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DENTAL DEVELOPMENT IN LOW BIRTH-WEIGHT CHILDREN

by

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Abstract

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Physical growth and development in the low birth-weight child has been of prime interest in the medical community for many years. It is well known that low birth-weight children experience a lag in statural growth as compared to normal birth-weight children. The purpose of this study was to compare the dental development and degree of dental malocclusion between a group of school-age, low birth-weight (LBW) children and children born of normal birth-weight (NBW). Thirty LBW children, 21 female and 9 male comprised the study sample. Dental impressions and plaster casts were made and medical histories were reviewed for pertinent perinatal medical data. All of the LBW children had been orotracheally intubated for various lengths of time and all were preterm with regard to gestational age. Thirty NBW children, 20 female and 10 male, were used for comparison. Each LBW child was matched with a corresponding NBW child according to the Quetelet Index. Results of the paired t-test indicated no statistically

significant differences in intercanine width, primary second intermolar width, permanent first intermolar width, arch depth, overbite and overjet. Significant differences in maxillary arch perimeter ($p < 0.05$) and palatal height ($p < 0.01$) were found. The incidence was similar between the two groups for Angle Class I and Class II molar relationships. However, in the LBW group 23% presented with Class III's as compared to 3% in the NBW group. The palatal height in the LBW group was not directly proportional to the length of time of postnatal intubation. Since there were no obvious indicators of mandibular prognathism, and there were significant maxillary arch perimeter differences, it would appear that there exists a skeletal component to the high incidence of Angle Class III malocclusion found in the LBW group. Tertiary neonatal care of the low birth-weight infant appears to have long term effects on arch length and palatal height. There is also a possible effect on growth of the midface.

I dedicate this work to

Lisa,

my wife and very best friend.

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INTRODUCTION

The subject of the present study examines the dental development and manifestations of dental malocclusion in low birth-weight children. To increase survival rates, low birth-weight infants are usually transferred shortly before or after birth to a neonatal intensive care facility which is able to offer advanced life support. Since the growth and development of an infant is predicated on a normal term delivery, any insult during the early formative period has repercussions that follow the infant through early and middle childhood. It is understood that low birth-weight children are, generally speaking, smaller in stature than normal birth-weight children , at least until the end of the first decade of life. If overall growth of the low birth-weight child is retarded, it seems logical that the size of the jaws that house the teeth will also be smaller. Since tooth size is genetically determined with little environmental influence, the question arises as to whether or not there is a higher prevalence of tooth size-arch length discrepancies resulting in more dental malocclusions in the low birth-weight population.

The purpose of this study was to evaluate the occlusion of the low birth-weight child. Specifically, dental arch length and arch width measurements were taken and subsequently related to the medical history for each of the participants. Every year roughly 8% of all infants (6% Caucasian and 12% Black) are born of low or very low birth-weights. This

represents an appreciable number of children in the dental practice who may have specific needs other than routine dental care. The goal of this study was to determine the appropriate dental care that may be rendered to the low birth-weight child to provide an optimal level of dental health throughout their lives.

The subject population for the study included very low birth-weight children, <750 grams birth-weight, and low birth-weight children, 750 - 1,499 grams birth-weight. The mean gestational age for the very low birth-weight children was twenty-six weeks and the mean weight at birth was six hundred seventy-five grams. There was an equal distribution of very low and low birth-weight children in the study.

Data was collected on all of the participants who were between six and eight years of age. This chronologic age corresponds to the time during dental development when (1) all primary teeth are in position in the oral cavity, (2) eruption of the six year molars takes place, and (3) the period of the mixed dentition begins. The children in the present study were of various races, sexes, and socioeconomic backgrounds. Each of these variables may have an effect on the status of dental development at the time of examination, i.e., the number of teeth present, missing, and the reason for each.

The rationale for selection of this topic stems from the recent dental literature. Some authors have stated that there may be developmental defects in the tooth enamel as well as alveolar defects in low birth-weight infants having survived with the aid of technological advancements in

perinatal medicine (Metlay, McPherson, and Doshi 1989). It has also been reported that certain life-sustaining procedures may have adverse effects on the developing tooth buds (Leighton 1982). In particular, biochemical imbalances which may later cause alterations in the calcified tissues of the developing tooth buds have been implicated. Certainly, the life of the infant is paramount to the side effects of any life-sustaining procedures, including decalcification of or alteration in the teeth. However, recognition of this phenomenon will enable the dental practitioner to render appropriate dental care where necessary.

Low birth-weight children are commonly mechanically ventilated shortly after birth. The need for ventilation is a result of immaturity of the infant and his breathing apparati. Mechanical ventilation provides for maintenance of the human life which, at this time, is very frail. Often ventilation can continue postnatally for weeks or even months. Oxygen is delivered to the neonate by either oral or nasal intubation. With either of these two modes of delivery there are adverse side effects to the developing hard and soft tissues. Oral intubation is most commonly used. Physical effects of orotracheal tubes over a period of weeks or months can be detrimental to the growth and development of the dental alveolus. It is during the early postnatal period that we see enormous changes in the size of the infant. If, during this period of rapid growth and development, a mechanical obstruction is introduced, i.e., orotracheal tubes, it seems logical that the overall development of that structure will be impaired. It has been reported in the literature that it is quite easy to manipulate the direction

and/or rate of growth of bones in young laboratory animals. It has also been shown clinically that bones can be shortened or lengthened with the application of a force in a particular direction or for a specific amount of time. Either of these complications, alone or in combination, may have a direct effect on the orofacial development.

The importance of this study lies in the the management of the low birth-weight child with regard to dental health. As mentioned previously, there are many life sustaining procedures in perinatal medicine. These procedures are necessary for the medical well being of the child. If, during growth and development of the child, there exists a condition precipitated by neonatal medical attention , the dental practitioner must be able to deal appropriately with the outcome. Enamel decalcification can be handled, if necessary, with conventional dental restoration. However, if there is an impairment of the natural growth of the jaws, the pediatric dentist or orthodontist can implement interceptive oral orthopedic treatment to restore the natural course of growth of the jaws. Long term, inadequate growth of the lower face, i.e., upper and lower jaws, may have profound effects on the facial esthetics of the individual, as well as the dental and periodontal health. Therefore, it is important that the practitioner recognize the etiology of the disturbance and provide the appropriate treatment to alter or repair the disruption caused by the disturbance.

In order to evaluate the dental development in low birth-weight children, thirty low and very low birth-weight children were examined. The chronologic age at the time of the examination ranged from six to eight

years. During a follow-up visit to a local tertiary care facility, the children were given a dental exam consisting of (1) visual examination of all hard and soft intraoral structures, (2) dental impressions for production of plaster casts, and (3) frontal and lateral photographs of the head and neck. Medical records were retrieved for all pertinent perinatal information such as birth-weight, gestational age, total neonatal risk number, intubation time, etc.

All dental measurements were performed on plaster casts and recorded for statistical analyses. The casts also serve as a record for possible future study regarding longitudinal evaluation of dental eruption.

The information gathered from the low birth-weight group was compared to similar information gathered from a matched control group. The control was gathered from the Bolton-Brush Study and matched for body mass. Medical records were evaluated for normal and routine postnatal care and the dental casts were measured in the same manner as the low birth-weight group.

Comparisons between the two groups were made with regard to size of teeth, canine and molar width, arch depth, palatal height, anteroposterior dental relationships, vertical dental relationship, and Angle classification of malocclusion. Within the low birth-weight group, correlations were made with regard to medical history and dental manifestations.

LITERATURE REVIEW

Introduction

It has become clear that many of the principal problems of perinatal medicine are prenatal in origin. There are many influences on the the size of a child at birth. Some of the factors to be considered include race, sex, size of the mother and father, health and diet of the mother, and maternal lifestyle, i.e., smoking or drug use. Other factors that may contribute to the size of a child at birth are biochemical and physiological, or even obstetric and pediatric. Successful reproduction involves psychological, economic, social, geographic, and organizational factors which are beyond the influence of the medical profession. For instance, poor social circumstances are often accompanied by several other adverse factors, such as small stature, more than the average number of previous pregnancies, heavy smoking and advanced age. It has been shown that, although associated and cummulative, these factors are truly independent of each other in their effect on perinatal mortality (Butler and Alberman, 1969). Therefore, lack of prenatal care, poor nutrition, low socioeconomic and educational status, teen-age pregnancy, and the deleterious effects of alcohol, drug use, and smoking during pregnancy, are all highly relevant to the prevention of low birthweight (Morrison and Maykut, 1979; Blinick et al., 1976).

Historically there has been a marked change in the attitude toward the newborn. Acceptance of neonatal mortality rates in the order of one to two hundred per one thousand births has given way to a more intense concern for survival. With more modern techniques of neonatal care, it is evident that there exists a greater degree of quality of survival. Concern for the quality of survival can be seen in the planned nature of pregnancies, following the wider availability of effective contraception and therapeutic abortion. This implies that every pregnancy is planned and wanted, although this may be desirable it is not universal. It has been reported that fifty percent of pregnancies in a recent hospital survey were unwanted before delivery and that twenty percent remained unwanted after delivery (Scott and Stone, 1973).

Liberalized abortions have the immediate effect of eliminating fetuses who would be subsequently at high risk of perinatal death. These abortions are authorized for medical or social reasons, for instance, poor health, extremes in age, unmarried mother, and poor socioeconomic circumstances. This fact is reflected in the low perinatal mortality rates for such countries as Bulgaria and Romania, which on the other hand have relatively high postneonatal mortality rates. These countries, however, tend to have a high incidence of low-birth-weight delivery, as high as twenty-five percent, which may be related to cervical incompetence from repeated nonparturitional cervical dilation. Improvements in socioeconomic conditions and a new understanding of the causes and control of infection, in the more developed parts of the world, have resulted in major reductions

in maternal, infant, and perinatal mortality from the late nineteenth century to the 1940's (Swyer, 1979). Maternal mortality and morbidity were largely controlled, but fetal and neonatal mortality remain a substantial problem.

During the course of the review of the literature common words such as neonatal, low birth weight, and others will be used quite regularly. It is important that there exist specific definitions of these words. Standardization of definitions provide a firmer basis for comparisons and help in determining the social, medical, and maternal characteristics which influence perinatal outcomes. The World Health Organization Standards regarding perinatal status are listed for purposes of clarity and understanding (based on World Health Organization recommendations as interpreted by the Committee on the Fetus and Newborn of the Canadian Paediatric Society and the Society of Obstetricians and Gynaecologists of Canada):

> *Birth* is the complete expulsion or extraction from its mother of a fetus weighing 500 grams or more, irrespective of the gestational age.
>
> *Live Birth* is the complete expulsion or extraction from its mother of an infant weighing 500 grams or more who breathes, shows beating of the heart, pulsation of the umbilical cord, or definite movement of the voluntary muscles.
>
> *Stillbirth* is the complete expulsion or extraction from its mother of a fetus weighing 500 grams or more who shows no sign of life at or after birth.
>
> *Abortion* is the complete expulsion or extraction from the mother of a fetus or embryo weighing less than 500 grams.
>
> *First Week Death* is the death of a live born infant weighing 500 grams or more at birth who dies during the first seven completed days of life up to, but not including, the moment he becomes 168 hours of age.

Low Birth Weight refers to fetuses or infants less than 2500 grams at birth

Full Size refers to fetuses or infants weighing 2500 grams or more at birth

Gestational Age refers to the number of completed weeks/days which have elapsed between the first day of the last normal menstrual period to delivery of the fetus or infant

Small-for-gestational-age refers to any infant whose birth weight is at the tenth percentile or less for gestational age

Large-for-gestational-age refers to any infant whose birth weight is at the ninetieth percentile or more for gestational age

Appropriate-for-gestational-age refers to any infant whose birth weight falls between the tenth and ninetieth percentiles for gestational age

Neonatal Period refers to the interval from the time of birth to the first twenty-eight completed days of life

Weight and Gestational Age

The importance of birth weight in predicting problems in newborn infants is uncontested. One knows that the 1,000 gram infant will have numerous problems and is best cared for in an intensive care nursery and that the 2,000 gram infant may develop respiratory distress syndrome, jaundice, or feeding problems. At the other end of the scale, one worries about the 4,000 gram infant who may incur birth trauma. The role of gestational age is not quite so clear. Immaturity of various systems is to be expected in preterm infants and placental insufficiency occurs more often in postterm infants. It is entirely logical that weight and gestational age are interrelated and that deviation in weight or gestational age, from a

physiologic range, will result in increased neonatal morbidity (Lubchenco, 1981).

The Academy of Pediatrics through its Committee on the Fetus and Newborn, recommended that all newborn infants be classified by birth weight, gestational age, and some standard for intrauterine growth (Silverman, 1967). Prior to this recommendation, infants were categorized into two subdivisions, namely, low birth weight (<2,500 grams) and full birth weight (> 2,500 grams).

The definition of term birth according to the World Health Organization, with support from the European pediatric groups, has been placed at thirty-seven weeks. The University of Colorado Medical Center, on the other hand, uses thirty-eight to forty-two weeks to designate term birth based on a scatter of birth around forty weeks, which is a near normal distribution curve and includes eighty percent of the population when plus or minus two weeks is used. The three subdivisions for the fetus or infant are large-for-gestational age (LGA), appropriate-for-gestational age (AGA), and small-for-gestational age (SGA).

Infants born before thirty-eight weeks are considered preterm, those born between thirty-eight and forty-two weeks are term, and infants born at forty-two weeks or later are considered to be postterm.

Premature infants can readily be distinguished from the full term counterpart by the comparing skin texture, skin color, skin opacity, plantar creases, nipple formation, breast size, ear form, and genitalia (Dubowitz, Dubowitz, and Goldberg, 1970). Infants who are delivered prior to term,

irrespective of their birth weight, are subject to various disorders which complicate their neonatal course. Neonatal mortality rises progressively with increasing degrees of prematurity (Usher, Allen, and McLean, 1971). Sequelae may affect the growing premature infant for many months or years after birth (Drillien, 1961).

Intrauterine growth standards are constructed from birth weights of infants born at different gestational ages. Common problems associated with these standards are based on the nature of the populations from which they are gathered. The data comes from a very heterogeneous population and, therefore, the results are generalized over such different groups such as race, male and female, smokers, diseased fetuses, socioeconomic level, and more. The importance of such a curve is that it provides a standard of intrauterine growth that makes it possible to select high risk infants for close observation.

During early fetal life, virtually all growth is due to increases in cell number (hyperplasia). Increases in cell size (hypertrophy) become dominant during the later part of gestation. It is not clear how long the increase in cell number continues nor what variations occur in different organs. Interference with the growth of the fetus during the period of hyperplasia results in organs which contain fewer cells than normal, but cells of normal size. If the insult occurs during the period of hypertrophy, the cells will be normal in number but small in size. An intrauterine insult throughout the periods of both hyperplasia and hypertrophy will result in both fewer and smaller cells. In an earlier study it was noted that every

organ can be affected by intrauterine malnutrition (Naeye, 1966). Central nervous system and skeletal growth, together with that of heart and lungs, appears to be the least affected, while the adrenals, liver, spleen, and thymus often are severely reduced in size. Brain cell numbers continue to increase after birth. There is, however, some disagreement as to when cell number no longer increases. Estimates vary between eight and fifteen months after forty weeks gestation. After this period of time increases in cell size are accountable for the tremendous growth increases to the point that the neural structures reach approximately ninety percent of their adult size by the age of five or six (Sinclair, 1985).

The growth curves mentioned above were constructed from values of birth weights attained by infants born at specific weeks of gestation. The lowest ten percent of values in each week of gestation represent the tenth percentile. An infant whose birth weight is on or below the tenth percentile curve is considered to be small-for-gestational-age, while a large-for-gestational-age infant has a birth weight on or above the ninetieth percentile. Since these curves being discussed represent normal intrauterine growth for any particular segment of the population and are constructed from a large number of pregnancies, errors are few and fail to skew the data.

It is evident from the growth curves that the greatest slope corresponds to the time when length, weight, and head circumference increase most rapidly. General interpretation of this data shows that during the twenty-fourth and thirty-seventh weeks of gestation there is the most

overall increase in size of the fetus. If the fetus is to be born during this rapid growth phase, as are many preterm infants, their overall growth appears to be less than normal. In a companion study, measurements made on infants suffering from malnutrition, who by defintion are of abnormally low weight for gestational age, were compared with measurements obtained from normal infants. This comparison shows that infants underweight for gestational age have measurements of skeletal growth smaller in all dimensions than normal infants of the same gestation, and similar in all dimensions to those of less mature normal infants of the same birth weight (Usher and McLean, 1969).

Care of the High Risk Infant

At the time of delivery, the care of the high risk neonate is paramount to its eventual quality of life. It has been reported that lack of prenatal care has been shown to be the single most important factor predisposing to serious illness in low birth weight infants during the first few months of life (Lubchenco et al., 1989). Birth is an exchange of environments from intrauterine to extrauterine. With the changes that occur during this transition, signs of disease are often difficult to differentiate from the normal physiologic adjustments. If the neonatal morbidity and mortality are to be decreased, recognition of any irregularities must occur as soon as possible after delivery. The transition to extrauterine life initially calls for a change in function of several organ systems, such as respiration, and liver and kidney function. Secondly, independent homeostasis of metabolic processes must occur. Once this transition has occurred, normal growth and development

can proceed. In some infants this transition is very smooth, in some it requires assistance, and in others it does not occur at all.

It should be noted at this time that in order to properly care for the high risk neonate, technologically advanced equipment must be available along with skilled personnel for immediate interceptive treatment. Facilities that are equipped with neonatal intensive care units are designated Level 3; those with capabilities for the care of most premature infants are Level 2; and those without any special facilities for premature newborns are Level 1. In one particular study of 13,560 births in a metropolitan area, across the entire range of birth weights (501 grams to 2,250 grams), adjusted mortality rates and odds ratios for the three hospital levels showed that mortality was significantly higher in both level one and level two units compared to level three (Paneth et al., 1982).

Of the causes of neonatal morbidity in the low birth weight infant, respiratory distress syndrome, respiratory failure, apnea, and infection are the most common. Sixty percent of all infants had respiratory distress syndrome and only five percent survived. The most common problem was apnea (85 %) (Alden et al., 1972). The causal relationship between complications during the delivery leading to intrauterine and postpartum hypoxia and incidence of respiratory distress syndrome is well documented (Miller, 1962). We know that the premature infant is at high risk for apnea. Causes include failure to maintain a neutral thermal environment, metabolic disorders such as hypoglycemia and hypocalcemia, sepsis, hypoxia,

anemia, hemorrhage, and immaturity of the respiratory center (Rigatto and Brady, 1972).

Periodic breathing is the normal respiratory pattern of the premature infant and no significant hypoxia occurs. Typically, periodic breathing occurs in twenty-five to fifty percent of premature infants, and irregularities of respiration similar to this occur at one time or another in nearly all babies (Daily et al., 1979). Classically the pattern consists of a period of apnea of five to ten seconds, followed by ventilation of ten to fifteen seconds at a rate of fifty to sixty per minute. The overall respiratory rate is thirty to forty per minute (Chernick et al., 1974). During the period of apnea, no changes in heart rate, color, or body temperature occur. The most striking characteristic of the phenomenon is the marked change in frequency with the level of maturation; periodic breathing is more frequent the more immature the baby and becomes dramatically less frequent after thirty-six weeks of gestational age. (Parmalee et al., 1972).

In many instances, tactile stimulation such as rubbing the rib cage, gently tugging the leg, or flicking of the bottoms of the feet will help the infant to breathe again. Occasionally the infant will need more than tactile stimulation. In the care unit there will always be an oxygen setup with an ambu bag and appropriate size mask available for resuscitation. When apneic episodes become severe, mechanical ventilation may be required.

Periods of apnea of more than twenty seconds and/or those accompanied by bradycardia and cyanosis are termed apneic spells. With prolonged monitoring, at least twenty-five percent of the babies in a

premature intensive care unit demonstrated such spells (Daily et. al., 1979). Bradycardia and cyanosis are followed by hypotonia after twenty seconds and unresponsiveness after forty-five seconds. Therefore, it is not uncommon for infants suffering from apneas, respiratory distress syndrome, or respiratory failure to be placed on mechanical ventilators or respirators. Positive pressure respirators and occasionally manual ventilation are used by means of an endotracheal tube. The effects of the presence of the tube, whether orotracheal or nasotracheal, have received much attention and will be discussed later.

One study shows that reports on infants surviving ventilatory therapy have been encouraging, with the incidence of major neurologic and intellectual defects being in the range of ten to twenty percent (Reynolds, 1974). Another study regarding physical growth of low birth weight infants who were mechanically ventilated showed that these children at ages of one, two, and three tended to be slightly below average for both height and weight (Fitzhardinge et al., 1976).

Oral Complications

Orotracheal intubation necessary to maintain vitality in the premature infant is not without ensuing complications. In this section, a detailed discussion of the effects of orotracheal intubation on growth and development will be reviewed.

Prolonged endotracheal intubation is often necessary for low birth weight infants with respiratory distress (Hatch, 1968). Reports have suggested that one frequent complication of prolonged intubation is the

formation of a palatal groove caused by pressure from the orotracheal tube against the hard palate (Metlay et al., 1989). Possible consequences of the aquired groove include problems with speech, dentition, hearing, and middle ear disease (Ginoza et al., 1989).

In one particular study, Erenberg and Nowack (1984) found that palatal groove formation is a frequent complication in both the low birth weight and term neonate requiring an orotracheal tube. The incidence of this complication is greatest in the neonate requiring a tube for more than fifteen days; however, a palatal groove was seen in one neonate as early as twelve hours following orotracheal intubation. The cause of the palatal groove is most likely related to the position of the endotracheal tube in the oral cavity and the state of development of the palatal bones. Following orotracheal intubation, the tube rests against the center of the hard palate. The oral plate and the maxillary alveolar arch are the principal components of the superior wall of the mouth. All elements of the bony palate are present in the neonate. The median palatal suture is a firm, fibrous articulation without fusion. The transverse suture between the palatine process of the maxilla and the intermaxillary bone is usually open and closes during the first postnatal year. The bony palate of the neonate is usually short and high vaulted (Bosma, 1985). Thus, a palatal groove most likely forms due to the continuous pressure of the endotracheal tube against the median palatine suture.

The incidence of palatal groove and enamel defects in a study of twenty-five children two to five years old who were all between twenty-four

and thirty-two weeks gestation and weighing 800 - 2,000 grams birth weight was shown to be significantly related to the use of neonatal intubation (Punwani et al., 1989). Yet another study by Saunders et al.,(1976), cites that prolonged intubation with nasotracheal tubes has been associated with nasal deformity and an increased incidence of infection and that orotracheal intubation can cause an aquired palatal groove. Therefore, for patients who require prolonged intubation, a system of rotation which utilizes the right nares, the left nares, and the mouth would probably minimize those upper airway complications associated with both nasotracheal and orotracheal intubation.

The use of nasotracheal intubation is not without complications of its own. The nasotracheal tube provides an adequate airway for assisting ventilation in infants by bag, respirator, and continuous positive airway pressure (Smith, 1966). Although the nasotracheal tube is more difficult to insert and position, it has an advantage over the orotracheal tube in the ease of securement. Complications of endotracheal tubes, both oral and nasal, include obstruction by kinking or by mucous, inadvertent extubation, malpositioning of the tube, infection, tracheal ulceration, subglottic edema, chronic subglottal granuloma formation, subglottal stenosis, and vocal cord injury (Striker et al., 1967). In a report by Jung and Thomas (1974), nasal vestibular stenosis was seen in infants after prolonged nasotracheal intubation. The causes of this deformity are felt to be pressure on the nasal vestibule and/or excessive motion of the tube. The report mentions that after follow-up the deformity has an undesirable cosmetic deformity and may

require corrective surgery. There is no mention in the literature at this time regarding the potential damage to the nasal septum which is believed by many to be an important growth site of the developing midface. As Scott (1953), states that the nasal septum is an extension of the cranial base and that this cartilage is the primary skeleton of the upper part of the face.

In an attempt to alleviate the problems associated with the palatal groove caused by the orotracheal tube, a study was conducted to compared the effects of a modified orotracheal tube. Standard endotracheal tubes are constructed of a polyvinylchloride (PVC) material. The rigidity of these PVC tubes is believed to be strongly related to the development of the grooves in the intubated newborn. Recently an endotracheal tube constructed of a softer modified polyvinylchloride material was introduced. In a study by Molteni and Bumstead (1986), a comparison was made between the incidence and severity of palatal grooves in low birth weight infants orally intubated with conventional and modified PVC endotracheal tubes. Their study demonstrated no relationship between the development of a palatal groove and the use of a hard or soft endotracheal tube. The incidence and severity were closely related to birth weight and total intubation time, but they were unrelated to tube consistency.

In a case report by Duke et al.,(1976), it was shown that prolonged intubation resulted in more severe deformation of the palate. One case showed that after ninety days of orotracheal intubation there was clefting of the entire hard palate on an infant from the incisive foramen to the soft palate. There existed no communication between oral and nasal cavities at

this time. After six months slight closure was noticeable. In another case, the infant was intubated for fifty days and concommitantly developed a cleft of the entire hard palate with no communication to the nasal cavity. After four months, no noticeable closure has occurred. It was noted that this uncommon complication of intubation might be avoided by securing the tube to the corners of the mouth in an alternating fashion rather that in the midline. However, this would also increase the possibility of extubation on turning of the infant's head.

A simple question arises as to the severity and/or persistence of the aquired palatal grooves in relation to the orotracheal intubation procedures. One study showed that there is quite contrasting tissue response after a two year follow-up. One example shows that after four months of mechanical ventilation of a 1,050 gram infant born at twenty-eight weeks gestation, a five millimeter median palatal groove had increased in width during the first ten months but by two years of age the contour of the palate had returned to normal. Another example showed that after only eight days of artificial ventilation for respiratory distress syndrome of a 1,230 gram infant born at twenty-eight weeks gestation displayed normal palatal contours. It was not until four months that a four millimeter groove was present which persisted and slightly increased in size by the age of two (Warrick-Brown, 1987). This report demonstrates the individual variability of the response to early trauma inflicted on the neonate as a result of orotracheal intubation.

Prevention of Palatal Grooves

Advances in pediatric intensive care and the greater use of respirators in treating respiratory disease has unquestionably reduced the mortality rate in preterm infants. However, it has been suggested that various dental anomalies may be the result of prolonged endotracheal intubation. Grahnen et. al. (1974), suggested that the prevalence of enamel hypoplasia might be associated with respiratory distress at birth. Saunders et al., (1976), reported two cases of palatal groove formation and Duke et al.,(1976), reported two cases of aquired clefts of the hard palate, as described above. Even the use of a modified, soft endotracheal tube does not lead to a reduction in the amount of palatal grooving as discussed earlier by Molteni and Brumstead (1986).

There are several factors that might account for the abnormal palatal form. The narrow high vaulted palate may be an oral manifestation of the typical narrow elongated head of the preterm infant, where the head posture in the incubator might have contributed to the palatal collapse. The orotracheal tube may press on the alveolar ridge and midline of the palate, disturbing palatal growth and the downward and forward growth of the maxilla. This might be aggravated by the direction of pressure applied to the front of the tube in order to hold the endotracheal tube in its desired position. It is common to find the babies sucking on the tube and this could result in a molding of the oral tissues and in particular, the alveolus (Leighton,1982).

Orthodontists have become increasingly more involved and important in the care of sick newborn babies along with the pedodontist and

prosthodontist. Acrylic palatal plates , which will be discussed next, have been used to protect the developing palate and to support the feeding tubes. Prior to discussing this topic, it should be noted that a study was done by Ash and Croft (1989), to test whether or not it was medically safe and efficacious to take impressions of the palate of an unhealthy newborn that may be undergoing some type of mechanical ventilation. The heart rate and transcutaneous oxygen and carbon dioxide tensions were monitored while palatal impressions were taken and dental plates fitted in thirteen sick newborn babies. Twenty-four such procedures were uneventful and only one procedure gave rise to transient hypoxia.

In this study, it had been demonstrated that simple orthodontic procedures can be carried out safely on very ill babies without causing any apparent disturbance to their respiration or adverse effects on their cardiopulmonary function. Indeed, the majority of the procedures were carried out on babies who were dependent for survival on mechanical ventilation. One baby had become transiently hypoxic during this study. It is expected that occasionally a critically ill baby will become temporarily hypoxic during care procedures (Danford et al., 1983).

The basis for construction of acrylic palatal plates for the prevention of palatal groove formation was initially adopted in response to success shown with these appliances for use in securing orogastric tubes in order to feed infants who were unable to feed by suckling. A study by Sullivan and Haringman (1981), demonstrated that this appliance was well tolerated by patients and easily manipulated by the nursing staff during routine patient

care. It was suggested that this appliance should be considered in all premature and small infants where feeding by nasogastric intubation is contemplated due to the deleterious effects on the nares.

In a study by Ginoza et al., (1989), it was demonstrated that the application of an acrylic palatal plate can significantly diminish the degree of groove formation that occurs as a result of prolonged orotracheal intubation. In those patients who did not receive the palatal appliance, the severity of the palatal groove detected was directly correlated with the duration of intubation.

Similarly, another report of infants fitted with an intraoral appliance covering the palate and alveolus within twenty-four hours after intubation demonstrated normal palatal structures as determined from postextubation casts (Fadavi et al., 1990). This study results highlight two important points: first, palatal grooves are common in postintubated premature infants, and second, palatal grooving can be prevented with the use of an intraoral device that prevents the endotracheal tube from directly pressing on the palate.

In an impressive study by Ash and Moss (1987), the features of premature low birth weight infant palates were examined. Babies of less than thirty-two weeks gestation at birth were compared with thirty who had required orotracheal intubation for ten or more days. By random selection half of these babies were fitted with a protective supporting appliance during the intubation phase.

The palates of the intubated babies were considerably narrower than the control palates, both at the initial and subsequent observations. The mean palatal widths of the plate and no plate groups were similar at the initial and thirty-two week stage.

All three groups demonstrated an initial narrowing of the palate, which persisted in the intubated, no plate group. There was a significant percentage change from the first recording to the thirty-two week stage, indicating that the intubated babies had a tendency to greater narrowing of the palate. By the time the control and plate groups had reached term, the mean anterior palatal widths had grown to match their initial birth dimensions. However, the mean width for the no plate group remained less than the dimension at the first impression. The percentage change in growth between the thirty-two week and term observations was significant for the control and plate groups, but was not significant for the no plate group.

These findings support the clinical observations that the palates of intubated babies without protective appliances remain narrower than the palates of babies who have appliances during intubation and of non-intubated babies. This could indicate that the protective plate distributed the pressure from the endotracheal tube over the upper jaw more evenly, allowing for unimpeded growth of the palate.

Another important clinical finding in the developing and growing low birth weight child is the incidence of dental defects. Although the defects vary as to etiology and clinical significance, a brief discussion is necessary owing to the subject of this paper.

Prior to discussing the basic principles in tooth formation, it should be noted that in a case study of an eight hundred and fifty gram infant that died three days after birth there were noticeable histologic alterations in the developing maxillary incisors following orotracheal intubation for three days. There was a noticeable indentation in the maxillary alveolar ridge corresponding to the placement of the orotracheal tube. Sections taken through the alveolar ridge showed considerable disruption of the enamel organ. The findings were consistent with dilaceration of the root of the left maxillary incisor (Boice et al., 1976). Theoretically, the deciduous malformed root may later have presented mechanical problems in the development of the succedaneous tooth regarding tooth alignment. It may possibly have interrupted odontogenesis of the permanent tooth resulting in either a missing tooth or some form of aberration of that tooth.

In another report it was suggested that endotracheal intubation may have traumatic effects on the developing primary dentition of newborn infants (Moylan et al., 1980). Therefore, a study by Seow et al., (1984), was conducted to examine the prevalence and distribution of developmental dental defects in low birth weight infants in order to determine the possible adverse effects of laryngoscopy and endotracheal intubation.

It was shown upon examination of the primary dentition of sixty-three low birth weight, prematurely born children, that developmental defects of the maxillary anterior teeth occurred in eighty-five percent of forty intubated children as compared to twenty-two percent of non-intubated children, a four-fold difference. Therefore, traumatic injury caused by laryngoscopy and

endotracheal intubation at the critical period of amelogenesis may contribute to defects in the dentition of low birth weight infants whose dental development is already compromised by derangements of calcium and other systemic factors.

At this time it would seem prudent to review the basic morphodifferentiation of the primary dentition. Formation and calcification of the crowns of the primary incisor teeth occur prenatally, except for the cervical portions. Dentitional development (i.e., the earliest cellular differentiation and proliferation) begins at about the sixth week of intrauterine life. Further cell proliferation and invagination in the embryonal oral membranes continue with the formation and growth of the primary tooth buds. Calcification begins at about fourteen weeks at the incisal portion of the primary central incisors, at about fifteen and a half weeks at the cusp tips of the primary first molars, at about sixteen weeks at the incisal portions of the primary laterals, at about seventeen weeks at the incisal tips of the primary canines, and at about eighteen weeks at the cusp tips of the primary second molars. Calcification of the maxillary incisors usually begins before that of the mandibular incisors (Kraus and Jordan, 1965). Once enamel is laid down at any particular location it does not change, and when the crown is completely calcified no more enamel can ever form on it because the ameloblasts which deposit the substance making up the enamel prisms eventually disappear. This is unlike bone which permits the addition and removal of calcium through internal exchanges.

If a systemic disorder occurs which disturbs calcification, the parts of teeth being formed at the time will be abnormal, and abnormal formation will continue as long as the disturbance continues. After the disturbance stops, structural formation and calcification may continue normally. Thus, the abnormal structure remains as a permanent sign of disturbance. If these teeth are examined after they are shed, histologic evaluation may lead to the time of disturbance in terms of appropriate prenatal age.

The age of the subjects under observation is another important factor in evaluating the extent and significance of early disturbance in enamel formation in primary teeth. Malformed enamel on parts of the teeth which calcify earliest in the prenatal period, such as the incisal portions of the primary incisors and the occlusal portions of the primary molars, may become worn away comparatively rapidly as a result of functional attrition and disappear. Studies for the purpose of detecting early malformation yield the best results with children about four years of age or younger (Rothstein, 1974).

Enamel hypoplasia and discolored teeth are found in the teeth of premature babies, especially in their primary teeth (Grahnen and Larsson, 1958). Possible causes include nutritional and metabolic disorders, hypoxia during delivery, or prolonged neonatal jaundice. Although there are numerous clinical reports concerning abnormal morphology and incomplete development of the primary teeth, very few basic research works concerning the teeth of premature babies have been reported.

In one particular study by Fearne et al., (1990), the findings for enamel defects in the primary dentition of a group of low birth weight children were related to their perinatal medical histories. Examination of one hundred and ten low birth weight children and ninety-three control children aged five years showed that significantly more of the low birth weight children (seventy-one percent) had hypoplasia than controls (fifteen percent). In the low birth weight group, defects were seen more often in children classified as ill during the perinatal period, who received ventilator support or intravenous alimentation and in those children born at less than thirty-two weeks gestation, compared to the low birth weight children without these perinatal problems. It was speculated that the the high incidence and the cause of enamel defects in sick preterm infants may be due to oxygen deprivation and mineral depletion.

In a study by Stimmler et al., (1973), twelve young children, born at term, who had neonatal symptomatic hypocalcemia at birth were studied. The children were examined at four years of age, and all had enamel hypoplasia of the primary teeth which was related to the neonatal hypocalcemia at birth. The locations of the hypoplastic lesions were not the same as those in the survivors of a previous study of survivors of preterm birth, but were usually indicative of abnormal or deficient formation of enamel at those parts of the teeth being formed at term and in the neonatal period. All of the children reported by Stimmler, et. al., had convulsive type movements of the limbs soon after birth, characteristic of neonatal hypocalcemia, but no other systemic condition was reported. Although the

number of children reported was not large, the report is of value because of a single medical factor, which was constant, and its undeniable relationship to the enamel dysplasia.

Another study to investigate the incidence and location of tooth developmental disorders, namely enamel hypoplasia and discolored teeth, which are often seen in premature babies was conducted by Funakoshi et al., (1980). The study consisted of fifty-two infants from two to five years of age with complete deciduous dentition. Of those, thirty-two children were appropriate-for-gestational-age and twenty were small-for-gestational-age. Enamel hypoplasia was seen in twenty-seven percent and discolored teeth in two percent. The incidences showed no significant differences between the AGA and SGA groups. Incidences were high in babies in the uterus for thirty to thirty-four weeks weighing less than 2,100 grams on delivery. Enamel hypoplasia was found in both the posterior and anterior areas in eighty percent and only in the anterior area in twenty percent. Discoloration was distributed throughout the dentition. Typical abnormality was limited to one-third of the cutting margin of each tooth in almost all cases, and there were wave-like abnormalities of enamel formation.

Whether the frequency in the changes of the hard tissues of the primary teeth is increased in children who have had pre-,and/or neonatal asphyxia was the study conducted by Grahnen et al., (1969). They found that enamel hypoplasia tended to be more common in the asphyxia group that in the controls, but the difference was not statistically significant. Also,

enamel hypoplasia was not more common in children born before term or after term than in the material as a whole.

Finally, in a study by Johnsen et al., (1984), it was shown that in infants with dental defects, there was no significant correlation with pregnancy risk factors, gestational age, birth weight, septicemia, first week caloric intake, serum bilirubin, or calcium. However, infants with enamel hypoplasia were more likely to have severe respiratory distress syndrome than infants with unaltered enamel.

It should be noted that two-thirds of calcium and phosphorus contents in the whole body of the fetus are accumulated during the latter three months of pregnancy. Therefore, premature babies have missed these accumulations. In spite of the fact that rapid growths, especially accumulations of calcium and phosphorus in the skeletal system, are required of premature babies, calcium deposition in the bone is low, and the shorter the fetal period, the worse is the bony mineralization during several months after birth. If birth coincides with the calcification period of enamel, there is sufficient possibility of causing disturbance in this site (Sarnet and Schoure, 1942).

Review of Facial Growth

The head of a four week old human embryo is mostly just a brain covered by a thin sheet of ectoderm and mesoderm. Where the mouth will be is marked by a tiny depression, the stomodeum. The eyes have already begun to form by a thickening of the surface ectoderm (the future lens), which meets an outpouching from the brain (the future retina). The eyes are

still located at the sides of the head, however, as in a fish. As the brain continues to grow and expand, the eyes are rotated toward each other and toward the midline of what is soon to become a face (Enlow 1990).

During this period of early formative development, between the fourth and sixth weeks in utero, the head area can be visualized as a series of what is known as pharyngeal arches and pharyngeal clefts. Our area of interest is the growth of the face, and the first pharyngeal arch is the precursor to the developing maxilla and mandible. It is also known as the mandibular arch.

The mandibular arch has two distinct processes, the mandibular and the maxillary. Each is the primordial component to the mandibular and maxillary bones. These processes migrate toward the midline. The paired mandibular processes unite at the midline, whereas the maxillary processes unite near the midline with the medial processes of the frontomaxillary process. This forms the primary palate, the philtrum of the upper lip, and a resulting mouth in the embryo. At this point in time (sixth week), the tongue and floor of the oral cavity drops inferiorly allowing the lateral shelves of the maxilla to move medially. Union of these two halves forms the secondary palate of the maxilla. Ossification soon begins in this and other bones of the developing face.

At the same time the bones of the lower face are beginning their ossification, the dentition has already started its development. At six weeks in utero, formation of the dental lamina is apparent. This primordia of dental tissue invaginates into the underlying mesenchyme of growing maxilla and

mandible. The dental lamina itself undergoes a proliferation into what is known as tooth buds. The first buds to form are the mandibular anterior teeth and the maxillary teeth follow in one to two days. By the eighth week all buds for the maxillary and mandibular teeth are present in some stage of early differentiation. Each of these tooth buds contains three distinct parts. The first part, the enamel organ, is derived from ectoderm and eventually produces the enamel part of the tooth. The second part, the dental papilla, is derived from mesenchyme and produces the pulp and dentin of the tooth. And the third part, the dental sac, is also derived from mesenchyme and produces the cementum, periodontal ligament, and the alveolar socket (Forrester et al., 1981).

During this time of tremendous cellular and morphodifferentiation, ossification of the bones occurs. Bones of the cranial base undergo endochondral ossification, whereas most of the bones of the growing face undergo intramembraneous ossification. The cranium, maxilla and mandible begin their ossification with a single trabeculae of bone. After continued bone growth, the size of each bone increases by apposition of new bone at the surfaces and at the sutures. Largely sutural growth is responsible for the displacement, downward and forward, of the maxilla. The mandible, lacking sutural articulation with the cranium, has proliferation of the condylar cartilage with subsequent osseous replacement as a method of primary displacement. In this manner, both the maxilla and mandible are moved forward and downward in the developing and growing face.

The growth of the cranium is highly differentiated. The brain and the visual organs, for instance, attain practically fully developed size before the age of puberty. By comparison, the growth of the facial structure is functionally more intimately related to the growth of the body structure as a whole and therefore continues to a considerable extent during adolescence. The midfacial structure and the nasal cavity grow at a rate which is commensurate with the need for increased oxygen requirement, whereas the jaws develop at a comparatively high rate to keep up with the increase in metabolism which continues up to adult age. From a functional viewpoint, the cranial base forms the partition between the brain and the facial structure. Accordingly, the internal and external cranial base must develop at widely different rates in order to accommodate the different development of the brain and the facial structure. Expansion of the brain case during childhood is thus followed by a period of formative development during adolescence in which the cranial base continues to undergo a considerable change. During the formative development of the cranial base and the brain case, a lowering of the two medial and the posterior cranial fossae occurs in relation to the anterior one. As an effect of this differential growth of the cranial base, the the glenoid fossa suffers a rearward and at the same time downward displacement in the cranium. It is evident therefore, that the growth of the cranial base will exercise a marked influence on the jaw position and on the occlusion of the teeth. The displacement of the temporal bone within the cranial structure with growth, and hence of the temporomandibular joint, varies in extent from case to case. Vertical and

horizontal growth of the lower jaw varies with the direction of growth at the condyle. The vertical component of growth at the mandibular condyle and the lowering of the medial cranial fossa, and hence of the temporal bone, determine the extent to which the mandible will be lowered in the facial pattern. The dorsal displacement of the temporal bone and the sagittal growth component of the mandibular condyle are the growth factors which together determine the longitudinal development of the lower face. In most cases these factors counteract each other. The lowering and extension of the maxilla in the facial pattern are affected by sutural growth, accompanied by a simultaneous periosteal growth of the alveolar arches in height, length, and width. The growth of the bones forming the midfacial structure and the maxilla is associated with the growth and development of both the cranial base and the mandible (Bjork 1954).

The maxilla is an attached bone which ultimately receives its support from the external table of the brain case. The term ultimately is used because only at one place does it make direct contact with the case. This is at the frontonasal junction where its frontal process, which runs up medially to the orbit, meets and articulates with the nasal notch of the frontal bone. The growth that takes place at this site seems to be localized largely on the maxillary side. There we gain the impression that this bone, by growing upward against a fixed base, is pushed downward. But the maxilla forms the major portion of the of both nasal cavity and orbits, neither of which descends as fast as does the entire bone. A similar rate of descent would maintain the infantile proportions of these parts, both of which are large at

birth. To prevent their overenlargement, new bone is laid on the superior surface of the floors of the nasal cavity and the orbits and in this manner the adult proportions of the face are achieved. At the posterior part of the alveolar process we have the area known as the tuberosity, and this is another active growth site. Here the maxilla meets the pterygoid process which descends from the sphenoid bone of the basicranium. Interposed between them, however, is the pyramidal process of the palatine bone, a provision which allows for rapid growth of the masticatory apparatus, while maintaining the stability of the palate. Again in this region growth is shown to be largely confined to the maxillary side of the junction and backward growth here results in a forward pushing of the entire bone. Thus, by the combined activity of growth at the frontonasal junction and at the maxillary tuberosity, the maxilla is carried downward and forward (Brodie 1947).

The mandible is a freely moveable bone contacting other bones only at its condylar process which meets the basicranium in the glenoid fossa. Its growth has been studied more than any other bone with the exception of the femur and is relatively well understood (Brodie 1947).

The general form and proportions of the mandible are established well before birth and like other bones it reveals a generalized growth for a few years thereafter. The chief growth site for this bone lies in the condylar head. Activity here calls for a cartilage proliferation and transformation to bone similar to that found in the epiphyses of long bones. The condyle meets the ramus of the mandible at an angle and because of this its growth is upward and backward. Since the growth is expressed against a stable

cranial base, the resultant displacement is downward and forward. This is similar to the overall displacement seen in the maxilla as mentioned above. If growth at the condyle were the sole mode of overall growth of the mandible, this bone would appear quite different in the adult and the infant. The reason that this bone maintains its overall shape throughout life (until tooth loss in late adulthood), is that there are fields of remodeling throughout the entire bone. These resorptive and depository fields allow for displacement of the bone while maintaining the morphology of the bone. As the condylar cartilage differentiates into bone the mandible is carried downward and forward. Resorption of bone along the anterior aspect of the ramus combined with deposition of new bone at the posterior border of the ramus accounts for enlargement of the tooth bearing segment of the bone as well as relative anteroposterior position of the mandible to the cranial base.

Obviously, as with virtually any attempts to explain nature, there are many viewpoints regarding the nature of growth of the face and facial bones. To this point, the explanation was largely focused on the bones as the actual driving force of the growth of the face. The following explains growth from a slightly different vantage point and is taken from the theories according to Moss (1969), and are known as the functional matrix theory of facial growth.

It is a basic postulate of the method of cranial functional analyses that, with the exception of the embryonic tissue differentiation, all other aspects of cranial tissue growth (osseous, cartilaginous and fibrous) are secondary and compensatory reflections of the morphogenetically and temporally prior growth and operation of the cranial functional matrices. The primary growth

of all these matrices, taken together with the secondary growth of all of the skeletal units, comprises the totality of head growth. Periosteal functional matrices are virtually self-defining. They are best exemplified by the effect of muscles upon the skeletal units which subserve their contractile function. Whether these muscles attach their tendinous portions directly into the skeletal tissue or indirectly by fusion with only the outer fibrous layer of periosteum, they all produce a direct, rapid, and complementary response by their specific skeletal units. All periosteal matrices act homologously, usually by means of the process of osseous deposition and resorption. They act to alter either or both the size and shape of a skeletal unit. Therefore the growth and actions of the skeletal muscle tissues is the driving force behind the growth and displacement of the facial bones. In a very real sense, according to the explanation proposed by Moss, the bones serve only to act as a scaffold for the soft tissue matrices around them.

A final consideration in the review of facial growth regards the eruption of the dentition and its effect on the developing maxilla and mandible. With the eruption of the teeth, a new and important structure, the alveolar process appears. Growth of the alveolar process occurs vertically, laterally, and anteriorly through surface bone apposition and resorption. At age two, an important stage is reached when all deciduous teeth have fully erupted. Whereas the flexible tongue had, for the most part, separated the two jaws from each other, a firm and precise occlusion now exists. After eruption of the second deciduous molar, the length of the anterior segment of the lower jaw, measured from the symphysis to the second deciduous

molar, does not change appreciably in size during life. Except for some chin thickening, growth takes place by additions to the posterior regions of the rami in the mandible and the tuberosity in the maxilla. Between ages six and twelve, virtually all increases in size of the maxilla and mandible occur as length increases as mentioned above and by vertical alveolar height increases with the eruption of the permanent teeth.

STATEMENT OF THESIS

The purpose of the present study was to investigate the dental development and manifestations of dental occlusion in a sample of low birth-weight children. Advances in the science of perinatal medicine have provided life to even the smallest and most immature of preterm infants. The outcome of this life support therapy, as related to dental development, was the focus of this study.

A review of the literature indicates that virtually all children born less than 1,500 grams birth-weight require endotracheal intubation. The effects of this intubation on the developing maxilla and maxillary anterior teeth have been well documented in low birth-weight children from birth to preschool age. In the present study, the author was interested in the dental development and dental occlusion in low birth-weight children of school-age (6-8 yrs).

METHODS AND MATERIALS

The study population consisted of thirty children born with low or very low birth-weight. Low birth-weight ranges between 750 and 1,499 grams and very low birth-weight is less than 750 grams. Table 1 summarizes the study sample. All of the children in the study group were cared for during, or shortly after, birth at a local tertiary neonatal facility (Rainbow Babies and Childrens Hospital, Cleveland, Ohio). The children were all participants in a larger longitudinal study at this facility (School Age Follow-up Program, Maureen Hack, M.D., Principal Investigator).

Children who were cared for at this hospital were being recalled for developmental and neurologic testing. The sample was collected over a thirty week period as the children presented for follow-up medical testing. During the testing period, time had been set aside for a dental exam. The only criteria necessary for inclusion in the study were that the child be 1,500 grams birth-weight or less, and that consent was obtained. No exclusions were made based on sex, age, or race. The author discussed with the parent or guardian the desire to include the child in the current study. After consent was obtained, the dental examination commenced.

Although most of the participants in the study had no problem with the routine dental examination performed, a few may not have coped with the examination as would be expected. Several children who had been

entirely uncooperative during the dental exam were omitted from the investigation. Perhaps, if the degree of dental malocclusion in developmentally or neurologically impaired low birth-weight children is substantial, then the overall results must be viewed accordingly.

TABLE 1.--Selection of Sample: Study and control groups

	TOTAL N	SEX	RACE	MEAN AGE*	MEAN BMI
VLBW	14	10-F 4-M	7-W 7-B	6.10	15.37
LBW	16	11-F 5-M	11-W 5-B	7.3	17.01
VLBW Control	14	10-F 4-M	11-W 3-B	6.3	15.87
LBW Control	16	10-F 6-M	14-W 2-B	6.6	17.20

*Age given in years.months

The samples were matched according to the Body Mass Index (BMI), also known as the Quetelet Index. Although this index is normally used to measure the degree of obesity among adult sized individuals, it can be used in the current study to match the children of the low birth-weight group,

according to height and weight, at the time of the dental assessment to the control group. Since the jaw size correlates with body size, the low and normal birth-weight samples were appropriately matched based on these criteria.

Adolphe Quetelet (1796-1874), is credited with naming the science of anthropometry. He devised the earliest of all the height and weight tables which stand out as the first of what has become one of the most widely used tools in health and nutrition assessment. The formula used for matching the study and control groups, based on Quetelet's pioneering analyses, was simply BMI = w / h x h; where BMI is the body mass index, w is weight and h is height (Weigley 1989). This quotient results in a small integer which enables one to more easily identify similar body sizes.

Therefore, once the weight and height were recorded for each of the low birth-weight children, the BMI was obtained. Selection of the control sample was accomplished by reviewing the records of the participants of the Bolton-Brush Growth Study located at Case Western Reserve University, School of Dentistry, Cleveland, Ohio. Similarly, the weight and height were used to obtain the BMI for each child in the control group. At this point, the BMI for each low birth-weight child was matched to each of the control children in order to obtain thirty matched pairs.

The information gathered for the control group contained full medical history, birth-weight, race, gender and dental models. The medical history for each child selected in the control was reviewed for normal childhood development. Any children who had experienced unusual ailments or birth

defects were eliminated from the control group. All of this information came from the collective records of the Bolton-Brush Growth Study.

During the follow-up medical examination of each low birth-weight child, time had been set aside for the dental assessment. Most of the participants underwent several hours of testing for the medical investigation prior to receiving a meal for lunch. It was during this time that the author was able to discuss with the parent or guardian the nature of the dental assessment to be performed.

The total time necessary for this procedure was approximately fifteen minutes. Initially, an exam of the intraoral structures was completed noting any irregularities of immediate concern. For instance, some of the children seen during this screening were seeing a dentist for the first time and, therefore, the information gathered by this cursory examination was of particular interest to the parents of the children involved.

The second phase of the dental examination consisted of obtaining molds of the dentition of each child. Impressions were made using an alginate impression material. Alginate is a reversible hydrocolloid material which uses a combination of water and the powdered alginate. Jeltrate alginate (LD Caulk Division of Dentsply International, Milford, Delaware) was used. Twenty-one grams of the powdered alginate was mixed with thirty-eight milliliters of warm water. This produced a creamy mixture which was placed into the impression tray and then into the mouth and over the dentition. Stock impression trays (Extendo-tray, TP Orthodontics, LaPorte, Indiana), which were anatomically consistent with the oral structures, were

used for holding the impression material in the mouth. Warm water, approximately forty degrees Celsius, was used in order to accelerate the setting time of the alginate. The tray had been already sized in the mouth over the dentition, having the flanges of the tray covered with soft wax. The wax allows for comfortable seating of the tray as well as maximal tissue displacement in order to capture the natural anatomy of the dental alveolus. Once the loaded tray had been placed into the mouth and over the dental arch, approximately thirty to sixty seconds was necessary for setting prior to removal of the tray from the mouth. As was previously noted, the compliance of the child on a first time experience with the dentist was of particular concern and several of the children in the study were eliminated since they were unable to tolerate the impression procedure. Impressions for both the maxillary and mandibular arches were obtained in this manner.

After the impressions were made, frontal and lateral photographs were taken (Kodak Ektachrome-100HC 35mm, Eastman Kodak Company, Rochester, New York). Photographs were taken as an adjunct in identifying any particular malocclusions that were featured by the low birth-weight group. Since photographs were not available in the control group from the Bolton-Brush records, no further comparisons were made between the two groups with regard to facial form, head form, or malocclusion.

The alginate impressions were immediately wrapped in moist paper towels and brought to the laboratory for pouring. The inside of each impression was dried with light air spray prior to pouring viscous plaster into it. The plaster was allowed to set for a minimum of sixty minutes before

removing the cast from the impression material. In this manner, the plaster models were obtained without any loss in dimensional stability. The capital of the models was then carefully sculpted, removing any residual artifacts, in order to obtain the best anatomy for making measurements from these casts.

The medical records of each of the participants in the low birth-weight group were reviewed for information that was thought to relate to the dental development of the child. The height and weight at the time of the dental examination was obtained for each child. This information was recorded as previously mentioned in order that the appropriate control group be collected. The gestational age of the child was recorded as well as the birth-weight so that correlations may be made regarding dental development and preterm birth. Other information gathered from the medical records included the type of intubation received during early neonatal life, the length of time that this intubation was required, and the total neonatal risk number. This risk number represents a reference as to the overall sickness of the low birth-weight child. A specific numerical value is given to a specific complication during early postnatal development. The higher the risk number, obviously, the more unhealthy the individual. This information was recorded in order that correlations be made among the low birth-weight children. Since no such risk factor is available in the records of the control children, no comparisons were made between the two groups using this data.

The number of days on oxygen during early neonatal existence and whether or not there were any noticeable neurologic deficits were also recorded at this time. The reason for obtaining this information was to determine the extent to which the overall growth of the palate, maxillary alveolus, mandible or mandibular alveolus may be affected by an early environmental insult to the growth of the bones housing the dental structures.

Using the plaster casts of the children in the study, dental measurements were obtained. The specific measurements included maxillary and mandibular deciduous canine width, deciduous second molar width, permanent first molar width, maxillary and mandibular arch depth to the deciduous second molars, arch perimeter to the deciduous second molars, anteroposterior and vertical occlusal relation, palatal height , Angle's classification for occlusion, and mesiodistal width measurements of the permanent maxillary central incisors and maxillary first molars(Appendix One). All of the measurements mentioned were obtained for both the study as well as the control groups.

The method for obtaining the points on the models from which the measurements were made was similar to that of the "Standards of Human Occlusal Development" (Center for Human Growth and Development, University of Michigan 1976). The point indicating the reference from which all measurements were made, was derived as follows. A line was drawn mesiodistally on each tooth through the contact points. A second line extended from the two widest points on the buccal and lingual surfaces of

each tooth.. The midline of each of these two lines was determined and subsequently bisected to find the actual center of each tooth consistently.

The following list defines the dental measurements that were made on each of the plaster casts for both low and normal birth-weight groups:

ARCH WIDTH (Canines): the distance between the canines at the centroids

ARCH WIDTH (Molars): the distance between the centroids of the deciduous second molars; the distance between the centroids of the permanent first molars

ARCH DEPTH: the distance from the midpoint of the most labial points of the central incisors to a line crossing the distal contacts of the deciduous second molars

ARCH PERIMETER: the length of a line which begins at the distal of the deciduous second molar on one side of the arch, passes through the centroid of the canine, over the incisal edges of the incisors, through the centroid of the opposite canine, and ending at the distal of the opposite deciduous second molar

ANTEROPOSTERIOR OCCLUSAL RELATIONSHIP (Overjet): the distance between the most labial point of the mandibular incisors and the most labial point of the maxillary incisors while in occlusion

VERTICAL OCCLUSAL RELATIONSHIP (Overbite): the distance between the incisal edges of the maxillary and mandibular incisors while in occlusion

PALATAL HEIGHT: the distance between the palatal raphe and the occlusal plane at the level of the deciduous first and second molars

In order to be sure that the size of the teeth were relatively the same for each of the two groups, mesiodistal widths were recorded for the permanent maxillary central incisors and first molars. The measurements

were averaged for these teeth and the result showed no appreciable difference in tooth size.

All dental measurements were made using an electronic liquid crystal display (LCD) digital caliper (Mitutoyo Corporation, Japan). These measurements were recorded to the one-hundredth of a millimeter. The measurements were performed at two different times and then averaged in order to be certain of the individual accuracy of each measurement.

The statistical analysis used for comparison of all of the dental measurements between the two groups was the paired t-test. In this manner, the data for each match between the low and normal birth-weight groups was analyzed for statistical significance for each particular measurement. The mathematical formula used for obtaining the t-statistic is as follows: $t=x-u / s/ n$.

Since the assessment of malocclusion based on Angle's Classification was used for both low and normal birth-weight the paired t-test was not applicable. The measure of malocclusion was based on an ordinate scale which could be subject to a chi square analysis. Due to the relatively small sample size, a Chi-square analysis was not performed on data relating to malocclusion. The data, however, is presented in the results section as a graph in order to relate the specific malocclusions between groups.

RESULTS

The data that had been collected from the groups of low birth-weight and normal birth-weight children were examined and tabulated to compare the differences based on individual matched pairs. As mentioned previously, the pairs were matched based on the Quetelet Index, also known as the body mass index.

There were thirty subjects in each of the two groups, however in the following tables the number of cases being compared may be less than thirty. Some of the thirty cases that were used for the comparisons were lacking one or more of the dental units that were necessary for the matched comparison. Therefore, the total number of cases represents those individuals who had all of the necessary dental units for that particular comparison. For instance, since the ages of the children fell right around the time of permanent first molar eruption, not all of the participants presented with permanent first molars. In this case, the number of cases being compared will be equal to the total number of cases which contained all permanent first molars. The same is true for each of the sets of dental measurements.

As discussed in the section on materials and methods, the specific dental measurements being compared were as follows: (1) intercanine widths for both maxillary and mandibular canines, (2) intermolar widths for

the primary second molars and permanent first molars in both the maxillary and mandibular arches, (3) arch depth from central incisors to the distal of the primary second molars in both the maxillary and mandibular arches, (4) arch perimeter from distal of the primary second molars for both maxillary and mandibular arches, (5) anteroposterior relationship of the arches measured as the amount of horizontal overbite from the labial surface of the mandibular central incisors to the labial surface of the maxillary central incisors, (6) vertical relationship of the arches measured as the amount of vertical overbite in the incisor area, and (7) the palatal height measured from the palatal raphe to the occlusal plane at the level of the primary first and second molars.

Measurement of the intercanine widths was performed in order to assess the transverse relationship in the anterior half of the dental arch. The measurements for both the low and normal birth-weight groups, as well as for the maxillary and mandibular arches are contained in Table 2. As can be seen in this table, there were no statistically significant differences between low birth-weight and normal birth-weight groups for either of the two arches.

The second measurement recorded the transverse relationship of the posterior aspect of the dental arch. The actual measurement represents the distance between the centers of the primary second molars as described in the section on materials and methods. As was the case with the primary intercanine widths, there were no statistically significant differences in primary second intermolar widths. Table 3 represents the data on primary

second intermolar widths for both maxillary and mandibular arches of the low and normal birth-weight groups.

TABLE 2.--Intercanine widths for maxillary and mandibular arches in low and normal birth-weight groups *

	MEAN	STD. DEV.	t-STAT.	p-VALUE
MAX C LBW	29.57	3.44	-1.43	.164
MAX C CONTROL	30.72	2.91		
MAND C LBW	23.25	2.63	-.68	.505
MAND C CONTROL	23.65	1.77		

*measurements are all calibrated in millimeters

Maxillary and mandibular permanent first molar intermolar widths were calculated in the same manner as were the intermolar widths for the primary second molars. The only difference to be noted here was that out of the thirty cases in each group, only thirteen matched sets were made. Since the children were matched based on the body mass index and not chronologic age, there were many children in the normal birth-weight group who were too young to have the permanent teeth already erupted.

Nonetheless, the measurements were made for all those having the permanent first molars. Table 4 represents the intermolar widths for both the maxillary and mandibular first molars in both the low and normal birth-weight groups. No statistically significant differences were found between the measurements in each group.

TABLE 3.--Primary second intermolar widths for both maxillary and mandibular arches in low and normal birth-weight groups *

	MEAN	STD. DEV.	t-STAT	p-VALUE
MAX E LBW	37.98	3.86	-.24	.813
MAX E CONTROL	38.16	2.80		
MAND E LBW	34.43	2.76	1.68	.105
MAND E CONTROL	33.55	2.18		

* All measurements calibrated in millimeters

Evaluation of the significance of arch depth was calculated in the same manner as the previous measurements. Arch depth, as measured from the incisal edges of the central incisors to a line crossing the distal of

the primary second molars, was recorded for both the maxillary and mandibular arches in both the low birth-weight and control groups. Table 5 represents the arch depth measurements in maxillary and mandibular arches for low and normal birth-weight groups. No statistically significant differences were found between the two groups with respect to maxillary or mandibular arch depth.

TABLE 4.--Permanent first intermolar widths for both maxillary and mandibular arches in low birth-weight and control groups *

	#	MEAN	STD. DEV.	t-STAT	p-VALUE
MAX 6 LBW	13	42.78	3.95	-.89	.393
MAX 6 CONTR.	13	43.66	2.50		
MAND 6 LBW	13	38.90	3.19	.50	.625
MAND 6 CONTR.	13	38.19	4.37		

* All measurements calibrated in millimeters

TABLE 5.--Arch depth measurements of maxillary and mandibular arches in low and normal birth-weight groups.*

	#	MEAN	STD. DEV.	t-STAT.	P-VALUE
MAX AD LBW	26	29.37	2.44	.61	.546
MAX AD CONTR.	26	29.00	2.05		
MAN AD LBW	30	24.76	2.20	-.55	.586
MAN AD CONTR.	30	25.08	2.35		

* All measurements calibrated in millimeters

The next variable to be shown is that of arch perimeter. Arch perimeter was measured as a smooth arc which passed from the distal of the primary second molar on one side of the arch to the distal of the primary second molar on the opposite side of the arch. The arc passed through the central grooves of each of the posterior teeth on one side of the arch, across the cusp tips and incisal edges of the anterior teeth, and through the central grooves of the posterior teeth on the opposite side of the arch. Measurements were recorded for both low and normal birth-weight groups in both maxillary and mandibular arches. Interestingly, the differences

between the measurements of arch perimeter in the maxillary arch between low and normal birth-weight children was found to be statistically significant, whereas the differences in the mandibular arch were not significant Table 6 represents the arch perimeter measurements of the maxillary and mandibular arches for both low and normal birth-weight groups.

TABLE 6.--Arch perimeter values for maxillary and mandibular arches in low and normal birth-weight groups*

	#	MEAN	STD. DEV.	t-STAT	p-VALUE
MAX AP LBW	30	78.79	7.59	-2.10	**.045**
MAX AP CONTR.	30	82.05	5.47		
MAN AP LBW	30	70.72	7.36	-1.19	.243
MAN AP CONTR.	30	72.42	5.05		

*All measurements were calibrated in millimeters

The last sets of specific dental measurements that were recorded for the low and normal birth-weight groups included a measure horizontal overbite, a measure of vertical overbite, and a measure of palatal height.

Table 7 represents the measurements described above for both low and normal birth-weight groups.

Anterior horizontal overbite, i.e., overjet, was measured as the horizontal distance between the labial surfaces of the most labial of the maxillary and mandibular incisors while in occlusion. The differences in this measurement between the two groups was found not to be statistically significant.

Anterior vertical overbite was measured as the vertical distance between the incisal edges of the maxillary and mandibular incisors while in occlusion. Once again, there was no statistically significant difference in these measurements between the two groups.

A measure of the height of the palate was obtained as the distance between the palatal raphe and the occlusal plane at the level of the primary first and second molars. The total number of matched pairs for this particular measurement was due to lack of identifiable palatal landmarks on the plaster casts of the control group. In this study, a statistically significant difference was found between the palatal height measurements of the low birth-weight group and the normal birth-weight, control group. As previously mentioned, perhaps the total sample of matched pairs for this determination was too low and not representative of the entire group. Table 7 represents the horizontal, vertical and palatal measurements for both low and normal birth-weight groups.

TABLE 7.--Overbite, overjet, and palatal height measurements for low and normal birth-weight groups.*

	#	MEAN	STD. DEV.	t-STAT	p-VALUE
OJ LBW	25	3.34	1.67	1.66	.110
OJ CONTR.	25	2.26	1.37		
OB LBW	25	2.58	2.24	-.14	.887
OB CONTR.	25	2.66	.82		
PAL HT LBW	13	14.27	1.53	3.14	**.009**
PAL HT CONTR.	13	12.38	1.68		

*All measurements calibrated in millimeters

Comparison of occlusion between the low and normal birth-weight groups displayed a variability that was more difficult to test statistically. A Chi-square analysis would be the appropriate test, however, the total number in each of the six subgroups was too small to test by a Chi-square analysis. Therefore, the distribution of occlusion in the two groups is

demonstrated by means of a simple column graph. This information is contained in Figure 1.

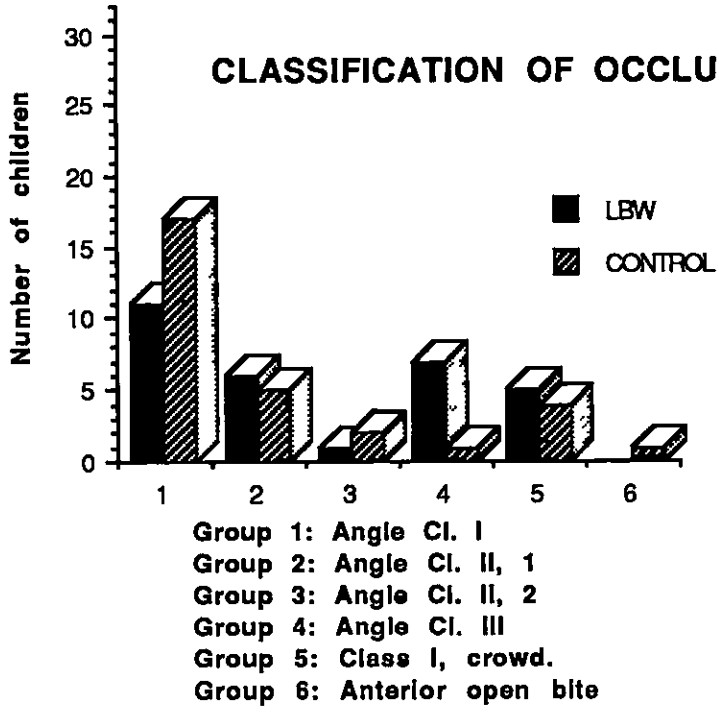


Figure 1. Occlusion based on Angle classification.
Note high incidence of class III occlusion in LBW group.

To this point in the section on results, attention has been focused on the differences between the low birth-weight and normal birth-weight child with regard to specific dental measurements that are indicators of dental occlusion. Within the low birth-weight itself, there were correlations made based on the birth-weight and total neonatal risk.

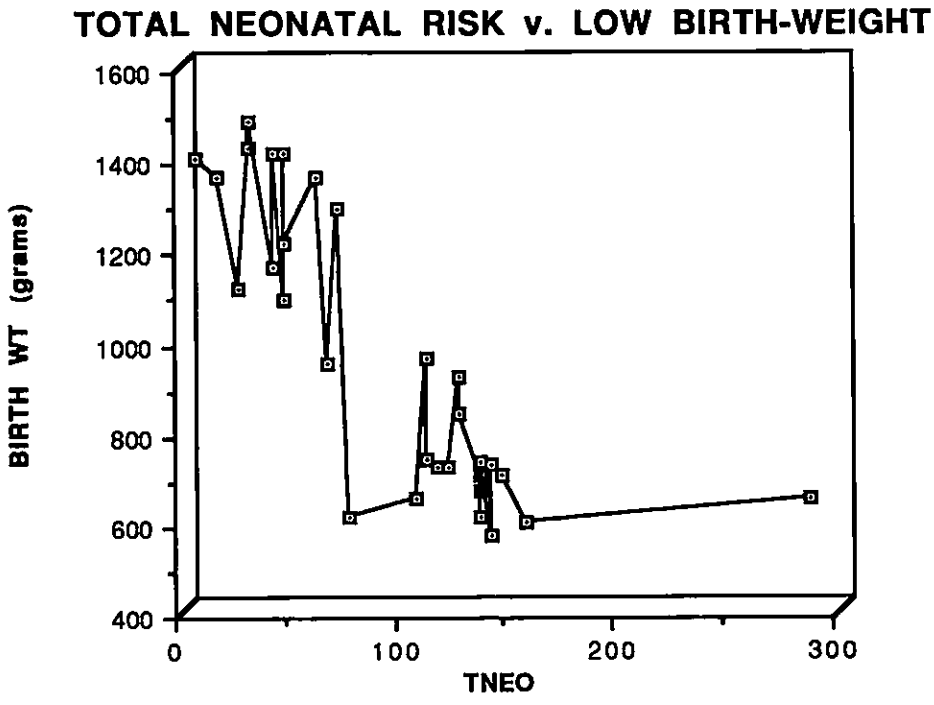


Figure 2. Total neonatal risk as a function of low birth-weight. Note the inverse relationship between the two variables.

Total neonatal risk is a numerical measure of the overall health , or sickness, of the neonate. For each ailment or medical complication suffered by the neonate, a score is given. The sum of all scores represents a degree of health at the time of early post-natal development. Therefore, the higher the score, the less ill the child is post-natally. Figure 2 represents the relationship between these risk scores and the individual birth-weights of each of the study population.

A comparison was made between the palatal heights of each of the low birth-weight children and their corresponding intubation times. Since the results showed a statistically significant difference in palatal heights between the low and normal birth-weight groups, it seemed logical that perhaps the intubation itself had an effect on the height of the palate. A linear comparison was made to determine whether or not a direct relationship could be drawn from the measurements of palatal height and the total intubation times. As can be seen in Figure 3, there appears to be no ideal correlation between these two variables. One would expect that as the intubation time increases, the pressure of the endotracheal tube on the developing hard palate would cause the increase in palatal height as measured from the occlusal plane. This, however, is not evident from Figure 3.

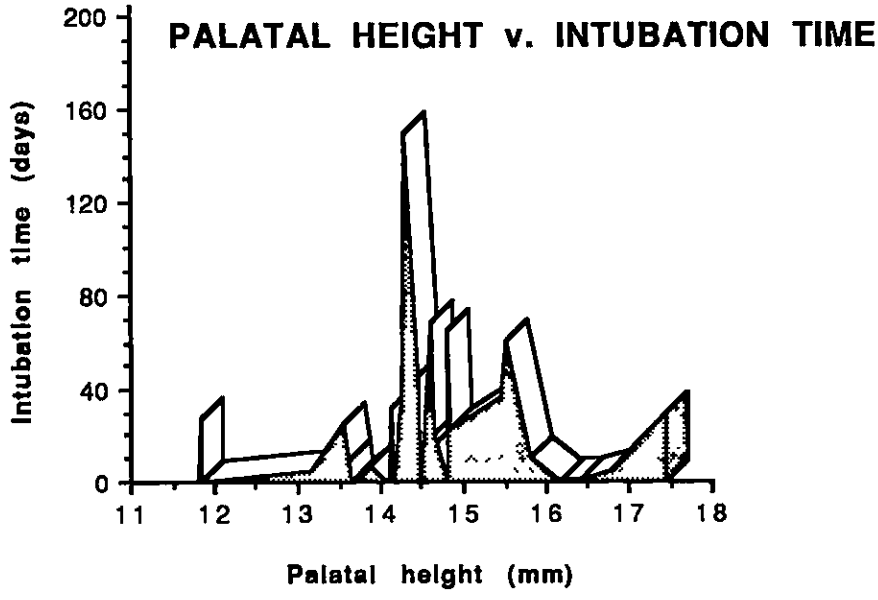


Figure 3. Palatal height v. Intubation time. Although a direct proportion would be expected, this is not represented

The data presented above shows that there are significant differences between low and normal birth-weight groups with regard to maxillary arch perimeter, palatal height, and the number of Class III malocclusion. The question arises as to the division of these categories within the study group itself.

As discussed earlier in the introduction and literature review, the study group can be further divided into low birth-weight (750-1,499 grams) and very low birth-weight (<750 grams). Therefore, the author decided to

compare these two sub-groups to determine whether or not one of the groups contributed more to the significance of the results obtained.

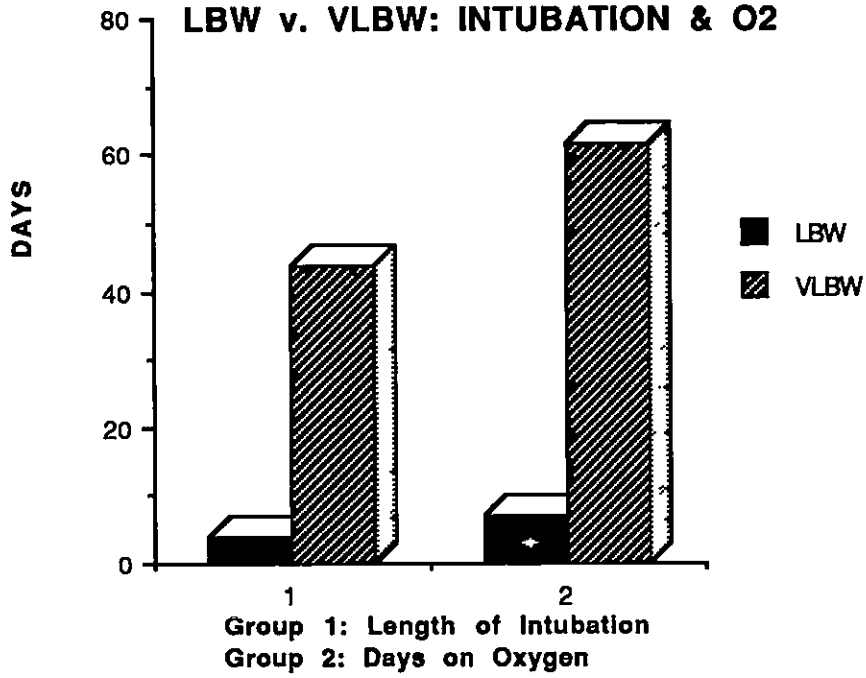


Figure 4. Comparison of intubation time and days on oxygen between low and very low birth-weight children

As can be seen in Figure 4, the are profound differences in the length of intubation and number of days on oxygen between the low birth-weight and very low birth-weight children.

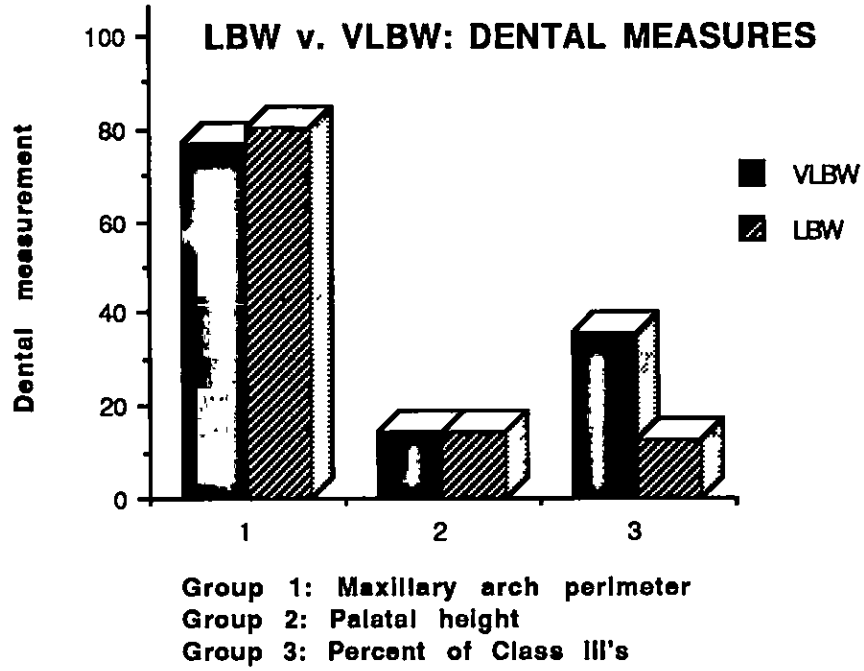


Figure 5. Comparison of dental measurements between low and very low birth-weight children. Only the percent of class III's shows marked difference

The three variables which were significantly different between the two study groups were maxillary arch perimeter, palatal height, and percent of Class III malocclusion. Comparing these variables between low and very low birth-weight children shows that only in the percentage of class III's is there a marked differnce. Figure 5 shows this clearly.

The accuracy of the dental measurements was checked using the Spearman-Brown reliability analysis. As can be seen in Table 8, the reliability was very high for all measurements.

TABLE 8.--Spearman-Brown Reliability Analysis

	MEASUREMENT 1*		MEASUREMENT 2*		
VARIABLE	MEAN	STD DEV	MEAN	STD DEV	R COEF
MX CAN WID	30.75	2.69	30.80	2.84	.99
MD CAN WID	23.97	2.47	23.93	2.53	.99
MX E WID	39.60	3.21	39.73	3.25	.98
MD E WID	34.88	3.32	34.94	3.22	.99
MX 6 WID	43.54	2.82	43.88	3.14	.98
MD 6 WID	39.05	3.44	38.98	3.61	.98
MX AR DEP	29.92	2.98	30.08	2.91	.99
MD AR DEP	25.13	2.07	25.26	2.09	.99
MX AR PER	78.69	8.27	78.48	8.43	.99
MD AR PER	68 27	8.12	68.13	8.18	.99
OVERBITE	3.73	1.11	3.77	1.13	.99
OVERJET	3.21	1.49	3.23	1.49	.99
PAL HT	14.83	.83	14.82	.94	.98

*All meaurements calibrated in millimeters

DISCUSSION

Review of Results

Results of the present study indicate that there exists a discrepancy between low and normal birth-weight children with regard to development of the dentition in the maxillary arch and perhaps overall growth of the maxilla. Studies have shown that physical development of the low birth-weight child progresses throughout early life, however it does not reach the growth level of the normal birth-weight child. Therefore, children of each of the two groups were matched on a body mass index which accounts for the variability in size at a particular age.

The differences found between the two groups were expected. The hypothesis stated that tertiary neonatal care has an effect on the development of the dentition in the low birth-weight child. The maxillary arch perimeter difference supported this. The effect on maxillary growth was expected but not measurable without proper radiographs. Since the arch depth and transverse arch measurements were similar for each group, it would appear that there was a component of maxillary hypoplasia or mandibular hyperplasia to the incidence of class III malocclusion observed.

Although the number and morphology of teeth present were the same for each group, the low birth-weight sample had a decreased maxillary arch perimeter as compared to the normal birth-weight group. Since more of the low birth-weight children already had permanent first molars than the normal birth-weight children (the age of the normal birth-weight children was slightly

lower in order to match pairs on body size), perhaps the mesial eruption pattern of the permanent first molars had something to do with this effect. Conventional wisdom would argue that no appreciable loss in arch length occurs when six year molars erupt. Since the transverse and arch depth measurements showed no statistically significant differences, it would seem that arch perimeter would follow. The decreased arch perimeter in the low birth-weight group would explain the incidence of crowded malocclusions seen in this group, which will be discussed shortly. The high incidence of Class III malocclusion (23%) in the low birth-weight group would support this finding, since the normal birth-weight group had a normal incidence of Class III malocclusion (3%).

Deciding to match the pairs in the study and control groups by body mass index also took into consideration the stage of dental development at that age and size. Generally by the age of two, and up to the age of six, all primary teeth have erupted into the oral cavity. Right around age six we see the beginning of eruption of the permanent first molars and some of the incisors. Since all of the dental measurements made for comparison included only those teeth, the overall size of the dental arch had to be adequate for each group to hold this number of teeth. The size of the teeth was also considered as a basis for dissimilarity. Since the tooth buds of these particular teeth are formed well after the average gestational age of the child, it was determined that tooth size would not contribute to discrepancies in the dental measurements.

Dental measurements for this study included transverse arch dimensions in both anterior and posterior areas of the arch. Transverse deficiencies were expected at least in the maxillary arch, if not both arches. There are possible explanations for narrowness of the maxillary arch in this population. Prolonged orotracheal intubation has been implicated in decreasing the transverse dimensions of the maxillary arch. In the present study, however, all low birth-weight children were intubated early in life but showed no transverse discrepancy. One possible explanation would be that there was a period of catch-up growth from the time of observed transverse deficiency (age two) to the time of examination for the study (age six). This catch-up growth of the maxilla may be a result of increased function of the oral musculature as described by Moss' theory of the functional matrix.

The statistically significant difference between the two groups with regard to palatal height can be interrelated to the transverse dimension. It has been shown that orotracheal intubation causes the formation of a palatal groove in neonates and concomitant transverse constriction as mentioned above. Perhaps the force generated by the tube redirects normal growth and development from a downward and forward direction causing the lateral aspects of the maxilla to fall inward. Although the low birth-weight group still demonstrated an increase in palatal height at age six, the lateral aspects of the maxilla had self-corrected to a more normal relationship within the oral cavity. The persistence of the increased palatal height by be attributable to an insult at the sutural level early in growth which may not have the ability to

undergo a period of catch-up growth. The alveolus was simply reshaped by the increasing function of the oral cavity as the child aged.

As detailed in the review of the literature, pressure on the hard palate by an endotracheal tube for prolonged periods of time often resulted in a palatal groove in low birth-weight children. Some of the children in the study had been intubated for months, yet no generalized maxillary constriction was evident. In one particular case, out of the thirty in the sample, there was a marked palatal groove which had persisted until the present. The intubation time for this child was not even the highest seen among all of the children in the study, nor were the dental transverse measurements the lowest. Perhaps the groove on the palate in this case is the result of a submucous cleft.

As will be discussed in a subsequent section of this discussion, the quality of the plaster models used for the dental measurements in the control group was perhaps not as accurate as the casts for the study group. Plaster models for the children in the control (made when compound impression material was utilized which loses some accuracy when removed from the mouth) were often difficult to measure. Many were not used for this reason and the total number of matched pairs only reached thirteen. With so few numbers, perhaps the statistical significance of palatal height measurements in this study is subject to skepticism. Greater numbers in each group may demonstrate a regression toward the mean for this variable.

The classification of occlusion according to Angle was used for comparison of interarch relationships. Additional subsets of occlusion were

listed by the investigator in order to cover most possibilities. Classification was divided into six groups: (1) Angle Class I, (2) Angle Class II, division 1, (3) Angle Class II, division 2, (4) Angle Class III, (5) Class I, crowded, and (6) anterior open bite.

Interestingly, there was a normal distribution of classifications in the normal birth-weight group, while there was a higher incidence of class III and Class I crowded dental malocclusions in the low birth-weight group. As described above, the decrease in maxillary arch perimeter in the low birth-weight group might explain the rate of Class I crowded malocclusions seen in this study. Normally, one would expect to see roughly 3% of all malocclusions as Class III, however, the low birth-weight group presented with 23% as Class III. There are differences in the rate of Class III malocclusions between Caucasian and Black populations. According to the National Survey on Dental Health, the incidence of Class III malocclusion among Blacks approaches 8%. In the present study, there were twice as many black children in the study group (n=12) than the control group. Although this may account for a slightly greater incidence of Class III malocclusions than the norm (3-8% for a group of Caucasian and Black children), it does not approximate the results of the study. The finding of 23% of the study group to have a Class III occlusion implies that race is not the only factor.

Once again, the issue of palatal or upper arch restraint as a result of endotracheal intubation arises. In order to have a Class III dental relationship, either all of the upper teeth or the upper jaw is positioned

further back in the face relative to the lower teeth or jaw. Or, perhaps, the lower teeth or jaw is positioned further forward in the face relative to the upper teeth or jaw. Without having the benefit of looking at the relationship of these parts by means of a lateral cephalometric radiograph, it would be pure speculation to determine, at this point, whether or not there is a skeletal component to this high incidence of dental Class III relationships in the low birth-weight group. Future studies may be able to determine the growth of the two jaws relative to each other provided that longitudinal data for this group deem it necessary to do so.

Within the low birth-weight group itself, a few conclusions were drawn regarding the health of the child during early post-natal development. As discussed previously, the total neonatal risk was recorded for all children in the low birth-weight group. The total neonatal risk (TNEO) was compared to birth-weight and, as expected, the lowest birth-weight infants had the highest TNEO and, the higher the birth-weight, the less was the TNEO in general. This was compared to see whether or not the lower birth-weight infants received more medical attention perhaps in the way of intubation. Any of the positive dental results mentioned above could then be extrapolated to the magnitude of the TNEO. For instance, a comparison was made between the palatal heights of each of the low birth-weight children and their corresponding intubation times. A direct linear relationship was expected between intubation time and palatal height, however, no ideal correlation existed. In some cases there was an increase in palatal height with

increased intubation time and in others there was not. There seems to be no obvious explanation for this variability.

After reviewing the results comparing the low and normal birth-weight groups, the author decided to subdivide the study group into low and very low birth-weight children (LBW - 750-1,499 grams and VLBW - <750 grams). This was done to determine whether one group may have contributed to the results more than the other. The significant results of maxillary arch perimeter, palatal height, and percentage of Class III malocclusion were compared between these two groups.

A comparison was made between low and very low birth-weight with regard to the length of time of intubation, and the number of days on oxygen. It was demonstrated in Figure 4 that there was a substantial difference between the two groups in both of these categories. The very low birth-weight children were intubated ten times longer than the low birth-weight children and received oxygen almost nine times longer.

From the standpoint that a physical impediment to growth, namely intubation, could affect development of the maxilla, it would be expected that the very low birth-weight children would contribute more to the significance of the results. Similarly, growing tissues require a sufficient amount of oxygen. Since the very low birth-weight children were in need of oxygen much longer than the low birth-weight children, we might expect that the rate of maxillary development would also be affected. However, the difference in maxillary arch perimeter and palatal height were not very different in the two groups as was evident from the graph in Figure 5. There was a difference in

the percentage of class III malocclusions between the two groups. There were five class III's in the very low birth-weight group and only two in the low birth-weight group.

Significance

Since most of the dental measurements displayed no statistically significant differences, the significance lies in the classification of dental occlusion. As mentioned previously, there were far fewer Class I malocclusions in the low birth-weight group with a high incidence of Class III dental malocclusions. The children presenting with the Class III malocclusion should be followed to determine whether or not there is a skeletal component involved in order that proper interceptive treatment may be implemented. It has been shown in the orthodontic literature that the Class III malocclusion is difficult to treat because of late mandibular growth in these patients. Generally, for a true skeletal Class III (mandibular hypertrophy) the only recourse toward correction involves orthognathic surgery. Whether the incidence of Class III malocclusion in the low birth-weight sample studied is a result of mandibular hypertrophy or maxillary retrusion can only be definitively answered using lateral radiographs of the head.

Limitations

The first of the limitations in this study to be discussed deals with the compliance of the low birth-weight children and the dental procedures that were done. Some of the children were severely uncooperative at the time of the dental exam and were excluded from the study. The nature of this

behavior was related to the overall neurologic development of the child. Although the medical data was not gathered for these children, it is speculated that neurologic and physical development may be related in this group. If this is the case, the numbers that were presented in the group of low birth-weight children may not be representative of the entire population low birth-weight children.

Another limiting factor had to do with the inability to obtain good alginate impressions for all low birth-weight children. Often the children would vomit during the procedure rendering the impression useless and unable to try for another. As in the case with the behavior problem child, only the most cooperative and calm children were used for collecting the raw data. Once again, this may be an argument for not having a legitimate sample of low birth-weight infants.

Another factor that may be considered a limitation is the quality of the plaster casts of the control group. As mentioned previously, the control group was taken from the Bolton-Brush Study. At the time when the impressions were made for producing dental plaster casts, the impression material used was a thermoplastic compound. This material was warmed slightly above body temperature until it became soft enough to mold over the dental arch. Once in the mouth, the material turned back into its hardened form. In order to facilitate removal from the oral cavity, the impression was broken into two or more pieces. These pieces were reassembled in order to pour plaster into it to produce the plaster cast of the dental arch.

Any dimensional changes that may have occurred during this procedure would generally be reflected in a transverse discrepancy between the actual oral tissues and what was measured on the plaster casts. Although the results demonstrated no significant differences between the transverse arch dimensions of the low and normal birth-weight groups, if this change in dimension did occur in the control casts, perhaps there would then be a difference.It is the opinion of the investigator that a different control group could have been utilized whereby dental impressions of both groups were made of the same material.

SUMMARY AND CONCLUSIONS

The present study measured the dental development in low birth-weight children. Specific dental measurements pertaining to arch width, arch depth, arch perimeter, anteroposterior and vertical occlusal relationships, palatal height and dental malocclusion were compared to a normal birth-weight sample. The statistical analysis used was the paired t-test. Differences in several of the above dimensions were found to be statistically significant. The following list represents all measurements and whether or not there was a significant difference.

1. ARCH WIDTH - (Canines, primary second molar, and permanent first molar - maxillary and mandibular). No statistically significant differences were found in any of these three arch width measurements indicating that no maxillary or mandibular transverse deficiencies were found.

2. ARCH DEPTH - (Maxillary and mandibular). No statistically significant differences were found between normal and low birth-weight children with regard to maxillary and mandibular arch depth, indicating relatively uniform distribution of teeth and arch forms.

3. ARCH PERIMETER - (Maxillary and mandibular). Differences in mandibular arch perimeter were found not to be statistically significant. Maxillary arch perimeter in the low birth-weight child was, on average, less than the normal birth-weight child and the difference was statistically significant with a p-value of 0.045.

4. OVERBITE AND OVERJET - (Anteroposterior and vertical occlusal relationships of the anterior teeth). Both low and normal birth-weight children presented with a wide range of overbite and

overjet measurements. The differences in these measurements between the two groups, however, were found not to be statistically significant.

5. PALATAL HEIGHT - (Maxillary measurement only). The mean palatal height measurement of the low birth-weight child was significantly greater than the palatal height of the control child. The degree of statistical significance was p-value 0.009. There was no correlation between length of time of intubation and palatal height.

6. CLASSAIFICATION OF OCCLUSION - (Angle's classification). The normal birth-weight group presented with a much higher percentage of Class I occlusion than did the low birth-weight group (17% versus 11%). The low birth-weight group had a much higher percent of class III malocclusion than the control group(23% versus 2%). All other malocclusion types were similar for both groups.

7. LOW VERSUS VERY LOW BIRTH-WEIGHT OUTCOMES. When comparing the length of time of intubation between low (n=16) and very low (n=14) birth-weight children, it was found that the very low birth-weight group was, on average, intubated ten times longer. When comparing the statistically significant variables to each of these sub-groups, no significant differences were found in arch perimeter and palatal height; there was a marked difference, however, in the percent of class III malocclusions seen. The very low birth-weight group presented with 37% versus 13% in the low birth-weight group with regard to Class III malocclusion.

Regarding all of the dental measurements, differences in only maxillary arch perimeter and palatal height were found to be statisticallty significant. The explanation perhaps for the perimeter difference could be due to the difference in the number of Class I and Class I, crowded occlusions between the two groups. An increase in maxillary anterior crowding would allow for a decrease in total maxillary arch perimeter.

The differences in the palatal height measurement between the two groups correlates with the intubation received by the low birth-weight group.

None of the control children had been intubated during early postnatal development, whereas all of the low birth-weight children in this study were intubated orally for prolonged periods of time.

This intubation had no effect on the transverse arch development in either maxillary or mandibular arches. Perhaps the direction of maxillary growth was altered, as a result of intubation, in such a way as to produce an unusually high incidence of Class III dental malocclusions. Whether or not there exists a skeletal component to the malocclusion remains a question since no radiographs were taken to identify skeletal relationships.

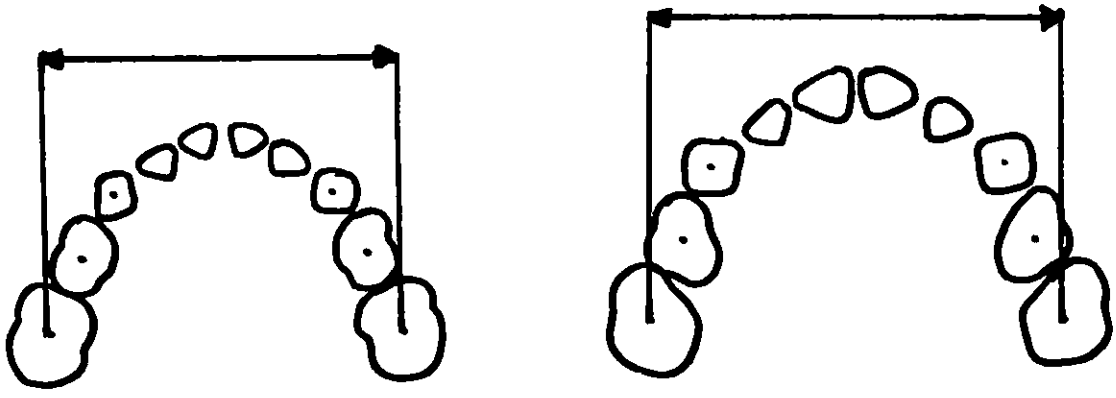
By itself, no added precaution is necessary regarding a high palatal vault with respect to interceptive treatment. Arch perimeter and the unusually high incidence of Class III malocclusion, however, should be of concern. Class III dental malocclusions, as well as Class III skeletal, are difficult to treat by means of orthodontics alone. Many times the only treatment for this type of problem is surgical if the malocclusion has as its primary component a prognathic mandible. If, however, there is a midface deficiency, i.e., maxillary hypoplasia, then early orthodontic treatment may prove beneficial to the growing child.

It is necessary, therefore, to monitor these low birth-weight children periodically to assess the further development of the dentition and the bones that house the teeth. As can be seen from this study, low birth-weight infants who have been orally intubated for long periods of time presented with a dental problem not unfamiliar to the practicing orthodontist. Early intervention appears to hold great promise in treating many variations in

dental and skeletal malocclusion and should prove to be beneficial to this unique group of individuals.

APPENDIX ONE

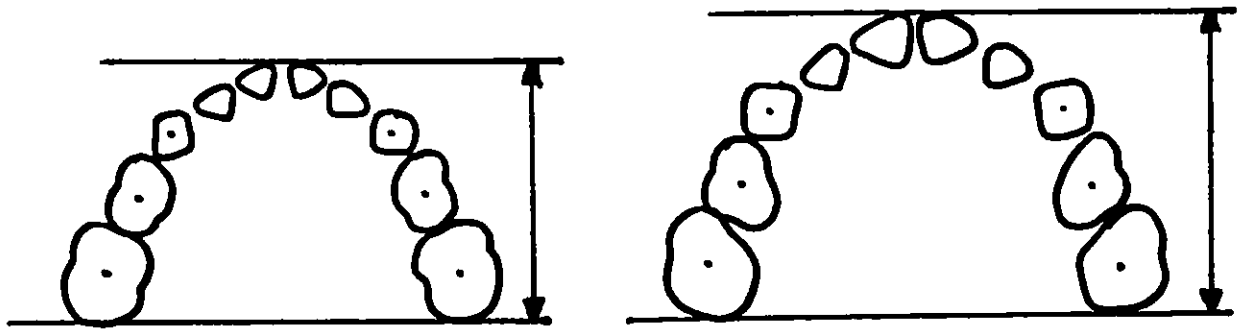
Included can be found illustrations depicting the method for determining the parameters of each of the measurements made on the dental casts.



Mandibular

Maxillary

Figure 7. Intermolar width measurement for both maxillary and mandibular arches represented by the distance between the centroids of the molars.



Mandibular

Maxillary

Figure 8. Arch depth measurement for both maxillary and mandibular arches represented by the distance from the midpoint of the most labial points of the central incisors to a line crossing the distal contacts of the deciduous second molars.

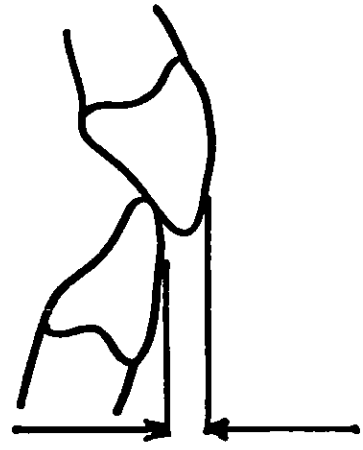


Figure 9. Anteroposterior occlusal relationship (overjet) measurement represented by the distance between the most labial point of the mandibular incisors and the most labial point of the maxillary incisors while in occlusion.

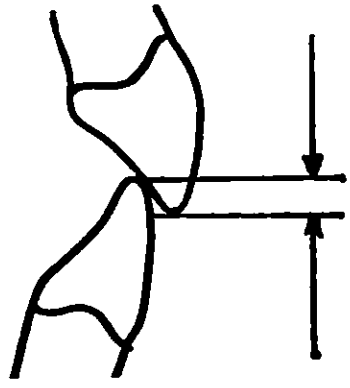


Figure 10. Vertical occlusal relationship (overbite) measurement represented by the distance between the incisal edges of the maxillary and mandibular incisors while in occlusion.

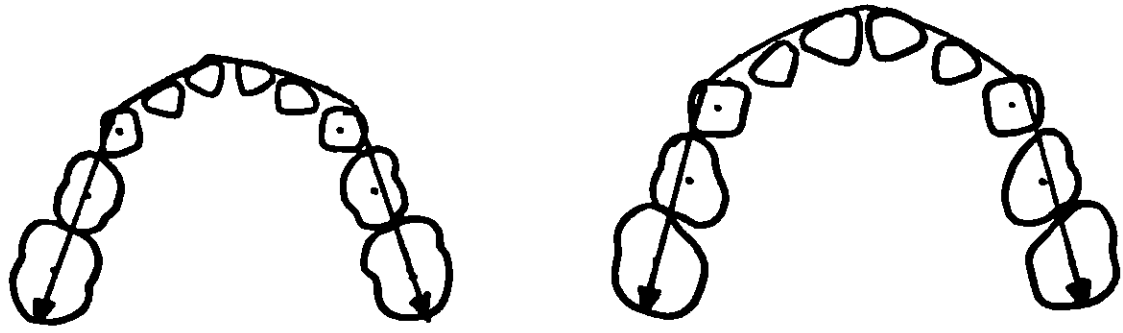


Figure 11. Arch perimeter measurement for maxillary and mandibular arches represented as the length of a line between distal contact points of the deciduous second molars passing around the curvature of the arch

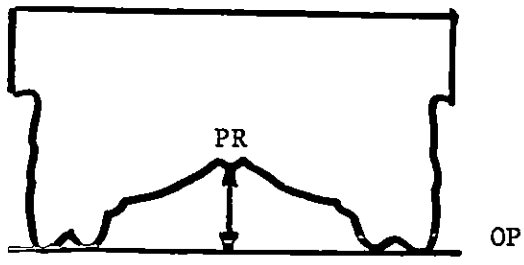


Figure 12. Palatal height measurement represented by the distance between the palatal raphe and the occlusal plane at the level of the deciduous second molars, PR=Palatal raphe, OP=Occlusal plane

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