**Republic of Iraq**
**Ministry of Higher Education**
**and Scientific Research**
**University of Baghdad**
**College of Dentistry**

# Growth Related to Orthodontics

A Project Submitted to

The College of Dentistry, University of Baghdad, Department of Orthodontics in Partial Fulfillment for the Bachelor of Dental Surgery

By

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# Certification of the Supervisor

I certify that this project entitled “Growth Related to Orthodontics” was prepared by the fifth –year student Ruqaia Nizar Abd AL Zahra under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

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# Dedication

All gratefulness, faithfulness to Allah for providing me the strength, patience, perseverance and the ability to undertake, and complete this study satisfactorily. To my family, my father and mother and my friends for their great support and for always believing in me. To my supervisor for his guidance and support.

**Ruqaia Nizar**

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| OT | Orthodontic Treatment |
| TMJ | TemporoMandibular Joint |
| IMO | Intramembranous ossification |
| CL ± CP | Cleft lip ± cleft palate |
| GR | Growth Rotation |

# Introduction

Orthodontic treatment (OT) is often carried out on growing children, so knowledge of facial growth and development is essential for the dental professional to understand the optimum timing of treatment, predictors for success, potential pitfalls, and the stability of the finished result **(Littlewood *et* al., 2019)**.

Phenomenon of growth have been described by Krogman as early as 1943**(Singh, 2007)**. It can be defined as an increase in size by natural development.

The OT may be done by moving teeth using fixed or removable appliance, or orthopedic change using functional appliances and the latest orthognathic surgery to move entire jaws into more favorable positions **(Singh, 2007)**.

In 1743 Bunon first used the term orthopedics in connection with the correction of malocclusion **(Singh, 2007)**. In a growing child with a developing dentofacial deformity, growth modification with functional appliances may be the preferred line of treatment **(Phulari, 2017)**.

For some OT, the patient’s growth status is important. In some cases, orthodontic treatment is more successful if they are still growing—for example, when a patient has an underlying skeletal problem that could be improved using a process known as growth modification. In others, treatment planning is best undertaken when growth is complete (e.g. an adolescent with a severe Class III malocclusion **(Littlewood *et* al., 2019)**.

# Aim of the Study

This project aims to have a brief review about the growth in relation to orthodontics.

# Chapter One: Review of literature

## 1.1 Definition

Growth described by many authors as is an increase in size **(Todd, 1931)**; change in proportion and progressive complexity **(Krogman, 1943)**; the self-multiplication of living substance **(Huxley, 1966)**; change in any morphological parameter, which is measurable **(Moss, 1969)**; and quantitative aspect of biologic development per unit of time **(Moyer, 1973)**.

- In general, the terms growth and development are interrelated and some basic differences between the two can be appreciated. Growth is considered an anatomic phenomenon, while development is a physiological and behavioral phenomenon. Growth is a change in size or quantity, i.e. growth is a measurable aspect of biologic life. Development on the other hand includes growth as well as differentiation **(Phulari, 2017, Thilander *et* al, 2018)**.

**1.2 Terminology Related to Growth:** according to **Singh, (2007)**.

***Growth fields:*** are the outside and inside surfaces of bone are blanketed by soft tissues, cartilage or osteogenic membranes. Within this, blanket areas known as growth fields, which are spread all along the bone in a mosaic pattern, are responsible for producing an alteration in the growing bone.

***Growth sites:*** are growth fields that have a special significance in the growth of a particular bone, e.g. mandibular condyle in the mandible, maxillary tuberosity in the maxilla. The growth sites may possess some intrinsic potential to grow.

***Growth centers:*** are special growth sites, which control the overall growth of the bone, e.g. epiphyseal plates of long bones. Unlike growth sites these are supposed to have an intrinsic growth potential.

## 1.3 Mechanisms of bone formation and growth

**1.3.1 The process of new mineralized bone formation** is known as ossification. This can occur in two ways:

•**Intramembranous ossification** (IMO)—formation of bone in a membrane.

•**Endochondral ossification** (ECO)—bony replacement of a cartilage model.

The IMO is a process in which bone is formed by osteoblasts. It is an important mechanism of bone formation in the cranial vault, mandible and maxilla **(Gill, 2008)**.

The ECO is the process in which bone develops from a cartilaginous precursor. Cartilage is well adapted to undergoing compressive loading because of its avascular nature. Therefore, it is a good precursor in loaded areas such as the long bones, cranial base and mandibular condyle **(Phulari, 2017, Littlewood *et* al., 2019)**.

### 1.3.2 Mechanisms of Bone Growth

**Bone remodeling:** is the basic growth process providing regional changes in the shape, dimension, and proportions of the bone. Along with an increase in size, remodeling facilitates constant reshaping of bone while maintaining the integrity and basic shapes of the bone **(Phulari, 2017, Littlewood *et* al., 2019)**.

**Cortical drift:** is the bony cortical plate drifts by depositing and resorbing the bone substance on the outer and inner surface respectively in the direction of growth. If the resorption and deposition takes place at the same rate, the thickness of the bone remains constant with only change in location of the cortical bone. On the other hand, if bone deposition is more than resorption, thickness of the cortical bone increases along with its movement. For example, the teeth follow the drift of their alveolar bone while the jaw is growing and thus they maintain their position within the surrounding bony structures **(Singh, 2007, Phulari, 2017, Littlewood *et* al., 2019)**.

**Displacement/translation:** is the change in the spatial position of a bone can occur by two types of displacement **(Gill, 2008, Phulari, 2017)**.

**1. Primary displacement:** refers to the change in position of a bone by its own enlargement.

**2. Secondary displacement:** occurs when the position of a bone is changed because of growth of an adjacent attached bone.

### 1.4 History of Craniofacial Growth Theories

It was commonly believed that the head and face grew from growth centers that were under strict genetic control **(Bishara, 2001)**. This theory was proposed by Brodie in 1941. Based on genes determine the overall growth control and the persistent pattern of facial configuration is under tight genetic control **(Phulari, 2017)**.

#### 1.4.1 Sutural Dominance Theory

Sicher 1952 was the main proponent of sutural dominance theory. The sutural concept adhered to the notion that within each suture resided the genetic information that would determine the amount of growth occurring at the site of that suture. This theory regarded suture to be a growth center, a center with an ability to generate tissue separating forces. The sutural theory advocated that the craniofacial suture generated tissue separating forces during growth thereby pushing apart the various bones of the craniofacial complex. However, this theory is disproved now and the research evidence show that the sutures are adaptive. Compensatory growth mechanisms and sutures act as growth sites rather than as growth centers. Thus growth in sutural area is secondary to functional needs. Craniofacial sutures are now considered as important growth sites that serve to facilitate the growth of cranial vault and mid-face. Sutures respond to mild tension forces by surface deposition of bone, thereby enabling bones of the face and skull to adapt **(Phulari, 2017)**.

**1.4.2 Cartilaginous Theory**: Scott 1950 proposed an alternative view, which is regarded as the second major hypothesis, on the nature of craniofacial growth. It was assumed that intrinsic, growth-controlling factors were present only in the cartilage and in the periosteum, thus growth in the sutures was secondary and entirely dependent on the growth of the cartilage and adjacent soft tissues **(Singh, 2007)**.

**1.4.3 Functional Matrix Theory of Growth:** introduced formally in the 1960s by Melvin Moss. This theory holds that neither the cartilage of the mandibular condyle nor the cartilaginous nasal septum is a determinant of jaw growth. Instead, it was theorized that growth of the face occurs as a response to functional needs and neurotrophic influences and is mediated by the soft tissue in which the jaws are embedded. In this conceptual view, the soft tissues grow, and both bone and cartilage react to this form of epigenetic control. Moss theorized that the major determinant of growth of the maxilla and mandible is the enlargement of the nasal and oral cavities, which grow in response to functional needs. Functional cranial components are comprised of the two elements: (1) a functional matrix refers to all the soft tissues and spaces that perform a given function and (2) a skeletal unit refers to the bony structures that support the functional matrix and thus are necessary or permissive for that function **(Carlson *et* al., 2005, Proffit *et* al., 2019)**.

**1.5 Growth periods:** according to Singh (2007) growth can be divided into:

**1.5.1 Prenatal growth**: classified into the following three phases

A. Period of ovum (from fertilization to the 14th day).
B. Period of embryo (from 14th to 56th day).
C. Period of foetus (56th day to birth).

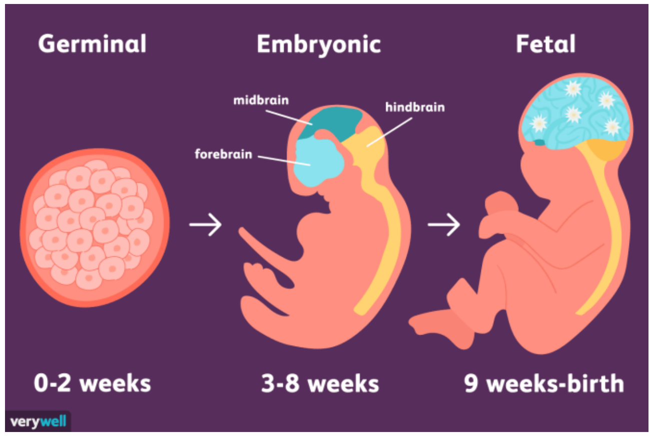

Figure1:Prenatalgrowth(https://www.google.com/urlsa)

**A-Period of Ovum:** this period lasts for two weeks from fertilization to implantation of the ovum to the uterine wall. In this stage, rapid proliferation of cells, occur with no or little differentiation (figure 2) **(Singh, 2007)**.

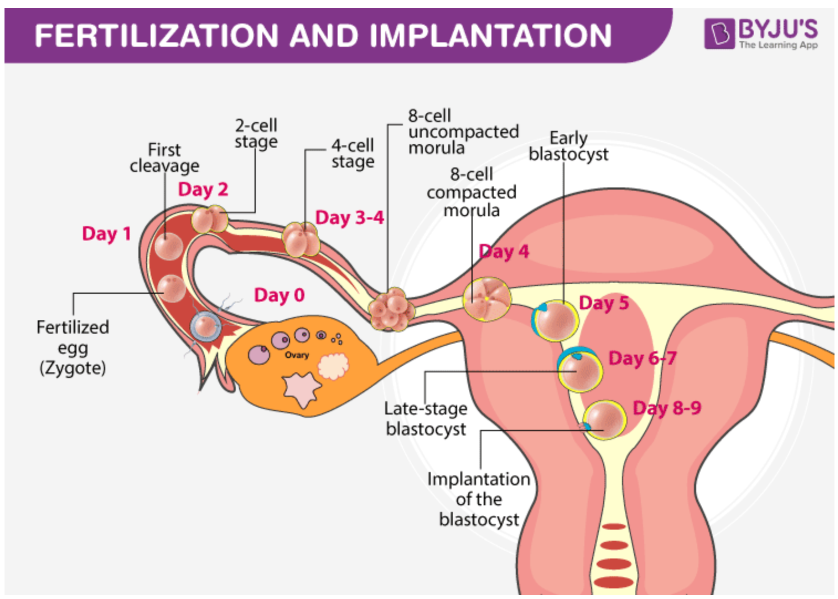

Figure 2: Period of ovum (https://www.google.com/urlsa)

**B-Period of Embryo:** cell proliferation and also differentiation occurs in this stage, which lasts from the 3rd week to the 8th week. Organogenesis occurs in this period which is characterized by differentiation of all major organs and systems. This stage of intrauterine life is particularly vulnerable to exposure of teratogens, such as viruses and drugs. Many recognized congenital defects including cleft lip and palate develop during this period (figure 3) **(Singh, 2007)**.

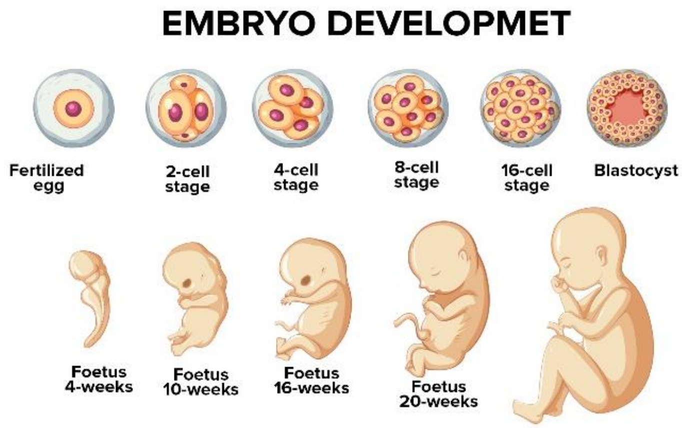


Figure 3: Period of embryo (https://www.google.com/urlsa)

**C-Period of Fetus:** from the 9th week up to birth term, the embryo is called a fetus. Further development is largely in the form of growth and maturation rather than differentiation. Overall increase in the size of the fetus occurs due to an accelerated growth. In addition to the increase in size, a change in the proportion of the structures also occurs (figure 4) **(Singh, 2007)**.

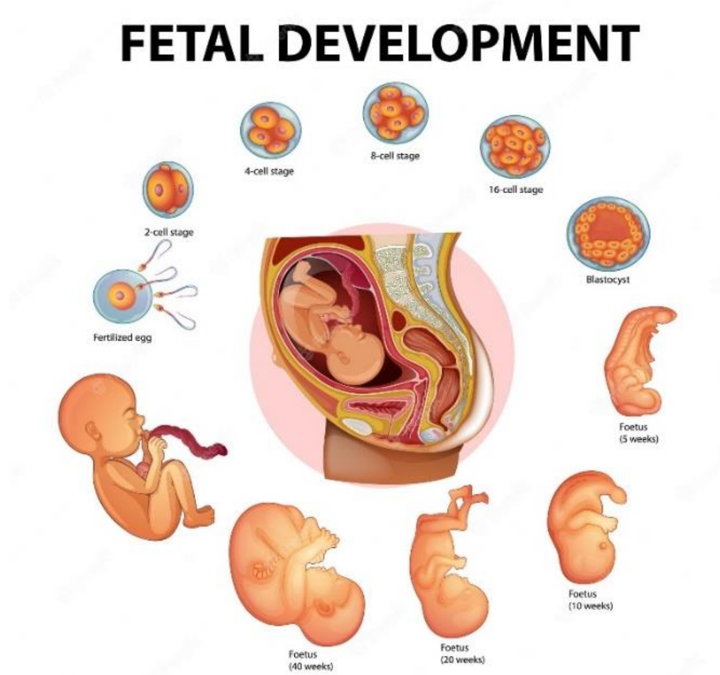


Figure 4 : Period of fetus(https://www.google.com/urlsa)

### 1.5.2 Postnatal growth

To understand growth in any area of the body, it is necessary to understand the following **(Proffit *et* al., 2019):**

(1) The sites or location of growth.

(2) The type of growth occurring at that location.

(3) The mechanism of growth (i.e., how growth changes occur).

(4) The determinant or controlling factors in that growth.

#### 1.5.2.1 Craniofacial Complex

A. The cranial vault the bone that covers the upper and outer surface of the brain.
B. The cranial base the bony floor under the brain, which is also a dividing line between the cranium and the face.
C. The nasomaxillary complex made up of the nose, maxilla, and the associated structures.
D. The mandible.

**A-Cranial Vault (Calvarium):** covers the upper and outer surfaces of the brain. It consists of a number of flat bones, which are formed from IMO. Adaptive growth occurs at the coronal, sagittal, parietal, temporal and occipital sutures to accommodate the rapidly expanding brain. As the brain expands, the separate bones of the cranial vault are displaced in outward direction. This intramembranous sutural growth replaces the fontanels that are present at birth. Apart from growth at sutures, growth also occurs by periosteal and endosteal remodeling. Resorption at the endosteal lining and apposition at the periosteum leads to an increase in the overall thickness of the medullary space between the inner and the outer tables. Cranial vault following the neural growth curve **(Gill, 2008, Phulari, 2017)**.

**B- cranial base:** is formed by ethmoid, sphenoid and occipital bones. The changes in the cranial base occur primarily as a result of endochondral growth through a system of synchondroses. A synchondrosis is a cartilaginous joint where the hyaline cartilage divides and subsequently is converted into bone.

- Intraethmoidal and intrasphenoidal synchondroses—close before birth. Intraoccipital synchondrosis—closes before 5 years of age. Sphenoid synchondrosis—closes before 6 years of age. But the spheno-occipital synchondrosis does not ossify until 13–15 years of age. Thus, major growth occurs at spheno-occipital synchondrosis, which would increase the anteroposterior dimension of the skull base and may produce active growth up to the age of puberty **(Phulari, 2017)**.

**C-Nasomaxillary Complex:** as maxilla is joined to the cranial base, its growth is strongly influenced by the changes occurring at the cranial base. Thus, the position of the maxilla is dependent on the growth of the cartilaginous nasal septum, which carries the nasomaxillary complex downward and forward. The maxilla develops postnatally entirely by IMO. Because there is no cartilage replacement, growth occurs in two ways:

(1) Apposition of bone at the sutures that connect the maxilla to the cranium and cranial base.

(2) Surface modeling and remodeling. In contrast to the cranial vault; however, surface changes in the maxilla are quite dramatic and as important as changes at the sutures. In addition, the maxilla is moved forward by growth of the cranial base behind it **(Singh, 2007, Proffit *et* al., 2019)**.

- The maxilla develops entirely by IMO. Sutural connective tissue proliferations, ossification, surface apposition, resorption and translation are the mechanisms for maxillary growth **(Proffit *et* al., 2019)**.

**D- Mandible:** in contrast to the maxilla, both endochondral and periosteal activity are important in growth of the mandible, and displacement created by cranial base growth that moves the temporomandibular joint (TMJ) plays a negligible role. Cartilage covers the surface of the mandibular condyle at the TMJ. Although this cartilage is not like the cartilage at an epiphyseal plate or a synchondrosis, hyperplasia, hypertrophy, and endochondral replacement do occur there. All other areas of the mandible are formed and grow by direct surface apposition **(Proffit *et* al., 2019)**.

Growth of mandible largely occurs due to IMO. However, few secondary cartilages, especially the condylar cartilage, accelerate its growth postnatally. The two halves of the mandible, separated by a symphysis at birth, are fused into a single bone by the age of 1 to 2 years **(Gill, 2008)**.

The alveolar and muscle processes are poorly developed, so the shape of the mandible in the newborn is determined by its basal arch. Most mandibular growth occurs by periosteal activity. The shape of the angle of the mandible and the coronoid process develop in reaction to forces from the attached muscles. The alveolar processes add to vertical growth with the eruption and development of the teeth. The mandible is displaced forward, by growth of the tongue. Growth at the condylar cartilage fills in posteriorly and periosteal remodelling maintains the shape of the mandible (Figure 5) **(Proffit *et* al., 2019)**.

The role of the condylar cartilage in mandibular growth remains unclear, but it is not a primary growth center. It appears to grow in response to other influences. Backward drift of the ramus as it remodels allows lengthening of the dental arch posteriorly and creates room for the permanent molars to erupt. Remodelling increases the width of the mandible posteriorly and lengthening of the mandible and remodelling causes the chin to appear more prominent. As with the maxilla, complex patterns of surface remodelling maintain and develop the shape of the mandible. Growth occurs at a steady rate of 2–3 mm per year in length of the body of the mandible until puberty when growth rates double. Mandibular growth slows to adult levels at around 17 years in girls and around 19 years in boys **(Gill, 2008, Thilander *et* al, 2018, Littlewood *et* al., 2019, Proffit *et* al., 2019)**.

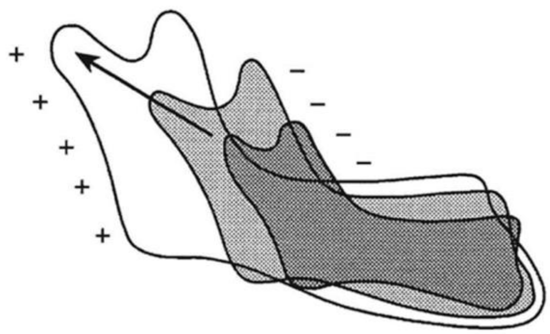


Figure 5: Growth at the condylar cartilage 'fills in' for the mandible following anterior displacement, while its shape is maintained by remodelling, including posterior drift of the ramus (Littlewood, *et* al., 2019).

### 1.5.2.2. Facial Soft Tissues

**A-Growth of the Lips**: the lips trail behind the growth of the jaws before adolescence, then undergo a growth spurt to catch up, because lip height is relatively short during the mixed dentition years, lip separation at rest (often termed lip incompetence) is maximal during childhood and decreases during adolescence (Figure 6) **(Proffit *et* al., 2019)**.

Figure 6: Growth of the lips trails behind growth of the facial skeleton until puberty, then catches up and tends to exceed skeletal growth thereafter. As a result, lip separation and exposure of the maxillary incisors is maximal before adolescence and decreases during adolescence and early adult life. (A) Age 9-11, prior to puberty. (B) Age 14-18, after the adolescent growth spurt. (C) Age 11-16. (D) Age 16-18 (Proffit *et* al., 2019).

- Lip thickness reaches its maximum during adolescence, then decreases to the point that in their 20s and 30s, some women consider loss of lip thickness a problem and seek treatment to increase it (Figure 7) **(Proffit *et* al., 2019)**.

Figure 7: Lip thickness increases during the adolescent growth spurt, then decreases (and therefore is maximal at surprisingly early ages). For some girls, loss of lip thickness is perceived as a problem by their early 20s. (A) Age 9-11, prior to puberty. (B) Age 14-18, after the adolescent growth spurt. (C) Age11-16. (D) Age 16-18 (Proffit *et* al., 2019).

## B-Growth of the Nose

Growth of the nasal bone is complete at about age 10. Growth thereafter is only of the nasal cartilage and soft tissues, both of which undergo a considerable adolescent spurt. The result is that the nose becomes much more prominent at adolescence, especially in boys. The lips are framed by the nose above and chin below, both of which become more prominent with adolescent and postadolescent growth, while the lips do not, so the relative prominence of the lips decreases. This can become an important point in determining how much lip support should be provided by the teeth at the time orthodontic treatment typically ends in late adolescence (Figure 8) **(Proffit *et* al., 2019)**. Recently a review was published of data on nasal growth, the maximum growth velocity of the nose in girls appeared to vary from before the age of 8 years until the age of 12 years, whereas boys generally demonstrate a maximum around the age of 13 years **(Verwoerd, 2010)**.

Figure 8: The nasal bone grows up until about age 10, but after age 10, growth of the nose is largely in the cartilaginous and soft tissue portions. Especially in boys, the nose becomes much more prominent as growth continues after the adolescent growth spurt (and this process continues into the adult years). (A) Age 4-9. (B) Age 12-14. (C) Age 14-18. (D) Age 17-18 (Proffit *et* al., 2019).

**1.6 Maxillary Sinus:** it forms around 3rd month. It develops as an expansion of the nasal mucous membrane into the maxillary bone. Maxillary sinus is small at birth about the size of a pea. It gradually enlarges by resorption of the internal walls of maxilla to reach the adult size **(Phulari, 2017)**.

**1.7 Growth of Palate:** it develops between 6th and 9th week of gestation. The entire palate develops from the following two structures:

**1) Primary Palate:** is the triangular-shaped part of the palate anterior to the incisive foramen. It is developed from frontonasal process. Primary palate forms the premaxilla, which carries the incisor teeth.

**2) Secondary Palate:** gives rise to the hard and soft palate posterior to the incisive foramen. It develops from the fusion of three parts as follows:

A. Two palatine shelves which extend from left and right maxillary process towards the midline.

B. Nasal septum, which grows downwards from the frontonasal process along the midline.
C. The developing palatine shelves are first directed vertically downward with the tongue interposed between them. After withdrawal of the tongue, the elongated shelves get oriented horizontally.
D. Horizontally oriented palatine shelves grow towards each other in the midline and are in close proximity with each other by 8 weeks of gestation. Initially, the palatine shelves are covered by an epithelial lining. Following epithelial degeneration, the connective tissues of palatine shelves intermingle with each other resulting in fusion. The left and right palatine shelves fuse with the posterior margins of the primary palate, as well as with each other in midline. Fusion does not occur simultaneously in all fronts. Initial contact occurs in the center posterior to incisive foramen between the palatine shelves. From this point, fusion progresses in anterior and posterior directions as indicated by arrows in. The nasal septum grows downward and gets fused with the medial edges of palatine shelves in the midline thus, separating the stomatodeum into nasal and oral cavities **(Bush and Jiang, 2012, Phulari, 2017)**.

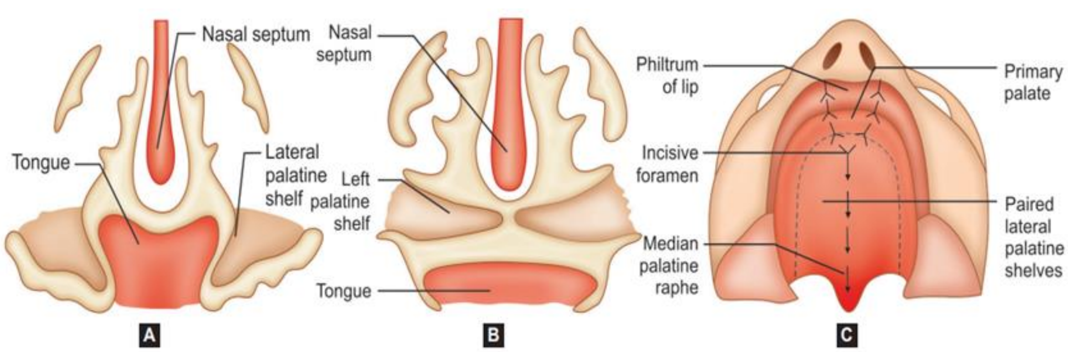


Figure 9: A to C: (A) Palatine shelves are initially directed vertically downwards with tongue interposed between them; (B) After the descent of tongue, palatine shelves grow horizontally and fuse with each other in midline and with the nasal septum; (C) Fusion of primary palate and palatine processes initiate near incisive foramen and progress in anterior and posterior directions (arrows) (Phulari, 2017).

**1.8 Cleft lip and cleft palate:** are the most common congenital malformations of the head and neck region.

**Cleft lip**: arises from failure of fusion between medial nasal processes and the maxillary process. It can be unilateral or bilateral; and can be extended into the alveolar process (CL ± CP) **(Phulari, 2017)**.

**Cleft palate:** arises from failure of palatine shelves to fuse with each other, or with the nasal septum or with the primary palate **(Phulari, 2017)**.

- Males are more commonly affected by orofacial clefts than females by a ratio of 3:2. Cleft lip with or without cleft palate is more common in males than in females (2:1), whereas isolated cleft palate is observed to be more common in females **(Gill, 2008, Phulari, 2017)**.

**Veau's classification** is morphological and described as four types of clefts:

**Group I:** Clefts of the soft palate only.

**Group II:** Clefts of the hard and soft palates extending up to the incisive foramen.

**Group III**: Complete unilateral clefts involving the soft palate, hard palate, alveolar ridge and the lip on one side.

**Group IV**: Complete bilateral clefts of the soft and hard palates, alveolar ridge and the lip **(Phulari, 2017)**.

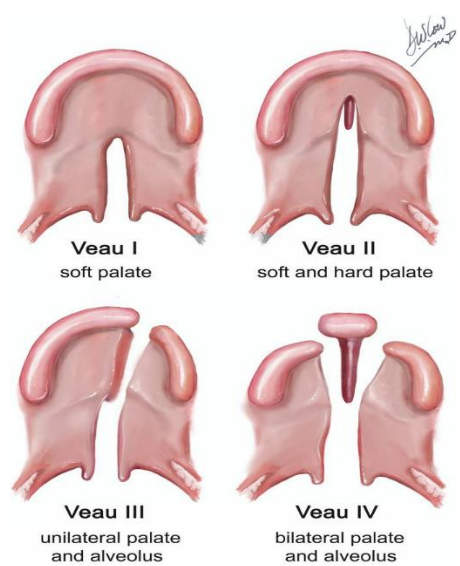


Figure 10: Veau's classification (https://www.google.com/urlsa).

- The clefting anterior to the incisive foramen is defined as the cleft of primary palate. The clefting posterior to the incisive foramen is defined as a cleft of secondary palate. A patient may have clefting of primary palate, secondary palate or both. The clefts can be complete, i.e. extending the entire distance from the lip to the soft palate or incomplete. The CL ± CP can be unilateral or bilateral; isolated cleft palate occurs in midline. Severity of CL ± CP may range from a small notch on the edge of the vermilion border to a wide cleft extending into the nasal cavity **(Gill, 2008, Phulari, 2017)**.
- The best age at which to institute orthodontic treatment for cleft- palate children is still an open question. There is evidence suggesting that while early treatment is beneficial for children with bilateral cleft lip and palate, orthodontic treatment prior to the permanent dentition state in children with unilateral cleft lip and palate has no appreciable effect on the pattern of facial growth **(Marazita, 2012)**.

## 1.9 Basic Tenets of Growth

**1.9.1 Pattern of growth:** reflects proportionality, usually of a complex set of proportions rather than just a single proportional relationship. Pattern in growth also represents proportionality, but in a still more complex way, because it refers not just to a set of proportional relationships at a point in time, but to the change in these proportional relationships over time. In other words, the physical arrangement of the body at any one time is a pattern of spatially proportioned parts. But there is a higher level pattern, the pattern of growth, which refers to the changes in these spatial proportions over time **(Proffit *et* al., 2019)**.

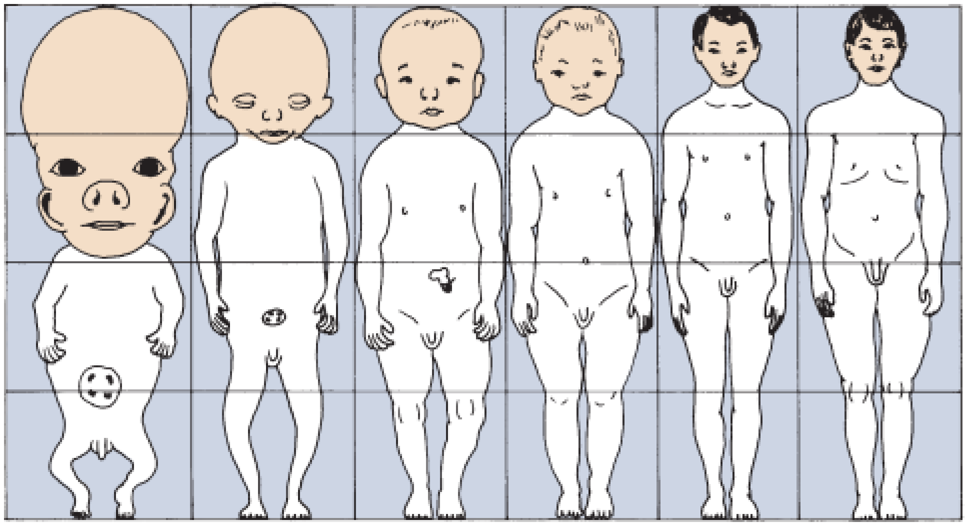

Figure 11: Schematic representation of the changes in overall body proportions during normal growth and development. After the third month of fetal life, the proportion of total body size contributed by the head and face steadily declines (Robbins, 1928).

The change in overall body proportions that occurs during normal growth and development was illustrated in Figure 11. In fetal life, at about the third month of intrauterine development, the head takes up almost 50% of the total body length. At this stage, the cranium is large relative to the face and represents more than half the total head. In contrast, the limbs are still rudimentary and the trunk is underdeveloped. By the time of birth, the trunk and limbs have grown faster than the head and face, so that the proportion of the entire body devoted to the head has decreased to about 30%. The overall pattern of growth thereafter follows this course, with a progressive reduction of the relative size of the head to about 12% in the adult. At birth the legs represent about one-third of the total body length, whereas in the adult they represent about half. As Figure 11 illustrates, there is more growth of the lower limbs than the upper limbs during postnatal life. All of these changes, which are a part of the normal growth pattern, reflect the cephalocaudal gradient of growth. This simply means that there is an axis of increased growth extending from the head toward the feet **(Bishara, 2001, Proffit *et* al., 2019)**.

### 1.9.1.1 Differential Growth (Scammon's Growth Curve)

Different tissues in the body grow at different times and different rates. Therefore, the amount of growth accomplished at a particular age is variable **(Cameron et al., 2002, Singh, 2007)**.

Scammon divided the tissues in the body into:

**a. Neural tissues**

**b. Lymphoid tissues**

**c. Somatic/general tissues (muscles, bone, viscera).**

**d. Genital tissues**

• Neural tissues complete 90 percent of their growth by 6 years and 96 percent by 10 years of age.

• Lymphoid tissues reach 100 percent adult size by 7 years: proliferate far beyond the adult size in late childhood (200% by 14 years) and involute around the onset of puberty.

• Somatic tissues show an S-shape curve with definite slowing of growth rate during childhood and acceleration at puberty going on till age 20.

• Growth of the genital tissues accelerate rapidly around the onset of puberty.

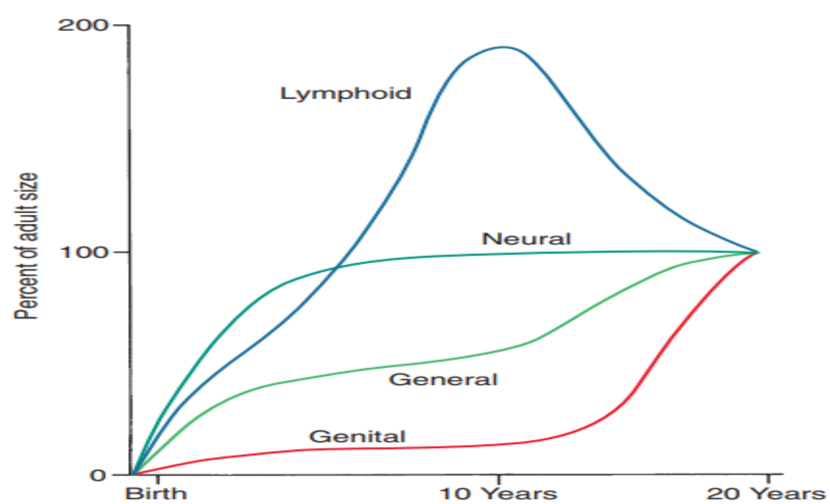


Figure 12 Scammon's curves for growth of the four major tissue systems of the body (Harris, 1930).

Another aspect of the normal growth pattern is that not all the tissue systems of the body grow at the same rate (Figure 12). Obviously, as the relative decrease of head size after birth shows, the muscular and skeletal elements grow faster than the brain and central nervous system. The overall pattern of growth is a reflection of the growth of the various tissues making up the whole organism. To put it differently, one reason for gradients of growth is that different tissue systems that grow at different rates are concentrated in various parts of the body **(Proffit *et* al., 2019)**.

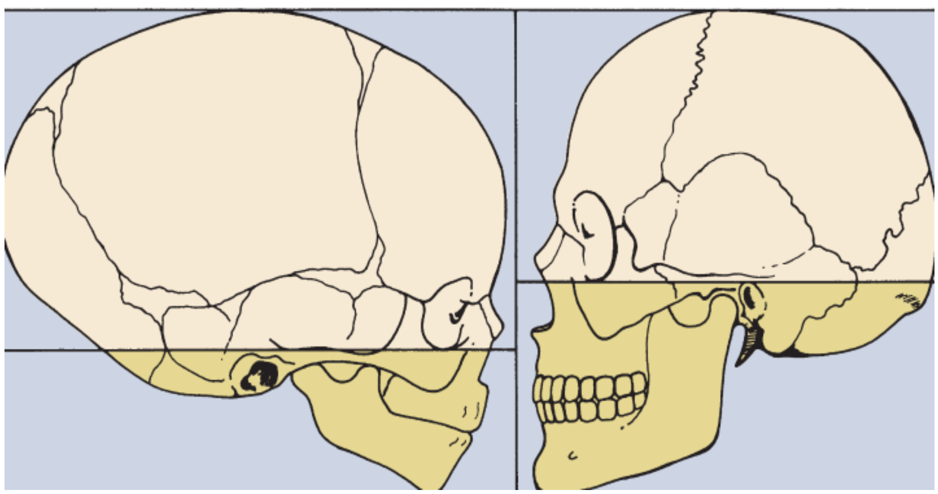

Figure 13: Changes in proportions of the head and face during growth (Lowery, 1973).

Even within the head and face, the cephalocaudal growth gradient strongly affects proportions and leads to changes in proportion with growth (Figure 13**.** When the skull of a newborn infant is compared proportionally with that of an adult, it is easy to see that the infant has a relatively much larger cranium and a much smaller face. This change is an important aspect of the pattern of facial growth. Not only is there a cephalocaudal gradient of growth within the body, there also is one within the face. From that perspective, it is not surprising that the mandible, being farther away from the brain, tends to grow more and later than the maxilla, which is closer **(Bishara, 2001, Proffit, *et* al., 2019)**.

**1.9.2 Variability of growth**: it indicates the degree of difference between two growing individuals in all four planes of space including the all-important time. Obviously, all people are not a like in the way that they grow, as in everything else. It can be difficult but clinically very important to decide whether an individual is merely at the extreme of the normal variation or falls outside the normal range. Rather than categorizing growth as normal or abnormal, it is more useful to think in terms of deviations from the usual pattern and to express variability quantitatively. One way to do this is to evaluate a given child relative to peers on a standard growth chart **(Singh, 2007, Proffit *et* al., 2019)**.

**1.9.3 Timing of growth:** all the individuals do not grow at the same time or in other words possess a biologic clock that is set differently for all individuals. This can be most aptly demonstrated by the variation in timing of menarche (onset of menstruation) in girls. This also indicates the arrival of sexual maturity. Similarly, some children grow rapidly and mature early completing their growth quickly, thereby appearing on the high side of the developmental charts until their growth ceases and their peer group begins to catch up. Others grow and develop slowly and so appear to be behind even though in due course of time they might catch up or even overtake others **(Cameron *et* al., 2002, Singh, 2007)**.

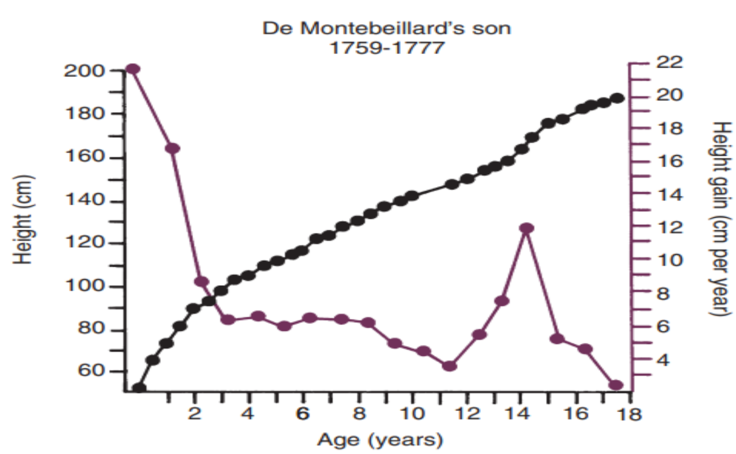


Figure 14: Growth can be plotted in either height or weight at any age (Proffit *et* al., 2019).

Variations in growth and development because of timing are particularly evident in human adolescence. Some children grow rapidly and mature early, completing their growth quickly and thereby appearing on the high side of developmental charts until their growth ceases and their contemporaries begin to catch up. Others grow and develop slowly and so appear to be behind, even though, given time, they will catch up with and even surpass children who once were larger. All children undergo a spurt of growth at adolescence, which can be seen more clearly by plotting change in height or weight (Figure 14)**,** but the growth spurt occurs at different times in different individuals **(Bishara, 2001, Proffit *et* al., 2019)**.

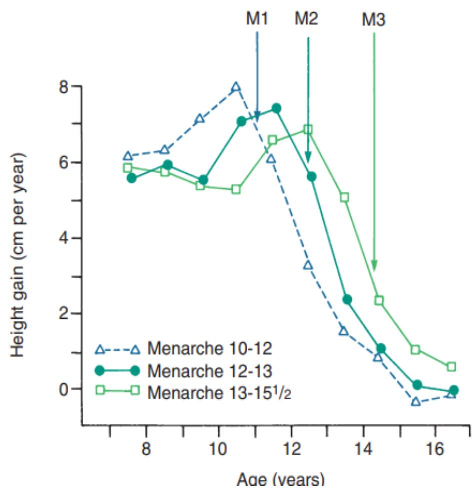


Figure 15: Growth velocity curves for early-, average-, and late-maturing girls (Proffit *et* al., 2019).

Growth effects because of timing variation can be seen particularly clearly in girls, in whom the onset of menstruation gives an excellent indicator of the arrival of sexual maturity. Sexual maturation is accompanied by a spurt in growth. When the growth velocity curves for early-, average-, and late-maturing girls are compared in (Figure 15)**,** the marked differences in size among these girls during growth are apparent. At age 11, the early-maturing girl is already past the peak of her adolescent growth spurt, whereas the late-maturing girl has not even begun to grow rapidly. This sort of timing variation occurs in many aspects of both growth and development and can be an important contributor to variability Although age is usually measured chronologically as the amount of time since birth or conception, it is also possible to measure age biologically, in terms of progress toward various developmental markers or stages **(Bishara, 2001, Proffit *et* al., 2019)**.

**1.10 Growth Spurts:** is the acceleration in growth associated with puberty. Such rapid increase in growth rate. The timing of growth spurts differs in boys and girls. Generally, girls precede boys in growth spurts by approximately two years **(Singh, 2007, Gill, 2008)**.

Table (1) Three major growth spurts can be seen during postnatal development (Singh, 2007)

| Name of spurt | Female | Male |
|---|---|---|
| Infantile/childhood growth spurt | 3years | 3years |
| Mixed dentition / Juvenile growth spurt | 6-7years | 7-9years |
| Prepubertal /adolescent growth spurt | 11-12years | 14-15years |

## 1.11 Growth rotations (GR)

They are most obvious in the mandible, dependent on differential growth of different structures contributing to posterior and anterior face height. Posterior face height is determined by several factors (1) The direction of growth at the condyles (2) Vertical growth at the spheno-occipital synchondrosis (3) The influence of the attached muscles on the ramus of the mandible. Anterior face height is determined by (1) The eruption of the teeth (2) Vertical growth of the soft tissues of the anterior neck **(Littlewood *et* al., 2019)**.

- Forward GR are more common than backward rotations, with the average being a mild forward rotation which produces a harmonious facial appearance. A marked forward GR tends to result in reduced anterior facial proportions and an increased overbite (Figure 16) **(Bishara, 2001, Littlewood *et* al., 2019)**.

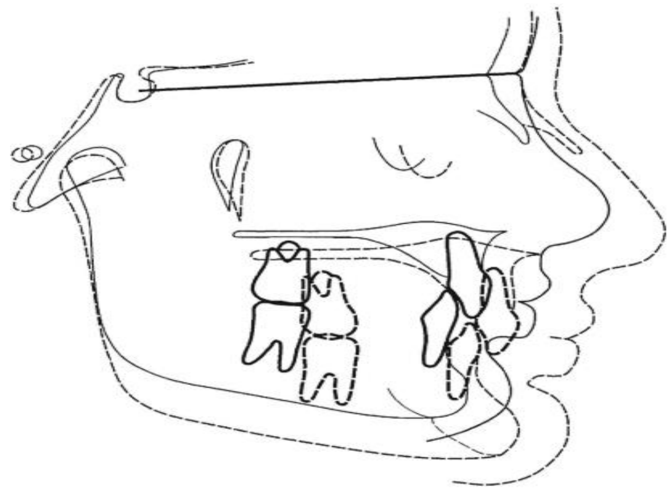

Figure 16: Forward growth rotation. Solid line 11 years, broken line 18 years of age (Littlewood *et* al., 2019).

- A marked backward rotation tends to result in an increased anterior vertical facial proportion and a reduced overbite or anterior open bite (Figure 17) **(Bishara, 2001)**.

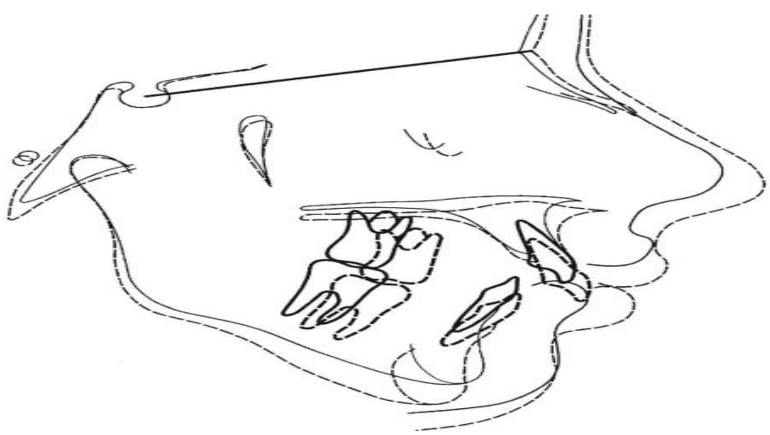

Figure 17: Backward growth rotation. Solid line 12 years, broken line 19 years of age (Littlewood *et* al., 2019).

# Chapter Two: Discussion

The process of human growth and development, which takes almost 20 years to complete. It is under the control of both genetic and environmental influences, which operate in such a way that, at specific times during the period of growth, one or the other may be the dominant influence **(Cemeron *et* al., 2012).**

There is a wide variation among populations, individuals and the two genders as to the attained size at each age, the timing of events such as adolescent growth spurt, and the age at which mature size is reached. In general, from birth to about 1 or 2 years, children grow rapidly, after this rapid infant and early toddler growth, growth slows until the adolescent growth spurt. Patterns of growth of the jaws and development of occlusion have a strong bearing on the need for orthodontic treatment and the timing and type of the treatment prescribed **(Kharbanda, 2011)**.

Since the orthodontic treatment may start from day one after birth, it is important to distinguish normal variation from the effects of abnormal or pathologic processes; therefore, a thorough background in craniofacial growth and development is necessary for every dentist. Even for those who never work with children, it is difficult to comprehend conditions observed in adults without understanding the developmental processes that produced these problems.

The main difference to remember when treating adults and children is the chance of growth, as that in younger patients the jawbones are still growing; therefore, early orthopedic treatment allows orthodontists to monitor the growth of the jaw and recommend further OT if it becomes necessary by using functional appliance to modify the growth of the jaws in children. However, for adults, these bones have stopped growing, which may mean the only possibility to align the jawbones is the orthognathic surgery.

# Chapter Three: Conclusions and Suggestions

## Conclusions

1. Growth and development from a new born to adulthood is characterized by a multiplicity of morphological, physiological and psychological changes.
2. Orthodontically, the answer to the clinical problems lies not only on better appliances but also on a complete understanding of craniofacial growth and its implication in the clinical situation for the appraisal of the treatment modalities that suit the patient better so as to achieve the best results in form of function, esthetics and structural balance.

## Suggestions

In addition to the radiographical assessment for growth, biological tests of serum can be suggested to be used as an indicator for growth of humans.

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