subjects studied, only 6.8% had a diastema greater than 2mm as compared to 0.4% (Cons *et al.,* 1978; Künzel and Blüthner, 1981), 2% (de Muñiz, 1986), 3.6% (Al-Emran *et al.,* 1990), 5.7% in Alberta and 24.5% in Trondelag (WORLD HEALTH ORGANISATION, 1985). However, our findings were appreciably lower than those found in other African studies; 15% in Kenya (Ng'ang'a *et al.,* 1996), 18% in Zimbabwe (Makoni *et al.,* 1997) and 32% in Tanzania (Mugonzibwa, 1993).

INTER-ARCH MEASUREMENTS

Molar Relationship

The percentage of subjects in this study with Class I molar relationship was 54.2% which is low when compared with other studies on Negroid populations. Altemus (1959) reported a prevalence of 83% in 3,280 African American children, Dacosta (1999) 84% in Nigeria, Otuyemi and Abidoye (1993) 88% in another Nigerian sample, Ng'ang'a *et al.* (1996) 93% in Kenya, while Kerosuo *et al.* (1988) reported 96% in Tanzanian adolescents.

A prevalence of Class II malocclusions of over 20% is reported in Caucasian populations in North America, Europe, North and South Africa (Helm, 1968; Cons *et al.,* 1978; Zietsman, 1979; Gardiner, 1982; Helm, 1982; Laine and Hausen, 1983; El-Mangoury and Mostafa, 1990; Tschill *et al.,* 1997; Spalding, 2001). Künzel and Blüthner (1981) report a prevalence as high as 40.5% in a German sample.

In Latin America, the Middle East, and Asia there appears to be a lower prevalence of 10% to 15% (Steigman *et al.,* 1983; de Muñiz, 1986; Woon *et al.,* 1989; al-Emran *et al.,* 1990; Tang, 1994). Black populations in sub-Saharan Africa present even lower figures of 1% to 10% (Isiekwe, 1983; Ferguson, 1988; Kerosuo *et al.,* 1988; Otuyemi and Abidoye, 1993; Diagne *et al.,* 1993; Ng'ang'a *et al.,* 1996).

Homogeneous Amerindian, Pacific islanders, and other indigenous groups have the lowest prevalence of Class II malocclusion of all ranging from 0% to 5% unless there is a mixture of heritage with Asian or European populations (Barmes, 1967; Lombardi and Bailit, 1972; Baume et al, 1973). This phenomenon is clearly evident on the continent of Australia where the

majority population, primarily of European origin has Class II malocclusion prevalence similar to that of Europeans, whereas the native Aboriginal population has less than 1% prevalence (Homan and Davies, 1973).

The molar relationship recorded in this study showed that the percentage of subjects with Class II molar relationship was 9.2% comparable to that of Sub-Saharan Africa which echoes the reports elsewhere in the literature; that Caucasians exhibit Class II malocclusions twice as high as that of Negroid populations (Emrich *et al.,* 1965; Horowitz and Doyle, 1970; Infante, 1975; Trottman and Elsbach, 1996).

The prevalence of Class III molar relationships in Caucasian populations ranges from 1% to 4% (Tschill *et al.,* 1997; Ngan, 2001). In Asian societies, it is appreciably higher, ranging from 4% to 13% (Ngan, 2001). In Africa it ranges between one percent (Kerosuo *et al.,* 1988; Otuyemi and Abidoye, 1993 and Ng'ang'a *et al.,* 1996) and two percent (Dacosta, 1999). In sharp contrast, African Americans show frequencies ranging between 5% and 8% (Altemus, 1959; Horowitz and Doyle, 1970; Garner and Butt, 1985). In this study, Class III molar relationship was observed in 3.2% of the population sample.

Although the prevalence of occlusal traits differs among populations, there is a universal distributional pattern of molar relationships with neutral (class I) being most common followed by disto-occlusion (Class II) and mesio-occlusion (Class III) as is reflected in the results of this study. However, it should be noted that about 12% of the sample had one or both segments unrecordable due to missing molars which may further highlight the shortcomings of Angle's classification as an epidemiological tool of registration.

Transverse Buccal Relationships

Posterior crossbites were not a common finding. They ranged from 0.5% in the molar region to 5.8% in the premolar region. This prevalence is in agreement with the statistics of other African studies (Gardiner, 1982; Otuyemi and Abidoye, 1993) but is lower than the frequency of 10% reported by Ng'ang'a *et al.* (1996).

Lingual crossbites were more common than buccal crossbites, comparable to the work of de Muñiz (1986). Contrary to this however, Otuyemi and Abidoye (1993) reported a prevalence of 1.4% of buccal crossbites and 0.3% of lingual crossbites while Al-Emran *et al.* (1990) and Ng'ang'a *et al.* (1996) found that buccal crossbites were twice more common than lingual crossbites (scissors bite).

Where measurable, the premolars were the most frequent teeth found in crossbite on both the left and right sides similar to the findings of Cons *et al.* (1978), who postulated that this could be the result of blocking out of the premolars due to premature loss of second primary molars.

Incisal Segments

<u>Overjet</u>

Comparing overjet findings with other studies is challenging due to the variation in categorising normal and increased overjet. Lavelle (1976), for example, defined "extreme maxillary overjet" as that exceeding 6mm while Isiekwe (1983) considered normal overjet to be 2-3mm and excessive overjet to be more than 3mm. Kerosuo *et al.* (1988) divided overjet into four categories: one (reverse overjet), two (0-4mm), three (5-8mm) and four (more than 8mm). Woon *et al,* (1989) considered 2-4mm as ideal and over 4mm as

excessive. Furthermore, Al-Emran *et al.* (1990) classified overjet as grades one to three whereby grade two denoted the 5-8.9mm range while grade three represented "marked" overjet of 9mm or more.

The majority of subjects in this study had an overjet in the range of 1 to 4mm consistent with other African studies (Isiekwe, 1986; Kerosuo *et al.,* 1988; Otuyemi and Abidoye, 1993; Ng'ang'a *et al.*, 1996). These values are low when compared to those of Caucasian populations. Horowitz and Doyle (1970) reported that only 10.2% of the Caucasian children in their study had an overjet less than or equal to 2mm. Other studies (Cons *et al.,* 1978; Künzel and Blüthner, 1981) have also reported lower frequencies where less than 30% of the samples had overjets less than or equal to 2mm.

A small percentage (2.1%) displayed overjets greater than 6mm compared to the ten percent of Ng'ang'a *et al.* (1996). Horowitz and Doyle (1970) found that 13% of the white subjects in their study had an overjet of 7mm or more whereas only 8% of the black subjects had a similar overjet. De Muňiz (1986) compared the overjets of Caucasian and Amerindian children in Argentina and found that the former had significantly larger overjets.

<u>Open Bite</u>

There is a high variation in prevalence reported in the literature. Isiekwe (1983) found 10.2% in a Nigerian sample, de Muňiz (1986) 2% in Argentinean children, Kerosuo *et al.* (1988) 8% in Tanzanian children, Al-Emran *et al.* (1990) 6.6% in a Saudi Arabian adolescents, while Otuyemi and Abidoye (1993) reported 7% and 7.3% in suburban and rural Nigerian school children respectively, Ng'ang'a *et al.* (1996) 8% in Kenya while Coetzee and Wiltshire (2000) found anterior edge-to-edge relationship in 18.7% and open bites in 10.3% of black South Africans. The frequency of open bite in the Ugandan sample ranged from 1% to 4%.

Overbite

In some studies, the degree of overbite is described as a fraction of the overlap of the incisors (Isiekwe, 1983; de Muñiz, 1986; Kerosuo *et al.,* 1988; Woon *et al.,* 1989; Kerosuo *et al.,* 1991; Otuyemi and Abidoye, 1993; Tang, 1994) while others record the millimetric measurement of overlap (Horowitz, 1970; Baume et al., 1973; Cons *et al.,* 1978; Künzel and Blüthner, 1981; Ferguson, 1988; Kaka, 1993; Al-Emran *et al.,* 1990; Brunelle *et al.,* 1996; Ng'ang'a *et al.*, 1996). As with overjet, the definition of normal and deep bite varies considerably (Al-Emran *et al.,* 1990; Brunelle *et al.,* 1996) making comparisons tenuous.

An average of 45% of the sample population in this study had an overbite of 1 to 2mm while 27% recorded an overbite of 3 to 4mm and less than 3% of the sample population registered an overbite greater than 5mm. This is in agreement with Al-Emran *et al.* (1990) who reported a prevalence of 3.6% overbite greater than 5mm but contrary to Ng'ang'a *et al.* (1996) who found this to be 7%.

Only 4.2 percent of the subjects had soft tissue impingement lower than the 8.6% recorded by Cons *et al.* (1978) but higher than that of Künzel and Blüthner, (1981) who found a prevalence of 0.7% in their sample. Kelly and Harvey (1977) suggested that the prevalence of soft tissue impingement might be underestimated due to the difficulty in viewing behind the upper anterior teeth which may explain the high prevalence reported by Cons *et al.* (1978), who carried out their research on dental casts.

A lower degree of incisor overjet and overbite is reported in African than Caucasian populations. Horowitz (1970) in his study found that 50% of the white children in his sample had overbites of 5mm or greater as compared to only 16% in the black children. Researchers (Bacon *et al.,* 1983; Otuyemi and

Abidoye, 1993) postulate that this may be due to the high prevalence of bimaxillary proclination seen in African populations, which is characterized by a reduced inter-incisal angle, reduced overjet and overbite, upper and lower incisor proclination and a tendency towards prognathism.

Midline Deviations

Midline deviations were found to be twice as common in the mandible (31.8%) than in the maxilla (16.2%). Although the prevalence is higher, the pattern is in agreement with that propounded by Al-Emran *et al.* (1990) who cited a frequency of 8.4% in the mandible and 4.2% in the maxilla as well as Coetzee and Wiltshire (2000) who found mandibular deviations in 34.1% and maxillary deviations in 20.4% of their sample. Midline deviations were more commonly to the left than to the right, in contrast to Künzel and Blüthner (1981) and Coetzee and Wiltshire (2000).

CONCLUSION

Implications of the Study

This study, the first of its kind in Uganda has provided the country with baseline data for planning of orthodontic services using an objective method. Parts of the findings of this study have already been accepted for publication by an internationally acclaimed journal. Appendix V (figure 18) is the letter of acceptance of the article submitted for publication from Professor D. O'Mullane, editor of the Community Dental Health journal. Appendix VI is a full-text version of the article. Preliminary findings of this study were also presented at the International Association for Dental Research (IADR) congress held in Capetown in September 2003 (Appendix VII).

The results of this study opens the door to further research into the epidemiology of malocclusion, orthodontic treatment need and demand in

Uganda. Given the diverse cultural practices, research into the impact of the perception of facial appearance on the orthodontic treatment demand is warranted.

Limitations

It should be noted that comparisons of data on the prevalence of malocclusions presents a challenge because of the diversity of evaluation criteria used and the broad age spectrum that many of the studies cover. In the strictest sense, this study is only comparable to other research conducted using the same registration criteria like Cons *et al.,* 1978; Künzel and Blüthner, 1981; World Health Organisation, 1985; de Muñiz, 1986; Ferguson, 1988; Kaka, 1993; Tschill, Bacon and Sonko, 1997 among others.

Furthermore, caution should be exercised in interpreting the measurements of dentition anomalies in the absence of radiographs, study models and a detailed dental history. It is therefore likely that congenitally missing teeth, impacted teeth and teeth missing due to extraction or trauma in the sample population may have been over or under-reported, a limitation acknowledged by Baume *et al.* (1973). Heikinheimo (1978) further suggests that occlusal traits observed on study casts seem to reflect a higher prevalence of deviations than when a direct intra-oral examination is done.

CHAPTER SIX:

CONCLUSION

The findings of this study indicate that ideal occlusion as described by Angle (1907) in the Ugandan sample is very rare. What is clear is that the baseline data documented can help define in statistical terms the expected variation of the occlusal traits in Ugandan adolescents. Normal occlusion for Ugandan adolescents would thus be: the absence of developmental anomalies, crowding or spacing, anterior irregularities not greater than 1mm and midline diastemata no greater than 2mm, a normal molar relationship, no posterior crossbites or open bites, overjet no greater than 4mm and no reverse overjet, midline deviations no greater than 2mm to the left or right and the absence of soft tissue impingement.

However, how this translates into a need for treatment is less clear. Assessment of the need for treatment presents even greater difficulties. While occlusal traits can be investigated with a high level of objectivity by using indices like the one employed in this study, it is difficult to see how such a feat can be achieved when assessing treatment need (Foster and Day, 1974). This is where the WHO and FDI collaboration (Bezroukov *et al.,* 1979) falls short in that they combine an objective method of recording occlusal traits with a subjective method of assessment of treatment need.

As McLain and Proffit (1985) pointed out, the aesthetics and psychosocial component of malocclusion continues to be one of the strongest motivators for orthodontic treatment. Efforts by the WHO and FDI (Baume *et al.,* 1973; Bezroukov *et al.,* 1979) to describe and measure malocclusion have not addressed the degree of psychological handicap, specifically the degree to which the occlusal state interferes with normal function for an individual in his particular social environment. For a country like Uganda that has minimal exposure to orthodontics, further investigation into the knowledge, perceived need and demand for orthodontic treatment as well as the availability of resources to plan for comprehensive orthodontic programs is warranted.

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APPENDIX

Appendix I

MEASUREMENT OF OCCLUSAL TRAITS (FDI COCSTOC-MOT FORM)
Name:…………………………………………………………………………………
Date of Birth: [ ][ ][ ][ ][ ][ ] Sex: [ ]

A: Dental Measurements		CODE	TOOTH
1. Anomalies of Development			
a) Congenitally Absent Teeth	C		
b) Supernumerary Teeth	S		
c) Malformed Teeth	M		
d) Impacted Teeth	I		
e) Transposed Teeth	T		
2. Missing Due to Extraction or Trauma	X		
3. Retained Primary Teeth	R		

B. Intra-Arch Measurements				R. Lateral		Incisal		L. Lateral	
1. Crowding (Insufficient arch space)	C	UPPER							
2. Spacing (Excessive arch space)	S								
Normal	N	LOWER							
Non-recordable segment	A								
3. Anterior Irregularities				2	1		1	2	
Score only the largest irregularity for each arch to the nearest whole millimetre		UPPER							
		LOWER							
4. Upper Midline Diastema. If Unrecordable, enter "A" in Box									

C. Inter-Arch Measurements		RIGHT					LEFT				
1. Lateral Segments	CODES	47	46	45	44	43	33	34	35	36	37
Anteroposterior: Molar Relation	D+, D, N, M, M+										
Vertical: Posterior open bite	N, O										
Transverse: Posterior Crossbite	B, N, L										
If tooth is absent, measurement is unrecordable	A										

2. Incisal Segments		RIGHT	LEFT
Anteroposterior: Overjet	± mm		
Vertical: Overbite	± mm		
Transverse: Midline Deviation	± mm., side		
Soft Tissue Impingement	L,P		
If tooth is absent, measurement is unrecordable	A		

Appendix II

PERCENT OF SAMPLE WITH DENTOFACIAL ANOMALIES:
DENTITION (WHO 1985)

Study area	Congenital absence	Super-numerary Teeth	Malformed Teeth	Impacted teeth	Tranposed Teeth	Missing Teeth	Retained Teeth	Any Dentition Anomaly
Alberta	0.7	0.1	1.6	1.2	NA	NA	NA	NA
Baltimore	1.1	0.0	1.7	0.6	0.2	8.5	3.8	14.5
Ontario	4.1	0.0	1.5	1.9	0.2	19.0	7.1	27.1
Quebec	3.7	0.3	0.3	3.0	NA	NA	NA	NA
Sydney	1.6	0.2	1.2	2.0	0.2	29.9	0.4	33.1
Hannover	1.2	0.2	0.3	0.1	0.1	32.7	0.4	33.7
Yamanashi	4.2	0.4	2.6	5.4	0.7	5.6	8.3	23.0
Canterbury	2.3	0.0	0.4	1.4	0.1	15.4	6.2	22.8
Dublin	6.3	0.2	2.2	7.0	0.5	40.5	11.8	53.4
Trondelag	3.7	0.2	2.2	4.2	0.2	29.7	2.9	37.9
Leipzig	4.0	0.0	0.5	2.1	3.8	15.8	4.0	25.5
Lodz	4.1	0.4	2.0	13.9	0.2	43.7	6.3	54.8
Kampala*	0.5	1.0	19.6	6.9	1.0	52.9	18.1	30.0

PERCENT OF SAMPLE WITH DENTOFACIAL ANOMALIES: SPACE (WHO, 1985)

Study Area	Crowding	Spacing	Anterior Irregularites	Diastema	Any Space Anomaly
Alberta	34.5	12.9	17.8	5.7	52.4
Baltimore	22.9	20.0	34.4	20.9	60.9
Ontario	28.1	17.6	30.1	14.1	52.4
Quebec	20.9	16.2	23.4	6.5	43.5
Sydney	21.3	10.2	31.9	7.9	47.9
Hannover	9.9	5.6	24.3	8.5	35.6
Yamanashi	39.2	11.7	36.3	9.5	55.6
Canterbury	19.7	18.8	26.4	21.8	55.0
Dublin	48.9	32.2	74.2	20.7	88.4
Trondelag	30.3	29.8	28.2	24.5	67.1
Leipzig	12.0	8.1	14.3	7.5	31.5
Lodz	34.7	51.3	40.8	15.0	80.3
Kampala*	17.9	18.2	33.6	6.8	54.2

PERCENT OF SAMPLE WITH DENTOFACIAL ANOMALIES:

OCCLUSION (WHO, 1985)

Study area	molar relation	Posterior openbite	Posterior crossbite	Overjet	Overbite	Midline deviation	Soft tissue impinge-ment	Any occlusal anomaly
Alberta	15.8	1.5	9.0	7.1	9.9	14.6	5.5	36.3
Baltimore	23.8	12.5	9.1	7.9	19.3	26.1	9.6	60.8
Ontario	35.6	5.2	19.4	15.1	16.2	21.4	3.3	60.7
Quebec	10.3	3.4	12.9	9.6	12.7	21.9	5.2	43.7
Sydney	15.7	3.4	8.1	25.2	16.1	1.6	6.0	45.4
Hannover	26.8	2.7	14.1	19.1	24.0	32.4	3.3	66.4
Yamanashi	35.9	13.6	5.4	10.0	3.0	24.1	1.1	56.3
Canterbury	23.0	4.1	8.9	14.7	14.6	17.5	5.2	49.6
Dublin	53.8	7.2	19.2	32.9	39.7	38.2	10.1	82.8
Trondelag	29.8	3.2	12.2	13.2	11.7	23.4	4.8	53.2
Leipzig	32.4	2.5	7.8	11.2	13.7	18.4	2.2	47.4
Lodz	39.6	4.9	14.7	7.0	9.3	33.6	3.7	61 7
Kampala*	**38.1**	**18.9**	**23.9**	**22.4**	**46.3**	**54.7**	**4.5**	**84.8**

PERCENT OF SAMPLE WITH DENTOFACIAL ANOMALIES:

COMBINED CATEGORIES (WHO, 1985)

Study area	Dentition & space	Dentition & occlusion	Space & occlusion	Dentition, Space & occlusion
Alberta	NA	NA	22.4	NA
Baltimore	10.8	11.2	42.5	8 5
Ontario	17.3	21.2	40.1	14 2
Quebec	NA	NA	29.0	NA
Sydney	18.7	17.0	25.5	11 4
Hannover	13.4	24.9	28.5	11 2
Yamanashi	15.1	16.6	37.3	11.7
Canterbury	16.2	15.7	33.3	12 5
Dublin	50.5	48.4	75.7	46 1
Trondelag	30.4	26.5	41.2	22 8
Leipzig	11.8	17.7	22.1	9 2
Lodz	50.1	40.3	55.2	38 1
Kampala*	**17.4**	**28.1**	**48.0**	**93.0**

Appendix III

CONSENT FORM

I…………………………………………………………….………..…
parent/guardian of ………………………………………………… hereby
give permission to Dr. Aisha Bataringaya-Sekalala to conduct an orthodontic
(dental) examination on my child.

I understand that the examination is solely for academic purposes and does
not imply that any orthodontic treatment will be offered and that my child shall
be referred to the school/district dentist if any oral or dental problems are
found.

I also understand that the information obtained will be made available to the
University of the Western Cape, South Africa and to the Ministry of Health,
Uganda but personal details regarding my child shall remain confidential.

I agree to photographs being taken of your child's mouth that may later be
used in scientific publications.

YES	NO

Signed:…………………………………………………
Date:……………………………………………………

Appendix IV

DEAR PARENT/ GUARDIAN:

I am Dr. Aisha Bataringaya-Sekalala, an assistant lecturer at the Department of Dentistry, Faculty of Medicine, Makerere University. Currently, I am undertaking a Masters Program in Orthodontics at the University of the Western Cape, Cape Town, South Africa.

Orthodontics is a Specialty in Dentistry that deals with the straightening and aligning of crooked teeth. Currently, there is no specialist orthodontist in Uganda and therefore no baseline data on the status of our children's teeth.

In partial fulfilment of my degree, I am working on a dissertation entitled:

"A Survey of the Occlusal Traits in an Adolescent Population in Uganda."

My study group is 14-year-old school children. The study involves a dental examination and record of the way the child's teeth are arranged. The examination is solely for academic purposes and does not imply any orthodontic treatment will be offered. However, the child shall be referred to the school/district dentist if any oral or dental problems are found. The examination will be carried out in July of this year. Although the information obtained will be made available to the University of the Western Cape, South Africa and to the Ministry of Health, Uganda, personal details regarding the child shall remain confidential.

Your child's school has been randomly sampled and from an ethical point of view, I require your consent before I can carry out any dental examination of your child. Your child has been given a consent form to bring home. Kindly sign it and return it to the school on the first day of second term if you consent to your child undertaking in this study.

Thank you,
Yours sincerely,

Dr. Aisha Bataringaya-Sekalala
For further information, please contact me on email: abataringaya@uwc.ac.za

Appendix V

Figure 15: Hypoplasia of 23 and 33

Figure 16: Invagination of 33, with missing 23

Figure 17: 33 and 43 are missing while 42 is severely hypoplastic, probably due to accidental damage during the *ebinyo* procedure. Alveolar ridge shows bone loss typical in extractions.

Community Dental Health

In reply please quote:
Ref:

21st September, 2004

Our Ref: 1974

Dr. Aisha Bataringaya,
Dept. of Orthodontics
Faculty of Dentistry & WHO Oral Health Collaborating Centre
University of the Western Cape
Private Bag X08,
Mitchells Plain, 7785, Capetown
South Africa

Dear Dr. Bataringaya,

Re: "The impact of ebinyo, a form of dental mutilation,on the malocclusion status in Uganda"

I have now received reports on your paper from two referees and, in light of these reports, I am delighted to accept this paper for publication. However, as Table 2 has been deleted from the document the text will need to be amended accordingly.

In order to proceed with the publication process I will need a hard copy of the amended paper, and a copy on an IBM Windows 98 floppy disc with both text and tables presented in Rich Text Format.

You will receive proofs from the publisher in due course but there will be a delay owing to the rather large number of accepted papers currently being processed.

Yours sincerely,

Professor Denis O'Mullane
Editor

Figure 18

Appendix VI

THE IMPACT OF EBINYO, A FORM OF DENTAL MUTILATION, ON THE MALOCCLUSION STATUS IN UGANDA

Aisha Bataringaya[1], Maurice Ferguson[1], Ratilal Lalloo[2]

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KEY WORDS:

Malocclusion, Occlusal Traits, Uganda, Dental Mutilation, Ebinyo, False Teeth

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WORD COUNT: 2986

  Abstract: 234 words

ABSTRACT

Introduction: The practice of extraction of *ebinyo* or *false teeth* is based on the belief that the rubbing of herbs on the gum (in the region of the canine) or the removal of the primary and/or permanent canine tooth buds will lead to the relief of childhood fevers and diarrhoea. The prevalence reported of this practice in Uganda and neighbouring countries is varied.

Objective: A survey carried out in Kampala to determine the occlusal traits of fourteen-year-old children offered an opportunity to assess the effects of *ebinyo* (a dental mutilation based on local customs and superstitions) on the occlusal status of the sample population.

Methods: 402 children aged fourteen years were examined according to the criteria of the Fédération Dentaire Internationale Commission on Classification and Statistics for Oral Conditions method for measuring occlusal traits (COCSTOC-MOT) proposed by Baume *et al.,* (1973).

Results: The most common dental anomaly was teeth missing due to extraction or trauma. Canines (28%) and mandibular first molars (28%) exhibited the highest frequency. Missing canines were four times more common in girls than boys, and three times greater in the maxilla than the mandible. Canines also accounted for 12.8% of the malformed teeth observed in the study.

Conclusion: The results of this study show that the practice of ebinyo, although carried out early in the life of the child, can impact on the occlusal status in the permanent dentition years later.

INTRODUCTION

The term *ebinyo* when literally translated means "false teeth". It is derived from the language of the Baganda, the largest Bantu speaking tribe in Uganda. Other tribes may use a different term such as; *Two lak* in Acholi, *Gidog* in Langi, *Lake jo marak* in Japadhola, *Ikela/Icela* in Atesot, *Ebiino* in Banyankole and *Bino* in Basoga. However, the word *ebinyo* has transcended the ethnic divide and is now widely used even in northern Uganda (Accorsi *et al.,* 2003).

In many communities in Uganda, diarrhoea, fever and vomiting in children are attributed to the developing dentition, with the belief that if the "offending teeth" are not removed, the child will die. As observed by Ballester (1999), whereas infant illnesses may be attributed to the teething period, they are in fact as a result of the poor health conditions in which these children are reared. These teeth are locally termed as *ebinyo* (Halestrap 1971). *Ebinyo* encompasses both the child's ailment as well as the treatment offered by the traditional healer. The practice of *ebinyo* is based on the belief that the rubbing of herbs on the gum or the removal of the primary and/or permanent canine tooth buds will lead to the relief of childhood fevers and diarrhoea.

The procedure is done as early as one month and up to three years of age. Most studies report a peak age of four to eighteen months (Matee and van Palenstein, 1991; Hiza and Kikwilu, 1992; Rasmussen *et al.*, 1992; Welbury

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et al., 1993; Holan and Mamber, 1994; Hassanali *et al.*, 1995; Kikwilu and Hiza, 1997).

Morgensen (2000) coined the term germectomy for the more radical form of the practice involving removal of the primary canines and/or permanent tooth germ. However, even when the procedure is aimed at removal of the primary canine, damage to the surrounding tissues is an ever-present possibility. Depending on the extent of damage, the permanent canine maybe missing, impacted or malformed (Pindborg 1969).

This practice seems to have spread through vast geographical areas within a few decades and similar practices have been reported in many Sub-Saharan countries. One of the earliest documented reports on this practice noted that the Nuer tribe of the Nilotic Sudan enucleated the canines of infants with a piece of iron (Pindborg 1969). Baba and Kay (1989) referred to a traditional practice in Southern Sudan, named *lugbara* that involves the removal of unerupted canines as a treatment for childhood illnesses. This practice is said to have been introduced in Southern Sudan by refugees from Uganda. In Khartoum, the lancing of the swollen alveolar process over the unerupted canine with a heated instrument is known as *haifat* (Rasmussen *et al.,* 1992).

In Tanzania, such teeth are regarded as *nylon or plastic teeth* because of the plastic texture of the tooth follicle when it is extracted (Kikwilu & Hiza, 1997) while in Kenya they have often been referred to as "worm teeth" (Hassanali et al., 1995). In Ethiopia, they are regarded as "killer canines" because of the

belief that if these teeth are not removed, the child will die (Welbury *et al.,* 1993).

In Uganda, early reports indicated that the practice was predominantly in the Acholi and Lango tribes in Northern Uganda, near the border with Sudan (Pindborg 1966, Halestrap 1971; Amin, 1972). However, it is now widespread and has been reported in the western (Bwengye 1989) and eastern (Kirunda 1999) parts of the country. This may be due to the movement of the Ugandan army, of which the majority of personnel are from the Northern tribes (Morgensen 2000). Cobbs (1972) reported in Mbarara, a district in Western Uganda, *ebinyo* was viewed as the "Acholi disease", in reference to the Acholi tribe of Northern Uganda.

Most researchers have looked at the social and public health impact *ebinyo* and similar practices. However, few studies have addressed the effect such practices have on the occlusion. To our knowledge, this is the first study assessing the long-term effect that this practice would have on the overall occlusal status of adolescent children in Uganda.

A survey of the occlusal traits in an adolescent population was carried out in Kampala, Uganda in May 2003. Although the main purpose of this survey was to determine the occlusal traits, it offered an opportunity to assess the effects of *ebinyo* on the occlusal status of the sample population.

METHODS

This was a descriptive study documenting the occlusal traits of the sample population. Multistage random sampling was done in the 135 secondary schools within Kampala district. Every tenth school was selected from an alphabetical list of the 135 secondary schools in Kampala. A total of thirteen schools were visited. The secondary sampling unit involved selecting the subjects. Every tenth 14-year-old on the class register of Senior One students was selected and a total of thirty-one subjects were selected from each school. Children who had undergone orthodontic treatment or those who did not have signed parental consent were excluded from the study, and the same sampling method was applied to replace them. A total of 402 subjects were examined, which is about 2% of the 14-year-old population in Kampala District.

The subjects had to be fourteen as at their last birthday. This age group was selected because the full complement of the adult dentition is in the mouth without the perio-prosthodontic problems associated with adults.

The subjects were examined according to the criteria of the Fédération Dentaire Internationale Commission on Classification and Statistics for Oral Conditions method for measuring occlusal traits (COCSTOC-MOT). A tooth was considered impacted if there was no history of previous extraction(s), and if the contour of the underlying ridge indicated the presence of a missing

tooth. It was considered missing due to extraction when there was reduction in alveolar bone dimensions in the extraction site. If the subject gave no history of extraction(s), and if the contour of the underlying ridge did not indicate an impacted tooth, the examiner assumed the tooth to be congenitally missing (Baume *et al.,* 1973).

Examination was done under natural light using an orthodontic ruler, sharp pencil, tongue depressor and disposable gloves. Occlusal traits were noted on the COCSTOC-MOT form and children who were found to need dental treatment were referred to Mulago Hospital for further attention.

The data were captured using Excel worksheets and SPSS 11.0 was used to analyse the data.

RESULTS

Of the 402 children examined 204 of them had a tooth anomaly, the most common of which was teeth missing due to extraction or trauma at 52.94% (Table 1). Of these, canines and mandibular molars had the highest frequency (Figure 1). Missing canines alone contributed to 11.76% of all the tooth anomalies.

Although peg-shaped lateral incisors were the most common malformation observed in the study, malformed canines accounted for 1.96% of all the dental anomalies. The combined effect of missing and malformed canines was 13.72% of the tooth anomalies.

Missing canines were four times more common in girls than boys, and three times more common in the maxilla than the mandible. Enamel hypoplasia and malformations of the canines and adjacent teeth, missing lateral incisors, rotations, and canine transposition were among the other occlusal traits noted (Table 1 and figure 1). Some of the occlusal traits attributable to *ebinyo* are illustrated in Figures 2, 3, and 4.

DISCUSSION

The frequency of mandibular extractions has been reported as being five times that of the maxillary first molar (Muňiz 1986) and the results of this study reflect similar findings. The high frequency of extracted permanent canines (28%) in this sample is unique. It is unlikely that permanent canines at the age of fourteen would be missing due to caries due to its morphology and relatively short duration in the oral cavity. By and large, many of the occlusal traits related to the canine that have been described are attributable to the practice of *ebinyo*, which seems to still be rife in many communities in Uganda. Depending on the traditional practitioner, *ebinyo* ranges from rubbing of herbs on the gums to the gouging out of the canines (Morgensen 2000). It is the more extreme form of this practice that would result in the kind of dental anomalies that would have a long-term impact on the occlusal status of the children.

The prevalence of missing canines in our sample was comparable to earlier studies in the region. Pindborg (1969) found that 16% of a sample of 322 members of the Acholi tribe in Northern Uganda had been affected by *ebinyo.* Welbury *et al.,* (1993), found that 15% of primary canines and 7% of permanent canines were mutilated in a sample of 300 families in Addis Ababa. These workers suggested that hypoplastic canines should be included when calculating the prevalence. Thus in the Ugandan sample, the combined effect of malformed and missing canines would elevate the impact of this practice on the occlusal traits to the levels recorded.

Higher frequencies have been reported ranging from 22% (Rasmussen *et al.,* 1992), 37.4% (Hiza and Kikwilu, 1992), to 100% (Baba and Kay, 1989). Hassanali *et al.,* (1995) noted a prevalence of 87% in the six months to two-year age group and 72% in the three to seven-year-olds as evidenced by one or more missing deciduous canines.

Contrary to earlier reports (Hiza and Kikwilu, 1992; Holan and Mamber, 1994; Matee and van Palenstein, 1991; Pindborg 1969; Welbury *et al.,* 1993), the prevalence of missing canines was higher in the maxilla than the mandible. However, many of the children examined in these studies had a deciduous dentition and therefore, as noted by Holan and Mamber (1994), any inference concerning the long-term effect of this practice on the permanent dentition could not be made.

The belief in ritualistic extractions is so deeply rooted that the practice is not only confined to communities in Sub-Saharan Africa. Holan and Mamber (1994) reported a prevalence of traditional extraction of primary canines as 59% in a group of Ethiopian Jewish children living in Israel. Cases have been reported in Ethiopians living in Sweden (Erlandsson and Backman1999), Somali children living in the United States (Graham et al. 2000) and the UK (Rodd and Davidson, 2000) and a Ugandan family in the UK (Dewhurst and Mason 2001).

In addition to tooth loss and malformations, ritualistic extractions has been shown to affect arch widths. Hassanali and Amwayi (1993) documented a significant reduction the mandibular arch size in Maasai children who had undergone traditional extraction of mandibular permanent central incisors when compared to the non-extraction group.

The practice of *ebinyo* may have an impact on the eruption times of the permanent canines. Pindborg (1969) found that many children affected by the *ebinyo* practice had eruption of the permanent canines before 9 years of age. The mean eruption times of permanent canines in Ugandan children has been reported as 7.5 and 9.0yrs in the mandible and 9.1 and 9.5yrs in the maxilla for girls and boys respectively (Krumholt et al. 1971). This is one to one and a half years ahead of Caucasoid norms. However, this could not be substantiated because the entire sample studied was 14 years old.

Ebinyo is a potential risk to the health of the child. Infants are often seen at clinics with complications following tooth bud removal by traditional doctors. Mosha (1983) observed that of the 124 children that reported at Kaloleni dental clinic following removal of *nylon teeth*, ten died from oral sepsis. Some of the children who were discharged were re-examined one year later and found to have primary canines absent or malformed.

In Lacor Hospital in Northern Uganda between 1992-1998, *ebinyo*-related complications were among the leading causes of hospital admissions. Of these complications (like septicaemia and severe anaemia) a high number resulted in death. In this six-year period, 740 admissions were due to *ebinyo* and 156 of these children died. This is a high case fatality rate of 21% compared to the proportional mortality rate of 3.3% (Iriso *et al.,* 2000).

Ebinyo is condemned by the formal health care system, which has for many years advocated for the eradication of this practice. Intensification of oral rehydration programmes (Bwengye 1989) educational sessions between health personnel and traditional healers (Kirunda 1999) have been some of the strategies employed in rural communities to address this problem. In Eastern Uganda, one of such strategies was to adopt the use of sterile herbal medicines that could be applied to the gums at the site of *ebinyo* (Kirunda 1999). However, even in its least traumatic form like rubbing of herbs on the gingiva, *ebinyo* can still delay and complicate the clinical management of the child's ailment by introducing or aggravating infection.

In rural communities, traditional health workers such as birth attendants and herbalists are often the first point of health-care contact, and as such, play a valuable role in the delivery of primary health care (Kubuleki 1999).

The continued belief in *ebinyo* is reinforced by the mothers who report an improvement in the child's health following treatment by traditional healers after failing to get relief at government health services (Kikwilu and Hiza, 1997; Welbury *et al.,* 1993). Education should target traditional healers who are respected members of the community and are more likely to have an impact in change of attitude in their communities.

CONCLUSION

The results of this study show that the practice of ebinyo, although carried out early in the life of the child, can impact on the occlusal traits in the permanent dentition years later.

Furthermore, the continued practice indicates a preference of traditional healing over Western medicine in these communites and that the education to eradicate this practice should be intensified.

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Table 1: Frequency of Tooth Anomalies

Developmental Anomalies	Number	Percentage
Congenitally Absent Teeth	1	0.49%
Supernumerary Teeth	2	0.98%
Malformed Teeth	40	19.61%
Impacted Teeth	14	6.86%
Transposed Teeth	2	0.98%
Missing Due to Extraction or Trauma	108	52.94%
Retained Primary Teeth	37	18.14%
TOTAL	**204**	**100%**

Figure 1: Missing teeth due to extraction or trauma
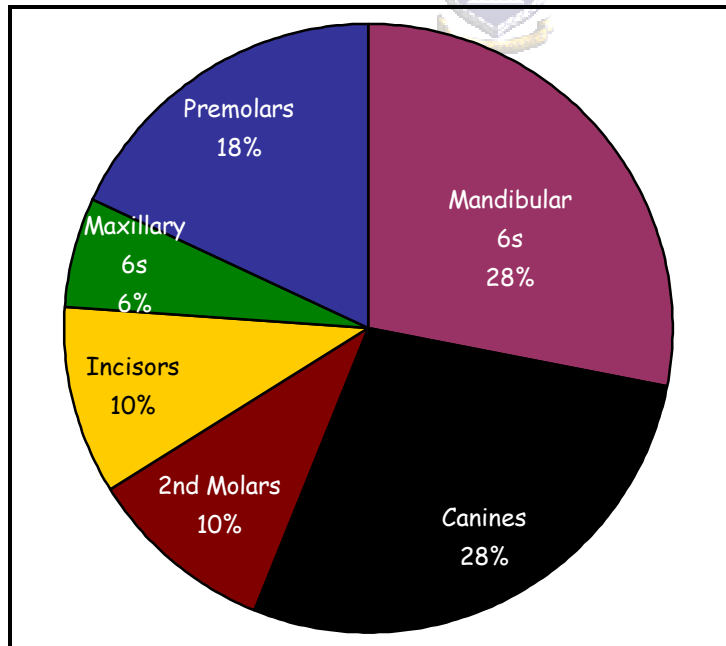
PICTURES

Fig 2: Hypoplasia of 23 and 33

Figure 3: Invagination of 33, with missing 23

Figure 4: 33 and 43 are missing while 42 is severely hypoplastic, probably due to accidental damage during the procedure. Alveolar ridge shows bone loss typical in extractions.

APPENDIX VII

XXXVIII IADR (SOUTH AFRICAN DIVISION) CONGRESS

VINEYARD HOTEL, CAPETOWN

11TH AND 12TH SEPTEMBER, 2003

ABSTRACT OF PRESENTATION:

19	A Survey of Occlusal Traits in an Adolescent Population in Uganda. A BATARINGAYA-SEKALALA*, University of the Western Cape, Cape Town

The prevalence of occlusal traits in Uganda is not known. The reported incidences of malocclusion in different parts of the world vary from 45% to 78%, making it clear that a majority of children have irregular teeth and an occlusal relationship that differs from the ideal. The purpose of this study was to determine the occlusal traits in an adolescent Ugandan population in Kampala using the FDI Commission on Classification and Statistics for Oral Conditions-Method of Measuring Occlusal Traits (COCSTOC-MOT) by Baume et al. (1973). A multistage random sampling of secondary schools in Kampala was done and four hundred and two 14-year olds were examined to determine anomalies of tooth development, missing and retained primary teeth, to assess intra- and inter-arch relationships and to compare the occlusal traits by gender. The most common dental anomalies found were mandibular first molars missing due to extraction (48.6%). The frequency of canines missing due to tooth bud mutilation (locally known as "ebinyo") was high at 23.4%. In the subjects examined 67.5% had a Class I molar relationship, 17.3% were Class II and 7.7% were Class III. The survey indicated that the distribution of certain occlusal traits in the Ugandan adolescent population were similar to those in other studies. This study was supported by the University of the Western Cape (South Africa) and Makerere University (Uganda).

Figure 19