Chapter 1: Introduction

We have seen thousands faces of people in our lifetime. Each face is recognized to us as a different individual and this is due to the range of variation in the shape of their faces. It is a fact that the face is the most important part of the human body. It is involved in interpersonal communication, emotional expression and most other forms of social interaction. The face is also the primary feature of the body by which people recognize one another. Even newborn infants have a natural ability to recognize familiar faces.

Every person’s face is unique and different. It has been said that the face of man is his window to the world and such reflects his health, emotion and character. The face comprises a few components; a lower jaw and chin, cheekbones, a mouth and upper jaw, a nose, two orbits and the forehead and supra orbital ridges for the neuro cranial parts relating to the face. Even though the face comprises only a few components but this few components can underlie such great variation in facial form. Very slight alterations in the configuration of one component that comprise the face can make a substantial difference in the appearance and the character of one’s face as a whole. For facial harmony to exist there must be some degree of relative proportion of the various parts through which an overall balance is achieved. No individual component of the face exists or functions in isolation from the other integral parts.

Many attempts throughout history have been made to develop parameters to quantify idealized facial proportions and in essence to quantify human faces. Attempts to quantify human faces initially stemmed from the Greek philosophy that all beauty and aesthetics were based on mathematics. Significant studies related to selected facial proportion and dimensions with large numbers of subjects were not conducted until the 20th century. In the last one hundred years, the studies were conducted primarily by plastic surgeons and orthodontists who were continuously studying faces and attempting to quantify selected facial proportions and dimensions (Marquardt, 1997).

1.1 Facial growth

Growth and development is a strictly controlled biological process. Growth itself is the composite changes of all components. Child development refers to change or growth that occurs in a child during the life span from birth to adolescence. This change occurs in an orderly sequence. Growth of the facial skeleton during puberty and adolescence results in the characteristic curves and angle of adult face (Ridley, 1992).

There are many changes in the shape of an individual’s face over his lifetime. In young adults, there is considerable growth of the skeletal structures along with an increase in muscle tissue and changes in the volume of fatty tissue. In middle life there is little change in the bone structure but continued growth in cartilage especially in men and in later life changes in both muscle tone and skin elasticity affect the outer shape of the face considerably (Hutton et al, 2003).

Craniofacial deformity arises as variations of the normal development process. Therefore must be evaluated against a perspective of normal development especially for those performing reconstructive and aesthetic facial surgery. They must adhere to the principles of proportions, symmetry and balance. Hence measurement of the craniofacial complex is important for studies of human growth, population variation and clinical treatment (Kolar & Salter, 1996).

Here is where the study of anthropometry has an important role to play.

1.2 What is anthropometry

Human have long been keenly interested in depicting the characteristics of human anatomy. In classical Greece and Rome, artists used numerous canons, rules of simple proportions to describe the ideal form of human figure.

The term "anthropometry" is derived from the Greek word anthropos which means 'human' and metron, which means 'measure'. It is the biological science of measuring the size, weight and proportions of the human body thus it replaces the visual examination (anthroscopy) which is very subjective and not reliable (Farkas 1994).

Face anthropometry is the science that is specifically dedicated to the measurement of human face thus it will provide valuable information on differences in shape and size of the face of different race, age and sex.

Measurement of the human face has been performed since the Greek era' (Vegter & Hage, 2000).

Throughout the last century, anthropometry has witnessed an extensive development. Anthropometry evaluation begins with the identification of particular locations on a subject called landmark points; defined in terms of visible or palpable features (skin or bones) on the subject. A series of measurement between these landmarks is then taken using carefully specified procedure and measuring instruments such as calliper, ruler or measuring tape. As a result, repeated measurements of the same individual which is taken a few days apart is very reliable and measurements of different individuals can be successfully compared (De Carlo 1998).

In general, anthropometry has many practical uses, at individual level it is used to assess the person as being in need of special consideration or to assess a response to some intervention. In populations, anthropometric data are used to make decisions about the need for intervention programme, what type of interventions is needed and to whom they should be delivered (Sunutar Setboorsarng, 2005).

1.3 Why this research area

Every person's face is different and has its own characteristic. The improvement of a patient's facial appearance is an objective common to a number of clinicians. Therefore planning an improvement requires guidelines or some kind of generally agreed 'ideal' set of facial proportions.

Current concept in diagnosis and treatment planning focus on the balance and harmony of the various facial features however harmony and facial balance are not fixed concepts. Subjective as it is, a concept of normal is essential for the surgeon to identify the normal from the abnormal (Czarnecki & Currier, 1993).

For years, the anthropometric measurements for surgical reconstructions are based on basic values for western population, resulting in the time of surgical repair being based on western growth pattern which actually differs from the Malay populations. In other words, it means that the control or normative data are not readily available to be used as a guide during surgery.

This problem has not been given a serious thought. Based on this observation the rationale for this research area begins. Essentially this study has been conducted to generate our own data for pre pubertal Malay children at age seven and twelve year old. Anthropometric analysis of the craniofacial framework in children is the first step in establishing the morphological changes of the aging faces as well to study the growth and development in these groups.

As the result it can provide the surgeon with anthropometric normal values and establishes the first set of specific craniofacial parameters in seven and twelve year old healthy Malay children in Malaysia. Basically these norms will be helpful in the diagnosis, prognosis and therapy of craniofacial disturbances in pre pubertal boys and girls. The mean value will help us to identify patterns for craniofacial growth at this age group. These norm data can readily available act as facial references whenever we do the facial analysis or whenever diagnosis needs to be made. Lastly the proportion analysis can be used for the evaluation of treatment results.

Chapter 2 : Literature Review

2.1 Craniofacial anatomy

The face is part of the front head between the ears and from the chin to hairline (Sinnatamby, 2001).

The basic shape of the face is determined by the underlying bones, the facial muscles and the subcutaneous tissue. The skin of the face is thin and pliable (Moore & Agur, 2002).

The skin of the face possesses numerous sweat and sebaceous glands. It is connected to the underlying bones by connective tissue in which are embedded the muscles of facial expression (Snell, 1992).

The skeleton of the head is called the skull. It consists of several bones that are joined together to form the cranium. The skull also includes the mandible even though it is a separate bone. The skull is then divided into calvarium which encloses the brain and the facial skeleton. The joints of the skull are immovable and fibrous in type and known as sutures. However this excludes the temporomandibular joint which permits free movement. In old age the sutures are gradually obliterated by fusion of the adjoining bones (Chaurasia, 2003).

2.2 Development of the bones

Bone develops by two main process, intra membranous and endochondral ossification. In general the craniofacial skeleton is form both endochondrally and intramembranously. The cranial base, the nasal septum and the condyle of mandible are of endochondral origin whereas the maxilla and cranial vault are intramembranous in origin (Sadowsky, 1998).

During all the years of growth there is constant remodelling with destruction by osteoclasts and replacement by osteoblast whether the original development was intramembranous or endochondral (Sinnatamby, 2001).

Enlow (1982) described that in all areas of skeletal growth, bone grows intramembranously in tension areas and endochondrally in pressure areas. He said that the growth of all bones has cartilage growth plate and this is presumed to be regulated entirely and directly by the intrinsic genetic programming within the cartilage cells. In endochondral ossification they provide linear growth of bone towards the direction of pressure. As a result, as the interstitial cartilage expansions provides pressure adapted growth on the pressure side of the cartilage plate, an equal amount of cartilage is removed and replaced by bone on the other side. So the bone will lengthen towards its force and weight bearing area.

It is essential to appreciate that the cartilage is not converted into bone but it is destroyed and then replaced by bone (Sinnatamby, 2001).

Alternatively the intramembranous bone growth was believed to have a different source of control. This osteogenic process is sensitive to biomechanical stresses and strains and it responds to tension and pressure by either bone deposition or resorption. Tension specifically induces bone formation while pressure triggers resorption. The membranes associated with bone (periosteum, sutures, periodontium) have their own internal growth and remodelling process. As the new bone is deposited, the membrane does not move away but undergoes extensive fibrous changes in order to sustain constant connections with the bone. It forms the collagenous fibre continuity from the membrane into the matrix of the bone. As the fibres in the membrane became enclosed within the new bone deposits, the membrane-produced fibres become incorporated as bone fibres. It is followed by fibrous remodelling within the membrane to provide continuity between membrane and bone fibres (Enlow, 1982)

2.3 Embryology of the head and face

The development of the human embryo from the time of fertilization through birth is an important period for human appearance.

In early embryonic development of the head and neck, a series of distinct bilateral mesenchymal swellings appear on the ventral aspect of the embryo. These swelling are pharyngeal or brachial arches that form most of the structures of the head and neck (Stiernberg, 1997).

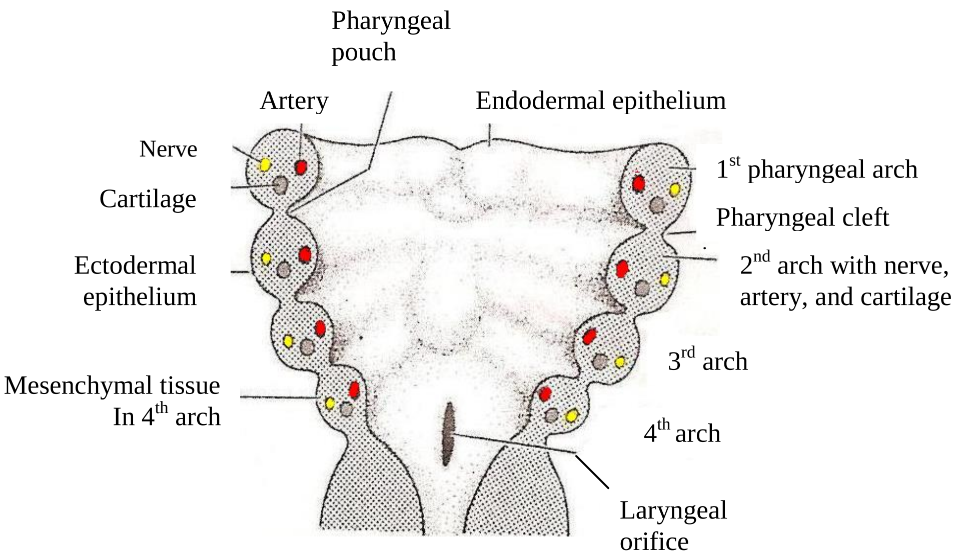

Figure 2.3.1 (From Sadler TW, Medical Embryology, 7th edn. pg 318, 1995)

The pharyngeal arch consists of a core of mesenchyme covered externally by ectoderm and covered internally by endoderm (Figure 2.3.1)

Facial development occurs mainly between the fourth and eight weeks of gestation. At the end of fourth week, facial prominences consisting primarily of neural crest-derived mesenchyme and formed mainly by the first pair of pharyngeal arch appear (Figure 2.3.2) (Sadler, 1995).

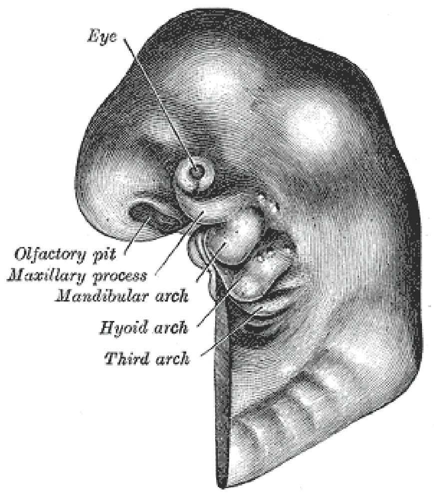

Figure 2.3.2 (From Henry Gray, 2000; Anatomy of the human body, 20th edn.)

Early in development, the face of the embryo is bounded cranially by neural plate, caudally by the pericardium and laterally by the mandibular process of the first pharyngeal arch on each side. In the centre of this area is a depression of ectoderm known as stomadeum and in the floor of the depression is the buccopharyngeal membrane (Snell, 1992), Figure 2.3.3

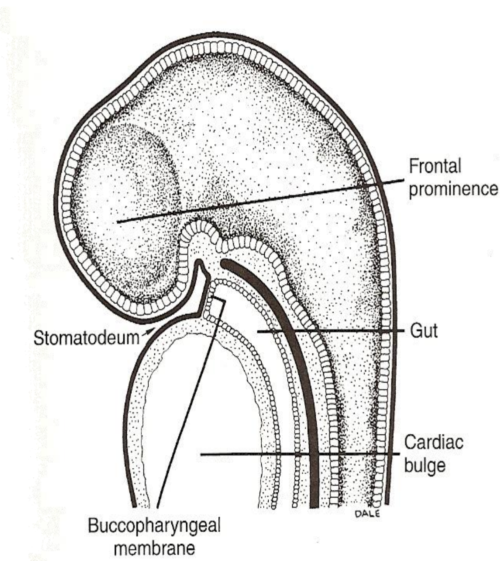

Figure 2.3.3 (From Ten Cate's; Oral Histology, 6th edn. pg 33, 2003)

Buccopharyngeal membrane separates the stomadeum from the primitive gut and with the beginning of facial development the buccopharyngeal membranes breaks down so that the stomadeum communicates with the pharynx. The face is derived from five facial processes surrounding the stomadeum (Meikle, 2002).

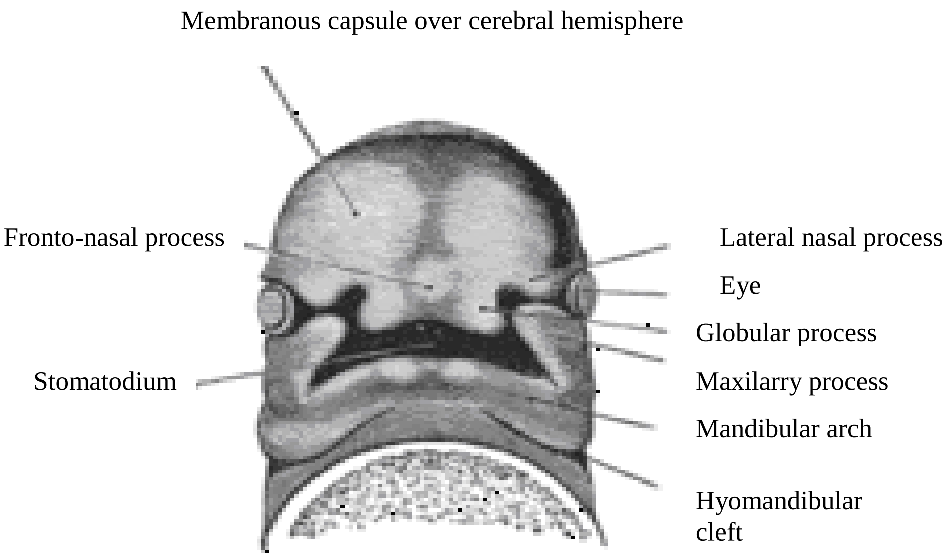

Figure 2.3.4 (From Henry Gray, 2000; Anatomy of the human body, 20th edn.)

The processes are frontonasal process which lies above, the two mandibular processes lying below and the two maxillary processes located at the side of the stomadeum (Figure 2.3.4). These processes are produced by proliferating zone of mesenchyme lying beneath the surface of ectoderm. The mandibular and maxillary processes are from the first pharyngeal arches (Berkowitz, 2002).

The frontonasal process begins as proliferation of mesenchyme on the ventral surface of the developing brain. It later forms the forehead and dorsum apex of the nose (Snell, 1992).

During the fourth week the lower jaw is the first part of the face to form. It results from the merging of the medial ends of the mandibular process. This process also forms the lower lip and chin (Meikle, 2002).

During the second month, proliferation of the underlying mesenchyme of the lower part of the frontonasal process creates prominent elevations, the medial and lateral nasal processes (Figure 2.3.5).

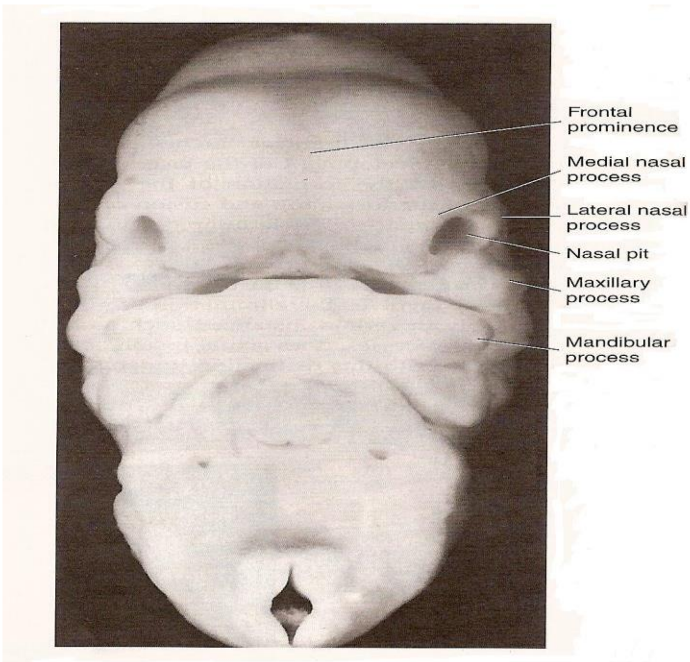

Figure 2.3.5 (from Ten Cate's; Oral Histology, 6th edn. courtesy H. Nishimura pg 38)

During the sixth week, the maxillary processes grow medially and fuse with the lateral nasal processes and then with the medial nasal process. The lateral nasal process forms the alae and sides of the nose (Meikle, 2002) (Figure 2.3.6)

The medial nasal process forms the philtrum of the upper lip and premaxilla. The maxillary processes extend medially to form the upper jaw and the cheek (Snell, 1992) (Figure 2.3.6)

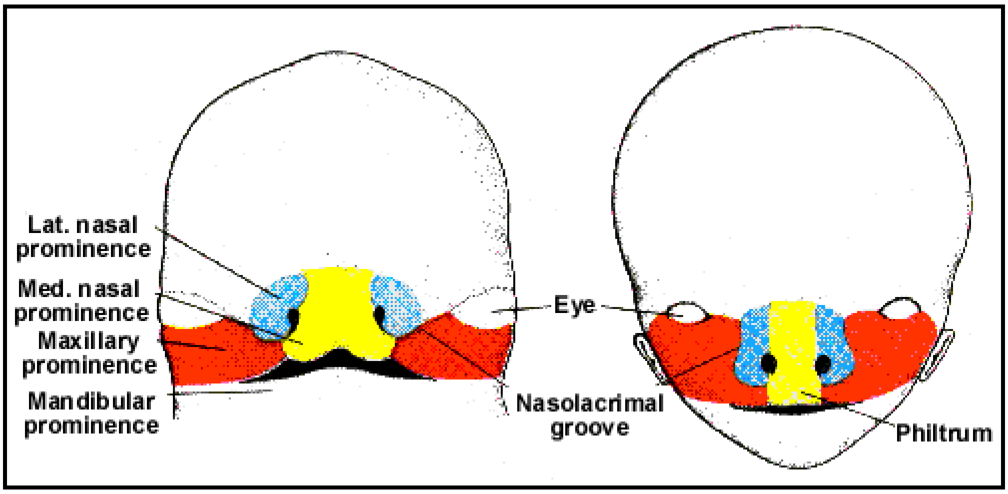

Figure 2.3.6 (From Sadler TW, Medical Embryology 7th edn. pg 334)

There has been a divergence of opinion regarding the embryological origins of the upper lip. One view suggests that the maxillary processes overgrow the medial nasal processes to meet in midline and form the upper lip. It is based on the innervations of the fully form of upper lip by maxillary nerve with no input from the ophthalmic division. The maxillary processes are being supplied by the maxillary nerve and the frontonasal process by the ophthalmic nerve. Alternatively, it has been suggested that the maxillary processes meet the medial nasal processes without such overgrowth, the middle third of the upper lip derived from the frontonasal process (Berkowitz, 2002).

This view was supported by Warbrick (1960) who made a microscopic study of fifteen serially sectioned human embryos and could find no evidence for the overgrowth of the medial nasal process by maxillary processes (Meikle, 2002).

2.4 Basic concepts in growth and development

Growth and development involve complex mechanism and progressive changes over time. Developmental change is a basic fact of human existence and each person is developmentally unique.

Growth is defined as increase in number and size whereas development refers to a stage of growth and maturation encompassing morphogenesis, differentiation and acquisition of functioning (Mao & Nah, 2004).

The agents responsible for growth can be divided into genetic factors originating in the genome and environmental factors which are usually mechanical or functional activity and both arising externally (Meikle, 2002).

Genes can be regulated by environmental cues including myriad types of mechanical stimuli. However much less is known how environmental cues such as mechanical forces regulate genes involved in skeletal growth (Mao & Nah, 2004).

2.5 Craniofacial growth and development

Enlow in many publications detailed descriptively and spatially the growth and development of the craniofacial complex and how changes in various areas affecting the relationship of anatomic parts in other areas.

Facial growth is a process requiring intimate morphogenesis interrelationships among its entire component growing, changing and functioning soft and hard tissues parts. No part is developmentally independent and self contained. The multiple growth processes in all the various parts of the face and cranium occurs simultaneously so that the same craniofacial form and pattern are maintain throughout the growth processes. It means that the proportions, shape, relative sizes and angles are not altered as each separate region enlarges. As the result the geometric form of the whole face for the first and last stages is exactly the same, the only changes occurs are the overall size (Enlow, 1982).

Enlow and Hans (1996) emphasized that the face of a child undergoes sequential alterations in profile and in facial proportions as growth progresses.

As an example the mandible of young child look small in relation to his maxilla but later this small mandible will 'catches up' to provide a balance anatomy of the face. The forehead looks bulbous in a young child but becomes sloping as the frontal sinus develops. The nasal region is shallow early in post natal life but later becomes markedly expanded relative to other cranial and facial regions.

Schever and Back (2004) stated that the growth of the vault and eyes in their contained orbits follow the rapid pattern of neural growth whilst the lower part of the facial complex is primarily related to the development of the dentition and muscle of mastication. This results in a skull in foetus, infant and young child that has very different proportions from that seen in later childhood, adolescence and adult life hence the large head and eyes and relatively small face of infants and young child.

2.6 Theories of growth control

It is necessary to learn how facial growth is influenced and controlled in order to understand the aetiology process of craniofacial deformity. However what determines growth remains unclear and continues to be the subject of intensive research. It also has a long and controversial history.

Despite of large considerable data that exists with regard to craniofacial growth, we still have limited understanding in many areas. All we have are only theories or hypothesis.

Over the years many theories or hypothesis of growth controls have been proposed, ranging from sutural concept by Sicher, the importance of chondrocranial development by Scott and the functional matrix theory by Moss (Sadowsky, 1998).

It is also important to distinguish between the theories of growth control and a site of growth and a centre of growth. A site of growth is a location at which growth occurs and a centre is a location at which independent (genetically controlled) growth occurs. All centres of growth are also sites but the reverse is not true (Proffit, 2000).

Three major theories in recent years have been attempted to explain the determinants of craniofacial growth (Proffit, 2000):

i) Bone like other tissues, is the primary determinant of its own growth however this view was discarded in 1960s (Proffit, 2000).

ii) The cartilage is the primary determinant of its own growth while bone responds secondarily and passively (Proffit, 2000).

iii) The functional matrix theory in which the skeletal elements are embedded is the primary determinant of growth and both bone and cartilage are secondary followers (Proffit, 2000).

The major difference in these theories is the location at which genetic control is expressed.

The cartilage theory suggests that genetic control is expressed in the cartilage while bone responds passively to being displaced. This indirect genetic controlled is called epigenetic (Proffit, 2000).

The functional matrix theory was put formally by Moss in 1960s. Currently it is the most popular theory. Moss's theory, postulates that the bones of the head grow in response to the function of two types of matrix; the periosteal matrix which includes the facial muscles and the teeth and the capsular matrix which includes the neural mass and functional spaces of the mouth, nose and pharynx. He further emphasize that the periosteal matrix is responsible for altering the size and shape of the bones while the capsular matrix alters spatial relationships between various parts of the head. Moss's point of view is when this functional matrix grow or is moved (muscles, glands, nerves, vessels, fat etc…) the related skeletal unit responds appropriately to this morphogenetically primary demand (Moss & Salentijn, 1969).

In the functional matrix theory, the genetic control is located outside the skeletal system and that growth of both bone and cartilage is controlled epigenetically, occurring only in response to a signal from other tissues (Profit, 2000).

Moss (1997) provided a revision of the functional matrix hypothesis in 1997. In a series of articles he examined the relatives' roles of the biophysical and biochemical factors in the regulation of morphogenesis as well the genomic and epigenetic process in the regulation of craniofacial development.

2.7 How the cartilage and functional matrix theories plays a role in craniofacial growth

In the cartilage theory, the major determinant of craniofacial growth is the growth of the cartilage. This theory is quite attractive because if cartilaginous growth was the primary influence then the cartilage at the condyle could be considered as a pacemaker for growth of that bone and the remodelling of the ramus and other surface changes could be viewed as secondary to the primary cartilaginous growth (Proffit, 2000).

The traditional concept of mandibular growth also views the condyle as a primary growth centres which is under the control of intrinsic factors. It also displaces the mandible downward and forward (Meikle, 1973).

Condylar cartilage is defined as a secondary cartilage because it develops on a pre existing piece of membranous bone and the only movable joint to play a significance role in bone growth of the mandible through the activity of a growth centre contained within the joint capsule (Mckay &Yemm, 1992).

The question of whether secondary condylar cartilage possesses a similar growth potential as primary cartilages has been the subject of controversial viewpoints and much experimentation (Copray et al, 1986).

Copray et al. (1986) did an experiment where he tried to establish an intrinsic growth potential of the mandibular cartilage in a well-defined serum free organ culture system and it showed limited intrinsic growth potential and the tissue separating capacity, making the mandibular condylar cartilage not fulfilling criteria as a primary growth centre.

Moss in his concept suggested the growth of the condyle occurs as a secondary or adaptive response to its functional matrix (Moss and Salentijn, 1969).

It has been suggested that the proliferation of the condylar cartilage is a response to growth not its cause. This view has been supported by experiment showing that mandibular growth is relatively unaffected following condylectomy providing normal mandibular function is maintained (Ogus and Toller, 1986).

As for the nasomaxillary growth, there is a cartilage in the nasal septum that is involved. According to the cartilage theory, the cartilaginous nasal septum serves as a pacemaker for other aspects of maxillary growth (Proffit, 2000).

From the transplantation experiments, it demonstrates that the nasal septal cartilage was found to grow nearly as well in culture as epiphyseal plate cartilage (Copray, 1986).

The location of the cartilage makes the downward and forward translation of maxilla possible. If the sutures of maxilla served as reactive areas, they would respond to this translation by forming new bone when the sutures were pulled apart by forces from the growing cartilage (Proffit, 2000).

As for the functional matrix theory, Moss maintained that post natal growth of the middle third of the face is in part an adaptation to the functional demands of increase nasal respiration. As the nasal air spaces expand, the associated cartilages and bone grow and this is in response to the increase in nasal cavity space not the cause of it. However the role of the functioning spaces has been the most controversial part of the theory because if a functional nasal airway does play a significant role in maxillary growth, the cause and effect relationship might be expected to be demonstrable between the nasal airway obstruction and altered facial morphology (Meikle, 2002)

Attempt to support or disprove these theories have been extensive. However experimental models for both hypotheses have experienced flaws and opinion remains divided (Howe, 2004).

Basically growth and development is the net result of environmental modulation of genetic inheritance. Cells are influence by genes and environmental cues to migrate, proliferate, differentiate and synthesize extracellular matrix in specific directions and magnitudes. Mechanical forces, one of the environmental cues readily modulate bone and cartilage growth. This forces are transmitted to tissue-borne and cell-borne mechanical strain that in turn regulate gene expression, cell proliferation, differentiation, maturation and matrix synthesis, the totality of which is growth and development (Mao & Nah, 2004).

2.8 The changing features of the growing face

The post natal changes of the craniofacial complex that occur with growth have been studied by numerous investigators. In order to extend the understanding of growth, researchers have investigated pre natal growth and development as well. Studies have shown that the pre natal craniofacial growth patterns during the last two trimesters are similar to post natal craniofacial growth. However little is known about early development of patterns of facial morphology and the mechanisms of differential growth during the embryonic and early foetal periods (Diewert, 1985).

We always think that a baby face is a cute face. Baby face has large appearing eyes, puffy cheeks, dainty jaws, a smallish pug nose, a low nasal bridge, a small mouth and overall wide and short proportions. However as the face grows and develop through years, these and many of other features of the baby's face gradually undergo marked changes. The chin develops, jaw size catches up and the eyes appear less wide set. Actually the general features of any fully grown face are quite different from those of the same individual as an infant and young child (Enlow & Hans, 1996).

Growth increments and development progress rates vary considerably during pre and post natal periods in the life of human being. The coordinated regulation of parts growing at different rates and in different directions, together with the modelling of bone by apposition and resorption, is what converts the foetal skull into the mature-appearing adult skull. Comparing the infant skull to an adult skull, the face at birth equals about one eight of the entire skull, whereas in adulthood it occupies about one half of the skull. The facial skeleton grows more rapidly after birth and this growth takes place over a longer period of time (Levihn, 1967).

Growth is not merely a process of size increases. Instead the facial enlargement is a developmental process which involved of many component parts. These components may mature earlier or later than the others, to different extends in different directions and different rates. It involves a gradual maturation with a complex of different but functionally interrelated organs. At the end it will requires a regional changes in proportion by localised ongoing adjustment to achieved proper fitting and function among all the parts (Enlow & Hans, 1996).

Basically the child's face is not merely a miniature of the adult face. Brodie (1941) in a roentgenographic study found that the morphogenetic pattern of the head by the third month of post natal life or perhaps earlier and once attained does not change (Levihn, 1967).

Below is just the example of the changing features of the growing face:

The baby's face appears diminutive relative to the larger cranium above and behind it. However these respective proportions will change as the growth of the brain shows considerably after about the third or fourth year of childhood, the facial bones otherwise continues to enlarge for many years to accommodate airway and masticatory growth and functions. The eyes appear large in the young child but appear smaller in proportion in adults. This is because as facial growth continues, the nasal and jaw regions which is developed later cause the disproportion to the earlier maturing orbit and its soft tissues. It is the same where the eyes of the infant seem quite wide set with a broad appearing nasal bridge between them. This is due to the low nasal bridge and much of the width of the bridge has already been attained in the infant. When the growth continues, the eyes spread further laterally but only to a relatively small extend. Actually the eyes of the adult face are not much apart than those in the child but it look so because of the larger nose, higher nasal bridge, and increase in the vertical facial dimension and the widening of cheekbones makes the eyes of the adult appear much close together (Enlow & Hans, 1996).

2.9 Child versus adult features

The face of prepubertal boys and girls are essentially comparable. In the female, facial development begins to slow markedly after about thirteen or so years of life. For the male, at about the time of puberty the sex related dismorphic facial features just described begin to fully manifest and this maturation process of the facial superstructures continues actively throughout the adolescent period and into early adulthood (Enlow & Hans, 1996).

Growth of the facial skeleton during puberty and adolescence results in the characteristic curves and angles of the adult face. Infants and children have a large amount of subcutaneous fat in their face and together with highly elastic skin and not fully develop of facial skeleton give them a round face and cherubic appearance (Ridley, 1992).

The young child's head form looks more brachycephalic because it is still wide and vertically short. This is due to the precocious of basicranium relative to facial development. They have the short nose, round and pug-like, the nasal bridge is low, the nasal profile is concave, the forehead is bulbous and upright, cheekbone are prominent, the face looks flat and the eyes seem wide set and bulging. The face is vertically looks short because the nasal part is still small, the secondary dentition has not fully established and the jaw bones have not yet grown to the vertical extend that later support the full dentition and the enlarging masticatory muscles and airways (Enlow & Hans, 1996).

2.10 Anthropometry

Anthropometry is the study of human measurement for use in anthropological classification and comparison. The measurement of living subject was first developed by a German anatomist, Johanne Sigismund Elsholtz for his doctoral thesis in 1654 (Kolar & Salter, 1996).

In the 18th and 19th centuries most facial measurements were taken directly from skulls and only a few soft tissue measurements were performed. These measurements were used predominantly to prove that certain groups of people were superior to others (Vegter & Hage, 2000).

In the 19th and 20th centuries, anthropometry was a pseudoscience used to classify potential criminals by facial characteristics. Cesare Lombroso's criminal anthropology (1895) claimed that murderers have prominent jaws and pickpockets have long hands and scanty beards. He described how gangsters, murderers, alcoholics, fire-raisers, epileptics and dwarfs could be distinguished from normal people by anthropometric assessment of skull shape, the face, shape of nostrils, tooth form, size of masseter muscle and the size of frontal sinus (Vegter & Hage, 2000).

However anthropometric studies are today conducted for numerous different purposes. In spite of the appearance of more sophisticated technologies, it remains an efficient, cheap, non invasive method for describing craniofacial morphology. Even though anthropometry lacks the detail if compare to more powerful technologies, but it is still better suited for population studies because of the availability of comparative normal databases. The major advantage afforded by anthropometry is its technical simplicity a fact which makes it a readily available tool for evaluating patients, planning facial surgery or delineating basic features of craniofacial syndromes (Ward, 1989).

However the anthropometry is not void of errors because the disadvantage of anthropometry are improper identification of landmarks and improper measuring technique but this can overcome if the examiner becomes familiar with the measurement and as pointed out by Ward & Jamison (1991) in their study that the magnitude of error was low (within a millimetre) and significant errors related inversely to the size of the measurement and landmark identification that would be difficult to identify are admittedly not particularly reliable (Edler, 2001).

2.11 Anthropometry vs. sophisticated technologies

2.11.1 Anthropometry vs. Cephalometry

Cephalometry has been used to provide a vast array of data useful for the representation of ideal proportions (Edler, 2001). However as pointed out by Moyers and Bookstein (1979), the traditional cephalometric analysis provided limited or even misleading information regarding the true shape and size of craniofacial structures. They argued that two dimensional measurements cannot reveal differences clearly visible in three dimensions. Direct anthropometric measurement of the face cannot overcome all these problems but it clearly provides a more accurate representation of size dimensions than can measurements from two dimensional (Farkas et al, 2002).

Budai et al. (2003) compared the relations and proportions of the face in healthy young white adult men and women using anthropometric and cephalometric measurements and found that the vertical anthropometric and cephalopmetric measurements in the facial profile were in highly significant percentage normal as compared with their normative data established for healthy populations. In fact the cephalometric normal measurements were smaller than those of the anthropometric. There also significant differences between proportions on the surface and skeleton of the subjects. This gives an idea to us to be cautious in clinical practice to judge the morphological changes of the face separately and on the skeleton of the patient.

2.11.2 Anthropometry vs. Photogrammetry

Routine medical photogrammetry complements the narrative of a patient's chart as suggested by Dickson and Hanna (1976) and Morello et al (1977) but its usefulness is limited unless the prints are of standardized views and sizes (Farkas et al. 1980).

A number of precautions must be taken to ensure the scientific accuracy of photogrammetry and the routine use of photogrammetry has also been hindered by the high cost of equipment such as high quality camera lens for photography and cepholometry chair for positioning the subject (Guyot et al, 2003).

Four potential sources of error in photogrammetry which is unreliable landmarks, focal angle and distance in relation to the subject, alignment between negative and paper surface during enlargement and measurement errors on pictures (Guyot et al, 2003).

Farkas et al (1980) reported that only twenty of a total of hundred photographic measurements were correlated with clinical measurement. They also founds that depth measurements on profile views are always smaller when made by direct measurement since the tragus is always in a more anterior plane than the other landmarks (nasion, subnasale and gnation). They also found a 46% differences in the distance between the base of columella (subnasale) and tip of nose when obtained by direct measurement and by photographic measurements on frontal view.

Logically photographic measurements are reliable only if the points being measured are located on the same plane (Guyot et al, 2003).

2.11.3 Anthropometry vs. Computer-Assisted Three Dimensional Technique

Traditionally the 3D data can be generated from computed tomography (CT) and magnetic resonance imaging (MRI). Axial, sagittal and coronal views and 3D reconstruction can be included (Xia et al, 2000). However neither CT nor MRI can provide the natural photographic appearance of the texture of the facial surface (Ayoub et al, 1998).

The human face is three dimensional, so the clinicians must have accurate three dimensional information about the craniofacial region to plan their operations effectively. Without this, the surgeons cannot precisely estimate the outcome of a particular procedure. We can't denied that the three dimensional human face creation and modelling are important subjects such as computer aided simulation surgery since they are used widely in maxillofacial surgery (Xia et al, 2000).

This technique generates stunningly detailed images that can reveal important information about the underlying anatomy not obtainable through two dimensional cephalometric imaging or direct measurement of the surface of the head and face. The only disadvantages are they are very expensive and increase radiation exposure. The other deficiency is the lack of published reference data from which population means and standard deviations can be obtained (Ward, 2002).

2.11.4 Future Hope for the Anthropometry

It is well known that the anthropometric data feeds a range of enterprises that depend on knowledge of the distribution of measurement across human population. This range from the design of products or devises to fit most people to the uses in medicine such as to assess nutritional status, monitor the growth of the children, planning and assessment for plastic and reconstructive surgery to the use in forensic anthropology (Sunutar Setboorsarng, 2005).

Recently attempt was made to use the anthropometric data in the construction of face models for computer graphics application. De Carlo in his works used the published proportion data done by Farkas in young North American Caucasian men and women. He use this published direct measurement data to form a facial geometric variation in the young North American Caucasian. Basically there were two step involved in the process where the first step is to produces a plausible set of constraints on the geometry using anthropometry statistics and the second step is to derives a surface that satisfies the constrains using variation modelling. His work is a new computational approaches for the task that rely on anthropometry results, and it could also figure in a user interface for editing face models by allowing feature to be edited while related features systematically changed but preserving natural proportions or ensuring that faces respect anthropometry properties common to their population group (De Carlo et al, 1998).

It gives an idea the importance of continuing to gather and analyze anthropometric data of diverse human population.

2.12 Craniofacial Anthropometry in clinical practise

The first clinical program in craniofacial anthropometry was carried out at Charles University Prague in 1960s as part of extensive, long term study of children with cleft lip and palate (Kolar & Salter, 1996).

Farkas is considered to have most importantly influenced modern facial and soft tissue anthropometry and his core work is based on meticulous direct measurements of different ages and ethnics origin. It is now augmented by a large group of Asians of various ages and group of young African-Americans (Farkas, 1994).

During the post natal development of the face, growth occurs in all three planes, vertically (height), transversely (width) and anteroposteriorly (depth). With age, differences in rates and extent of growth among these dimensions produce major changes in facial proportions, observed until the time of maturity (Farkas et al, 1992).

Information about the normal growth of the craniofacial skeleton and soft tissue and the relationship between regions is essential if abnormal growth patterns are to be understood and reconstructive surgery is to be carried out. Many investigators and clinicians have emphasized the usefulness of anthropometry in gathering such information (Farkas & Posnick, 1992).

In the past the diagnosis of craniofacial dysmorphism was based mainly on visual inspection (anthroposcopy) rather than direct measurement on the craniofacial complex. As a result it is often difficult to reach agreement on anthroposcopy diagnosis among clinicians. By right the congenital and post traumatic deformities are best treated with the knowledge of normal values for the involved region to produce the best aesthetic and functional result. For these reason, standards based on ethnic data are desirable because these standards reflect the potentially different patterns of craniofacial growth resulting from racial, ethnic and sexual differences (Evereklioglu et al, 2002).

In 2003, Farkas et al provide the normal data of the anthropometric proportion indices of craniofacial complex in boys and girl in healthy North American (1-5 years old).

Goel et al. (1987) provided the normal anthropometric data of the orbits in Indian populations in six months to fourteen years of age. They use this value to diagnosed hypertelorism or telecanthus.

A similar study was done by Madjarova et al. (1999) to establish an anthropometric normal data for the orbits in Bulgarian newborns. They compared their data with published data for other Caucasian ethnic group of infants and found the differences in measurement. They concluded that the anthropometric differences between ethnic groups of Caucasian already exist shortly after birth. It shows that the knowledge of the soft orbital data in early post natal development in healthy populations is essential for determination in individuals of deviations from normal data.

Evereklioglu et al. (2002) provide a normal craniofacial anthropometric data in Turkish population of the age 7 – 40 years old. They found that these developmental data and normal values of the measurements in healthy subject are useful for dysmorphologist in the early identification of some craniofacial syndromes

Ocular measurement has been done in healthy normal Chinese children in Taiwan and they compared their data with published data for Caucasian children and found that the inner and outer canthal and interpupillary distance were wider for the Chinese children but the palpebral fissure length was not significantly different. They also noted that the inner canthal distance was wider than palpebral fissure length at the same age and they argued that it was not right to diagnose hypertelorism in Chinese children in Taiwan. As the result they suggested that the measurements should be adjusted with normal standards specific for the race (Wu et al, 2000).

When corrective surgery is indicated it is important for the surgeon to know the mean and standard deviations of key measurements at varying age, the rates of growth of each facial region, completion of growth and times of maturation. This information can help the surgeon to determine both the extent and preferred timing of surgery within specific regions of craniofacial skeleton (Farkas et al. 1992).

Cross sectional studies of the patterns of post natal facial growth based on anthropometric surface measurements have been carried out in growing Caucasian children (Farkas and Posnick, 1992; Farkas et al, 1992, 1992b, 1992c).

Farkas et al. (1992) performed head and face measurement in North American Caucasians between 1-18 years of age. This study was intended to enhance the knowledge of the age related growth changes in the surface anatomy within specific regions of the head and face in general population. He found that growth trends and relationship between aspects of the head are predictable. He reported that by one year of age the circumference and length of the head showed the highest levels of developmental level compared with their adult size. By ten years of age, head length reach full maturations in females and for the males, the maturation reach by age of fourteen. Head width showed the most advanced maturation by age of fourteen in female and fifteen in males. Early rapid growth in head height and head length took placed between 1 and 4 years of age and between 1 and 6 years in forehead width. As a result the data that obtained from this study can be used for planning the timing and reconstructive surgery in patients with cranial vault growth disturbances such as craniosynostosis.

Vertical skeletal growth has been measured using anthropometric technique developed by Farkas (1981). It was found that there were average annual changes of 1-2mm in the pre pubertal period. The zygomatic and gonial widths each increased by about 7mm from 6-10 years of age. As the gonial width was initially less, the proportionally changed more. Sex differences in zygomatic width of about 1mm and bi-gonial width of 3mm also have been found. The sex difference in nasal dimensions has generally been found to be quite small in the pre pubertal period, but the male nose was found to be up to 1mm larger in most of its dimensions (Nute & Moss, 2000).

Recently Cozza et al (2005) carried out the anthropometry pilot study on pre pubertal children of aged between 7 and 12 years old. About thirty craniofacial measurement and body measurement of height, weight, length and circumference were taken. They found that skull and face measurements increased less than body dimensions but face increased more than skull and the result was valid for both males and females. They found the differences between males and females for standing height, mandibular height and lower facial height. However they concluded that there is no body parameter was found to be a good indicator of craniofacial growth during this period and jaw is the area of face that showed higher development.

In conclusion the knowledge of the normal data in healthy population is essential for determinations in individuals of deviations from normal data. These values also help in identification of some craniofacial syndrome and can be used for the pre and post operative evaluation.

2.13 Anthropometry role in aesthetic of different ethnic

Proportion of aesthetic face started when people trying to define the concept of beauty. Aristotle wrote that the chief forms of beauty are in order and symmetry and definite. However Immanuel Kent suggested that the beautiful is that which pleases universally without requiring a concept. While the philosophers unsettles with the definitions of beauty, artists and artisans took a much more practical approach, settling on reference plane and ideal proportions. These ideas form the basis of facial analysis begins with rules. Many of aesthetic rules were developed through the study of accepted beautiful faces. The general concepts of aesthetic analysis include symmetry, equality of portions and repetitive proportions. This concept forms the divine or golden proportions. However one must bear in mind constantly that the facial proportions were influenced by culture and ethnicity (Richard, 1997).

The knowledge of the normal values of a specific region of the craniofacial is essential to produce the best aesthetic and functional results. Some surgeons still used the neoclassical canons in facial analysis. Neoclassical canons of facial proportions were derived by the artists and anatomists of the 17^{th} and 18^{th} centuries. Studies using anthropometry have shown little applicability of these neoclassical canons to white, Asian, Carribean and African-American populations (Farkas et al, 1985, Sim et al, 2000, Porter and Olson, 2001)

Farkas with his extensive works, comparing and measuring more than 100 dimensions and proportions in hundreds of people gave him the ability to define the standards for almost every soft tissue measurement in the head and face (Farkas, 1994).

Hajnis et al. (1994) found significant differences between facial measurements in white ethnics and various races and these contributed to the knowledge of diversity in facial proportions.

Comparison study of the facial proportions between Southern Chinese and white women by Sim et al. (2000), showed the differences in facial proportions between these groups. It showed that the Chinese face were wider in intercanthal distance, nasal base and has a different profile in lower face and eyelid. The Chinese nose was also less prominent with the alae more flared and nasal tip less prominent

Kawakami et al (1989) did a comparison study of facial position between typical Japanese and Caucasians. However he used the golden proportion for this relationship. They found that the Japanese tend to have a larger upper lip and shorter chin length compared with the Caucasians. The data they obtained was used in their pre and post operative aesthetic facial analysis.

A comparison of aesthetic populations between Oriental and Caucasian nose was done by Leong and White (2004). They found that the oriental nose projected less from the face and was broader at the intercanthal level and the alae base but not bony base.

Le et al. (2002) tested the validity of six neoclassical facial canons between Asian groups comprising Vietnamese and Thais to the North American Caucasian. They found that the validity of the five other facial canons was more frequent in the Caucasian as compared to Asian. The Asians has a wider intercanthal distance in relation to shorter palpebral fissure, a much wider nose with a wide facial contour, a smaller mouth width and a lower face smaller than the forehead height.

Jennifer in 2004 showed that the proportional facial relationships of the African American men significantly different from those of the North American white men and from neoclassical standards. As a result they set a new standard from their normative data for pre operative facial analysis.

In making a diagnosis of certain anomalies and syndromes, abnormal facial features such as telecanthus, ocular hypertelorism or hypotelosrism are taken consideration by clinicians or surgeons. As an example visual impression is mostly used to describe the anatomical inter pupillary distance. However this is not adequate because of variations in facial features such as wide nasal bridge, epicanthus and telecanthus (Evereklioglu, 2002).

As a result from these findings, the normal data that measured from the healthy subjects and different ethnic are useful in the early identification of some craniofacial syndromes.

As for facial plastic and reconstructive surgery, even though the basic principle of the surgery are applied to everyone but the important fact that should be borne in mind, is the aim to retain ethnicity and natural appearance of the face as well to restore the good functional result.

Anthropometry represents a snapshot in time and measurements not taken are lost forever as the individual grows, ages and dies. It would be very useful to have some system that would preserve as much as possible of this transitory information for later re-analysis as measurement and statistical technique improved.

Chapter 3 : Methodology

3.1 Subject

The study group consisted of convenient samples of Malay primary school children comprising of seven and twelve years old boys and girls. The study group were recruited from Sekolah Rendah Kebangsaan Bandar Baru Bangi Selangor. Each age group totalled one hundred participants with equal number of male and female subjects. The participants were generally healthy and exhibited no craniofacial abnormalities either acquired through road traffic accidents or other forms of trauma, congenital or developmental discrepancies and had no history of plastic or reconstructive surgery. Subjects of mixed parentage or mixed grandparents were excluded from this study. The female that already have theirs menstrual activity were also excluded from this study.

3.2 Physical facilities

Clinical measurements were conducted in a room well lite by natural light and the subjects were seated upright in the examining chair with the examiner seated facing the subject at eye level. This will provide the best view of the head and face. To prevent the subjects from feel tired during the examination the provided chair should has a straight back with armrests.

A vertical leg rest is required to enable the examiner approaches the subjects close enough to apply the callipers without having to stretch forward constantly which will tire the arms and back. A swivel chair allows the subjects to be turned to the desired view and the examiner to be stationary during the examination.

3.3 Anthropometry measurements in selected craniofacial region

3.3.1. Positioning of the subject

The subjects will be seated upright on a straight backed chair. The examiner is standing or sitting in front of the subject. Readings are taken at rest and standard position of the head. The rest position of the head is determined by the subject’s own feeling of natural head balance. The standard orientation of the head is achieved by positioning the head in the Frankfort Horizontal Plane (FHP). FHP is a horizontal line from the top of the external auditory canal to the lowest point on the inferior border of the orbit. FHP is the standard position for measurement of the vertical dimensions of the head and face.

3.3.2. Instruments

a. Sliding caliper

The sliding caliper is the standard anthropometric instrument and the sliding caliper used was the Mitutoyo Sliding caliper. It consists of two basic parts namely the metric digital scale with two pairs of perpendicular arms at the origin of the scale, a slide and a thumbscrew. Both arms have two tips; the larger pair was mainly used for linear measurements in which the shortest distance is determined between two landmarks.

Figure 3.3.2a Sliding caliper

b. Spreading caliper

This type of caliper consists of two curved arms connected at their bases with a pivoting screw. The gradations on the scale are reduced in size in order to make them match the width at the tips. The readings are taken at the inner edge of the bracket on the right arm. This calliper did not have an attached metric scale so the measurements were made against a millimetre metal ruler.

Figure 3.3.2b Spreading caliper

c. Modified double callipers with a bubble level

A modified double sliding calliper is made by using a 45cm T – shaped plastic ruler. The horizontal arm is attached at 90° to the vertical arm in anteroposterior view. It consists of a sliding block which moves along the vertical arm of the instrument base. A bubble is attached to the side of the upper horizontal arm of the ruler. The bubble level is used to correct any tilt in the instrument during measurement.

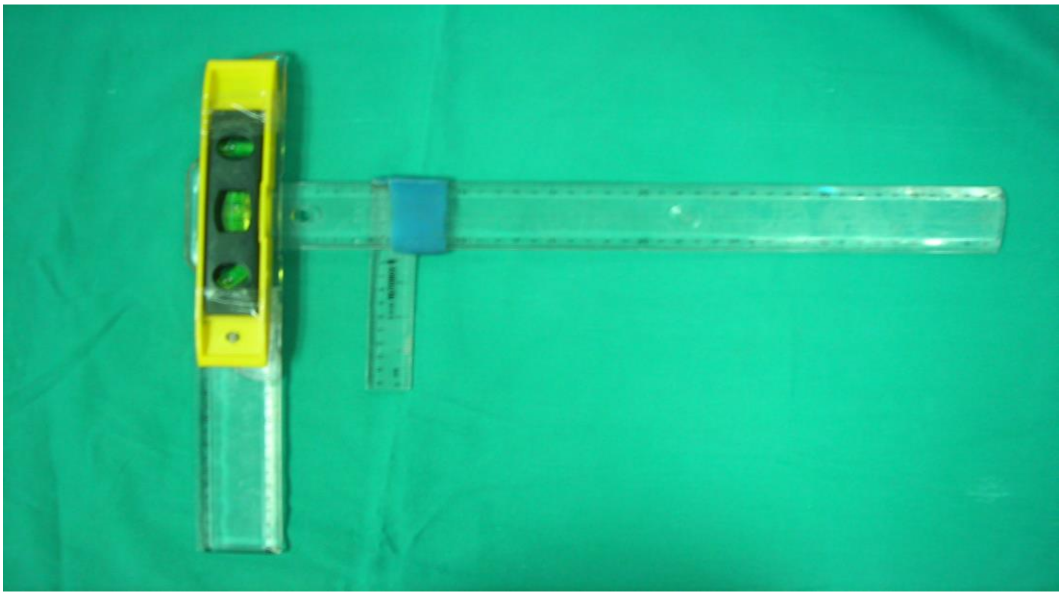

Figure 3.3.2c Modified sliding callipers with a bubble level

d. Measuring tape

This plastic measuring tape has millimetre markings along both edges and is used in measuring head circumference. When doing the measurement the tape must be pulled tight around the hair to get an accurate reading.

e. Skin marker

When the landmark is used for more than one measurement for example nasion or subnasale then these landmarks are marked on the skin. The purpose of marking this landmark is to avoid error in locating these landmarks so that the same spot will used.

f. Printed data entry forms

The data entry form was printed on different coloured papers for easier identification of each group of subjects. (Appendix C)

3.4 Measuring sequence

In order to maximize data entry in the minimum time, only one instrument is used at a time. This is because switching one instrument to another will slows down the examination process and affects the precision of each reading.

3.5 Measurements of the craniofacial complex

Twenty two linear measurement were taken; five for the head, seven for the face, four for the orbits, 3 for the nose and 3 for the lips and mouth. The relationship between these measurements was determined using seventeen proportion indices; 2 for the head, six for the face, two for the orbits, four for the nose and three for the lips and mouth. Every measurement was taken twice by the same examiner and recorded in the corresponding form. In case if there is a large discrepancy between initial two measurements than the third measurement must be taken and two closer readings would then be used. Prior to this study, an intra examiner and inter-examiners calibration exercise was done at the Department of Oral and Maxillofacial Surgery. This methodology and evaluation of indices of the craniofacial region was adapted from Hajnis et al. (1994).

3.6 Craniofacial landmarks

To ease orientation and ensure uniformity in anthropometric terminology, the landmarks are named according to Greek or Latin anatomical terminology. Abbreviations of the landmarks are used instead of full names and lowercase letters are used instead of uppercase letters. As for example n denotes nasal point on the surface as oppose to uppercase N in roentgenocephalometry.

Table 3.6.1 Craniofacial landmarks of the head

No	Landmark	Definition
1	Vertex(v)	The highest point of the head when the head is in the Frankfort Horizontal Plane
2	Glabella (g) or nasal eminence	The most prominent point in the median sagittal plane between the supra orbital ridges
3	Opyhron (on)	The point at the mid plane of a line tangent to the upper limits of the eyebrow
4	Opisthocranium (op)	The most prominent posterior point of the occiput
5	Eurion (eu)	The most prominent lateral point on each side of the skull in the area of parietal and temporal bones

Table 3.6.2 Craniofacial landmarks of the face

No	Landmark	Definition
1	Zygion (z)	The most lateral point on the zygomatic arch, identified by the maximum bizygomatic (facial) breadth
2	Nasion (n)	The midpoint of the nasofrontal suture
3	Subnasale (sn)	The midpoint of the angle at the columella base where the lower border of the nasal septum and the surface of the upper lip meet. The landmark is identified in base view of the nose or from the side
4	Stomion (sto)	The midpoint of the labial fissure when the lips are closed and the teeth shut in the natural position
5	Gnathion (gn) or Menton	The lowest median landmark on the lower border of the mandible. This is a bony landmark and requires pressing the instrument down to reduce the effect of the soft tissue as much as possible
6	Tragion (t)	The notch on the upper margin of the tragus

Table 3.6.3 Craniofacial landmark of the orbit

No	Landmark	Definition
1	Endocanthion (en)	The point at the inner commisure of the eye fissure
2	Exocanthion (ex)	The point at the outer commisure of the eye fissure
3	Palpebrale Superius (ps)	The highest point in the mid portion of the free margin of each upper eyelid
4	Palpebrale inferius (pi)	The lowest point in the mid portion of the free margin of each lower eyelid

Table 3.6.4 Craniofacial landmark of the nose

No	Landmark	Definition
1	Alare (al)	The most lateral point on each alar contour
2	Nasion (n)	The point in the midline of both nasal and root and the frontonasal suture
3	Subnasale (sn)	The midpoint of the angle of the columella base where the lower border of the nasal septum and the surface of the upper lip meet
4	Pronasale (prn)	The most protruded point of the nasal tip, identified on the lateral view of the rest position of the head

Table 3.6.5 Craniofacial landmark of the lips and mouth

No	Landmark	Definition
1	Cheilion (ch)	Point located at each labial commisure
2	Sublabiale (sl)	Determines the lower border of the lower lip or the upper border of chin correspond with the mentolabial ridge

3.7 The proportion index

The relationship of two or more measurements taken from the surface of the head and face is quantified by the numerical proportion index. The formulation of an index is derived by;

$$\text{Index (I)} = \frac{\text{Numerator (smaller measurement)}}{\text{Denominator (larger measurement)}} \times 100$$

From the formula, the smaller measurement is expressed by a percentage of the larger one. It provides information about relative sizes of two parts of the body. The mean index value is obtained from a representative number of selected similar subjects and represents the average proportion between the related measurements.

Standard deviation (SD) quantifies the normal differences between the index values of the members of the samples. It determines the width of the normal range of the index from 2 SD below to 2 SD above the mean. All indices in the normal range are regarded as variations of normal proportions. Even in the most homogenous sample, individual proportion indices may differ somewhat due to individuality. There are numerous proportion indices that have been developed but in this study only seventeen indices were chosen from the craniofacial region which was thought best to represent the differences in these subjects.

3.8 Anthropometric measurement

The measurements of the head, face, orbits, nose, lips and mouth are carried out according to standard methods of physical anthropometry (Farkas, 2000)

Table 3.8.1 Head measurement

No	Landmark	Measurement definition and instrument
1	head width (eu-eu)	The distance between the eurions. Instrument: spreading calliper
2	Length of the head (g-op)	The distance between the glabella and the occipital Instrument: spreading calliper
3	Height of the head (v-n)	The distance between vertex and nasion Instrument: modified double sliding calliper
4	Craniofacial height (v-gn)	The distance between vertex and gnathion, it measured the vertical height of the head and the face. Instrument: modified double sliding calliper
5	Head circumference (on-op)	The circular distance of the head Instrument: soft measuring tape

The proportions derived from these measurements are :

1. Cephalic index = eu-eu x 100/g-op
2. Head craniofacial height index = v-n x 100/v-gn

Table 3.8.2 Facial measurement

No	Landmark	Measurement definition and instrument
1	Face width (zy-zy)	The widest part of the face between the zygons Instrument: spreading calliper
2	Mandible width (go-go)	The distance between the gonions Instrument: spreading calliper
3	Face height (n-gn)	The distance between the nasion and the gnathion Instrument: sliding calliper
4	Upper face height (n-sto)	The distance between the nasion and the stomion Instrument: sliding calliper
5	Mandible height (sto-gn)	The distance between the stomion and the gnathion Instrument: sliding calliper
6	Maxillary depth (t-sn), left	The distance between tragion and the subnasale Instrument: spreading calliper
7	Mandible depth (t-gn), left	The distance between tragion and gnathion Instrument: spreading calliper

The proportions derived from these measurements are :

1. Facial index = n-gn x100/zy-zy
2. Mandibular index = sto-gn x 100/go-go
3. Upper face-face height index = n-sto x 100/n-gn
4. Mandible-face height index = sto-gn x 100/n-gn
5. Mandible face width index = go-go x 100/zy-zy
6. Middle lower third face index = t-sn x 100/t-gn

Table 3.8.3 Orbital measurements

No	Landmark	Measurement definition and instrument
1	Intercanthal width (en-en)	The distance between the endocanthions Instrument: sliding calliper
2	Binocular width (ex-ex)	The distance between exocanthions Instrument: sliding calliper
3	Eye fissure length (ex-en), left	The distance between the endocanthion and the exocanthion Instrument: sliding calliper
4	Eye fissure height (ps-pi), left	The distance between the free edges of each eyelid Instrument: sliding calliper

The proportions derived from these measurements are :

1. Intercanthal index = en-en x 100/ex-ex
2. Eye fissure index = ps-pi x 100/ex-en

Table 3.8.4 Nasal measurement

No	Landmark	Measurement definition and instrument
1	Nose width (al-al)	The distance between the most lateral points on the alae Instrument: sliding calliper
2	Nose height (n-sn)	The distance between the nasion and the subnasale Instrument: sliding calliper
3	Nasal tip protrusion (sn-prn)	The distance between the subnasale and the pronasale Instrument: sliding calliper

The proportions derived from these measurements are :

1. Nasal index = al-al x 100/n-sn
2. Nasal tip protrusion length-nose width index = sn-prn x 100/al-al
3. Nose-face height index = n-sn x 100/n-gn
4. Nose-face width index = al-al x 100/zy-zy

Table 3.8.5 Lips and mouth measurements

No	Landmark	Measurement definition and instrument
1	Upper lip height (sn-sto)	The distance between subnasale and the stomion Instrument: sliding calliper
2	Mouth width (ch-ch)	The distance between the cheilions of the closed mouth Instrument: sliding calliper
3	Lower lip height (sto-sl)	The distance between the stomion and the sublabiale Instrument: sliding calliper

The proportions derived from these measurements are :

1. Upper lip height-mouth width index = sn-sto x 100/ch-ch
2. Lower-upper lip height index = sto-sl x 100/sn-sto
3. Mouth-face width index = ch-ch x 100/zy-zy

3.9 Statistic analysis

Data collected are entered into SPSS software (version 11.5) and statistical analysis was performed by the use of parametric test, one way ANOVA test to compare the difference in means between two groups. The significant value is set at 95% ($p=0.05$). Data are presented as mean ± SD.

Chapter 4 : Results

4.1 Head

In the head region, five anthropometric parameters were measured; head width (eu-eu), head length (g-op), head height (v-n), craniofacial height (v-gn) and head circumference (on-op). 2 indices namely the cephalic index (eu-eu x 100/g-op) and head-craniofacial height index (v-n x 100/v-gn) were calculated.

4.1.1 Head width (eu-eu)

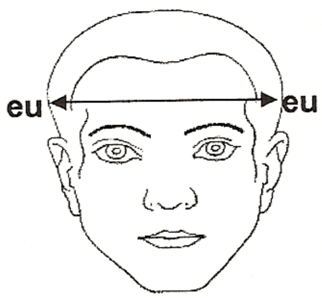

Table 4.1.1 Head width (eu-eu)

Gender / Group	Age	Mean ± SD	p-value
Male	7	142.62 ± 5.15	0.00
Female	7	138.76 ± 4.87	
Male	12	146.36 ± 5.39	0.78
Female	12	145.28 ± 7.17	
Male	7	142.62 ± 5.15	0.00
Male	12	146.36 ± 5.39	
Female	7	138.76 ± 4.87	0.00
Female	12	145.28 ± 7.17	

The mean values for the head width (eu-eu) for the female and male aged 7 and 12 years are shown in Table 4.2.1. The head widths in both 7 and 12 year old male are generally larger than the female's. There is a significance difference in head width between 7-year-old male and female ($p<0.05$) but no significant difference is noted in the 12 year old ($p>0.05$). It also showed that there is a significant difference ($p<0.05$) when comparing the head width of both genders as age increased.

4.1.2 Head length (g-op)

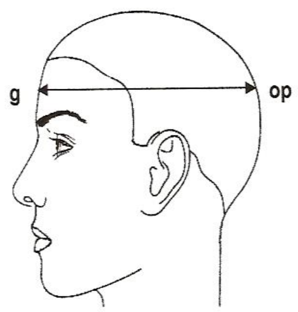

Table 4.1.2 Head Length (g-op)

Gender / Group	Age	Mean ± SD	p-value
Male	7	175.20 ± 9.33	0.02
Female	7	169.34 ± 7.28	
Male	12	179.80 ± 9.21	0.99
Female	12	179.66 ± 14.27	
Male	7	175.20 ± 9.33	0.23
Male	12	179.80 ± 9.21	
Female	7	169.34 ± 7.28	0.00
Female	12	179.66 ± 14.27	

The results for head length are shown in table 4.1.2. The head length of the 7 and 12 year old male was higher than the female. However the difference was only significant ($p<0.05$) in age group of 7-year-old. The head lengths were higher in the elder group of both genders; however there is no significant difference ($p>0.05$) between males but a significant difference ($p<0.05$) between females.

4.1.3 Head height (v-n)

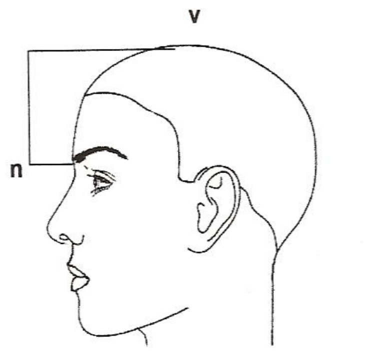

Table 4.1.3 Head height

Gender / Group	Age	Mean ± SD	p-value
Male	7	86.74 ± 9.56	1.00
Female	7	86.58 ± 8.26	
Male	12	95.12 ± 11.92	0.15
Female	12	91.06 ± 8.09	
Male	7	86.74 ± 9.56	0.00
Male	12	95.12 ± 11.92	
Female	7	86.58 ± 8.26	0.09
Female	12	91.06 ± 8.09	

For this parameter, it is found that the head height (v-n) is higher in male for both age groups. However the differences were not statistically significant ($p<0.05$). The head height was higher in elder group of both genders. However statistically the head height only showed significant difference in the male group ($p<0.05$). (Table 4.1.3.)

4.1.4 Craniofacial height (v-gn)

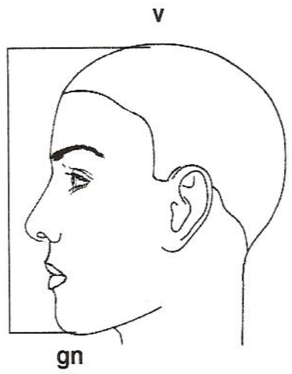

Table 4.1.4 Craniofacial height (v-gn)

Gender / Group	Age	Mean ± SD	p-value
Male	7	190.72 ± 7.60	0.88
Female	7	189.02 ± 2.31	
Male	12	208.52 ± 2.09	0.00
Female	12	200.56 ± 5.19	
Male	7	190.72 ± 7.60	0.00
Male	12	208.52 ± 2.09	
Female	7	189.02 ± 2.31	0.00
Female	12	200.56 ± 5.19	

Males in both age groups had a higher measurement in comparison to the female (Table 4.1.4). The result showed significant difference ($p<0.05$) only when comparing 12 year old male and female. However the craniofacial height is higher in elder group and this difference was statistically significant for both genders ($p<0.05$).

4.1.5 Head circumference (on-op)

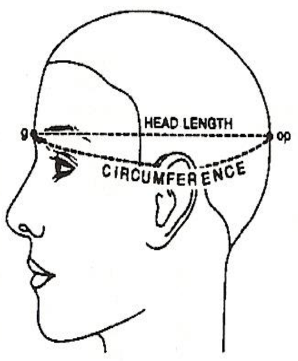

Table 4.1.5 Head circumference (on-op)

Gender / Group	Age	Mean ± SD	p-value
Male	7	512.90 ± 3.28	0.33
Female	7	496.06 ± 5.97	
Male	12	537.92 ± 3.12	0.95
Female	12	532.62 ± 2.42	
Male	7	512.90 ± 3.28	0.06
Male	12	537.92 ± 3.12	
Female	7	496.06 ± 5.97	0.00
Female	12	532.62 ± 2.42	

Table 4.1.5 showed a result of head circumference. The head circumference of male showed the largest value in both age groups. However this difference is not statistically significant ($p>0.05$). It was also found that the head circumference was higher in the elder groups. However the result was statistically significant only for the female ($p<0.05$).

4.1.6 Cephalic Index (eu-eu x 100/g-op)

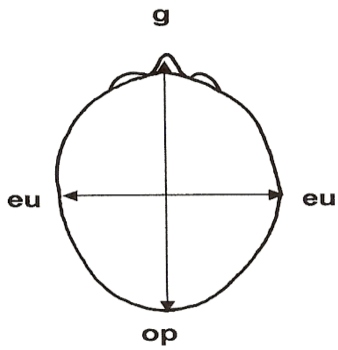

Table 4.1.6 Cephalic Index (eu-eu x 100/g-op)

Gender / Group	**Age**	**Mean ± SD**	**p-value**
Male	7	81.61 ± 4.95	0.96
Female	7	82.06 ± 4.05	
Male	12	81.92 ± 4.98	0.88
Female	12	82.20 ± 5.74	
Male	7	81.61 ± 4.95	0.99
Male	12	81.92 ± 4.98	
Female	7	82.06 ± 4.05	0.82
Female	12	82.20 ± 5.74	

In general the cephalic index of male for both age groups was lower than the female (Table 4.1.6). However the differences were not statistically significant (p>0.05). Age wise the elder group shows slight higher value than the younger group for cephalic index. However the result is not statistically significant (p>0.05).

4.1.7 Head-Craniofacial Height Index (v-n x100/v-gn)

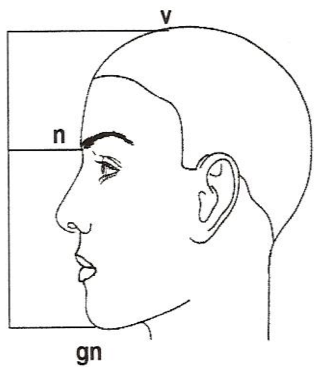

Table 4.1.7 Head-Craniofacial Height Index

Gender / Group	Age	Mean ± SD	p-value
Male	7	45.47 ± 4.59	0.98
Female	7	45.77 ± 3.10	
Male	12	45.57 ± 4.74	0.99
Female	12	45.83 ± 4.01	
Male	7	45.47 ± 4.59	0.99
Male	12	45.57 ± 4.74	
Female	7	45.77 ± 3.10	0.99
Female	12	45.83 ± 4.01	

In general the head-craniofacial height index (Table 4.1.7) of the male and female showed very slight difference for the same age groups. However the findings is not statistically significant ($p>0.05$). Age wise, there was also almost no differences between genders for both age group. However this differences were not statistically significant ($p>0.05$). This suggested an almost constant proportion between the head with the craniofacial, irrespective of age and gender.

4.2 Face

There are seven (7) anthropometric measurements obtain; face width (zy-zy), mandible width (go-go), face height (n-gn), upper face height (n-sto), mandible height (sto-gn), left maxillary depth (t-sn) and left mandibular depth (t-gn). From these measurements, five (5) proportion indices were derived.

4.2.1 Face width (zy-zy)

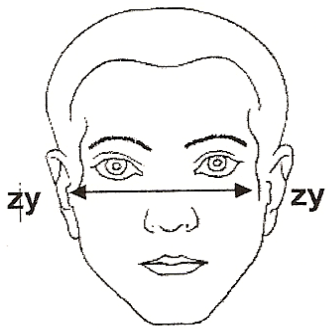

Table 4.2.1 Face width (zy-zy)

Gender / Group	Age	Mean ± SD	p-value
Male	7	116.72 ± 5.43	0.05
Female	7	113.12 ± 4.96	
Male	12	127.56 ± 8.34	0.88
Female	12	126.52 ± 8.48	
Male	7	116.72 ± 5.43	0.00
Male	12	127.56 ± 8.34	
Female	7	113.12 ± 4.96	0.00
Female	12	126.52 ± 8.48	

The face width for both male and female in 2 different age groups are showed in Table 4.2.1. Basically male in both age groups had a larger face width as compared to the female. However the differences was not statistically significant ($p>0.05$). The results also showed that the face width were significantly larger in the elder age group for both genders ($p<0.05$).

4.2.2 Mandible width (go-go)

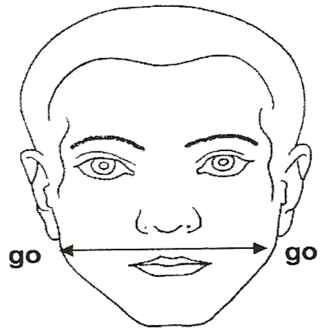

Table 4.2.2 Mandible width (go-go)

Gender / Group	Age	Mean ± SD	p-value
Male	7	94.08 ± 5.67	0.06
Female	7	90.82 ± 4.83	
Male	12	103.00 ± 7.45	0.01
Female	12	98.98 ± 7.65	
Male	7	94.08 ± 5.67	0.00
Male	12	103.00 ± 7.45	
Female	7	90.82 ± 4.83	0.00
Female	12	98.98 ± 7.65	

Table 4.2.2 showed that the mean values for the mandible width were larger in male of both age groups. However the difference was statistically significant only for the 12 year old ($p<0.05$). Irregardless of gender, the mandible width was larger in the elder group and the differences were statistically significant ($p<0.05$).

4.2.3 Face height (n-gn)

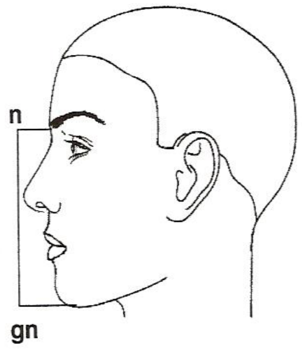

Table 4.2.3 Face Height (n-gn)

Gender / Group	Age	Mean ± SD	p-value
Male	7	100.54 ± 6.03	0.06
Female	7	97.58 ± 3.90	
Male	12	110.80 ± 6.88	0.31
Female	12	108.83 ± 5.51	
Male	7	100.54 ± 6.03	0.00
Male	12	110.80 ± 6.88	
Female	7	97.58 ± 3.90	0.00
Female	12	108.83 ± 5.51	

The results for face height results showed in Table 4.2.5. The mean value for the face height was smaller in female as compared to male within the same age group. However the gender difference was statistically not significant ($p>0.05$). The face height was generally higher in the elder groups. The difference was significant for both gender ($p<0.05$).

4.2.4. Upper face height (n-sto)

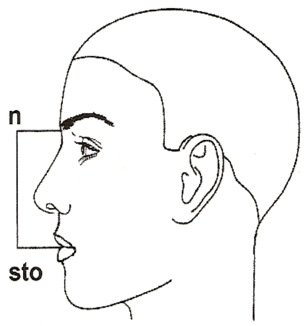

Table 4.2.4 Upper face height (n-sto)

Gender / Group	Age	Mean ± SD	p-value
Male	7	65.00 ± 4.67	0.24
Female	7	63.37 ± 3.40	
Male	12	72.10 ± 5.33	0.15
Female	12	70.26 ± 3.83	
Male	7	65.00 ± 4.67	0.00
Male	12	72.10 ± 5.33	
Female	7	63.37 ± 3.40	0.00
Female	12	70.26 ± 3.83	

For this parameter, the male has a higher upper face height than the female for both age groups (Table 4.2.4). However the difference were not statistically significant ($p>0.05$). The face height were higher in the elder group and the differences were statistically significant for both gender ($p<0.05$)

4.2.5. Mandible height (sto-gn)

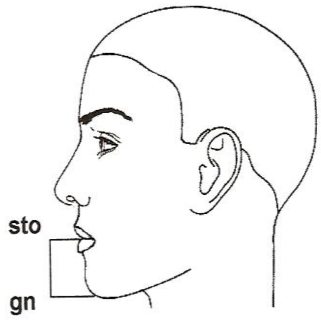

Table 4.2.5 Mandible height (sto-gn)

Gender / Group	Age	Mean ± SD	p-value
Male	7	36.43± 2.94	0.63
Female	7	35.59± 3.59	
Male	12	41.55± 4.38	0.71
Female	12	40.80 ± 3.67	
Male	7	36.43± 2.94	0.00
Male	12	41.55± 4.38	
Female	7	35.59± 3.59	0.00
Female	12	40.80 ± 3.67	

As shown in Table 4.2.5., the mean value for mandible height was higher in male of both age groups but the differences were not statistically significant ($p>0.05$). It is also found that the mandible height were higher in elder groups and the difference were statistically significant for both gender ($p<0.05$).

4.2.6. Left maxillary depth (t-sn)

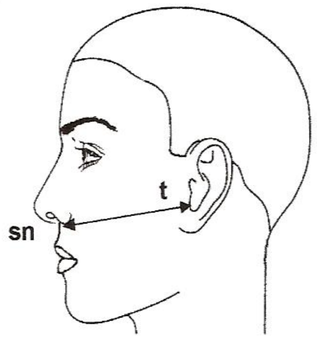

Table 4.2.6 Left maxillary depth (t-sn)

Gender / Group	Age	Mean ± SD	p-value
Male	7	107.58 ± 4.38	0.07
Female	7	105.02 ± 4.66	
Male	12	119.08 ± 6.30	0.01
Female	12	115.99 ± 5.42	
Male	7	107.58 ± 4.38	0.00
Male	12	119.08 ± 6.30	
Female	7	105.02 ± 4.66	0.00
Female	12	115.99 ± 5.42	

As shown in the Table 4.2.6., the mean value for maxillary depth was larger in male of both age groups but the difference was statistically significant only in the 12-year-old group ($p<0.05$). It was also found that the maxillary depth was generally larger in the elder children and the results were significant for both genders ($p<0.05$)

4.2.7. Mandibular depth (t-gn), left

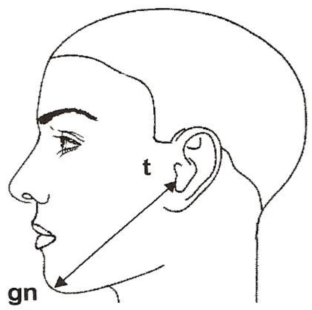

Table 4.2.7 Mandibular depth (t-gn), left

Gender / Group	Age	Mean ± SD	p-value
Male	7	115.28 ± 5.21	0.03
Female	7	111.86 ± 4.69	
Male	12	130.14 ± 7.18	0.01
Female	12	126.47 ± 7.25	
Male	7	115.28 ± 5.21	0.00
Male	12	130.14 ± 7.18	
Female	7	111.86 ± 4.69	0.00
Female	12	126.47 ± 7.25	

When analysing the mandibular depth (Table 4.2.7), it was found that the male has a larger mandibular depth for both age group and these findings were statistically significant ($p<0.05$). It was shown that the mandibular depth were higher in the elder age groups and the differences were statistically significant for both genders ($p<0.05$).

4.2.8. Facial Index (n-gn x 100/zy-zy)

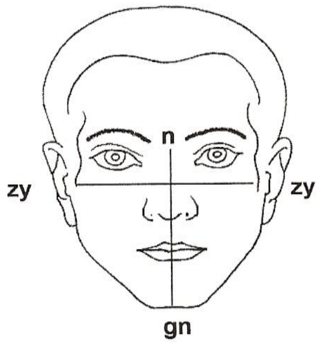

Table 4.2.8 Facial Index (n-gn x 100/zy-zy)

Gender / Group	Age	Mean ± SD	p-value
Male	7	86.22 ± 5.26	0.99
Female	7	86.39 ± 4.67	
Male	12	87.06 ± 5.71	0.89
Female	12	86.29 ± 5.92	
Male	7	86.22 ± 5.26	0.86
Male	12	87.06 ± 5.71	
Female	7	86.39 ± 4.67	1.00
Female	12	86.29 ± 5.92	

Table 4.2.8 showed that at age 7, the mean facial index was almost similar between male and female. At age 12 the index was slightly larger in male as compared to the female. However this difference was not statistically significant (p>0.05).

In male, it was shown that the mean was larger in elder group. Interestingly for female, the facial index showed a slightly smaller mean in elder group. However these differences were not statistically significant (p>0.05).

4.2.9. Mandibular index (sto-gn x 100/go-go)

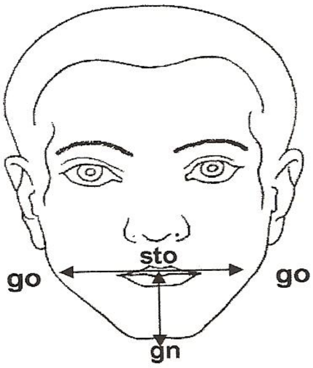

Table 4.2.9 Mandibular index (sto-gn x 100/go-go)

Gender / Group	Age	Mean ± SD	p-value
Male	7	38.78 ± 3.03	0.96
Female	7	39.32 ± 4.10	
Male	12	40.50 ± 4.81	0.68
Female	12	41.43 ± 4.49	
Male	7	38.78 ± 3.03	0.16
Male	12	40.50 ± 4.81	
Female	7	39.32 ± 4.10	0.06
Female	12	41.43 ± 4.49	

The mean mandibular index (Table 4.2.9) for the female was higher for both age group but the differences were not statistically significant ($p>0.05$). It has been shown that the mandibular index was higher in elderly age group but statistically the difference was not significant ($p>0.05$).

4.2.10 Upper face-face height index (n-sto x 100/n-gn)

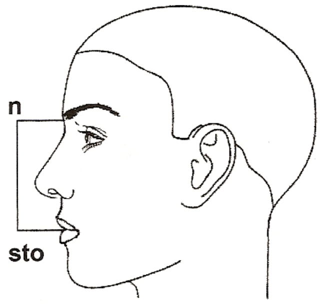

Table 4.2.10 Upper face-face height index (n-sto x 100/n-gn)

Gender / Group	Age	Mean ± SD	p-value
Male	7	64.66 ± 2.81	0.94
Female	7	64.96 ± 2.68	
Male	12	65.08 ± 2.98	0.78
Female	12	64.98 ± 2.21	
Male	7	64.66 ± 2.81	0.86
Male	12	65.08 ± 2.98	
Female	7	64.96 ± 2.68	0.89
Female	12	64.98 ± 2.21	

From Table 4.2.10 shows the upper face-face height index of the 7 and 12-year-old school children. Generally the proportions of upper face to the face height were rather constant irrespective of age and gender difference.

4.2.11 Mandible-upper face height index (sto-gn x 100/n-gn)

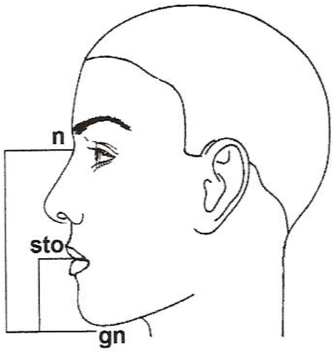

Table 4.2.11 Mandible-upper face height index (sto-gn x 100/n-gn)

Gender / Group	Age	Mean ± SD	p-value
Male	7	36.24 ± 1.98	0.97
Female	7	36.46 ± 2.46	
Male	12	37.50 ± 3.14	1.00
Female	12	37.48 ± 2.65	
Male	7	36.24 ± 1.98	0.07
Male	12	37.50 ± 3.14	
Female	7	36.46 ± 2.46	0.20
Female	12	37.48 ± 2.65	

The means for the mandible-upper face height index is showed in Table 4.2.11. It was noted that the 7-year-old female has a larger index, but as the male reached age twelve, they in turn had a larger mandible-upper face height index. However these differences were not statistically significant ($p>0.05$). The elder group of both genders had a slightly higher mean in mandible-upper face height index. However the differences were not statistically significant ($p>0.05$)

4.2.12 Mandible-face width index (go-go x 100/zy-zy)

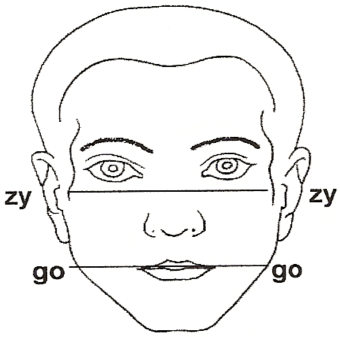

Table 4.2.12 Mandible-face width index (go-go x 100/zy-zy)

Gender / Group	**Age**	**Mean ± SD**	**p-value**
Male	7	80.68 ± 4.69	0.97
Female	7	80.33 ± 3.65	
Male	12	80.81 ± 4.14	0.02
Female	12	78.31 ± 4.74	
Male	7	80.68 ± 4.69	0.99
Male	12	80.81 ± 4.14	
Female	7	80.33 ± 3.65	0.09
Female	12	78.31 ± 4.74	

Generally the male had a larger mandible-face width index than the female. However the difference was only statistically significant in the 12 year old group ($p<0.05$). In female, the mandible-face width index decreased from 80.33% to 78.31% when comparing the elder age group with young age group. This change was not observed in the male group, in which the index was slightly higher in the elder age. However, the se differences were not statistically significant ($p>0.05$). (Table 4.2.12.)

4.2.13 Middle-lower third face depth index (t-sn x 100/t-gn)

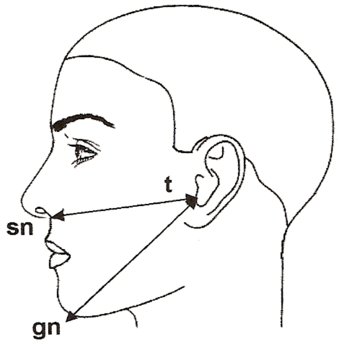

Table 4.2.13 Middle-lower third face depth index (t-sn x 100/t-gn)

Gender / Group	Age	Mean ± SD	p-value
Male	7	93.37 ± 2.60	0.69
Female	7	93.90 ± 2.17	
Male	12	91.54 ± 2.46	0.94
Female	12	91.79 ± 2.47	
Male	7	93.37 ± 2.60	0.00
Male	12	91.54 ± 2.46	
Female	7	93.90 ± 2.17	0.00
Female	12	91.79 ± 2.47	

For the middle-lower third face depth index, female has a larger result for both age groups. However statistically the differences were not significant ($p>0.05$). The middle-lower third face depth index were significantly smaller in elder age group and this was observed in both gender ($p<0.05$).

4.3 Orbits

In the orbit region, four anthropometric measurements were obtained. These measurements were; intercanthal width (en-en), binocular width (ex-ex), left eye fissure length (ex-en) and left fissure height (ps-pi). From these measurements, two proportions indices were derived, namely intercanthal index and eye fissure index.

4.3.1. Intercanthal width (en-en)

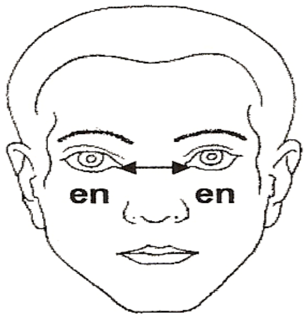

Table 4.3.1 Intercanthal width (en-en)

Gender / Group	Age	Mean ± SD	p-value
Male	7	32.41 ± 2.04	0.38
Female	7	31.70 ± 2.19	
Male	12	34.48 ± 2.13	0.54
Female	12	33.88 ± 2.54	
Male	7	32.41 ± 2.04	0.00
Male	12	34.48 ± 2.13	
Female	7	31.70 ± 2.19	0.00
Female	12	33.88 ± 2.54	

Table 4.3.1. shows that male had a larger intercanthal width than female for both age groups. However the difference is not statistically significant (p>0.05). It was also noted that the intercanthal width was larger in elder age groups. This difference were statistically significant for both genders (p<0.05).

4.3.2. Biocular width (ex-ex)

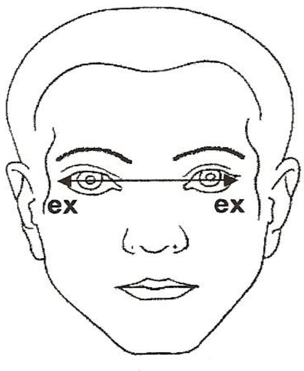

Table 4.3.2 Biocular width (ex-ex)

Gender / Group	Age	Mean ± SD	p-value
Male	7	92.74 ± 3.89	0.02
Female	7	89.74 ± 4.37	
Male	12	101.02 ± 4.00	0.15
Female	12	99.28 ± 4.21	
Male	7	92.74 ± 3.89	0.00
Male	12	101.02 ± 4.00	
Female	7	89.74 ± 4.37	0.00
Female	12	99.28 ± 4.21	

The biocular width was higher in the males for both age groups (Table 4.3.2). However statistically the difference was only significant for the younger age group. The biocular width was higher in elder age groups of both genders. Statistically these differences were significant ($p<0.05$).

4.3.3. Eye fissure length (ex-en), left

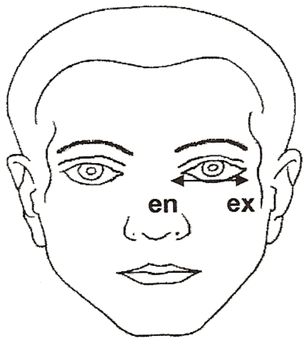

Table 4.3.3 Eye fissure length (ex-en), left

Gender / Group	Age	Mean ± SD	p-value
Male	7	33.46 ± 1.88	0.15
Female	7	32.62 ± 2.01	
Male	12	35.89 ± 1.96	0.88
Female	12	35.60 ± 2.10	
Male	7	33.46 ± 1.88	0.00
Male	12	35.89 ± 1.96	
Female	7	32.62 ± 2.01	0.00
Female	12	35.60 ± 2.10	

Table 4.3.3 shows that the eye fissure length was slightly higher in male for both age groups. However, statistically the difference was not significant ($p>0.05$). The eye fissure length was also higher in the elder age groups and the differences were significant for both genders ($p<0.05$).

4.3.4. Eye fissure height (ps-pi), left

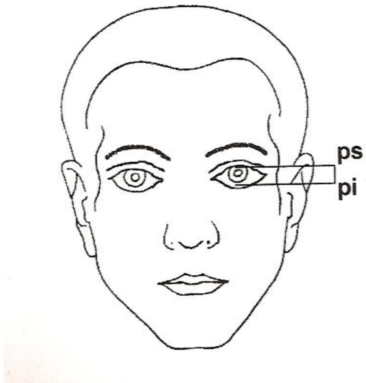

Table 4.3.4 Eye fissure height (ps-pi), left

Gender / Group	Age	Mean ± SD	p-value
Male	7	9.65 ± 0.83	0.99
Female	7	9.69 ± 0.98	
Male	12	8.9 ± 0.74	0.50
Female	12	9.1 ± 0.85	
Male	7	9.65 ± 0.83	0.00
Male	12	8.9 ± 0.74	
Female	7	9.69 ± 0.98	0.02
Female	12	9.1 ± 0.85	

For both age groups, male had a slightly lower eye height. However the differences were not statistically significant ($p>0.05$). Interestingly the findings showed that the eye fissure height was lower in elder age groups and this occurred significantly for both genders ($p<0.05$) (Table 4.3.4).

4.3.5. Intercanthal index (en-en x 100/ex-ex)

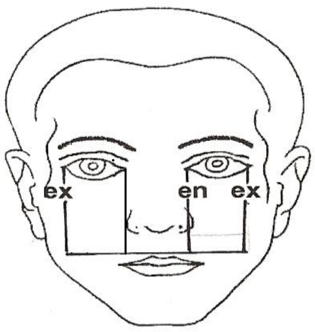

Table 4.3.5 Intercanthal index (en-en x 100/ex-ex)

Gender / Group	Age	Mean ± SD	p-value
Male	7	34.96 ± 1.82	0.77
Female	7	35.34 ± 2.02	
Male	12	34.14 ± 1.83	1.00
Female	12	34.13 ± 2.18	
Male	7	34.96 ± 1.82	0.16
Male	12	34.14 ± 1.83	
Female	7	35.34 ± 2.02	0.01
Female	12	34.13 ± 2.18	

The 7-year-old female showed a slightly greater mean value for the intercanthal index. For the 12-year-old group the difference was almost negligible. However statistically both differences were not significant ($p>0.05$). The intercanthal index was smaller in elder age group of both genders. However statistically the differences was only significant for the female ($p<0.05$).

4.3.6. Eye fissure index (ps-pi x 100/ex-en)

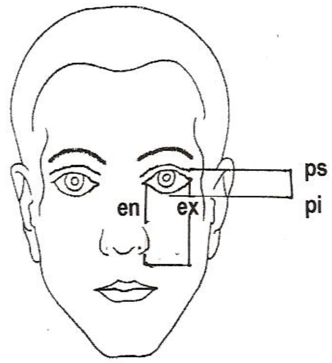

Table 4.3.6 Eye fissure index (ps-pi x 100/ex-en)

Gender / Group	Age	Mean ± SD	p-value
Male	7	28.89 ± 2.59	0.34
Female	7	29.78 ± 3.21	
Male	12	24.99 ± 2.01	0.31
Female	12	25.91 ± 2.73	
Male	7	28.89 ± 2.59	0.00
Male	12	24.99 ± 2.01	
Female	7	29.78 ± 3.21	0.00
Female	12	25.91 ± 2.73	

From the Table 4.3.6 it can be noted that female had a greater eye fissure index for both aged groups. However the difference were statistically not significant ($p>0.05$). It was found that the eye fissure index was smaller in the elder age group of both genders. The differences were statistically significant ($p<0.05$).

4.4 Nose

Three anthropometric measurements were carried out in the nose region, namely nose width (al-al), nose height (n-sn) and nasal tip protrusion (sn-prn). From these measurements four proportion indices were obtained; the nasal index, the nasal tip protrusion length -nose width index, the nose-face height index and the nose-face width index.

4.4.1 Nose width (al-al)

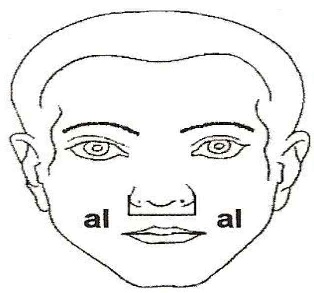

Table 4.4.1 Nose width (al-al)

Gender / Group	Age	Mean ± SD	p-value
Male	7	32.48 ± 1.52	0.21
Female	7	31.66 ± 1.71	
Male	12	36.13 ± 2.61	0.11
Female	12	35.18 ± 2.38	
Male	7	32.48 ± 1.52	0.00
Male	12	36.13 ± 2.61	
Female	7	31.66 ± 1.71	0.00
Female	12	35.18 ± 2.38	

The mean values for nose width for both age groups were larger in the male as shown in Table 4.4.1. However both differences were not statistically significant ($p>0.05$). The nose width was larger in elder age group of both genders. The se differences were statistically significant ($p<0.05$).

4.4.2 Nose height (n-sn)

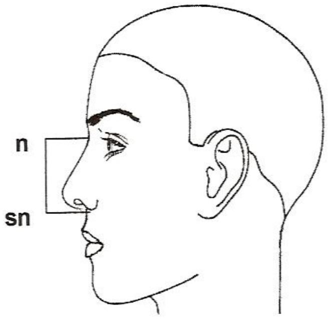

Table 4.4.2 Nose height (n-sn)

Gender / Group	Age	Mean ± SD	p-value
Male	7	45.02 ± 3.20	0.88
Female	7	44.52 ± 2.52	
Male	12	50.96 ± 4.80	0.96
Female	12	51.29 ± 2.73	
Male	7	45.02 ± 3.20	0.00
Male	12	50.96 ± 4.80	
Female	7	44.52 ± 2.52	0.00
Female	12	51.29 ± 2.73	

For this parameter, the nose height (Table 4.4.2) was higher in the 7-year-old male. However the reverse was true for the 12-year-old. Both differences were not statistically significant ($p>0.05$). The nose height was higher in elder age group and this was statistically significantly for both genders ($p<0.05$).

4.4.3 Nasal tip protrusion (sn-prn)

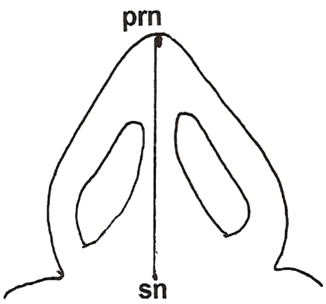

Table 4.4.3 Nasal tip protrusion (sn-prn)

Gender / Group	Age	Mean ± SD	p-value
Male	7	11.90 ± 1.30	1.06
Female	7	11.88 ± 1.40	
Male	12	14.24 ± 2.30	0.89
Female	12	14.47 ± 1.25	
Male	7	11.90 ± 1.30	0.00
Male	12	14.24 ± 2.30	
Female	7	11.88 ± 1.40	0.00
Female	12	14.47 ± 1.25	

Table 4.4.3 shows that in the 7-year-old the male had a larger nasal tip protrusion. On the other hand the reverse was true for the 12-year-old. However both differences were not statistically significant ($p>0.05$). The nasal tip protrusion was higher in elder age group of both genders. This differences were statistically significant ($p<0.05$).

4.4.4 Nasal index (al-al x 100/n-sn)

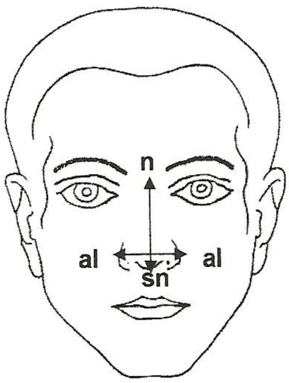

Table 4.4.4 Nasal index (al-al x 100/n-sn)

Gender / Group	Age	Mean ± SD	p-value
Male	7	72.45 ± 5.67	0.79
Female	7	71.28 ± 4.80	
Male	12	71.51 ± 8.39	0.15
Female	12	68.82 ± 6.32	
Male	7	72.45 ± 5.67	0.88
Male	12	71.51 ± 8.39	
Female	7	71.28 ± 4.80	0.22
Female	12	68.82 ± 6.32	

Table 4.4.4 shows that male generally has a larger nasal index than female of both aged groups. However the differences were not statistically significant (p>0.05). The nasal index showed a smaller index in the elder age group. This occurred for both genders. However these findings were not statistically significance (p>0.05).

4.4.5 Nasal tip protrusion-nose width index (sn-prn x 100/al-al)

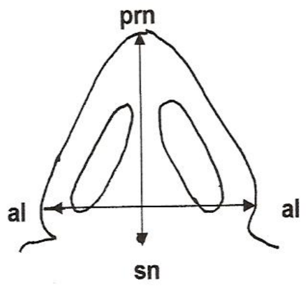

Table 4.4.5 Nasal tip protrusion length -nose width index (sn-prn x 100/al-al)

Gender / Group	**Age**	**Mean ± SD**	**p-value**
Male	7	36.69 ± 3.93	0.80
Female	7	37.54 ± 4.09	
Male	12	39.52 ± 6.57	0.26
Female	12	41.26 ± 3.95	
Male	7	36.69 ± 3.93	0.01
Male	12	39.52 ± 6.57	
Female	7	37.54 ± 4.09	0.00
Female	12	41.26 ± 3.95	

Generally the female had a greater nasal tip protrusion-nose width index than male for both 7 and 12-year-old age groups (Table 4.4.5). However these differences were not statistically significant ($p>0.05$). The results also showed that the elder age group had a significantly higher index in nasal tip protrusion-nose width and this happened for both genders ($p<0.05$).

4.4.6 Nose-face height index (n-sn x 100/n-gn)

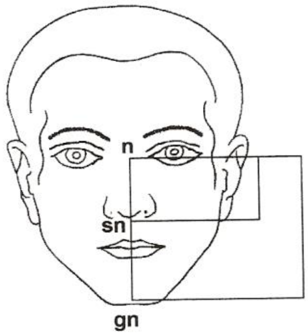

Table 4.4.6 Nose-face height index (n-sn x 100/n-gn)

Gender / Group	Age	Mean ± SD	p-value
Male	7	44.83 ± 2.75	0.39
Female	7	45.65 ± 2.46	
Male	12	45.94 ± 2.53	0.07
Female	12	47.19 ± 2.61	
Male	7	44.83 ± 2.75	0.14
Male	12	45.94 ± 2.53	
Female	7	45.65 ± 2.46	0.01
Female	12	47.19 ± 2.61	

For the nasal-face height index (Table 4.4.5), females of both age groups had a greater index as compared to the male but the differences were not statistically significant ($p>0.05$). The index showed a higher mean in elder age groups but the differences was only statistically significant for the female ($p<0.05$).

4.4.7 Nose-face width index (al-al x 100/zy-zy)

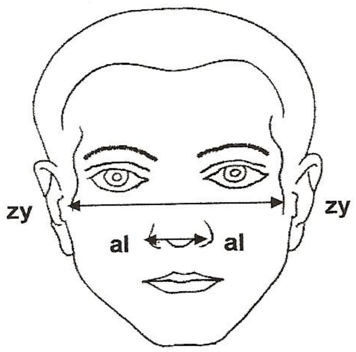

Table 4.4.7 Nose-face width index (al-al x 100/zy-zy)

Gender / Group	Age	Mean ± SD	p-value
Male	7	27.87 ± 2.75	0.97
Female	7	28.03 ± 2.46	
Male	12	28.40 ± 2.53	0.42
Female	12	28.24 ± 2.61	
Male	7	27.87 ± 2.75	0.46
Male	12	28.40 ± 2.53	
Female	7	28.03 ± 2.46	0.95
Female	12	28.24 ± 2.61	

Table 4.4.7 showed the means for nose-face width index. For the 7-year-old, the female had a greater index than the male. For 12-year-old group the male has a greater index than female. However these differences were not statistically significant ($p>0.05$). The elder age groups of both genders also showed a slightly higher index than younger group but the differences were also not statistically significant ($p>0.05$)

4.5 Lips and mouth

In this region, three linear anthropometric measurements were obtained; upper lip height (sn-sto), mouth width (ch-ch) and lower lip height (sto-sl). Three proportion indices are derived form these measurements; upper lip height-mouth index, lower – upper lip height index and mouth-face width index.

4.5.1 Upper lip height (sn-sto)

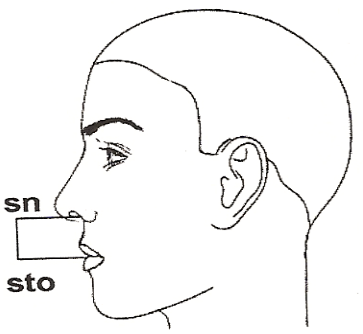

Table 4.5.1 Upper lip height (sn-sto)

Gender / Group	Age	Mean ± SD	p-value
Male	7	20.06 ± 1.10	0.00
Female	7	18.30 ± 1.71	
Male	12	21.39 ±1.60	0.00
Female	12	19.90 ± 1.63	
Male	7	20.06 ± 1.10	0.00
Male	12	21.39 ±1.60	
Female	7	18.30 ± 1.71	0.00
Female	12	19.90 ± 1.63	

Male had a greater upper lip height as compared to female for both age groups (Table 4.5.1). The differences were statistically significant ($p<0.05$). The upper lip height showed a slight higher mean in elder age of both genders group and this was statistically significant ($p<0.05$).

4.5.2 Mouth width (ch-ch)

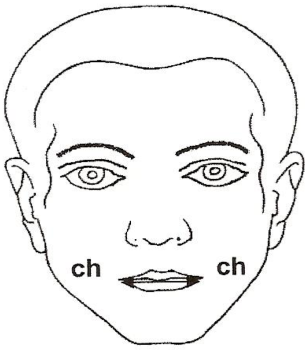

Table 4.5.2 Mouth width (ch-ch)

Gender / Group	Age	Mean ± SD	p-value
Male	7	39.75 ± 2.23	0.12
Female	7	38.57 ± 2.67	
Male	12	45.17 ± 2.72	0.17
Female	12	44.07 ± 2.94	
Male	7	39.75 ± 2.23	0.00
Male	12	45.17 ± 2.72	
Female	7	38.57 ± 2.67	0.00
Female	12	44.07 ± 2.94	

The mean for mouth width were generally higher in male for both age groups (Table 4.5.2). However statistically the differences were not significant ($p>0.05$). The mouth width showed a higher mean in elder age group and statistically the differences were significant ($p<0.05$) for both genders.

4.5.3 Lower lip height (sto-sl)

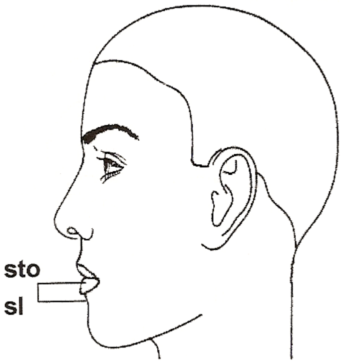

Table 4.5.3 Lower lip height (sto-sl)

Gender / Group	Age	Mean ± SD	p-value
Male	7	14.34 ± 1.35	0.59
Female	7	13.98 ± 1.38	
Male	12	16.45 ± 1.61	0.05
Female	12	15.73 ± 1.28	
Male	7	14.34 ± 1.35	0.00
Male	12	16.45 ± 1.61	
Female	7	13.98 ± 1.38	0.00
Female	12	15.73 ± 1.28	

The result for lower lip height result is shown in Table 4.5.3. The lip height is higher in male for both age groups. However the differences were not statistically significant ($p>0.05$). The elder group recorded a higher lower lip height and that were statistically significant for both gender ($p<0.05$).

4.5.4 Upper lip height-mouth width index (sn-sto x 100/ch-ch)

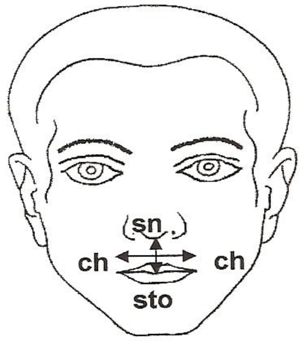

Table 4.5.4 Upper lip height-mouth width index (sn-sto x 100/ch-ch)

Gender / Group	Age	Mean ± SD	p-value
Male	7	50.60 ± 3.37	0.00
Female	7	47.61 ± 4.91	
Male	12	47.51 ± 4.38	0.04
Female	12	45.32 ± 4.47	
Male	7	50.60 ± 3.37	0.00
Male	12	47.51 ± 4.38	
Female	7	47.61 ± 4.91	0.04
Female	12	45.32 ± 4.47	

Generally for age groups the male had a greater upper lip height-mouth width index (Table 4.5.4). The differences in these mean value were statistically significant ($p<0.05$). The upper lip height-mouth width index showed smaller values in the elder age group and these differences were statistically significant for both gender ($p<0.05$).

4.5.5 Lower-upper lip height index (sto-sl x 100/sn-sto)

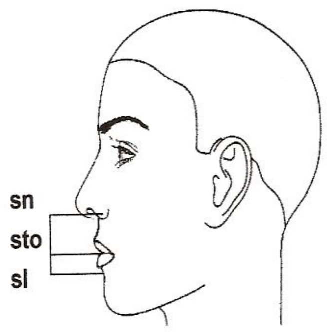

Table 4.5.5 Lower-upper lip height index (sto-sl x 100/sn-sto)

Gender / Group	Age	Mean ± SD	p-value
Male	7	71.59 ± 6.97	0.00
Female	7	76.77 ± 7.95	
Male	12	77.37 ± 9.69	0.60
Female	12	79.34 ± 6.85	
Male	7	71.59 ± 6.97	0.00
Male	12	77.37 ± 9.69	
Female	7	76.77 ± 7.95	0.37
Female	12	79.34 ± 6.85	

Table 4.5.5 showed a mean value for lower-upper lip height index. Basically for both age-groups the female had a greater index as compared to the males in both age groups. However the differences was only significant in 7 year old ($p<0.05$). Both male and female showed a higher index for the elder age group. Interestingly the differences was only statistically significant for the male ($p<0.05$).

4.5.6. Mouth-face width index (ch-ch x 100/zy-zy)

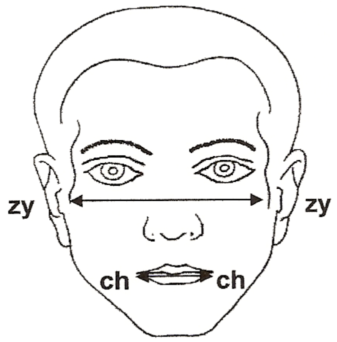

Table 4.5.6 Mouth-face width index (ch-ch x 100/zy-zy)

Gender / Group	Age	Mean ± SD	p-value
Male	7	34.12 ± 2.38	1.00
Female	7	34.11 ± 2.16	
Male	12	35.54 ± 3.02	0.57
Female	12	34.90 ± 2.28	
Male	7	34.12 ± 2.38	0.02
Male	12	35.54 ± 3.02	
Female	7	34.11 ± 2.16	0.38
Female	12	34.90 ± 2.28	

Table 4.5.6 shows the means for mouth-face width index. There were almost no difference in this index for both genders ($p>0.05$). The index shows a slight higher index in elder age group and the difference was statistically significant ($p<0.05$) in male only.

Chapter 5 : Discussion

'***The pursuit of truth and beauty is a sphere of activity in which are permitted to remain children all our lives' … Albert Einstein.*** However growth and development never stops, beginning in the foetus and continuing throughout adult life.

Craniofacial growth is a complex interplay of structure and function and involves an interrelationship between all component parts. No part is independent or self contained. Changes in facial shape and form always take place as the face grows into adulthood. In general, human faces show much similarity and the presence of individual variation in facial characteristic is well recognized and gives a great clinical significant. This variability becomes clinically manifest in the individual size and shape of the adult craniofacial complex (Enlow, 1980).

Enlow (1982) suggested that the face of prepubertal boys and girls are essentially comparable. In females, facial development slows after age of 13 or the skeletal growth changes in the face slows and ceases shortly after puberty. In males, facial development begins to be fully manifested at puberty and continues throughout the adolescent period and into early adulthood. It means that similarities that exist between sexes during childhood are altered markedly during teenage.

The growth from infant into an adult is characterised by increases in height and weight and also by changes in posture and proportions and by maturation of the skeleton and sex organs (Ranly, 1988).

Spalding stated that during post natal growth, the cranial vault growth completes before the cranial base and is then followed by nasomaxilla and finished with the mandible. It means that the mandible has the most delayed growth but the most postnatal growth of all the facial bones (Spalding, 2004).

As the purpose of this cross sectional study was to provide the norm or standard data for the pre-pubertal Malay boys and girls, the differences in growth pattern between these 2 age-groups and gender differences play an important role in influencing the results obtained. In the next discussion, the growth changes that take place between these 2 age-groups and also the differences between genders will form the basis for discussion to explain the results obtained.

5.1 Craniofacial Anthropometric measurement analysis in Malaysian pre pubertal Malay children age 7 and 12-year-old

Quantitative anthropometric measurements have been proven to be very useful in evaluation of post natal development in the craniofacial region (Farkas & Posnick, 1992). We know that the human growth continues throughout life and as what is expected, the analyzed data in this cross sectional study showed that eighteen out of twenty two linear anthropometric measurements showed a significantly higher measurement in the elder age group for both genders ($p<0.05$). However the head length (g-op) and head circumference (on-op) showed a significantly higher mean values in the elder female children whereas the head height (v-n) was higher in the elder male children only.

Interestingly the eye fissure height (ps-pi) showed a significantly smaller mean in the 12-year-old as compared to the 7-year-old. This was significant statistically significant for both genders ($p<0.05$).

From this study, it was found that most proportion indices remained unchanged when comparing the samples of 2 different age groups. Of the seventeen proportion indices, 3 calculations showed a significantly smaller proportion index in the 12-year-old as compared to 7-year-old group. These indices were middle-lower third face depth index (t-sn x 100/t-gn), eye fissure index (ps-pi x 100/ex-en) and upper lip height-mouth width index (go-go x 100/ch-ch). These finding were statistically significant for both genders. The only proportion indices that was significantly higher in the elder children were the nasal tip protrusion-nose width index (sn-prn x 100/al-al). This was statistically significant for both genders ($p<0.05$).

The lower-upper lip height index (sto-sl x 100/sn-sto) and the mouth-face width index (ch-ch x 100/zy-zy) showed statistically significantly higher indices in the elder male children only. Higher nose-face height index (n-sn x 100/n-gn) was observed in the female children only ($p<0.05$). Lastly the intercanthal index (en-en x 100/ex-ex) showed a significantly smaller proportion index in the elder age group but this was only observed in the female ($p<0.05$).

Generally when comparison was made between genders in the same age group, it was noted that the males had a larger measurement than females for both aged group. For the 7-year-old, the linear anthropometric measurements showed a significant difference ($p<0.05$) between gender in 6 parameters. They were head width (eu-eu), head length (g-op), maxillary depth (t-sn), mandibular depth (t-gn), binocular width (ex-ex) and upper lip height (sn-sto). However most proportion indices remained the same. Significant differences ($p<0.05$) were observed in the upper lip height-mouth width index (sn-sto x 100/ch-ch) and that was higher in males and in the lower-upper lip height index (sto-sl x 100/sn-sto) that was higher in the female.

For the 12-year-old children, generally the male had larger measurements than the female. Linear anthropometric data analysis showed statistically significant difference ($p<0.05$) between gender in 5 parameters namely, the craniofacial height (v-gn), mandibular width (go-go), maxillary depth (t-sn), mandibular depth (t-gn) and upper lip height (sn-sto).

For the proportion indices, significant differences between gender were noted only in the mandible-face width index (go-go x 100/zy-zy) and the upper lip height-mouth width index (sn-sto x 100/ch-ch) in which males recorded higher indices. From the findings, it suggests that other proportion indices remained rather constant.

5.1.1 Head

The head region grows and functions in a three-dimensional manner. According to Spalding, the post natal growth of the cranial vault is markedly highest in vertical dimension, the anteroposterior is somewhat less and the transverse is the least (Spalding, 2004).

In this study, the linear measurement of the head width (eu-eu) reflects the transverse growth; the head length (g-op) reflects anteroposterior growth while the head height (v-n) reflects the vertical dimensions of the head. It was found that the male showed the highest growth in head height followed with head length and head width and this agree well with Spalding findings. Interestingly female between 7- year-old and 12-year-old groups showed a highest growth in head length followed with head width and head height. Why female has a different growth pattern at this region remain a question until further studies are undertaken.

A few studies found that the growth of the cranium is related to the developing brain. Foster(1999) found that the cranium has grows rapidly before birth and continues to grow rapidly up to 1 year of age, accommodating the brain. By seven year old, the cranium has reached about 90% of its final volume and then the growth is increases slowly to maturity.

Farkas and Posnick (1992) also found that the cranial vault grows rapidly in the first year of life and with the velocity of the growth plateau in the following 5 years The skull, as cited by Behrents (1985) also grows rapidly from birth to the seventh year and then the growth is slow from the seventh year until the child approaches puberty. Spalding (2004) suggested that the pressures exerted by the developing brain determine the size and shape of the cranium. As the brain expands, the pressure creates tension across the sutures and compression against the cranial bones resulting in intramembranous bone growth by suture and surface apposition.

From the analyzed data of the healthy Malay pre pubertal children, it was noted that the head width (eu-eu), head length (g-op), head height (v-n) and head circumference (on-op) were higher in the elder children (Table B-1). These finding explained the continuous growth of the head region during this pre pubertal period. The continuous growth at this region was most probably due to the continuous growth of the brain. The finding in head width was statistically significant in elder group of both genders (Table A-1). The head length and head circumference were significantly higher in the elder female school children (Table A-2) whereas the head height was only significantly higher in elder group of male only (Table A-3). These finding showed that depending on the areas of the head, the male and female may showed a different rate of growth whereby at some area female had growths that exceeded the male’s and vice versa; or both of them achieved a same rate of growth between 7 and 12 year old.

Gender differences showed that the male generally showed a larger measurement than female in the same comparable aged group. This was observed in head width (eu-eu), head length (g-op), head height (v-n) and head circumference (on-op).

It was shown that even though the male had a larger mean value, but it was female who showed a bigger difference in head width (eu-eu) and head length (g-op) when comparing the elder children to the younger groups (Table B-1).

For the head length, again the male had a larger measurement but still the female was found to have bigger difference in head length compared to male when comparing the elder children to the younger ones (Table B-1). However the gender difference was only significant in 7-year-old age group with almost no different in age group of 12-year-old. Apart from the enlargement of the brain due to growth, the increase in head length might be contributed by the continuous enlargement of the frontal air sinuses. Bjork (1955) analysed 243 radiographs of subjects between aged 12 and 20 year old. Tanner cited him to that the forward growth of the forehead at adolescence could indeed by the development of the brow ridges and the frontal sinuses (Tanner, 1962). When relating Bjork's findings to ours it suggest that at 12-year-old the development of the frontal air sinuses and the brow ridges that causes the forward growth of forehead or reflects the head length (anteroposterior) had already occurred at a same time in female and male, hence at the age of 12-year-old there were no significant difference between this genders (Table 4.1.2).

Interestingly our finding suggested that the head height (v-n) of the male had undergone more rapid growth than female (Table B-1). When comparison was made with the finding of Al-Junid on Malay adult aged 18-25years old, it was noted that the male have a continuous rapid growth in the head height as compared to female; (male: 104.4mm and female: 94.8mm) (Al Junid, 2005). However the female showed no statistically significant head height between 7 and 12 years old. The head height in the 12-year-old female of our study was only slightly lower than noted in 18-25 year old. This indicated that rapid growth in head height for female had already occurred before seven and growth occurs rather slows from seven to adulthood.

Head circumference (on-op) is the most frequently reported measurement in the medical literature. It has been used as an indicator of cranial volume and often used in the young infant as a rough measure of brain development (Thilander, 1995). It was noted that head circumference (on-op) of the male was generally larger than female in both aged group. The female showed a bigger difference in head circumference between the 2-age-groups studied. However the difference was not statistically significant ($p>0.05$).

Our study found that there was almost no different in cephalic index between the genders and between age-groups. This means that proportion wise, the proportional quality of the head was constant irrespective of gender and age. The cephalic index gives an idea whether the head is bracycephalic (short wide head) or dolichocephalic (long-narrow head). When the cephalic index measures up to 74.9, the head is considered dolicocephalic and if the index ranges between 75.0 and 79.9 it is called mesocephalic and when the range is between 80.0 to 84.9 then the head is considered brachycephalic (Farkas, 1994). The Malay school-children of both genders and age group in our study was found to have brachycephalic head (Table B-1)

Al-Junid (2005) found that the Malay adult also have a brachycephalic or relatively short wide head (Al-Junid, 2005). Both ours and Al-Junid finding suggested that the brachycephalic type of head in the Malay population had already taken shape during pre pubertal period.

The discussion for the craniofacial height (v-gn) and the head-craniofacial height index will be discussed in the face region because they are inevitably interrelated to each others.

5.1.2 Face

The face is the most important part of the human body. It is often said that **'*beauty is in the eye of the beholder*'** (Margaret Hungerfold), however for a clinician or surgeon, facial beauty arises from symmetry, balanced and harmonious proportions. The normal data that obtained form this study will help us in identifying the symmetry, balanced and harmonious proportion in these 2 groups of children.

The facial framework is identified horizontally or transversely by the width of the face and mandible, vertically by the facial heights and laterally by the depths of the maxilla and mandibular region (Farkas, 1992).

In this study the transverse framework are indicated by the measurement of face width (zy-zy) and mandibular width (go-go). The measurement of face height (n-gn), upper face height (n-sto), and mandibular height (sto-gn) gives an idea of the facial framework vertically. The depth of maxilla (t-sn) and mandible (t-gn) shows a lateral framework of the face.

As expected the data obtained in this study showed that the transverse, vertical and depth of the facial framework of 12-year-old group of both genders were significantly larger than 7-year-old group of both genders (Table B-1). This suggested that there was a possible continuous incremental growth that has happened during this period.

Thilander stated the facial skeleton increases in all dimensions during post natal growth period. Facial growth has been reported to end first in width, then in length and finally in height (Thilander, 1995). On contrary, Hellman (1935) noted that the depth of the face increased the most, followed by height and width.

In this study it was found that the biggest difference in measurement occurred in the mandibular depth and maxillary depth and was followed by differences in vertical height and width measurement. This finding agrees well with Thilander's statement that of all facial bones the mandible shows not only the largest amount of post natal growth but also the largest individual variation in morphology (Thilander,1995). The finding is also consistent with Hellman's observation where he found that the depth of the face increased the most followed by height and width.

Mandibular depth (t-gn), which is also a measurement of the lower third face depth showed the largest measurement among the facial framework. The theory behind the growth of the mandibular depth is that the mandible grows forward and downward due to displacement of the whole bone. This creates the conditions for a simultaneous growth in the size of the bone in the opposite direction, including a lengthening of the basal arch at the condyle. Together with the backward and upward condylar growth, the ramus is relocated posteriorly. Deposition thus occurs on the posterior margin of the ramus with simultaneous bone resorption along its anterior contours. At the same time the marked lengthening of the alveolar bone may also occasionally occur (Thilander, 1995).

The maxillary depth (t-sn) which is the measurement of the middle third face depth increased consistently with mandibular depth. The 12-year-old group has larger maxillary depth (t-sn) than 7-year old group and this was noted in both genders (Table B-1). The findings were statistically significant ($p<0.05$). The result suggested that there was a continuous growth at this region during this period of time. The maxillary growth occurs in an antero-inferior or forward-downward direction. The bone deposition occurs on the tuberosity and at adjacent sutures (temporozygomatic and nasomaxillary). The alveolar base elongates during this period and as a result creating space for posterior and late erupting teeth (Thilander, 1995). The resulting forward-downward translation also displaces adjacent bones and permits adequate space for the developing naso pharynx (Spalding, 2004).

This reflects the reason for the increment in the maxillary depth because the subjects in this study were still at the stage of mixed dentition (7 year old) and at the age of preparing to have fully permanent teeth (12 year old). The increment also indicated the development of the naso pharynx over this period of time.

The vertical dimension of the face is represented by the facial height. The upper anterior face height is primarily correlated with growth changes in the cranial base while the dimensions of the lower face height is dependent on muscle function, environmental factors as well as airway functional space and head posture (Thilander, 1995).

The measurement from nasion to stomion (n-sto) represents the upper face height. The vertical growth of the middle face occurs as a result of displacement of the maxilla antero-inferiorly to create space for an expansion of the nasal cavity and orbits. At the same time the vertical growth of the alveolar process is rapid during tooth eruption (Thilander, 1995).

Alternatively Spalding (2004) explained in detail that the increase in vertical facial height or more precisely in middle face is consistent with the growth of the maxilla. The downward and forward displacement of the maxilla is due to the continuous growth of the brain and cranial base. Further vertical growth of maxilla continues with contributions from frontomaxillary, frontonasal, frontozygomatic, eithmoidalmaxillary sutures and possibly the nasal septum. The vertical descent of maxilla is also further increased by remodelling with resorption on the nasal surfaces and simultaneous apposition on the oral surfaces. The maxillary growth also depends on various functional matrixes such as the influence of respiration to enlarging the nasal cavity, the influence of oral function in determining the oral structures and the role of surrounding facial soft tissues. The vertical growth of the maxillary alveolar process is rapid during dental eruption and this contributed to the vertical height of the face. (Spalding, 2004). This fact was reflected in the upper face height of our subjects since their age is consistent with the stage of eruption of permananet dentition.

The mandible height (sto-gn) or also considered as lower third face height measures the lower vertical face anteriorly. The result showed a statistically significant difference with a 12-year-old of both genders showing higher measurement than the 7-year-old. This again suggested of a continuous growth of the lower vertical dimension of the face during pre pubertal period as what happened to the upper and middle face height. The growth of the condylar cartilage contributes most of the total ramus height which will be reflected in the vertical face height. During childhood the inclination of condyle is more vertical as compared to at birth where the inclination of the condyles is more horizontal. This vertical inclination results in greater increase in height than length. The alveolar process also contributes a great portion of the vertical height of the lower face. Their development is entirely dependent on the presence and eruption of the primary and permanent dentition (Splading, 2004). Thus the eruption of the mandibular teeth enhances the vertical growth of the mandible and contributes to the height of the face as what we infer from our samples here.

The face height (n-gn) is represented by the measurement from nasion (point of nasal root) to gnathion (chin point). As expected the face height of the 12-year-old children was significantly larger than the 7-year-olds (Table B-1) since the facial height was a total of the upper and lower facial height. The increase in vertical face height thus was likely a result of the vertical growth of the maxillary and mandibular bone.

The 12-year-old had higher craniofacial height (v-gn) than 7-year-old in and this finding was significant. The craniofacial height represents the total height of the vertical dimension of the head and face. It is not a surprise to see the significant increase in this region because all the other measurements that represent the vertical head-face height (head height, upper face height and lower face height) were consistently larger in the elder group. It indicates that consistent growth of the head, upper face and lower face had occurred within this period of time.

The face width (zy-zy) represents the upper face width. The face width in the 12-year-old observed to be significantly higher in both genders. It suggested that there was a continuous growth in this transverse dimension of the face. The face width or the transverse growth of the face is contributed by the zygomaticomaxillary sutures and it also consistent with the growth of maxillary bone. The enlargement of the maxillary sinuses also contributes to the transverse growth in facial region (Spalding, 2004).

Generally we found that the facial width of the male was always larger in both age groups. Thus from this finding it can be suggested that large facial width is a feature of male that would continue into adulthood.

The mandible width (go-go) is a bigonion diameter that represented lower face width. It was noted that both genders of 12-year-old had higher mandible width ($p<0.05$). The mandible experiences the most delayed growth and the most postnatal growth of all the facial bones. Initially at birth, the mandible is in retrognathic position relative to the maxilla however rapid growth after postnatal corrects this discrepancy. It has been found the mandible growth continues longer to the end of adolescent growth. The peak in rate of mandibular growth at puberty usually results in the final correction of the mandibular position relative to the maxilla (Spalding, 2004).

The width of the mandible in this study was less than the facial width thus it suggests that the sample subjects in this study had not reached the puberty where the peak growth of the mandible should occur. It also noted that the width increases to be less than vertical changes (Snodell et al., 1993; Bishara et al., 1995). Similar to this, we found that the mean facial height mean was higher than the facial width.

As the male has a larger mandible width as compared to the female in both age groups, it may form a basis on why male has a more prominent jaw than female.

When further analysis was done from the gender point of view, it was noted that male showed a larger mean than female in the comparable age group for all dimensions of facial region (Table B-1). Taking the larger mean into consideration, the data suggested that male had more prominent angle of the jaw, broader face and more vertical height to start with during pre pubertal period. If this gender related differences continuous into adult life, then it gives a reason as why male has a manly look and female has a feminine look.

However it was found that at some area of the face, markedly in vertical facial height (n-gn); upper facial height (n-sto) and mandible height (sto-gn) and facial width (zy-zy) showed there were no significant differences between genders in the same comparable age-group. This suggests that the growth at this region are rather constant regardless their age and gender. The gender-related differences is markedly noticeable in the mandible width, maxillary and mandibular depth. This explains the difference in features between male and female; with male having more prominent and broader jaw. These features had already started to form during their pre pubertal age.

Proportion wise, the middle-lower third face depth index (t-sn x 100/t-gn) of the elder group of both genders was smaller than younger group. This finding was statistically significant. The smaller mean in this index was related to the higher mean value in mandible than maxilla.

Mandible-face width index (go-go x 100/zy-zy) shows proportion index of a mandibular width in relation to the facial width. There was no significant different between gender at age 7-year-old and a significant difference of about 2.5mm in age 12-year old, with the male's index was larger than female. The larger mandibular width and face width in male may have contributed to this. It suggests that by 12-year-old, the male had a manly look with a broader face and more prominent jaw while the female may retain some of their pre pubertal proportion.

Five parameters namely the facial index (n-gn x 100/zy-zy), the mandibular index (sto-gn x 100/go-go), the upper face-face height index (n-sto x 100/n-gn), the mandible-upper face height index (sto-gn x 100/n-gn) and head craniofacial height index(v-nx100/v-gn) showed no significant difference when comparing the two age groups and genders. As a result, these finding suggested that generally these proportion remain unchanged or rather constant irrespective of age and gender difference during period.

5.1.3 Orbits

The eyes play a major role in human communication. They have been often described as the *'window of the soul'* and perhaps the most capable part of the face to express human emotions.

Orbital measurements in children and orbital growth development have been reported by several authors (Juberg & Touchstone, 1975; Farkas, 1992; MacLachlan & Howland, 2002). It is a generally accepted fact that the position of the eyes is useful for the diagnosis of a large number of syndromes. Ocular adnexal changes and somatometric traits of the face such as epicanthus, telecanthus, flat nasal bridge, widely spaced eyebrows and blepharophimosis may create an illusory error in the identification of certain craniofacial syndromes. Therefore the normal value of the inner-canthal distance, outer canthal distance, interpupillary distance may help in the evaluation of telecanthus, ocular hypotelorism and hypertelorism (Evereklioglu, 2001). The study in the orbital region in Chinese Taiwan children revealed that the inner canthal distance (en-en) is wider than the palpebral fissure length (ex-en) while this result is the reverse in Caucasian children. From the finding it was suggested that it is not correct to diagnose hypertelorism in Chinese children in Taiwan base on the western data. It was suggested that the measurements should be adjusted with a normal standards specific for race (Wu et al, 2000).

From this study we have established our own data for the Malaysian children at age of-7 and 12-year-old. Hopefully these normals mean value can help us to differentiate hyper telorism from the normal eye position. It was found that the intercanthal width (en-en), binocular width (ex-ex) and eye fissure length (ex-en) was significantly higher in elder age group as compared to younger group (Table B-1). This gives evidence to a continuous growth at this region during this period of time. Interestingly it was noted that the eye fissure height (ps-pi) was significantly smaller in elder age group ($p<0.05$).

The overall intercanthal widths (en-en) in Chinese subjects in the Republic of Singapore are 34.4mm ± 2.7 in male and 34.0mm ± 2.3 in female aged 6-year-old. The intercanthal width was 37.5mm ± 2.8 in male and 35.6mm ± 2.9 in female for the 12 year old (Farkas, 1994). Our overall result was slightly lower than theirs (Table B-1). In comparison with the data of the 7- and 12-year-old Caucasian North America children (Farkas, 1992) our mean value was slightly higher than their results (7 year old male; 30.2 ± 2.5; 7 year old female; 30.1 ± 1.9 and 12 year old male; 32.0 ± 2.1; 12 year old female; 31.6 ± 2.6). This finding suggested that the intercanthal width (en-en) of the Malay population at this age group was in between the Chinese children and the Caucasian children. Therefore we should establish, confirm and use our own data in making a diagnosis for the orbital region. This data could also be used as a guide during reconstruction or as an evaluation for the success of reconstruction post operatively.

For the eye fissure length (ex-en), the measurement for the 12-year-old-group was statistically significantly larger than 7-year-old group (Table B-1). Our study showed that the eye fissure length was wider than intercanthal width. This is in contrast with the finding among the Chinese children in Taiwan whereby the intercanthal width was wider than the eye fissure length and caused the look of hypertelorism in their age group. Our finding was consistent with that of the Caucasian children where they have a wider in eye fissure length than intercantal width (Farkas, 1994).

The biocular width (ex-ex) is the measurement of the distant between the right and left outer commisure of the palpebral fissure. As expected it was shown that the 12-year-old manifested a higher measurement than 7-year-old. This finding was statistically significant ($p<0.05$). The increment in the biocular width gives rise to a question as whether the increment was due to the increase in intercanthal width or the eye fissure length. Farkas's (1992) observation in the 1 to 18 years old group showed that the intercanthal width gained 57.7% from its total growth increment from age 1 to 5 years old in contrast to the 16% of the total growth increment achieved in biocular width. The increase in intercanthal width was consistent with the growth in the interorbital spaces in infancy and early childhood. It suggested that the continuous, gradual annual increment occurs in binocular width (84%) is greater than intercanthal width (43.7%) after 5 year old (Farkas 1992). Based on Farkas's finding, it can be suggested that the increase in binocular width (ex-ex) at the age of seven and twelve were contributed much by the growth in palpebral fissure. It is a known fact that the development of the eye makes a major contribution to the induction of the orbit. Alternatively factors influencing the growth of the globe may influence the development of the orbit. Biometric study shows that the palpebral fissure developed more rapidly than the eye (Daniele, 1998). It shows that these inter related factors influences the growth in the orbital region.

Interestingly eye fissure height (ps-pi) showed that the elder groups were 0.59mm smaller in females and 0.75mm in males. These findings were significant. It is a wonder why the eye fissure height decrease in elder age group. Generally the eyes appear large in young children but appear smaller in proportion in adults. A young children appears to have a larger eye than adults because the orbit and its soft tissue matured earlier than the nasal and jaws (Enlow & Hans, 1996). Behrents (1985) suggested that with age the thickness of eyelid is reduced due to deposit of lipid. The eyes also appear sunken with drooping bags and deep supraorbital creases. It is suggested that since the eyes matured earlier than the nose and jaws, the orbit showed a minimal increment in relation to the face that increases more rapidly. This is therefore reflected in the size of the orbit that looked smaller. Since the soft tissue around the orbit also matured earlier, aging around the orbital soft tissue may occur at the early age as indicated in our finding.

Gender-wise showed that male generally had higher intercanthal width (en-en), binocular width (ex-ex) and eye fissure length (ex-en) but the reverse was true for eye fissure height (ps-pi).

There were no statistically significant difference in intercanthal width, eye fissure length and eye fissure height between genders of both age groups. This suggests that both genders may have the same growth rate for this region between age 7 and 12-year-old.

The difference between gender in binocular width was only significant in 7-year-old group whereas there was no significant different in twelve years old. We are unable to postulate a reason for this finding.

The intercanthal index (en-en x 100/ex-ex) is the relationship of the intercanthal width to the biocular width and it has a great influence in the visual judgement of the proportions of the orbits. The elder male and female showed a smaller intercanthal index but it was statistically significant only in the female. The smaller in intercanthal index might due to early maturation of the intercanthal width. It has been suggested earlier the increment for the intercanthal width is less than the length of the eye in older children. This suggestion was based on Farkas (1992) finding that the biocular width shows a more continuous, gradual annual increment after 5 years old than intercanthal width. Hence on a mathematical calculation of the intercanthal index, the figures become smaller in older samples. Alternatively at the beginning of the fetal life the face shows a relative hypertelorism. This is related to the lateral position of the ocular cups during the embryonic period. However this relative hypertelorism progressively diminishes during foetal life leading to a decrease in intercanthal width to biocular distance ratio. This process continues after birth until adult age (Daniele et al, 1998).

Female had a higher intercanthal index for the 7-year-old but in contrast, elder male had a larger intercanthal index. This observation might be explained by possible early maturation in intercanthal width in female.

The eye fissure index (ps-pi x 100/ex-en) of elder group was significantly smaller than younger group. The smaller mean value in this index might due to the overall decrease in eye fissure height. Female generally had a larger eye fissure index than male but this finding was not statistically significant ($p>0.05$).

5.1.4 Nose

The nose is the central focus and aesthetic unit of the face. It can be further subdivided into 5 subunit; dorsum, side, tip, ala and soft triangles. The border of the subunit allows for scar camouflage when reconstructing nasal defects (Ridley, 1992).

The nasal growth plays an important contribution to changes in the overall facial profile. The nasal growth occurs mostly over the first five years of life and includes growth of the bony and cartilaginous regions. Peaks in growth coincide with the development of the nasal airway complex (Farkas, 1992).

It was found that the nasal width (al-al), nose height(n-sn) and nasal tip protrusion were significantly higher in elder group of both genders and this suggested that continuous growth in the nasal region still happened by the time the children reach age 12-year-old.

The nasal width is proportional to the width of one eye at the nasal base (Ridley, 1992). However Epker and Fish (1986) stated that the normal alar base width is generally several millimetres wider than the intercanthal distance. Our finding is in agreement with their statement (Appendix- B). Alternatively an increase in nasal size has been reported whereby Burke and Hughes-Lawson (1989), using stereophotogrammetry and Snodell et al. (1993) using lateral cephalometry, showed a greater change in alar width. They concluded that the greater change in alar width is corresponding with the increase in intercanthal width due to orbital growth.

The nose height (n-sn) showed a statistically significantly higher in height in the elder group of both sexes (Table B-1). The increase in nose height has been explained by Behrents (1985) in a study through cephalometric technique. He stated that the most anterior point on the nose continues to move forward and downward direction in all ages. The increases in nose height are also explained by the enlargement of nasal airway (Behrents, 1985).

The measurement for the nasal tip protrusion (sn-prn) was significantly higher in the elder group as compared to younger group (2.34mm in males and 2.59mm in females). Chaconas (1969) while studying the cephalometric radiographs found that the tip of the nose grew forward with the anterior positioning of the nasal bone. He also found that the nose grew concomitantly with the maxilla and mandible.

In this study, it was noted that male generally was larger than female in all region of the nose except in nasal tip protrusion where the 12-year-old female showed a slightly larger mean than male. Behrents also shows that the males have a larger nose as compared to female.

The differences between genders for both aged group in nasal width showed a minimal differences by 0.82mm in the 7-year-old and 0.95mm in the 12-year-old. A few researchers noted that the nasal width has generally been found to be quite small in pre pubertal period with the male's nose being up to 1mm larger than the female (Farkas, 1981; Nanda et al. 1990; Snodell et al, 1993). However our findings were discovered to be not statistically significant.

The gender differences for both aged group in nasal height and nasal tip protrusion were not statistically significant, thus it suggested that these region may have undergone similar growth among male and female by the time the children reach age 12-year-old.

The nasal index (al-al x 100/n-sn) was significantly larger in the elder group; by 2.83mm in males and 3.72mm in females. The higher in nasal index might correlate with the increased in nose width and nose height. Generally male has a higher index than female. This finding was consistent with the higher mean value in nasal width and nasal height in male.

The nasal tip protrusion-nose width index (sn-prn x 100/al-al) showed that the elder group had a significantly higher index and this observed for both genders. This is consistent with the higher mean in nasal tip protrusion and nasal width in the elder group for both genders as compared to younger group.

The remaining of the indices, namely the nose-face height index (n-sn x 100/n-gn) and nose-face width index (al-al x 100/zy-zy) did not show any statistically significant difference irrespective of age and genders.

5.1.5 Lips and mouth

The lips are contained within the lower third of the face. It is a dynamic and expressive aesthetic unit of the face. Fullness and strong definition of the philtrum are associated with youth whereas the loss of lip highlights and flatness are associated with aging (Ridley, 1992).

It has been found that the rapid growth observed in transverse dimension follows vertical growth in the lips and mouth region. The vertical growth of lower lip was noted to be more than the upper lip.

Again in this region the elder group of both genders were significantly higher (Table B-1) in upper lip height (sn-sto), mouth width (ch-ch) and lower lip height (sto-sl). As a result it suggests the continuous growth in this region between 7 and 12-year-old.

Proffit stated that although the vertical height of the lips rarely is considered an important part of the growth pattern but the height of the centre part of the lips (philtrum) trails behind the vertical height of the face. This explains why the 12-year-old children of both genders were significantly higher than 7-year-old in upper (sn-sto) and lower lip height (sto-sl) because earlier finding in the face region had already found that the vertical dimension of the facial height was always higher in elder children. If the upper and lower lips follow the vertical dimension of the facial height then once the facial height increases the vertical height of the lips also follows. Proffit further stated that the lips grow earlier in girls than boys.

The mouth width (ch-ch) in elder children was statistically significantly higher than younger children If we take into consideration that the mouth also grows as the face grows, then the higher mouth width at this study group is consistent with the higher in nose width and facial width.

The upper lip height-mouth width index (sn-sto x 100/ch-ch) showed that the elder group was smaller than younger group and this was statistically significant (Table 4.5.4). The decrease in this index can be explained by the significant increase in mouth width as compared to upper lip height. The sex differences in upper lip height-mouth width index vary from 2.99mm in the 7-year-old group to 2.19mm in twelve years old group and this finding were statistically significant. It showed that the proportion or the ratio of upper lip height to mouth width is different in this range of age group for both genders. It indicates to us that further study needs to be done in this region for individual age of children between seven to twelve (i.e. 8yearold, 9 year old, 10 year old and 11 year old).

The lower-upper lip height index (sto-sl x 100/sn-sto) was statistically significantly higher in elder male only. The significant difference in male can be explained by the larger lower lip height in male than female but similar rate of increases in upper lip height in both sexes. There was a significant difference between genders (5.18mm) at age of seven only. It suggests that the difference in proportion only occurred at the age of seven at age of twelve, the proportion for this region almost the same irrespective of genders. As with the upper lip height-mouth width index, further study need to carry on children of different individual ages to ascertain when the differences between gender stops.

The mouth-face width index (ch-ch x 100/zy-zy) showed a statistically significance only in male (1.42mm, larger in the elder children). The index is higher due to the more obvious increase in mouth width as compared to face width in male.

5.2 Limitation of this study

Anthropometry is a direct measurement that uses standard landmarks and instrumentation to compare populations. By applying anthropometric, the facial sizes and proportions are gain and the surgeon uses this data to reproduce normal proportion for their patients when performing reconstructive surgery. It is well accepted now that the so-called ‘standard measurement’ should not apply to the whole race on earth (Rogers, 1974).

Although new technologies are developed and available in our daily clinical practise, it has been proven that anthropometry offers a cheaper, non-invasive, simple and provides a complete set of data for the studied age-group. Moreover the measurement taken is comparable between genders.

In this study, the methodology was adapted from the study done by Hajnis et al (1994). However there is always the possibility of human error when performing the measurement. Difficulty in identifying landmarks will result in poor repeatability and inconsistent measurements. As pointed out by Ward & Jamison (1991), the linear measurement of small magnitude leads to poor reliability because any given error would produce a greater percent deviation from the true distance. During measurement, high cooperation from the subjects is required. The use of high quality measurement tools also advisable. Contributing the difficulty in this study was the full cooperation from the subject in the age group of seven, as they get bored and tired very easily.

Even though the subjects chosen were of convenient sample and included students from the selected primary school but the time constraints due to the tight school time and the number of volunteer from the children table enables us only to select certain age group and small sample size.

The small samples size in this study contributes to the limitation in this study whereby it is not representing the norms for the whole population in Malaysia. The other factors that need to be considered when evaluating the changes in the growth pattern are as environment, diet, genetic and socioeconomic status of the subjects.

It is best if this study can be extended further by undertaking the craniofacial measurement from birth to eighteen years old. By doing so, the percentile of growth pattern for the Malay population can be obtained. A norm also can be derived for this population.

Chapter 6 : Conclusion

The present study establishes the base value for various parameters in the craniofacial complex of the healthy Malay children aged of seven and twelve year old. The analysis of the data does not simply indicate the differences in the measurements but also suggested changes due to growth in specific patterns which hopefully have clinical significant.

From this study, it was generally noted that most of the craniofacial measurements were higher in the elder age-group and these occurred for both genders. This suggested that the growth continuous for both genders during this period of time. Generally males have a larger mean value in most of the craniofacial region in both aged group compared to female. However interestingly, females appeared to have a greater degree of differences between 12-year-old and 7-year-old in this craniofacial measurement than males do in comparable age. In other words it suggests that female showed more growth than male but female is still at all times smaller than males during this period of age. The assumption can be made that male also grow more and were larger in early and late adulthood but is it best if further study is carried out so the comparison and conclusion can be confirmed.

From the proportion indices it was shown that the skeleton of craniofacial appears to grow in a remarkably constant fashion and certain area shows a significant difference between males and females, namely mandible-face width index (go-go x 100/zy-zy), upper lip height-mouth width index (sn-sto x 100/ch-ch) and lower-upper lip height index (sto-sl x 100/sn-sto).

In conclusion this study establishes the first normal set parameters of the craniofacial region in the 7- and 12-year-old in Malay children. It is possible that this normal value can be used for facial analysis, facial reference and also to specify patterns for craniofacial growth. Therefore, this available data is helpful in making a diagnosis as well as a guide during reconstruction or as an evaluation for the success of reconstruction surgery post operatively.

References

A. Bjo’’rk and V. Skieller (1972). *Am J.Ortho.* Volume 62, issue 4, October. Pg 339-383.

Al-Junid ST (2005). Anthropometry of the craniofacial complex: A comparison of three races in Malaysia. Dissertation submitted in fulfilment of the requirements for the degree of Masters In Clinical Dentistry (Oral & Maxillofacial Surgery).

Am Howe, Hawkins JK, Webster WS (2004). The growth of the nasal septum in the 6-9 week period of foetal development-Warfarin embryopathy offers a new insight into prenatal facial development. *Australian Dental Journal* **49(4)**: 171-176.

Ayoub AF, Siebert P, Moos KF et al (1998). A vision-based three-dimensional capture system for maxillofacial assessment and surgical planning. *Br J oral Maxillofac Surg* 36: 353-7.

B.D Chaurasia’s (2003). *Human Anatomy, regional and applied,* 3rd edn. New Delhi: CBC Publishers.

Berkovitz B.K.B, Holland G.R, Mxham B.J (2002). *Oral Anatomy, Histology and Embryology*. 3rd edn. Edinburgh, UK: Mosby, Elsevier Science Limited. Pg. 269-271.

Bishara, S.E, Jorgensen G.J and Jakobsen J.R (1995). Changes in facial dimensions assessed from lateral and frontal photographs. Part 11- Results and conclusions, *American J.Orthod and Dentfac Orthopedics,* 108, 489-499.

Budai M, Farkas Lg et al (2003). Relation between Anthropometric and cephalometric measurements and proportions of the Face of healthy Young White Adult Men and Women. *J.Craniofac Surg*. 14: 154-161.

Burke, P.H and Hughes-Lawson C.A (1989). Sterophotogrammetric study of growth and development of the nose, *American Journal of Orthodontics and dentofacial Orthopedics,* 96, 144-151.

Copray JC (1986): Growth of the nasal septal cartilage of the rat in vitro, *J Anat* 144: 99-111.

Copray JCVM, Jansen HWB, Duterloo HS (1986). Growth and growth pressure of mandibular condyle and some primary cartilages of the rat in vitro. *American J of Orthod and Dentofac. Orthopedics*: 90: 19-28.

Cortella S, Shofer FS, Ghafari J. (1997). Transverse development of the jaw: norms for the posteroanterior cephalometric analysis. *Am J. Ortho Dentofacial Orthop* 112: 519-522.

C.S Sinnatamby (2001). Last's Anatomy, regional and applied, 10th edn. Edinburgh: Harcourt Publishers.

Cozza P, Stirpe G et al (2005). Craniofacial and body growth: a cross sectional anthropometric pilot study on children during pre pubertal period. *Eur J Paediatr Dent*. **6(2)**: 90-6.

Czarnecki ST and Currier GF (1993). Perceptions of a balanced facial profile. *American Journal of Orthodontics and dentofacial Orthopedics* Vol 104, no 2 pp 180-187.

Daniele Denis, Olivier Burguiere, Carole Burillon (1998). A biometric study of the eye, orbit and face in 205 normal human fetuses. *Investigative Ophthalmology Visual Science* Vol 39, pp 2232-2238.

De Carlo D, Metaxas D, Stone M (1998). An Anthropometric face model using variational techniques in processing SIGGRAPG 98' pp 67-74. Department of Computer and Information Science University of Pennsylvania.

Diewert VM (1985). Development of human craniofacial morphology during the late embryonic and early fetal periods. *Am J Orthord Jul*; **88(1)**: 64-76.

El-Hakim H, Crysdale, W.S et al. (2001). A study of anthropometric measures before and after external septoplasty in children. A preliminary study. *Arch Otolarynol Head Neck Surg*. Nov: **127(11)**: 1362-6.

Enlow, D.H (1982). *Handbook of facial growth.* 2nd edn. USA, W.B. Saunders Company.

Enlow, D.H and Hans, M.G (1996). *Essentials of facial growth*. 1st edn. USA, W.B. Saunders Company.

Evereklioglu C et al (2002). Craniofacial Anthropometry in a Turkish population. *The Cleft Palate Craniofacial Journal*. Vol 39, No 2 pp 208-218.

Farkas LG (1994). Anthropometry of the head and face. New York: Raven Press.

Farkas LG, Bryson W, Tech B, Klotz J (1980). Is Photogrammetry of the face reliable? *Plast Reconstr Surg* **66(3)**: 346-354.

Farkas LG, Forrest CR, Litsas L (2002). Revision of neoclassical Canons in young adult Afro-Americans. *Aesthetic Plast Surg*. 24: 179-184.

Farkas LG, Hrezcko TA, Kolar JC, Munro IR (1985). Vertical and horizontal proportional of the face in young adult North American Caucasian: revision of neoclassical canons. *Plas Reconstr Surg*. 75: 328-338.

Farkas LG, Posnick JC, Hreczko TM, Pron GE (1992). Growth pattern in the orbital region: A morphometric study. *Cleft-Palate Craniofacial Journal*. **(29)**, 315-318.

Farkas LG, Posnick JC, Hreczko TM (1992). Growth patterns of the face: A morphomeric study. (*Cleft Palate-Craniofacial Journal.* **(29)** 308-315.

Farkas LG and Posnick JC (1992). Growth development of regional units in the head and face based on anthropometric measurements. *Cleft Palate Craniofacial Journal*. **(29)** pg 301-302.

Farkas LG, Posnick JC, HreckoTM 1992a. Anthropometric growth study of the head. *Cleft Palate Craniofac J* 29:303-308.

Farkas LG, Thompson BD, Katie MJ, Forrest CR (2002). Differences between Direct (Anthropometric) and indirect (Cephalometric) measurements of the skull. *J Craniofac Surg* 13: 109-110.

Ferrario VF, Sforza C, Dellavia C et al. (2003). Three dimensional nasal meorphology in cleft lip and palate operated adult patients. *Annals of Plastic Surgery*. Oktober **51(4)**: 390-397.

Foster TD ; *A Textbook of orthodontics* 3rd edn. Blackwell Scientific Publications.

Goel SP, Dayal SS, Ramesh Babu CS et al (1987). Anthropometric assessment of inter canthal interpupillary and outer orbital dimensions: normal range. *Journal of the Anatomical Society of India*. Dec; **36(3)**: 160-6.

Guyot L, Dubue M et al. (2003). Comparison between direct clinical a digital phoogrammetric measurements in patiens with 22q11 microelectron. *Int. J. Oral Maxillofac Surg*. 32: 246-252.

Hajnis K et al (1994). Racial and ethnic morphometric differences in the craniofacial complex. In : Anthropomety of the head and face. Farkas LG. New York: Raven Press. Pp 201-218.

Houpt MI (1970). Growth of the craniofacial complex of the fetus. *Am J Orthod.* 58: 373-383.

Hutton TJ, Buxton BF, Hammond P, Potts HWW (2003). Estimating average growth trajectories in shape-space using Kernel smoothing. IEEE transactions on medial imaging.

Jennifer PP (2004). The average African American male face: An anthropometric analysis. *Arch Facial Plast Surg*. 6: 78-81.

Kawakami SC, White PS (2004). A comparison of aesthetic proportions between the Oriental and Caucasian nose. *Clin-Otolaryngol*. Vol **29(6)**: pp 672-676.

Kolar JC and Salter EM (1996). Craniofacial Anthropometry: Practical Measurement of the head and face for clinical surgical and research use. Charles C. Thomas Publisher LTD.

Krogman WM, Cooper HK et al. (1979). Craniofacial growth, prenatal and postnatal. Cleft lip and cleft palate: a team approach to clinical management and rehabilitation. WB Saunders, pp 22-107.

Leong SC, WhitePS (2004). A comparison of aesthetic proportions between the oriental and Caucasian nose. *Clin-Otolaryngol* Vol **29(6)**: pp 672-676.

Le TT et al (2002). Proportionality in Asian and North American Caucasian faces using neoclassical facial canons as criteria. *Aesth Plast. Surg*. **26(1)**: pp 64-69.

Levihn WC (1967). A cephalometric rontgenograpic cross sectional study of the craniofacial complex in fetuses from 12 weeks to birth. *Am J Orthodontic.* 53: 822-848.

Loise Schever & Sue Back (2004). *The juvenile skeleton*. Elseivier Publications.

MacLachan C, Howland HC (2002). Normal values and standard deviations for pupil diameter and interpupillary distance in subjects aged 1 month to 19 years. *Ophthalmic physiol opt*. **22(3)**: pp 175-182.

Mao JJ and Nah HD. Growth and development (2004). Hereditary and mechanical modulations. *Am J Orthod Dento facial Orthop* 125: 678-89.

Madjarova LM, Madzharov MM, Farkas LG, Katie MJ (1999). Anthropometry of soft tissue orbits in Bulgarian newborns: norms for intercanthal and binocular widths and length of palpebral fissures in 100 boys and 100 girls. *Cleft Palate Craniofac J*. Mar; **36(2)**: 123-6.

McKay GS, Yemm R. (1992). The structure and function of the temporomandibular joint. *Br. Dent J*. 5: 127-132.

MeikleMC. (1973). The role of the condyle in the post natal growth of the mandible. *Am J Orthod.* 64: 50-61.

Meikle MC (2002). *Craniofacial development, growth and evolution*. 1st edn. Norfolk, England: Bateson Publishing pg 262.

Moore and Agur (2002). *Essential Clinical anatomy*, 2nd edn. Baltimre: Lippincortt Williams and Wilkins.

Moss ML and Salentijn (1969). The primary role of functional matrix in facial growth, *Am J Orthod*. 55: 566-577.

Moss ML. (1997). The functional matrix hypothesis revisited 1. The role of mechanotransduction. *Am J Orthod Dentofac Orthop*. 112: 8-11.

Moss ML (1997). The functional matrix hypothesis revisited 2. The role of an osseous connected cellular network *Am J Orthod Dentofac Orthop* 112:221-6.

Moss ML. (1997). The functional matrix hypothesis revisited 3. The genomic thesis. *Am J Orthod Dentofac Orthop.* 112: 338-42.

Moss ML. (1997). The functional matrix hypothesis revisited 4. The epigenetic antithesis and the resolving synthesis. *Am J Orthod Dentofac Orthop.* 112: 410-7.

Moyer RE, Bookstein FL. (1979). The inappropriateness of conventional cephalometrics. *Am J Orthod*. 75:599-617.

Murphy WK, Laskin DM, Richmond MS. (1990). Intercanthal and interpupillary distance in the black population. *Oral Surg Oral Pathol*. 69: 676-680.

Nanda RS, Meng H, Kapila S and Gooruis J (1990). Growth changes in the soft tissue profile. *Angle orthodontist* 60, 177-190.

Nute SJ and Moss JP (2000). Three dimensional facial growth studied by optical surface scanning. *British Journal of orthodontics* **(27)**; 31-38.

Ogus HD, Toller PA. (1986). *Common disorder of the temporomandibular joint*. 2nd edn. Wright Bristol, pp 1-7.

Porter JP, Olson KL. (2001). Anthropometric facial analysis of the African American woman. *Arch Facial Plast Surg*. 3 pp 191-197.

Proffit WR and Fields Jr. HW (2000). *Contemporary orthodontics*. 3rd edn. USA Mosby.Inc.

Proffit WR, White RP Jr, Sarver DM. (2003). *Contemporary treatment of dentofacial deformity*. Mosby Publisher.

Ranly DM. (1998). *A synopsis of craniofacial growth* 2nd edn. Prentice-Hall International Inc.

Gliklich RE (1997). *Facial Surgery, Plastic and Reconstruction*. Cheney ML. Willians and Wilkins Publisher

Ridley MB (1992). *Facial plastic and reconstructive surgery* pg 99-100

Roger BO (1974). The role of physical anthropology in plastic surgery today. *Clin Plast Surg* **1(3)**; pp 439-498.

Rolf G. Behrents. (1985). *Growth in the aging craniofacial skeleton. Monograph 17 craniofacial growth series*. Center for human growth and development, the University Of Michigan.

Sadler TW (1995). *Langman's medical embryology*. 7th edn. Baltimore, Maryland USA: Williams and Wilkins.

Sadowsky PL. (1998). Craniofacial growth and timing of treatment. *Am J Orthod* pp. 113: 19-23.

Sim RS, Smith JD, Chan AS (2000): Comparison of the aesthetic facial proportions of Southern Chinese and white women. *Arch Facial Plast Surg*. **2(2)**: 113-20.

Snell RS (1992). *Clinical anatomy for medical students*, 4th edn. USA: Little, Brown.

Snodell SF, Nanda RS and Currier GF (1993). A longitudinal cephalometric study of transverse and craniofacial growth. *American J Orthod and Dentfac Orthopedc.* 104; pp 471-483.

Spalding PM (2004). *Craniofacial growth and development: current understanding and clinical considerations*. Peterson's principle of Oral and Maxillofacial Surgery. 2nd edn, Volume 2. BC Decker Inc, Hamilton.

Stiernberg CM. (1987). *Embryology and anatomy of the mandible in surgery of the mandible*. 1st edn. Bailey BJ and Holt GR. Thieme medical publishers, Inc. New York. Pp 1-10.

Sunutar Setboorsarng (2005). Child malnutrition as a poverty Indicators: An evaluation in the context of different development interventions in Indonesia. ADB Institute, Discussion paper no 21, published 14 Jan.

Vargervik K. (1995). Some aspect of bone formation and remodeling pertinent to craniofacial development and reconstructive treatment. *Acta Odontol Scand* 53: 167-173.

Vegter F, Hage JJ (2000). Clinical anthropometry and canons of the face in historical perspective. *Plastic and reconstructive surgery*, Oct 106**(5):** 1090-1096.

Ward RE: Facial morphology as determined by anthropometry; Keeping it simple. *J Craniofac Genet Dev Biol*. **9(1)** 45-60.

Ward Re (2002). Discussion, Re: Differences between direct (anthropometric) and indirect (cephalometric) measurements of the skull. Farkas LG et al. *J Craniofac Surg* 13: 109-110.

Wu KH, Tsai FJ et al. (2000) Normal value of inner canthal distance, inter papillary distance and palpebral fissure length in normal Chinese children in Taiwan. *Acta Paediatr Taiwan* Jan- Feb; **41(1)**: 22-7.

Xia J, Wang D, Samman N et al (2000). Computer-assisted three dimensional surgical planning and simulation: 3D color facial model generation. Int J Oral Maxillofac.Surg. 29: 2-10.