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 and 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 are 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.

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 (Zarnecki, 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 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 (Enlow, 1982).

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).

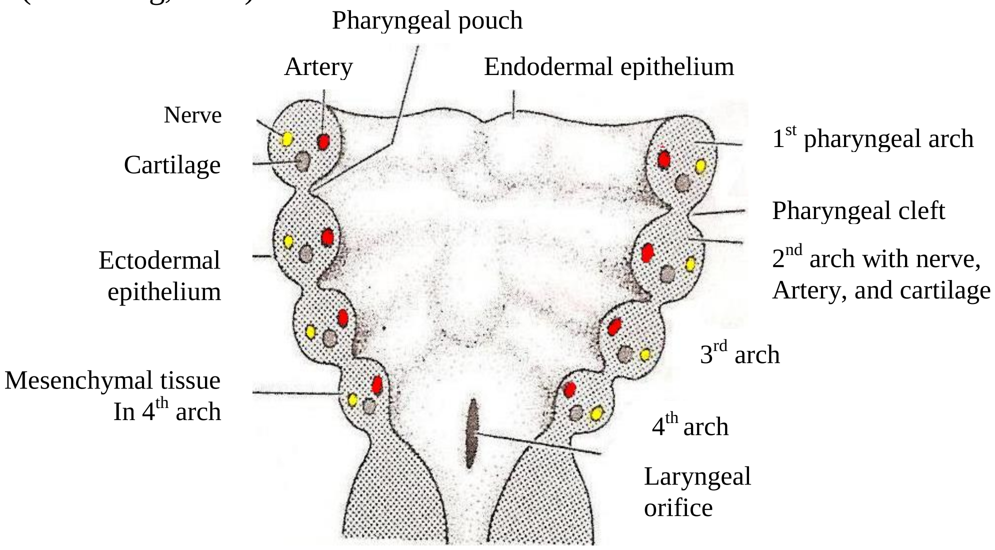


Figure 2.3.1

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).

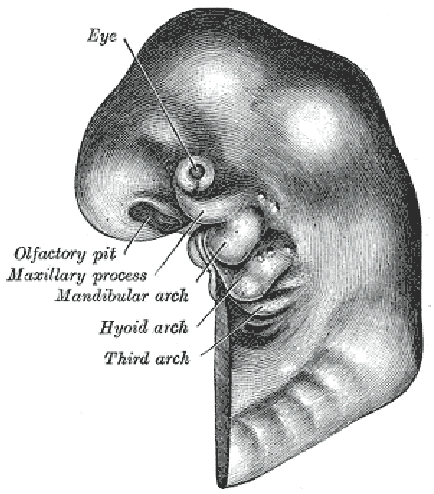


Figure 2.3.2

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

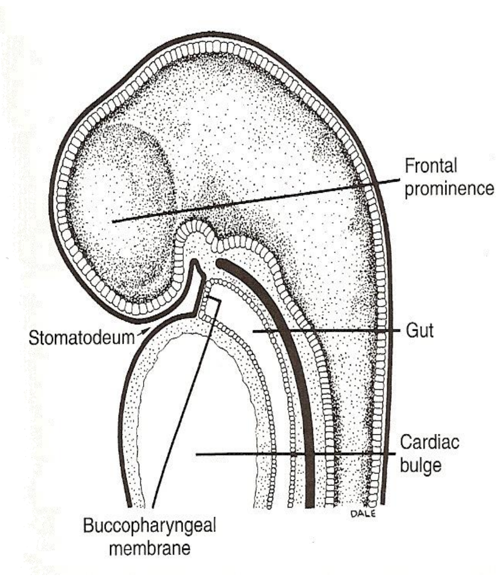


Figure 2.3.3

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).

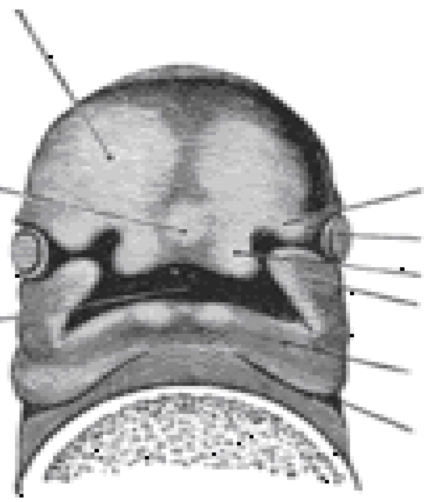


Figure 2.3.4

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).

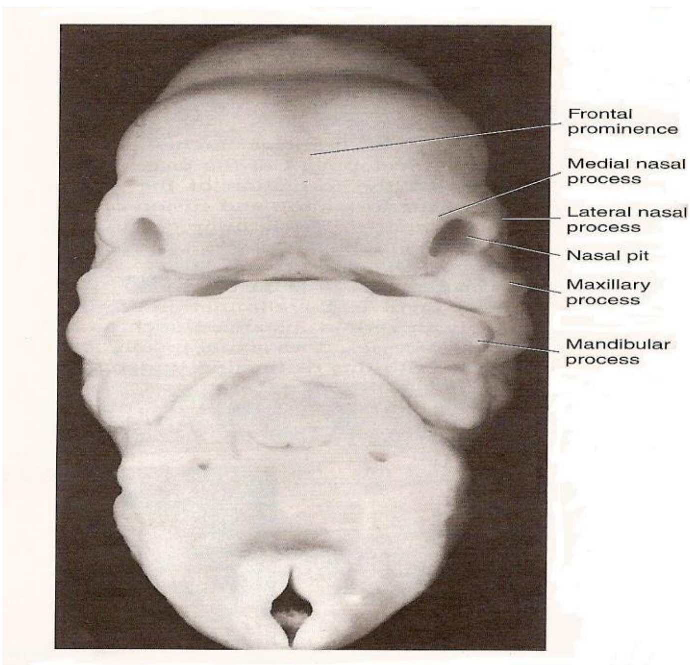


Figure 2.3.5

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)

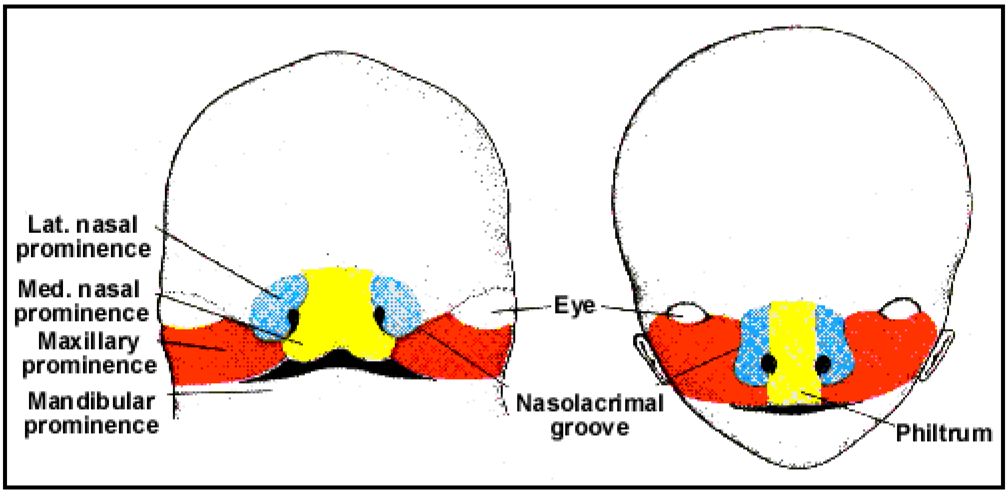


Figure 2.3.6

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 (Enlow & Hans, 1996).

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 (Enlow, 1982).

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 (Schever & Back, 2004).

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.

Even though there is a large considerable data that exists with regard to craniofacial growth, we still have limited understanding in many areas. All we have are 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 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 (Moss, 1997).

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. 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 (Copray et al, 1986).

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 and 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 and 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 and Hans, 1996).

According to Marion, the effects of aging begin to appear at the age of thirty. Skin laxity is first noted when the upper eyelids begin to overhang the palpebral lines. The inferior palpebral sulci and nasolabial folds become noticeable.

At about age of forty the wrinkles and glabellar furrow begin to appear. During this time, eyelid skin laxity became noticeable excess, and crow's feet began to appear at the lateral canthi. Mandibular sagging line also becomes detectable.

By fifty years of age the wrinkles at forehead and glabellar become prominent and may unite to form continuous line. Nasal tip began to drop and wrinkles around the mouth and neck start to develop. Early loss of subcutaneous fat indicated by sagging of the cheek skin.

At age sixty all skin wrinkles deepen. The size of the eyes diminutive because of progressive encroachment of the surrounding lid skin. Skin thickness begins to decrease and the loss of subcutaneous adipose tissue accelerates, thus producing noticeable deficits in the temporal, orbital and buccal areas.

By age of seventy the nasal tip has descended even further and the excess skin of the lower eyelids may develop bag like deformities. Continued loss of subcutaneous fat makes the malar complexes appear quite prominent and the orbits more hollow.

By age of eighty years old, wrinkles around the face produce typical appearance of advanced senescence. Loss of skin thickness, absence of subcutaneous fat, diminution in the size of cranial vault combine to make the facial skeleton more conspicuous than at any other time in life (Marion, 1992).

The interesting question sometimes is how about the people who look younger than his or her years? or older?

The reasons are only partially understood. Enlow mentioned that the onset of smile line and some other facial wrinkles is delayed or at least such lines look less marked in youthful-appearing individuals. Conversely if the lines appear more prominent and develop at earlier age the person may look older. Intrinsic physiologic as well the environment factors also contribute to this (Enlow and Hans, 1996). Eg. Exposure to sun can accelerate the aging process of skin. Major loss of adipose tissue also can accelerate the onset of facial wrinkles.

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 18^{th} and 19^{th} 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 19^{th} and 20^{th} 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 Antropometry 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, 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 (Moyers and Booktein, 1979).

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. 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 (Budai et al, 2003).

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).

In 1991, Diliberti and Olson emphasized 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 (Farkas et al, 1980).

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.

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

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 ethnic’s 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 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 (Goel et al., 1987).

Similar studies was done by Madjarova (1999) to establish a 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 (Madjarova et al.1999).

Evereklioglu et al 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 (Evereklioglu et al, 2002).

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).

The study of the nasal morphology in cleft lip and palate operated adult patients was done where they compare with a normal subjects and they found that nasal width, alar base width and inferior width of the nostrils were larger than the reference subjects. Nasolabial and nasal tip angles were smaller and facial convexity angle was larger. They concluded that the surgical corrections of the cleft lip and palate failed to provide a completely normal appearance (Ferrario et al, 2003).

El- Hakim (2003) did an anthropometric measurement pre and post external septoplasty in children to test the hypothesis that surgery on the growing nasal septum does not adversely affect nasal and midfacial dimensions. The result showed that there was no effect on development of the nose and midface if the nasal surgery was performed during childhood (El-akim et al. 2003).

Those findings shows that the pre operative facial measurements assists in the determination of which facial features need change to produce harmony with the face as a whole. Post operative determination of the same measurements allows for assessment of the adequacy and appropriates of the degree of improvement.

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. 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 (Farkas et al, 1992).

Vertical skeletal growth has been measured using anthropometric technique developed by Farkas (1981). It was found that there was 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 showed the higher development (Cozza et al, 2005).

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 definites. 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 number of all facial proportions influences by culture and ethnicity (Richard, 1997).

Anthropometry studies are an integral part of craniofacial surgery and syndromology (Farkas et al, 1992).

The knowledge of the normal values of the 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., 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 also less prominent with the alae more flared and nasal tip less prominent (Sim et al. 2000).

Kawakami done the 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 (Kawakami et al. 1989).

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 (Leong and White, 2004).

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 (Le et al, 2002).

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 (Jennifer, 2004).

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 example visual impression is mostly used to describe the anatomical inter papillary distance. However this is not adequate because of variations in facial features such as wide nasal bridge, epicanthus ad 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 the 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, are the aim is 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, age 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 are selected from Sekolah Rendah Kebangsaan Bandar Baru Bangi Selangor. Each age group totalled one hundred participants with equal number of boys and girls 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.

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 wo 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.

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.

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.

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 B)

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 proportion derived from the se measurement 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 proportion derived from the se 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 the se 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 proportion derived from the se 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 the se 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. It is well accepted that the one way ANOVA is to test for significant differences between two means of two or more groups and it is more efficient at detecting a true difference. If only two means are compared, ANOVA will give the same results as the t-test. Rather than conducting multiple t-test, a one way ANOVA test would be appropriate to obtain results for multiple comparisons of the 2 age group in this study. 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 measurements were measured; head width (eu-eu), head length (g-op), head height (v-n), craniofacial height (v-gn) and head circumference (on-op)

4.1.1 Head width (eu-eu)

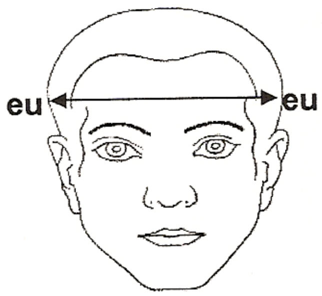


Table 4.1.1 Head width (eu-eu)

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 value 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 width in both 7 and 12 year old male are generally larger than the female's. There is a significance difference in head width between male and female in the 7 year old ($p<0.05$) 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 in both gender as the age increased.

4.1.2 Head length (g-op)

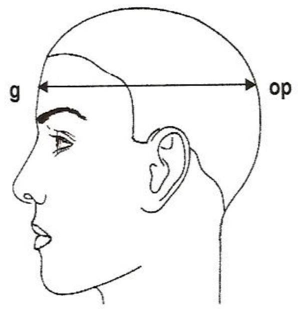


Table 4.1.2 Head Length (g-op)

Gender / Group	Age	Mean ± SD	p-value
Male	7	175.20 ± 9.33	0.02
Female	7	169.34 ± 7.28	
Male	12	179.10 ± 9.21	0.99
Female	12	179.66 ± 14.27	
Male	7	175.20 ± 9.33	0.23
Male	12	179.10 ± 9.21	
Female	7	169.34 ± 7.28	0.00
Female	12	179.66 ± 14.27	

The head length results showed in table 4.1.2. The head length of the 7 year old male is higher than the female and the difference is significant ($p<0.05$). However the female in 12 year old group has a higher head length compared to the male of the same age, but statistically the difference is not significant ($p>0.05$). The head length are higher in elder group in both gender 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)

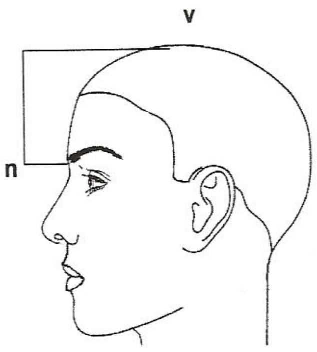


Table 4.1.3 Head height

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 as compared to female, however the differences were not statistically significance ($p<0.05$). It showed that the head height was higher in elder group than younger group in both genders. However statistically the head height only shows significant difference in the males group ($p<0.05$). Table 4.1.3.

4.1.4 Craniofacial height (v-gn)

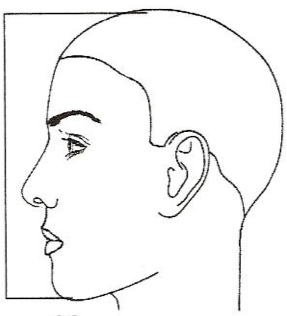


Table 4.1.4 Craniofacial height (v-gn)

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	

When measuring the craniofacial height, males in both age groups have a higher measurement in comparison to female (Table 4.1.4). The result shows significant difference when comparing male and female in 12 year old ($p<0.05$). However the craniofacial height is higher in elder group and this difference was statistically significance for both genders ($p<0.05$).

4.1.5 Head circumference(on-op)

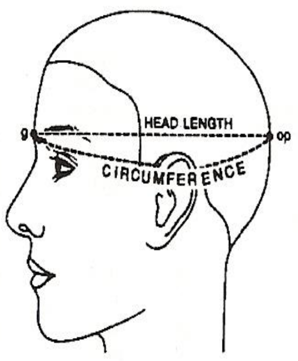


Table 4.1.5 Head circumference (on-op)

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 results of head circumference. The head circumference of male showed the largest value in both age groups however this different is not statistically significant ($p>0.05$). It is also found that the head circumference is higher in elder group than younger group. However the result was statistically significant only in female ($p<0.05$).

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

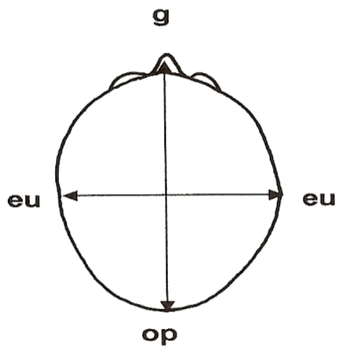


Table 4.1.6 Cephalic Index (eu-eu x 100/g-op)

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 is lower than the females (Table 4.1.6). However the differences are not statistically significant ($p>0.05$). Age wise the elder group shows slight higher value than younger group in cephalic index. However the result is not statistically significant ($p>0.05$).

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

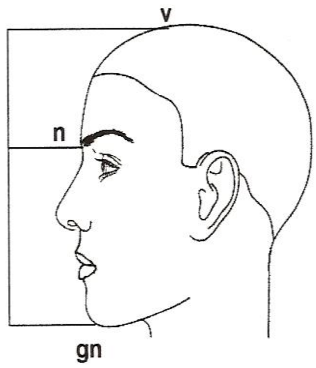


Table 4.1.7 Head-Craniofacial Height Index

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) between male and female shows very slight difference in the same age groups. However the findings is not statistically significance (p>0.05). Age wise, there is also almost no differences in this index between genders in the age group of twelve and seven. However this differences were not statistically significant (p>0.05).

4.2 Face

There are seven (7) anthropometric measurements performed; 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). Form these measurements, five (5) proportion indices are derived.

4.2.1 Face width (zy-zy)

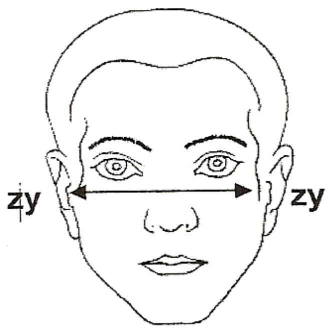


Table 4.2.1 Face width (zy-zy)

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 have a larger face width as compared to the female. However the differences is not statistically significant (p>0.05). The results also shows that the face width were larger in the elder age group than younger age group and the difference is statistically significant (p<0.05).

4.2.2 Mandible width (go-go)

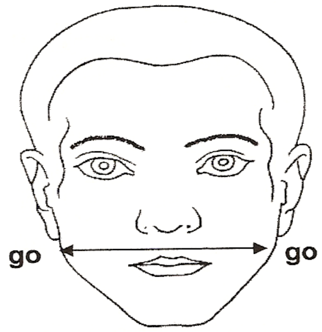


Table 4.2.2 Mandible width (go-go)

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 are larger in male for both age groups. However the difference was statistically significant in the group of 12 year old ($p<0.05$). Basically from the results, the mandible width was larger in the elder group as compared to younger group and the differences were statistically significant for both gender ($p<0.05$).

4.2.3 Face height (n-gn)

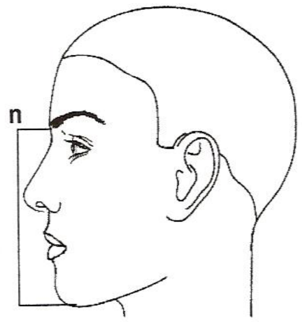


Table 4.2.3 Face Height (n-gn)

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	

Face height results showed in Table 4.2.5. The mean value for the face height is smaller in female as compared to male in the same age group. However the gender difference was statistically not significant ($p>0.05$)

The face height is higher in the elder group as compared to the younger group. The difference is significant for both gender ($p<0.05$).

4.2.4. Upper face height (n-sto)

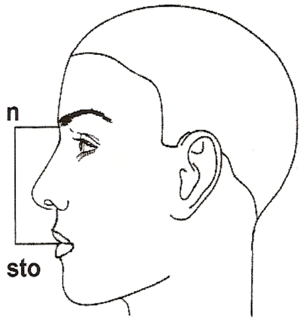


Table 4.2.4 Upper face height (n-sto)

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 in both age groups (Table 4.2.4). However the findings were not 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)

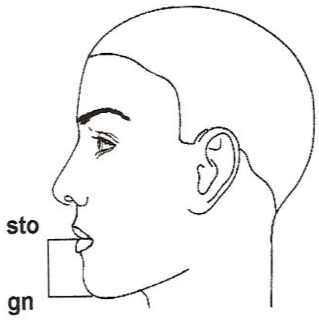


Table 4.2.5 Mandible height (sto-gn)

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 is higher in male for 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 group and the difference were statistically significant for both gender ($p<0.05$).

4.2.6. Left maxillary depth (t-sn)

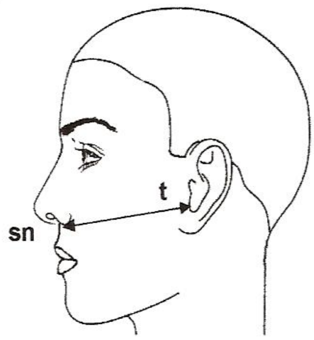


Table 4.2.6 Left maxillary depth (t-sn)

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 is larger in male for both age group but the difference is statistically significant only in the group of twelve year old ($p<0.05$). It is also found that the maxillary depth is larger in the elder age group and the results were significant in both genders ($p<0.05$)

4.2.7. Mandibular depth (t-gn), left

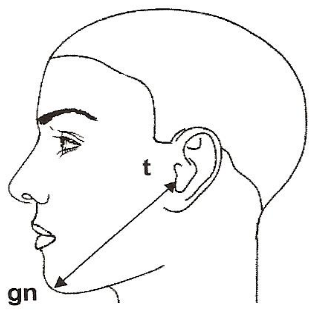


Table 4.2.7 Mandibular depth (t-gn), left

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

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

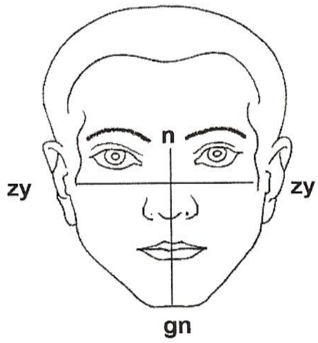


Table 4.2.8 Facial Index (n-gn x 100/zy-zy)

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 these differences were not statistically significant ($p>0.05$).

In male, it has been shown that the mean was larger in elder group. Interestingly for female, the facial index shows 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)

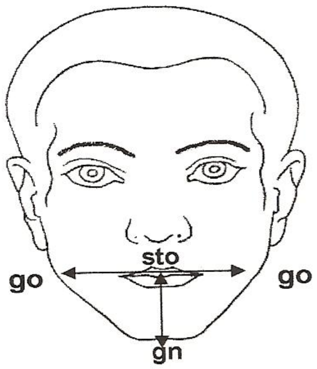


Table 4.2.9 Mandibular index (sto-gn x 100/go-go)

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 is higher in 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)

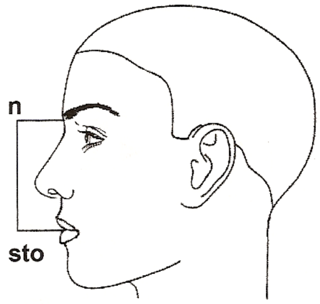


Table 4.2.10 Upper face-face height index (n-sto x 100/n-gn)

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, at age 7, the upper face-face height index for the female is slightly larger than for the male but at the age of 12, male has higher upper face-face height index. The index also higher in elder age group and it happen for both genders. However all these differences are not statistically significant ($p>0.05$).

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

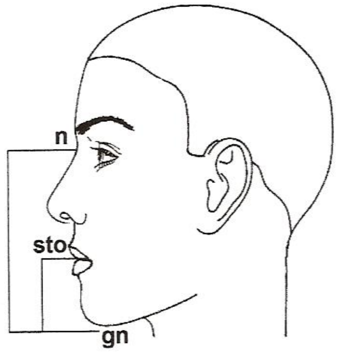


Table 4.2.11 Mandible-upper face height index (sto-gn x 100/n-gn)

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 mean of mandible-upper face height index is showed in Table 4.2.11. It was noted that the female of seven year old group has a larger index but as the male reached twelve years old they has a larger mandible-upper face height index than the female. However these differences were not statistically significant (p>0.05). There is a slight higher mean index in the elder group of age and it occurred for both genders. However the differences were not statistically significant (p>0.05)

4.2.12 Mandible-face width index (go-gox100/zy-zy)

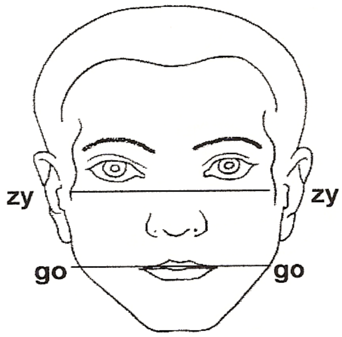


Table 4.2.12 Mandible-face width index (go-gox100/zy-zy)

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 has a larger mandible-face width index than the female. However the difference is only statistically significant in the 12 year old group ($p<0.05$). In female, the mandible-face width index decreases from 80.33% to 78.31% when comparing the elder age group with young age group. This change is not observed in the male group, which the index slightly higher in the elder age group compared to young age group. However, the 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)

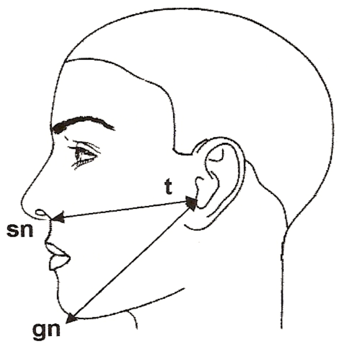


Table 4.2.13 Middle-lower third face depth index (t-sn x 100/t-gn)

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	
Male	7	93.37 ± 2.60	0.00
Female	12	91.79 ± 2.47	
Male	12	91.54 ± 2.46	0.00
Female	7	93.90 ± 2.17	

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 smaller in elder age group and it was observed in both gender. These finding however were not statistically significant ($p<0.05$).

4.3 Orbits

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

4.3.1. Intercanthal width (en-en)

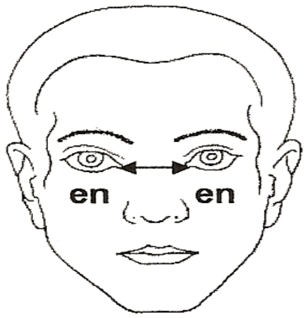


Table 4.3.1 Intercanthal width (en-en)

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 has a larger intercanthal width than female for both age groups. However the difference is not statistically significant ($p>0.05$). It also noted that the intercanthal width was larger in elder age group. This difference is statistically significant for both genders ($p<0.05$).

4.3.2. Biocular width (ex-ex)

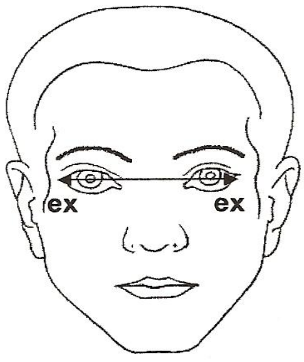


Table 4.3.2 Biocular width (ex-ex)

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	
Male	7	92.74 ± 3.89	0.00
Female	12	99.28 ± 4.21	
Male	12	101.02 ± 4.00	0.00
Female	7	89.74 ± 4.37	

The means for biocular width is larger in the male as compared to the female in both age groups (Table 4.3.2). However statistically the difference is only significant in younger age group. The biocular width is larger in elder age group for both male and female. Statistically the differences were significant for both gender ($p<0.05$).

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

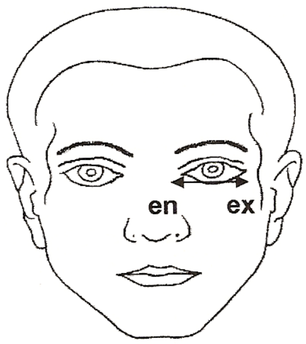


Table 4.3.3 Eye fissure length (ex-en), left

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 is slightly higher in male for both aged group. However statistically the difference was not significant ($p>0.05$). The eye fissure length also higher in the elder age group and the difference were significant for both genders ($p<0.05$).

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

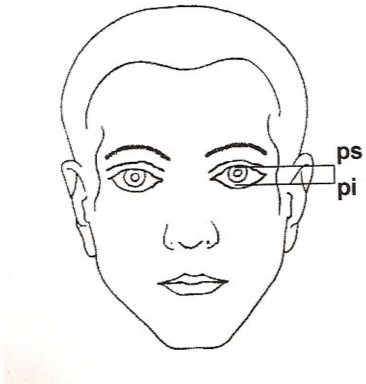


Table 4.3.4 Eye fissure height (ps-pi), left

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 has a slightly shorter eye height than female, however the differences are not significant ($p>0.05$). Interestingly the findings shows that the eye fissure height was smaller in elder age group and it occurred in both gender (Table 4.3.4). The difference was statistically significant($p<0.05$).

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

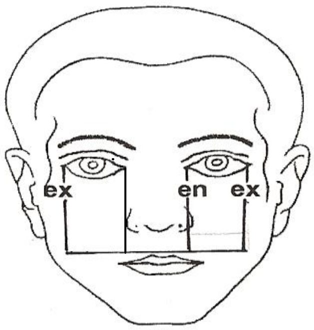


Table 4.3.5 Intercanthal index (en-en x 100/ex-ex)

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	

Female shows a slightly greater mean value in intercanthal index as compared to the male in seven year old group. For the twelve year old group the difference is almost negligible. However statistically the differences are not significant ($p>0.05$). The intercanthal index was smaller in elder age group for 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)

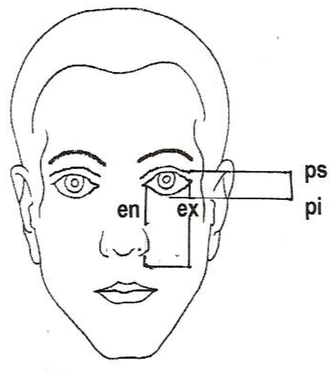


Table 4.3.6 Eye fissure index (ps-pi x 100/ex-en)

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 has a greater eye fissure index for both aged group. However the difference is statistically not significant ($p>0.05$).

It is has been found that the eye fissure index is smaller in elder age group and it was noted to occurred in both genders. The differences are statistically significant ($p<0.05$).

4.4 Nose

Three anthropometric measurements are 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 are obtained; nasal index, nasal tip protrusion length -nose width index, nose-face height index and nose-face width index.

4.4.1 Nose width (al-al)

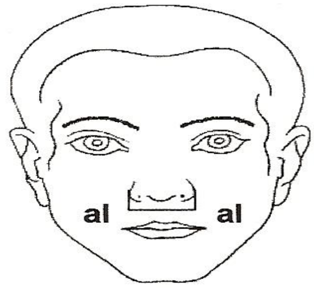


Table 4.4.1 Nose width (al-al)

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 recorded mean value for nose width is larger in male in both age groups as shown in Table 4.4.1. However both differences are not statistically significant ($p>0.05$). The nose width was larger in elder age group and this finding is same for both genders. The difference were statistically significant ($p<0.05$).

4.4.2 Nose height (n-sn)

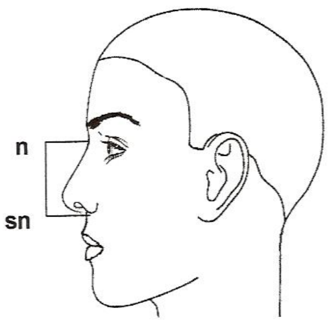


Table 4.4.2 Nose height (n-sn)

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) is higher in male as compared to the female in seven year old group. For the twelve year old group it shows that the female has a higher nose width than male. Both differences were statistically significant ($p>0.05$). The nose height was higher in elder age group and this occurred significantly in both male and female ($p<0.05$).

4.4.3 Nasal tip protrusion (sn-prn)

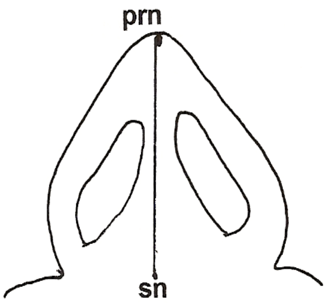


Table 4.4.3 Nasal tip protrusion (sn-prn)

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 7 year old group the male has a larger nasal tip protrusion than female. On the other hand for the 12 year old group it has been shown that the female has a larger nasal tip protrusion than male. However both differences were not statistically significant ($p>0.05$). The nasal tip protrusion was higher in elder age group and it occurred in both genders. This differences were statistically significant ($p<0.05$).

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

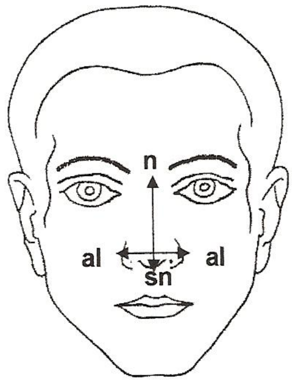


Table 4.4.4 Nasal index (al-al x 100/n-sn)

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 the male generally has a larger nasal index than female for both aged groups. However the differences were not statistically significant ($p>0.05$). The nasal index showed a smaller index in elder age group compared to younger age group and these smaller mean occurred in 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)

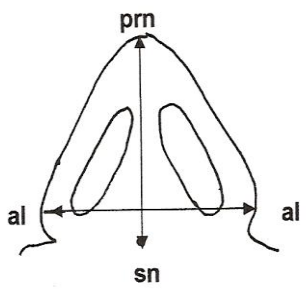


Table 4.4.5 Nasal tip protrusion length -nose width index (sn-prn x 100/al-al)

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

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

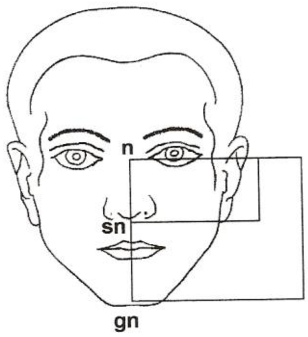


Table 4.4.6 Nose-face height index (n-sn x 100/n-gn)

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 have a greater index compared to male but the differences are not statistically significant ($p>0.05$). The index showed a higher mean in elder age groups but the differences only significant in female ($p<0.05$).

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

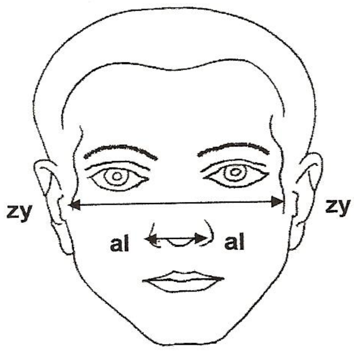


Table 4.4.7 Nose-face width index (al-al x 100/zy-zy)

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

4.5 Lips and mouth

In this region, three linear anthropometric measurements were performed; 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)

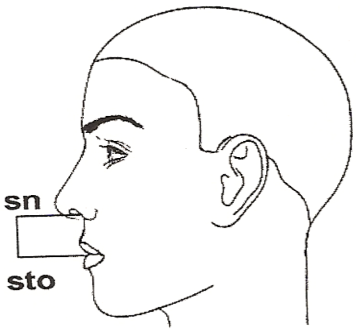


Table 4.5.1 Upper lip height (sn-sto)

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 has a greater upper lip height as compared to female in 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 group and it happened for both genders. The differences were statistically significant ($p<0.05$).

4.5.2 Mouth width (ch-ch)

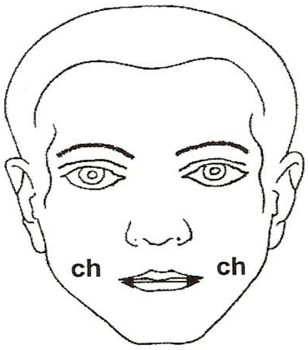


Table 4.5.2 Mouth width (ch-ch)

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 (Table 4.5.2) are generally larger in male as compared to female for both age groups. However statistically the differences were not significant ($p>0.05$). The mouth width showed a larger mean in elder age group and it happened in both gender. Statistically the differences were significant ($p<0.05$).

4.5.3 Lower lip height (sto-sl)

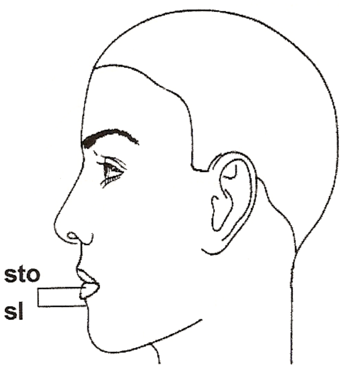


Table 4.5.3 Lower lip height (sto-sl)

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 results for lower lip height result shown in Table 4.5.3. The lip height is higher in male in both age groups. However the differences are not statistically significant ($p>0.05$). It is shown that the lower lip height have a higher mean in elder age groups for both male and female. The differences were statistically significant ($p<0.05$).

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

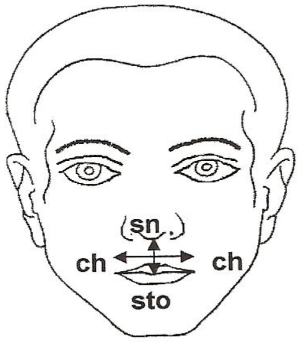


Table 4.5.4 Upper lip height-mouth width index (sn-sto x 100/ch-ch)

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 the male has a greater upper lip height-mouth width index as compared to female in both age groups (Table 4.5.4). The differences in these mean value are statistically significant ($p<0.05$). The upper lip height-mouth width index showed a smaller values in elder age group and these findings observed in both genders. Statistically these differences were significant ($p<0.05$).

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

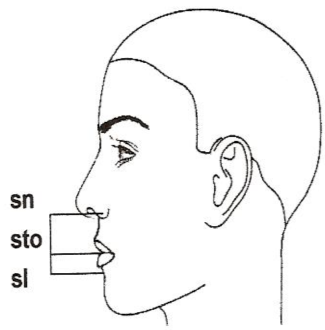


Table 4.5.5 Lower-upper lip height index (sto-sl x 100/sn-sto)

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 female has a greater index as compared to male in both age groups. However the differences is only significant in 7 year old group ($p<0.05$). Both male and female showed a higher index in elder age group. Interestingly the differences only significant in male ($p<0.05$).

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

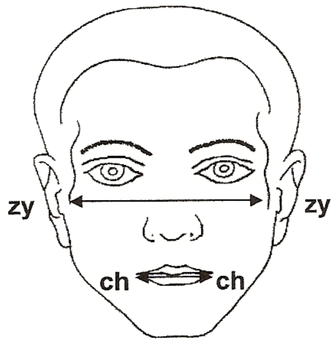


Table 4.5.6 Mouth-face width index (ch-ch x 100/zy-zy)

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. showed a means for mouth-face width index. There are almost no different in this index for both female and male in both aged groups. However the differences are not statistically significant ($p>0.05$). The index shows a slight higher index in elder age group however 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 mentioned 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 slow and cease 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 (Enlow, 1980).

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 completing before the cranial base and then followed by nasomaxilla and finishing 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 is to provide the norm or standard data for the pre pubertal Malay boys and girls. Thus the growth pattern between this aged group and the differences in growth between genders plays an important role. The understanding of the growth between this aged group will gives us a clue whether further study need to be done in this craniofacial measurement for each age group or we can use this normal data for all the children that falls in this range of aged group. In the next discussion, the growth changes that takes place between this 2 aged group and also between genders will be discuss separately according to the craniofacial region.

5.1 Craniofacial Anthropometric measurement analysis in Malaysian prepubertal Malay children of seven and twelve years 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 and as what we expected, the analyzed data in this cross sectional study showed that eighteen out of twenty two linear anthropometric measurement shows a significant higher in measurement in the elder aged group for both gender ($p<0.05$). However the head length (g-op) and head circumference (on-op) shows a significant higher mean values in elder group of female whereas the head height (v-n) shows a higher mean in elder aged group of male only.

Interestingly the eye fissure height (ps-pi) shows a significant smaller mean in the 12 year old when compared to 7 year old and it is significant for both gender ($p<0.05$).

From this study, it has been found out that most proportion indices remained unchanged when comparing the samples of 7 year old and 12 year old groups. From seventeen proportion indices, 3 parameters show a significant smaller in proportion indices in the 12 year old group compared to 7 year old group. The indices are 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). This finding was significant for both genders. The only proportion indices that was higher in elder aged group (12 year old) are the nasal tip protrusion-nose width index (sn-prn x 100/al-al) and it is significant for both gender ($p<0.05$).

Lower-upper lip height index (sto-sl x 100/sn-sto) and mouth-face width index (ch-ch x 100/zy-zy) shows a significant higher indices in elder age group and it was observed only in male whereas the nose-face height index (n-sn x 100/n-gn) observed in female ($p<0.05$).

Intercanthal index (en-en x 100/ex-ex) shows a significant smaller proportion indices in elder age group compared to younger group but it only happened in female ($p<0.05$).

Generally from the data analysis, when comparison was made between genders in the same age group it shows that the male has a larger measurement than female in both aged group.

For the seven year old group, the linear anthropometric measurements shows a significant different ($p<0.05$) between gender in 5 parameters. They are head width (eu-eu), head length (g-op), mandibular depth (t-gn), binocular width(ex-ex) and upper lip height (sn-sto).

In this 7 year old group, most proportion indices between genders remained the same. The significant different ($p<0.05$) observed in upper lip height-mouth width index (sn-sto x 100/ch-ch) in male whereas female has a larger lower-upper lip height index (sto-sl x 100/sn-sto) than male.

For twelve years old group, generally the male has a larger measurement than female. Linear anthropometric data analysis shows a significant different ($p<0.05$) between gender in 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 it shows a significant different between gender only in mandible-face width index (go-go x 100/zy-zy) and upper lip height-mouth width index (sn-sto x 100/ch-ch). From the findings, it shows that there is no different in others proportion indices between gender in this 12 year old group.

5.1.1 Head

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

In this cross sectional study, the linear measurement of the head width(eu-eu) represent the transverse growth of the head, the head length(g-op) represent anteroposterior while the head height(v-n) reflects the vertical dimensions of the head. In our study we use the head height as an aided to explain the upper face height. It has been found from this study that the male head height has a higher mean followed with head length and head width and this finding were consistent with Spalding findings as mentioned above. Interestingly female between 7 year old and 12 year old groups shows a highest growth in head length followed with head width and head height. Why female has a different growth pattern at this region is a question.

A few studies explained that the growth of the cranium is related to the developing brain.

Foster mentioned that cranium has grown 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 (Foster, 1990).

Alternatively Farkas and Posnick shows 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 (Farkas & Posnick, 1992).

Grays Anatomy commented that the skull grows rapidly from birth to the seventh year and then the growth is slow from the seventh year until the approach of puberty (Behrents, 1985).

Spalding mentioned 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 (Spalding,2004).

From the above findings, it shows that the growth that occurs in the head region or cranial vault in this sample subject might consider as slow growth before they reach puberty where the second period of activity occurs. The head growth in all direction (vertical, anteroposterior and transverse) and the increase in growth also basically to accommodate the developing brain.

From the analyzed data of the healthy Malay prepubertal children it shows that the head width (eu-eu) of 12 year old is 3.74mm higher than 7-year-old in male and 6.52mm in female and these finding were significant ($p<0.05$).

The male shows a larger measurement compared to female by 3.86mm in seven years old group and 1.08mm in twelve years old group but the different only significant in seven years old ($p<0.05$). It shows that even though the male has a larger mean value but the female shows a rapid increase in head width. This mean value in both sexes revealed continuous growth of the head width. Furthermore many studies demonstrated that the head width followed the neural growth curve (Snodell et al, 1993).

For the head length (g-op), male of 12-year-old is 3.90mm higher than 7-year-old and 10.32mm in female. In seven years old group, male has a larger mean value compared to female by 5.86mm but there is almost no different in age group of twelve. In this region the female shows a rapid increase in head length compared to male. When compared to the Singapore Chinese population measured by Farkas in 1987, it shows that even though the male has a larger mean value in head length (Male 6 year old, 167.3± 5.5mm, Female 6 year old, 161.5 ± 6.3mm, Male 12 year old, 172.0 ± 4.3mm, Female 12 year old, 169.5 ± 5.1) compared to female, still female shows a rapid increase from six years to twelve years old, by 8mm in female and 5mm in male (Farkas, 1994). The increase in head length might contribute by the continuous enlargement of the frontal air sinuses. Bjork's (1955) analysed 243 radiographs at age of 12 and 20 shows that the forward growth of the forehead at adolescence can indeed by the development of the brow ridges and the frontal sinuses (Tanner, 1962). Even though the study done by Bjork's was at the different age group, it reflects that at 12 year old the development of the frontal air sinuses and the brow ridges that cause the forward growth of forehead or reflect the head length(anteroposterior) already occurs in female and male since at the age of 12 year old there is no significant different between this genders.

Interestingly the 12-year-old male shows significant different in head height (v-n) by 8.38mm larger than 7-year-old. 12-year-old female was larger 4.48mm than 7-year-old but the finding was not significant. There is almost no different in comparison between female and male in seven years old and the different is about 4.06mm in twelve years old group, however both of these findings shows no significant different (p>0.05). From the result, it shows that the male has a rapid growth of head height and the finding shows that the growth at this region between 7 and 12 is different in males. However the female shows that no different in growth of head height during 7 to 12 year old.

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. In this study the head circumference for the female shows that the 12 year old is 36.56mm larger than 7 year old and in male, 12 year old is 25.02mm larger than 7 year old. However the findings only significant in female (p<0.05). The sex difference in head circumference varies from 16.84mm in seven year old group and 5.3mm in twelve years old group but the result shows no significant different (p>0.05). Form the data it shows that there is still increments occurs in growth between the age of seven and twelve and this indicate that the growth of the cranial volume still occurs. The data also indicates that the cranial volume growth occur more in female than male in this age group. The data also shows that the male head circumference is generally larger than female in both aged group. Longitudinal studies of lateral skull radiographs by Yoong (1957) and Roche (1953) shows that the thickness of the bones rounds the top of the skull increases by 15% with spurt at adolescence, however their argument is the bone thickness solely not contribute to the increment, the acceleration of the brain itself must take into consideration (Tanner, 1962). We can say that the cranial volume is same between genders since there is no different between genders in head circumference for both age groups. The other possibility is that the female cranial volume increases more than male initially since at the age of twelve years old both sexes shows a minimal difference. As the differences of head circumference between 12 year old and 7 year old is significant in female only, it gives an impression that further study need to be done to find out at what age during pre pubertal period this changes take place in female.

From the analyzed data, it shows that there is almost no different in cephalic index between the gender and almost no increases from seven to twelve years old. Proportion wise there is no different in the head width in related to the head length for both aged group and the proportion also does not increase much from the age of seven to twelve years old. Cephalic index was introduced by Anders Retzius (1843) where it defines the proportional quality of the head (Farkas, 1992). The cephalic index gives an idea either the head are bracycephalic (short wide head) or dolichocephalic (long-narrow head). When the cephalic index up to 74.9, the head considered dolicocephalic and if the index range 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). From the data, both female and male in both age group considered having a brachycephalic head (mean value; 81.61 ± 4.95mm for seven years old male, 82.06 ± 4.05mm for seven years old female, 81.92 ± 4.98mm for twelve years old male and 82.20 ± 5.74mm for twelve years old female). The child in comparison to adult actually looks more brachycephalic. The bracycephalic type of head might due to the brain, whereby the basicranium is precocious relative to facial development (Enlow & Hans, 1996).

The discussion of the craniofacial height(v-gn) and the head-craniofacial height index will be discuss in the face region because they are inevitable 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 this aged group.

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 and mandibular width. The measurement of face height, upper face height, and mandibular height gives an idea of the facial framework vertically. The depth of maxilla and mandible shows a lateral framework of the face.

As what we expected the data analysed in this study shows that the transverse, vertical and depth of the facial framework of 12-year-old group were significantly larger than seven-year-group in both genders. This revealed that there is a continuous incremental growth changes during the pre pubertal period.

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

The growth rate of the face is highest at birth then fall sharply and reaches a pre pubertal minimum level some 2 years earlier in girls than in boys. The growth rate then increases to a peak at puberty, declining again and tailing off till growth ceases in late teenage (Foster TD, 1990). However many studies demonstrated that the growth does not cease but rather proceeds at a slower rate beyond the fifth decade (Behrents, 1985).

In this study it shows that the most means increases occurred in the mandibular depth and maxillary depth and followed with an increase in vertical and width measurement. This finding is consistent with Thilander 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 also consistent with Hellman observation where he said that the depth of the face increased the most followed by height and width.

5.1.2.1. Lateral/anteroposterior/depth of the face.

Mandibular depth (t-gn), which also a measurement of the lower third face depth shows that 12-year-old group is 14.86mm larger than 7-year-old group in males and 14.61mm in females, this findings were significant ($p<0.05$). In this study, the mandibular depth shows the largest measurement in 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 occur on the posterior margin of the ramus with simultaneous bone resoption along its anterior contours. At the same time the marked lengthening of the alveolar may also occasionally occur (Thilander, 1995). From the findings, it shows that the male and female during pre pubertal period shows a same incremental in growth at this region.

The significant difference in sexes has been found, 3.42mm and 3.67mm in seven and twelve years old group respectively. The available data shows that there is a different of growth at this region during pre pubertal period between genders.

The maxillary depth (t-sn) which is the measurement of the middle third face depth increased consistently with mandibular depth. The male of 12-year-old is 11.5mm larger than 7-year old group and female 12-year-old group is 10.97mm larger than 7-year-old group. The findings were statistically significance ($p<0.05$). 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 elongated during this period and as a result creating the 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 of the increment in the maxillary depth because the subjects in this study are 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 indicates the developing naso pharynx at this age group.

The sexes differences in maxillary depth are about 2.56mm in seven years old group and by 3.09mm in twelve years group. However this differences is not significant ($p>0.05$). It explained that there is no different in the growth between sexes at this age groups.

From both of above findings we can have the proportion indices of the maxillary depth(t-sn) in relative to mandibular depth(t-gn). The proportion indices shows us a middle lower third face depth index (t-sn x 100/t-gn) or in other word it gives us a clue about a ratio of antero-posterior growth of the middle and lower third face. It shows a decrease by 2.11mm in females and 1.83mm in males but the results were not significant. The decrease in this index is related to the higher mean value in mandible than maxilla. Since the result was not significant, we might considered that male has a same proportion at this region during pre pubertal period (between age 7 and 12). Female also shares same proportion indices between 7 and 12 year old or during their pre pubertal period.

The differences in sexes were significant of about 0.53mm and 0.25mm in age group of seven and twelve respectively. This finding shows that the proportion of the antero-posterior of the maxilla in relation to the mandible was different between male and female in both aged groups. It means that the male and female does not share the same proportion indices at this region during their pre pubertal period.

5.1.2.2 Facial height/vertical height

The upper, middle and lower facial heights are highly independent variables. The facial height represents the vertical dimension of the face. The upper anterior face height seems primarily correlated with growth changes in the cranial base while the dimensions of the lower face height seems to be dependent on muscle function, environmental factors as well as airway functional space and head posture (Thilander. 1995).

The measurement from nasion to the stomion represents the middle face height. It has been found that the upper face height in 12-year-old was 7.1mm larger than 7-year-old in males and 6.89mm in female. The vertical growth of the middle face occurs as the 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) explain in detail that the increase in vertical facial height or more precisely in middle face is consistent with the growth of the maxilla bone. The downward and forward displacement of the maxilla is due to the continous growth of the brain and cranial base. Further vertical growth of maxilla is continues with contributions from frontomaxillary, frontonasal, frontozygomatic, eithmoidalmaxillary sutures and possibly the nasal septum. The vertical descent of maxilla is 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 matrix such as influence of respiratory to enlarged 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 finding is implicated to our subject since their age is at the stage of eruption of permananet dentition. This explained the increase in growth of the middle face for both aged group.

Sex differences in upper face height of about 1.63mm in seven years old group and 1.84mm in twelve years old group with male generally have a larger mean value than female have been found in this study. However the differences were not significant statistically. Based on the finding we can assume that for the vertical growth of the midface, the male and female shows a same growth pattern. The other explanation is that the gender differences at middle face region might develop after the aged of twelve years during the pubertal growth spurt.

Mandible height (sto-gn) or also considered as lower third face height measured the lower vertical face anteriorly. The result shows a significant different by 5.12mm larger in 12-year-old than 7-year old in males and 5.21mm in females. Generally male has a larger mean value than female and from the result there is not much different in increment for both genders. The growth of the condylar cartilage contributes most of the total ramus height which will reflect the vertical facial height. During childhood the inclination of condyle is more vertical compared 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 contribute 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 subject.

The differences in sexes of the mandibular height are by 0.84mm in males and 0.75mm in females and these findings are not significant. It indicates that during pre pubertal period the vertical growth for both sexes is the same. This consistent with many studies where it shows that the lower vertical growth shows a significant different after the age of twelve (Snodell et al, 1993).

Face height (n-gn) is represented by measurement from nasion (point of nasal root) to gnathion (chin point). From the analyzed data, the 12-year-old male is 10.6mm larger than 7-year-old in male and 11.25mm in female. These findings were statistically significance ($p<0.05$). The increase in vertical facial height is consistent with the growth of the maxillary and mandibular bone. It is expected that the facial height shows a significant different between older group and younger group. This is because from the finding the vertical height of upper, middle and lower face shows a significant different with all the elder group were higher than the younger group. As a result the facial height in this pre pre pubertal group is increase due to the continues vertical growth of the maxilla and mandible.

The sex difference in facial height varies from 2.96mm in seven years old group to 1.97mm in age group of twelve with males mean value larger than female in both age groups. However the differences between sexes were not significant(p>0.05). From the results it can be considered that both sexes achieved the same growth in facial height between 7 and 12 year old or during pre pubertal period. This is consistent with middle face height and lower face height that represent the facial height, where they showed no significant different (p>0.05) between sexes. It considered that the male and female during pre pubertal period have a same achievement in growth at this specific region.

Male 12-year-old is 17.8mm higher than 7-year-old and 11.54mm in female for the craniofacial height (v-gn) and these finding were significant.

The craniofacial height represent the total height of the vertical dimension of the head and face. It is not surprise to see the significant increase in this region because all the other measurement that represent the vertical head-face height (head height, middle face height and lower face height) is consistently increase or larger in elder group compared to younger group. It indicates the consistent growth of the head, middle face and lower face.

Generally male has a larger value compared to female and the difference is about 7.96mm in seven years old but the different is not significant (p>0.05). However there was a significant different of 1.7mm in twelve years old group. The differences between sexes at 12 years old is very small however if this was taken as consideration then is shows that the growth differences in sexes just have been started. It is difficult to explain why suddenly the sexes different occurs in the age group of 12 as the rest of the result that measures the vertical height of head and face shows no different between sexes. However the small sample size in this study might contribute to this differences.

5.1.2.3 transverse/width of face

The face width (zy-zy) is the measurement of bizygomatic diameter or it also represents the upper face width. The face width in 12-year-old is 10.84mm larger than 7-year-old in male and 13.4mm in female. The mean difference between genders in face width is 3.6mm in seven years old and only 1.04mm in twelve years old. However all findings were not significant thus it explained that there is not much different in growth increment in the transverse direction between this age. It also explained that the growth at the facial width between male and female is same. The face width or the transverse growths of the face are contributed by 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.

Generally male has a larger value in both age groups thus from this finding we can say that male has a larger facial width than female and the broader face in male may continue into adulthood.

Mandible width (go-go) is a bigonion diameter or lower face width, from the calculated data, the 12-year-old is 8.92mm larger than 7-year-old in male and 8.16mm in female and these differences shows a significant different ($p<0.05$).

Sex differences in about 3.26mm in age group of seven and 4.02mm in twelve years old group have been found and these mean is significant in age group of twelve. Sex differences in mandibular width of about 3mm have been found (Farkas, 1981).

Mandible is 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 that the maxillary growth is minimal after 10 years of age but 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 is less than the facial width reflects that the sample subject in this study not reach the puberty yet where the peak growth of the mandible should occurs. It also has been found that the width increases to be less than vertical changes (Snodell et al., 1993; Bishara et al., 1995). It also same in this study where the facial vertical mean is higher than the facial width.

As usual generally male has a larger value compared to female in both age groups. It explained why male has a more prominent jaw than female.

Mandible-face width index(go-go x 100/zy-zy) shows a proportion indices of a mandibular width in relation to a facial width. A decrease by 2.02mm in female and increase by 0.13mm in males but the results is not significant. The results also gives an impression that male during this pre pubertal period has a same proportion at this region. It also same for the female.

There is no significant different between sexes at age of 7 year old but a significant difference in sexes in group of twelve of about 2.5mm with the male are larger than female. The larger mandibular width and face width in male than female might contribute to this. It explained that by the age of 12 year old or just before they reach puberty, the different in sexes of this proportion has been started. It might explained where the male ready to become more manly looks with a more broader face and more prominent jaw and female has a more feminine looks.

Further study or measurement need to be carried out at this region to encounter at what age actually the different in sexes has been started during pre pubertal period.

The facial index (n-gn x 100/zy-zy) shows that a 12-year-old was 0.1mm smaller than 7-year-old in female. However the male of 12 year-old was 0.84mm larger than 7-year old. However this finding is not significant. The differences in sexes for the facial index almost the same but it is not significant. It means that proportion wise, there is no different between male and female in facial index.

The mandibular index (sto-gn x 100/go-go) shows an increase of 2.11mm for males and 1.77mm for females. The increases in index might due to the consistently increase of mandibular height and mandibular width. The differences in sexes were almost the same, 0.54mm and 0.93mm in seven and twelve years old respectively but the finding is not significant. It also shows that in this aged group the proportion of the mandibular height in relation to mandibular width of male and female is the same.

The upper face-face height index (n-sto x 100/n-gn) shows a minimally decrease in female by 0.38mm and increase by 0.42mm in males but the differences were not significant. The differences in sexes in this index also not significant and the differences were very small.

For the mandible-upper face height index (sto-gn x 100/n-gn), there is an increment by 1.02mm in females and 1.26mm in males form seven to twelve years. The increment is consistent with the increase in mandible height and upper face height. The differences in sexes is about 0.3mm with female larger than male and 0.5mm with male larger than female in seven years old and twelve years old group respectively. However this data is not significant.

As for the head craniofacial height index(v-nx100/v-gn), there is almost no different in mean value for both aged group. The increases in mean from seven to twelve years old also very minimal and these finding is not statistically significant (p>0.05). It reflects that, proportion wise of the head craniofacial height index of male and female for both aged group actually is the same. The increment in the proportion from seven to twelve years old also shows no different for both genders. This data indicates that the mean value can be use for the both genders and for both aged groups

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 accepted that the position of the eyes is relevant 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 studies in the orbital region in Chinese Taiwan children reveal that the inner canthal distance(en-en) is wider than the palpebral fissure length(ex-en) and this result is the reverse in Caucasian children. From the finding they suggested it is not correct to diagnose hypertelorism in Chinese children in Taiwan base on the western data. They also suggested that the measurements should be adjusted with a normal standards specific for race (Wu et al,2000).

Form this study we establish our own data for the Malaysian children at age of seven and twelve and hope this normal mean value can help us in differentiate the hyper telorism from the normal eye position.

The intercanthal width (en-en) shows a significant different between elder group by 2.07mm larger than younger group in males and by 2.18mm in females. Farkas mentioned that the increment in this region is due to the intensive growth in the interorbital space in infancy and early childhood and he claimed this region matured earlier in early childhood (Farkas, 1992).

Intercanthal width mean value in males is larger than females in both age group and it is significant ($p<0.05$). The overall intercanthal distant in Chinese subjects in the Republic of Singapore are 34.4 ± 2.7 in male and 34.0 ± 2.3 in female 6 year old. The intercanthal width is 37.5 ± 2.8 in male and 35.6 ± 2.9 in female for 12 year old (Farkas, 1994) Our overall result was slightly lower than theirs; (for 7 year old male; 32.41 ± 2.04, 7 old female; 31.70 ± 2.19, for 12 year old male; 34.48 ± 2.13 and 12 year old female; 33.88 ± 2.54). In comparison with the data of 7 and 12 year old Caucasian North America children by Farkas, our mean value is 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 shows that the Malay population at this aged group is in between the Chinese children and the Caucasian children. As a result we should use our own data in making a diagnosis or this valuable data also can be used as a guide during reconstruction or as an evaluation of the successful reconstruction post operatively.

The sexes different in intercanthal width are of 0.71mm and 0.6mm for seven years old and twelve years old group respectively. However the differences are not significant. This none significant different indicate that the male and female shows a same growth pattern in intercanthal width during theirs pre pubertal period.

The biocular width (ex-ex) is the measurement of a distant between the right and left outer commisure of the palpebral fissure. From the analyzed data it shows that the 12-year-old were 8.28mm longer in distant in males and 9.54 in females. This finding is significant ($p<0.05$). Generally the male has a larger biocular width than female. The increment in the biocular width give rise to a question whether the increment is due to the increase in intercanthal width or the palpebral fissure. From Farkas (1992) observation in 1 to 18 years old group it shows that the intercanthal width gaining 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 intercanthal width increases consistent with the growth in the interorbital spaces in infancy and early childhood. It shows that the continuous, gradual annual increment occurs in binocular width(84%) is greater than intercanthal width(43.7%) after 5 year old (Farkas 1992). From this finding we can say that the increases in binocular width at the age of seven and twelve are contribute much by the growth in palpebral fissure. We know 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.

The different in sexes in seven years old group is about 3mm and it is significant whereas there is no significant in twelve years old. The different in twelve year old group were only a fraction of a milimeter and this indicates by this age the growth pattern between sexes is almost the same.

From the both measurement (intercanthal and binocular width) the proportion indices of intercanthal index is derived. In other words the Intercanthal index (en-en x 100/ex-ex) is the relationship of the intercanthal width to the biocular width and it gives a great influence in visual judgement of the proportions of the orbits. The male shows a decrease in intercanthal index but it is not significant. However female shows a significant decrease in intercanthal index. The decrease in intercanthal index might due to the early maturation of intercanthal width. It means that in this age group the increment for the intercanthal width is less than the length of the eye. From Farkas (1992) observation, the biocular width shows a continuous, gradual annual increment after 5 years old than intercanthal width. This explained the decreases in this proportion index. 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 inter canthal width to biocular distance ratio. This process continues after birth until adult age (Daniele et al 1998).

The female has a higher intercanthal index in seven years old group but as they reached twelve years old the male has a larger intercanthal index. This observation might be explained by the early maturation of female in intercanthal width than male.

For an eye fissure length (ex-en), the 12 year-old-group was 2.43mm larger in males and 2.98mm in female and these findings were significant. Our study shows that the eye fissure length is wider than intercanthal width. In contrast with the Chinese children Taiwan it shows that the intercanthal width is wider than the eye fissure length and it causes the look of hypertelorism in their age group. Our finding is consistent with Caucasian children where they have a wider in eye fissure length than intercantal width (Farkas, 1994).

The different in sexes of about 0.84mm and 0.29mm in seven and twelve years of age respectively has been found in this study. However the results were not significant. The minimal different that occurs between sexes indicate that the early maturation at this region already occur as explained by Farkas thus the male and female shows a same growth pattern during pre pubertal period.

Interestingly eye fissure height (ps-pi) shows that the elder groups were 0.59 smaller in females and by 0.75mm in males. These findings were significant. It is a wonder why the eye fissure height decrease as the age increases. The eyes appear large in young child but appear smaller in proportion in adults. The young child 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) mentioned that with age the thickness of eyelid is reduced due to deposit of lipid and the eyes also appears sunken with drooping bags and deep supraorbital creases. We can assume that since the orbital matured earlier than the nose and jaws so as the rest of the face increase in size the orbit shows a minimal increment and this reflect the size of the orbit looks smaller. Since the soft tissue around the orbit also matured earlier, another assumption can be reveal from this finding is that the aging around the orbital soft tissue may occurs at the early age as well.

Generally female has a higher eye fissure height than male and a different of 0.04mm and 0.2mm were observed in seven and twelve years old age group but the differences were not significant. It shows that there is no different in eye fissure height of male and female at this age group.

Eye fissure index (ps-pi x 100/ex-en) shows a significant decrease by 3.9mm in males and by 3.87mm in females. The decrease in this index might due to the decrease in eye fissure height. Generally female has a larger in eye fissure height than male and this might due to the larger in eye fissure height in female compared to male. The sex's differences in eye fissure index of 0.89mm and 0.92mm have been found in seven and twelve years old of age respectively but the finding is not significant.

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 allow for scar camouflage when reconstructing nasal defects (Ridley, 1992).

The nasal growth plays an important contributor 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 occur coincide with the development of the nasal airway complex (Farkas, 1992).

The measurement of the nasal width is performed from the most lateral points of the nasal alae. The nasal width in 12-year-old male was 3.65mm larger than 7-year-old and 12-year-old female was 3.52mm larger than 7-year-old. These finding shows a significant different. 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 his 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. However the sex difference in nasal width has generally been found to be quite small in pre pubertal period as the male nose being up to 1mm larger than female (Farkas, 1981; Nanda et al.,1990; Snodell et al.,1993). Our data also shows the same finding where the male has a larger nasal width than female. The differences in sexes shows almost the same finding with theirs where it is almost 1mm with male larger than female (0.82mm in seven years old group and 0.95mm in twelve years old group). However our findings is not statistically significant. It means that there is no different in alar base growth between male and female.

Nose height (n-sn) shows a significant higher in height in elder group than younger group for both sexes. The 12-year-old was 5.94mm larger than 7-year-old in male and 6.77mm in female. By five years old the nose development approached about 76.9% from it eventual adult size. Early rapid growth of the nose height in males was observed between 1 to 4 years then between 11 and 12 years in females (Farkas,1992). This observation might explain why the female has a greater increase in nose height than males. The increase in nose height is explained by Behrents (1985) 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. He also shows that the males have a larger nose as compared to female. Our finding is in agreement with his finding.

The sex difference in nose height has been found about 0.5mm and 0.33 in seven years old group and twelve years old group respectively. However this finding was not significant. It shows that during this age group, the growth in nose height is the same between male and female.

The above measurement gives an indices of nasal index. Nasal index (al-al x 100/n-sn) shows a significant increase of 2.83mm in males and 3.72mm in females from seven to twelve years of age. The increase in nasal index might correlate with the increase in nose width and nose height. Generally male has a higher index than female. This finding is consistent with the larger mean value in nasal width and nasal height in male than female. The sex difference in nasal index of about 1.17mm and 2.69mm in seven and twelve years age group have been found. However the differences were not significant. It shows that the ratio of nasal width to nasal height in male is same as in female during this period of age.

Measurement of the nasal tip protrusion (sn-prn) shows a significant increase by 2.34mm in males and 2.59mm in females. Chaconas (1969) study the cephalometric radiographs and his finding shows that the tip of the nose grew forward with the anterior positioning of the nasal bone. He also demonstrated that the nose grew concomitantly with the maxilla and mandible. Farkas mentioned that the nasal tip protrusion did not mature in early age but at age of 16 in males and 14 years in female. It shows a smaller increment during pre pubertal period (Farkas,1992). The increment in nasal tip protrusion shows almost the same for both sexes and this might due to late growth at this region.

The sex difference in nasal tip protrusion in this study is very small by less than a mm for both age groups. This finding is consistent with Farkas study. However in this study the finding is not significant. It shows that during this period the growth between sexes at this region is the same.

The proportion of the nasal tip protrusion in relation to nose width index (sn-prn x 100/al-al) gives a significant increase of 2.83mm in males and 3.72mm in female. The female shows a higher increment in this proportion because in this study female at age of twelve has a larger measurement as compared to male in the same age group. However the sex differences are not significant and this finding shows that the proportion between male and female at this region is the same.

Nose-face height index (n-sn x 100/n-gn) only shows a significant increase of 1.54mm in female. This might due to the constant increase in nose height and face height.

The remaining of the index, nose-face width index (al-al x 100/zy-zy) did not show any significant changes as the age increase from seven to twelve years old and differences in sexes also not significant.

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). From the data analysis, it shows that the mean values in transverse growth shows the rapid increment than the vertical growth in the lips and mouth region. The vertical growth of lower lip is more than the upper lip.

The measurement of upper lip height (sn-sto) is taken from the base of columella to the stomion point of the labial fissure. The analyzed data shows a upper lip height in both sexes were significant larger in elder group than younger group (1.33mm for males and 1.6mm for females).

There also a significant differences in sexes. It has been found the different in sexes of 1.76mm in seven years old and 1.49mm in twelve years of age. Generally the male has a larger mean value than female.

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 lower face. He further stated that the lips grow earlier in girls than boys. Alternatively Farkas found that the upper lip height achieved 82% of its eventual adult size and increase to 93% by age of five. To take this as a consideration, it explained the small increment in the upper lip height in both sexes during this pre pubertal period..

The mouth width (ch-ch) shows that elder group was 5.42mm larger in males and 5.5mm in females. These findings were significant. If we take the consideration that the mouth grew as the face grew, than the increment in mouth width at this study group are consistent with the increment in nose width as well as the facial width. However from this study it shows that there was no significant difference in sexes. Meaning that during this age group the male and female shows a same growth pattern in this region. Generally male shows a larger mouth width than female.

Upper lip height-mouth width index (sn-sto x 100/ch-ch) shows a significant decrease in males (3.09mm) and females (2.29mm). The decrease in this index is explained by the significantly increase in mouth width compare to upper lip height. The sex differences in upper lip height-mouth width index vary from 2.99mm in seven years old group to 2.19mm in twelve years old group and the finding is significant. It shows 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 should alert us that further study need to be done in this region for each age group between seven to twelve and the age selection should be more widen.

From the measurement of lower lip height (sto-sl); it has been found a significant higher by 2.11mm in elder group of males than younger group and 1.75mm in female. Interestingly we noted that the increment in lower lip height is slightly more than the upper lip height. Proffit demonstrated that the most vertical growth of the upper lip is achieved in females by age of 14 and the lower lip continues to grow vertically to age of 16. In males, growth of both upper and lower lips continues into the late teens with more growth of the lower lip (Proffit, 2003). This explained the more increment in male than in females in this study. Male shows a generally larger in lower lip height than female. However there are no significant differences when comparing the gender in both aged group.

The increase of lower-upper lip height index (sto-sl x 100/sn-sto) is significant in male only by 5.78mm from seven to twelve years old. The significant increase in male is explained by the larger lower lip height in male than female and constant increase in upper lip height in both sexes. There is a significant difference in sexes (5.18mm) at age group of seven. It shows that the different in proportion only occurs at the age of seven and by the age of twelve the proportion in this region is same for both genders. This indicate that further study need to carried out at the level of each group during pre pubertal period to find out the actual age that started the differences in this proportion between genders.

The mouth-face width index (ch-ch x 100/zy-zy) shows a significant increase in male only (1.42mm from seven to twelve years old). The increase in this index is due to the obvious increase in mouth width than face width. The other parameter in mouth-face width index shows no significant different.

5.2 Limitation of this study

Anthropometry is a direct measurement that uses standard landmarks and instrumentation to compare populations. By anthropometric, the facial sizes and proportions are gain and the surgeon uses this data to reproduce cosmetically attractive proportion for their patients when performed reconstructive surgery. It is well accepted now that the so-called 'standard measurement' should not being applied 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 provide a complete data set of the studied age group. Moreover the measurement taken is comparable between sexes.

In this study, the methodology was adapted from the study done by Hajnis et al (1994). However there is always 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 table enables us only to select certain age group and small sample size.

The small samples size in this study contribute 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 is as environment, diet, genetic and socioeconomic status of the subjects.

It is best if this study can be extended further by doing the craniofacial measurement from birth to eighteen years old. By doing so, the percentile of growth pattern for the Malay population can be obtained. The norms measurement also can be readily made available for this population.

Hopefully in the future, this research area will be developed further with more advanced measurement tools, more precise measurement environments and more representative sample of subjects. It would be nice if more researchers are interested in this study despite of all the advanced technologies because up to now it been only a mission of a small number of researchers.

Chapter 6 : Conclusion

While there are many ways to approach craniofacial analysis, it is important that the technique used can be easily remembered and applied. By this way a routine systematic approach will be developed. This will help to maximize the evaluation of the subunit in question and minimizing the risk of overlooking other important abnormalities. Craniofacial anthropometric study has been shown to be useful in analyzing and determines the growth pattern.

The present study establishes the base value for various parameters in the craniofacial complex of the healthy Malay children at age of seven and twelve year old. Various dimensions of craniofacial region were measured. The analysis of the data does not simply indicate the differences in the measurements but also point out changes in growth patterns which will have a clinical significant.

This study reveals that as the age increase there also an increase in measurement for both sexes. We can conclude that both sexes grow during this period of age because most of the measurement shows that the elder group always has a larger measurement than younger group and it observed in both genders. 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 did males in comparable age. In other words it means that the female shows a faster grows or more growth than males but female still at all times smaller than males during this period of age. We can say that males grew a smaller amount over the period examined however males were larger to begin with in pre pubertal period. The assumption can be made that male also grew 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.

By the age of twelve years old, when comparison was made between sexes it shows that even though the differences were exists but the value were small. These indicate that male as well as female show a similar growth pattern among them when they reached 12 years old.

From the proportion indices it shows that the skeleton of craniofacial appears to grow in a remarkably constant fashion and certain area shows a significant different between males and females.

This study establishes the first normal set parameters of the craniofacial region in the seven and twelve years old in Malay population. As a result this normal value can be used for facial analysis, facial reference and also to specify patterns for craniofacial growth.

Appendix A

Table A-1 Linear measurement that shows significant different in both sexes from 7 to 12 year old; older group was larger than younger group (p<0.05)

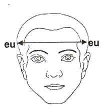
No	Landmark	Gender	Differences (mm)
1	Head width (eu-eu) 	Male Female	3.74 ↑ 6.52 ↑
2	Craniofacial height (v-gn) 	Male Female	17.8 ↑ 11.54 ↑
3	Face width (zy-zy) 	Male female	10.84 ↑ 13.4 ↑
4	Mandible width (go-go) 	Male Female	8.92 ↑ 8.16 ↑
5	Face height (n-gn) 	Male Female	10.6 ↑ 11.25 ↑
6	Upper face height (n-sto) 	Male Female	7.1 ↑ 6.89 ↑
7	Mandible height (sto-gn) 	Male Female	5.12 ↑ 5.21 ↑

Table A-1 **Linear measurement that shows significant differences in both sexes from 7 to 12 year old; older group was larger than younger group p<0.05 (continued)**

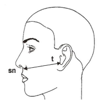
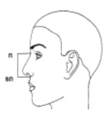
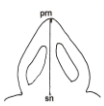
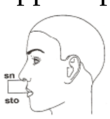
No	Landmark	Gender	differences (mm)
8	Maxillary depth (t-sn) 	Male Female	11.5 ↑ 10.97 ↑
9	Mandibular depth (t-gn) 	Male Female	14.86 ↑ 14.61 ↑
10	Intercanthal width (en-en) 	Male Female	2.07 ↑ 2.18 ↑
11	Biocular width (ex-ex) 	Male Female	8.28 ↑ 9.54 ↑
12	Eye fissure length (ex-en) 	Male Female	2.43 ↑ 2.98 ↑
13	Nose width (al-al) 	Male Female	3.65 ↑ 3.52 ↑
14	Nose height (n-sn) 	Male Female	5.94 ↑ 6.77 ↑
15	Nasal tip protrusion (sn-prn) 	Male Female	2.34 ↑ 2.59 ↑
16	Upper lip height (sn-sto) 	Male Female	1.33 ↑ 1.60 ↑

Table A-1 Linear measurement that shows significant differences in both sexes from 7 to 12 year old; older group was larger than younger group p<0.05 (continued)

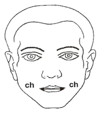
No	Landmark	Gender	differences (mm)
17	Mouth width (ch-ch) 	Male Female	5.42 ↑ 5.50 ↑
18	Lower lip height (sto-sl) 	Male Female	2.11 ↑ 1.75 ↑

Table A-2 Linear measurement that shows significant differences in female only from 7 to 12 year old; older group was larger than younger group p<0.05

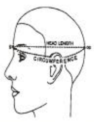
No	Landmark	Gender	Increment (mm)
1	Head length (g-op) 	Female	10.32 ↑
2	Head circumference (on-op) 	Female	36.56 ↑

Table A-3 Linear measurement that shows significant differences in male only; older group was larger than younger group p<0.05

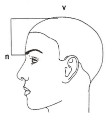
No	Landmark	Gender	differences(mm)
1	Head height (v-n) 	Male	8.38 ↑

Table A-4 Linear measurement that shows significant difference in both gender from 7 to 12 year old. Elder group was smaller than younger group p<0.05

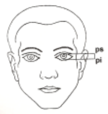
No	Landmark	Gender	differences (mm)
1	Eye fissure height (ps-pi) 	Male Female	0.59 ↓ 0.75 ↓

Table A-5 Proportion indices that shows significant increase (p<0.05) from 7 to 12 year old for both sexes; elder group was larger than younger group

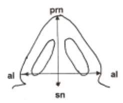
No	Landmark	Gender	Increment (mm)
1	Nasal tip protrusion-nose width index (sn-prn x 100/al-al) 	Male Female	2.83 ↑ 3.72 ↑

Table A-6 Proportion indices that shows significant decrease (p<0.05) from 7 to 12 year old for both sexes

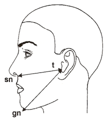
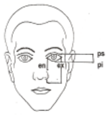
No	landmark	Gender	Decreases (mm)
1	Middle-lower face depth index (t-sn x 100/t-gn) 	Male Female	2.11 1.83
2	Eye fissure index (ps-pi x 100/ex-en) 	Male Female	3.9 3.87
3	Upper lip height-mouth width index (sn-sto x 100/ch-ch) 	Male Female	3.09 2.29

Table A-7 Proportion indices that shows significant increase from 7 to 12 year old in male only

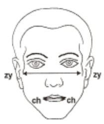
No	Landmark	Gender	Increment (mm)
1	Lower-upper lip index (sto-sl x 100/sn-sto) 	Male	5.78
2	Mouth-face width index (ch-ch x 100/zy-zy) 	Male	1.42

Table A-9 Proportion indices that shows significant increase from 7 to 12 year old in female only

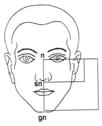
No	Landmark	gender	Increment (mm)
1	Nose-face height index n-sn x 100/n-gn) 	Female	1.54

Table A-10 Linear measurement in aged group of 7 that shows a significant different ($p<0.05$) between sexes

No	Landmark	Differences in mean value (mm)
1	Head width (eu-eu) 	3.86
2	Head length (g-op) 	5.86
3	Mandibular depth (t-gn) 	3.42
4	Biocular width (ex-ex) 	3.00
5	Upper lip height (sn-sto) 	1.76

All the measurement shows that male has a larger mean value than female

Table A-11 Proportion indices in aged group of 7 that shows a significant differences (p<0.05) between sexes

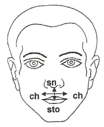
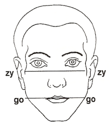
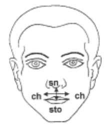
No	Landmark	Differences in mean value (mm)
1	Upper lip height-mouth width index (sn-sto x 100/ ch-ch) 	2.99, male larger than female
2	Lower-upper lip height index (sto-sl x 100/sn-sto) 	5.18, female larger than male

Table A-12 Linear measurement in aged group of 12 that shows a significant different (p<0.05) between sexes

No	Landmark	Differences in mean value (mm)
1	Craniofacial height (v-gn) 	7.96
2	Mandibular width (go-go) 	4.02
3	Maxillary depth (t-sn) 	3.09
4	Mandibular depth (t-gn) 	3.67
5	Upper lip height (sn-sto) 	1.49

All the measurement shows that male has a larger mean value than female

Table A-13 Proportion indices in aged group of 12 that shows a significant different ($p<0.05$) between sexes

No	Landmark	Differences in mean value (mm)
1	Mandible-face width index (go-go x 100/zy-zy) 	2.50
2	Upper lip height-mouth width index (sn-sto x 100/ ch-ch) 	2.19

All the measurement shows that male has a larger mean value than female

References

1. A. Bjo''rk and V. Skieller: Am J.Ortho. Volume 62, issue 4, October 1972. Pg 339-383.
2. Am Howe, Hawkins JK, Webster WS. 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 2004; 49(4) : 171-176.
3. Ayoub AF, Siebert P, Moos KF, et al; A vision-based three-dimensional capture system for maxillofacial assessment and surgical planning. Br J oral Maxillofac Surg 1998: 36: 353-7.
4. B.D Chaurasia's (2003). Human Anatomy, regional and applied, 3rd edn. New Delhi: CBC Publishers.
5. 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.
6. 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.
7. Budai M, Farkas Lg et al: Relation between Anthropometric and cephalometric measurements and proportions of the Face of healthy Young White Adult Men and Women. J.Craniofac Surg. 2003; 14: 154-161.

8. 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.
9. Copray JC: Growth of the nasal septal cartilage of the rat in vitro, J Anat 144: 99-111, 1986.
10. Copray JCVM, Jansen HWB, Duterloo HS; 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, 1986.
11. Cortella S, Shofer FS, Ghafari J. Transverse development of the jaw: norms for the posteroanterior cephalometric analysis. Am J. Ortho Dentofacial Orthop 1997. 112:519-522.
12. C.S Sinnatamby (2001). Last's Anatomy, regional and applied, 10th edn. Edinburgh: Harcourt Publishers.
13. Cozza P, Stirpe G et al. Craniofacial and body growth: a cross sectional anthropometric pilot study on children during pre pubertal period. Eur J Paediatr Dent. 2005; 6(2): 90-6.
14. Daniele Denis, Olivier Burguiere, Carole Burillon. A biometric study of the eye, orbit and face in 205 normal human fetuses. Investigative Opthalmology Visual Science Vol 39, pp 2232-2238; 1998
15. De Carlo D, Metaxas D, Stone M: An Anthropometric face model using variational techniques in processing SIGGRAPG 98' pp 67-74. 1998. Department of Computer and Information Science University of Pennsylvania.
16. Diewert VM: Development of human craniofacial morphology during the late embryonic and early fetal periods. Am J Orthord 1985 Jul;88(1): 64-76

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

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

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

20. Evereklioglu C, Dogany S, Hamdi Er, et al., Craniofacial Anthropometry in a Turkish population. The Cleft Palate Craniofacial Journal. Vol 39, No 2 pp 208-218.

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

22. Farkas LG, Bryson W, Tech B, Klotz J; Is Photogrammetry of the face reliable? 1980; 66: 346-354

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

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

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

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

27. Farkas LG, Posnick JC; Growth development of regional units in the head and face based on anthropometric measurements. Cleft Palate- Craniofacial Journal, 1992(29).
28. Farkas LG, Posnick JC, HreckoTM. Anthropoetric growth study of the head. Cleft Palate Craniofac J 1992a; 29:303-308.
29. Farkas LG, Thompson BD, Katie MJ, Forrest CR: Differences between Direct (Anthropometric) and indirect (Cephalometric) measurements of the skull. J Craniofac Surg 2002; 13: 109-110.
30. Ferrario VF, Sforza C, Dellavia C et al. Three dimensional nasal meorphology in cleft lip and palate operated adult patients. Annals of Plastic Surgery. Oktober 2003; 51(4): 390-397
31. Foster TD ; A Textbook of orthodontics 3rd edn. Blackwell Scientific Publications
32. Goel SP, Dayal SS, Ramesh Babu CS et al; Anthropometric assessment of inter canthal interpupillary and outer orbital dimensions: normal range. Journal of the Anatomical Society of India. 1987 Dec; 36(3): 160-6.
33. Guyot L, Dubue M et al.; Comparison between direct clinical an digital phoogrammetric measurements in patiens with 22q11 microelectron. Int. J. Oral Maxillofac Surg. 2003; 32: 246-252.
34. 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
35. Houpt MI: Growth of the craniofacial complex of the fetus. Am J Orthod 58: 373-383, 1970

36. Hutton TJ, Buxton BF, Hammond P, Potts HWW: Estimating average growth trajectories in shape-space using Kernel smoothing. IEEE transactions on medial imaging, 2003.
37. Jennifer PP: The average African American male face: An anthropometric analysis. Arch Facial Plast Surg. 2004; 6: 78-81.
38. Kawakami SC, White PS (2004). A comparison of aesthetic proportions between the Oriental and Caucasian nose.Clin-Otolaryngol. Vol 29(6): pp 672-676.
39. Kolar JC and Salter EM; Craniofacial Anthropometry: Practical Measurement of the head and face for clinical surgical and research use. Charles C. Thomas Publisher LTD, 1996.
40. Krogman WM, Cooper HK etal. Craniofacial growth, prenatal and postnatal. Cleft lip and cleft palate: a team approach to clinical management and rehabilitation. WB Saunders, 1979; pp 22-107
41. Leong SC, WhitePS (2004) A comparison of aesthetic proportions between the oriental and Caucasian nose. Clin-Otolaryngol Vol 29(6): pp 672-676.
42. 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
43. Levihn WC: A cephalometric rontgenograpic cross sectional study of the craniofacial complex in fetuses from 12 week to birth. Am J Orthodontics 53: 822-848, 1967.
44. Loise Schever & Sue Back (2004); the juvenile skeleton. Elseivier Publications

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

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

47. Madjarova LM, Madzharov MM, Farkas LG, Katie MJ. 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. 1999 Mar; 36(2): 123-6

48. McKay GS, Yemm R. the structure and function of the temporomandibular joint. Br. Dent J 1992;5: 127-132

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

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

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

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

53. Moss ML. the functional matrix hypothesis revisited 1. The role of mechanotransduction. Am J Orthod Dentofac Orthop 1997; 112: 8-11

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

55. Moss ML. The functional matrix hypothesis revisited 3. The genomic thesis. Am J Orthod Dentofac Orthop 1997; 112: 338-42
56. Moss ML. The functional matrix hypothesis revisited 4. The epigenetic antithesis and the resolving synthesis. Am J Orthod Dentofac Orthop 1997; 112: 410-7.
57. Moyer RE, Bookstein FL. The inappropriateness of conventional cephalometrics. Am J Orthod 1979; 75:599-617.
58. Murphy WK, Laskin DM, Richmond MS. Intercanthal and interpupillary distance in the black population. Oral Surg Oral Pathol. 1990; 69: 676-680
59. Nanda RS, Meng H, Kapila S and Gooruis J (1990). Growth changes in the soft tissue profile. Angle orthodontist 60, 177-190.
60. Nute SJ and Moss JP: Three dimensional facial growth studied by optical surface scanning. British Journal of orthodontics 2000(27); 31-38
61. Ogus HD, Toller PA. Common disorder of the temporomandibular joint. 2nd edn. Wright Bristol, 1986; 1-7
62. Porter JP, Olson KL. Anthropometric facial analysis of the African American woman. Arch Facial Plast Surg. 2001; 3: 191-197.
63. Proffit WR and Fields Jr. HW;(2000) Contemporary orthodontics. 3rd edn. USA Mosby.Inc.
64. Proffit WR, White RP Jr, Sarver DM. Contemporary treatment of dentofacial deformity. 2003, Mosby Publisher.
65. Ranly DM. A synopsis of craniofacial growth 2nd edn. Prentice-Hall International Inc, 1998.
66. Gliklich RE (1997) Facial Surgery, Plastic and Reconstruction. Cheney ML. Willians and Wilkins Publisher

67. Ridley MB (1992). Facial plastic and reconstructive surgery pg 99-100
68. Roger BO (1974) The role of physical anthropology in plastic surgery today. Clin Plast Surg 1(3); pp 439-498.
69. 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.
70. Sadler TW (1995). Langman's medical embryology. 7th edn. Baltimore, Maryland USA: Williams and Wilkins.
71. Sadowsky PL. Craniofacial growth and timing of treatment. Am J Orthod 1998; 113: 19-23.
72. Sim RS, Smith JD, Chan AS: Comparison of the aesthetic facial proportions of Southern Chinese and white women. Arch Facial Plast Surg. 2000 2(2): 113-20.
73. Snell RS (1992) Clinical anatomy for medical students, 4th edn. USA: Little, Brown.
74. Snodell SF, Nanda RS and Currier GF. A longitudinal cephalometric study of transverse and craniofacial growth. American J Orthod and Dentfac Orthopedc 1993, 104; pp 471-483.
75. 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.
76. 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.

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

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

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

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

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

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

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

84. Zarnecki ST: Am J Orthod Dentofacial Orthop, 1993; 104