Growth and development

Diagnosis and treatment plan are the keystone for orthodontic treatment and not the treatment procedure by itself f. knowledge of the growth related changes is essential the planning of orthodontic treatments.

Growth

Increase in size, change in proportion and progressive complexity- Krogman

Entire series of sequential anatomic and physiological change taking place from the beginning of prenatal life to senility-Meredith

Quantitative aspect of biological development per unit of time-Mayers

Change in any morphological parameter which is measurable-Moss

Development

It is an increase in the degree organization

Development = growth (change in quantity) +differentiation (change in quality) +translocation (change in position).

Craniofacial growth and development

Craniofacial growth and development can be divided in to two phases:

1. Pre-natal phase
2. Post-natal phase

Pre-natal phase:

Human life starts by the fertilization of ovum by spermatozoa in the fallopian tube of the female reproductive system.

Prenatal phase is a highly complex phenomenon with three stages

A- Period of ovum: conception to the 7-8 days of intra uterine life (IUL)

B- Period of embryo .2^{nd}- 8^{th} week I.U.L

C- Period of fetus. 3^{rd} month- birth

The development begins when the sperm fertilize the oocyte resulting in the formation of a zygote. Fertilization occurs in the ampulla of the uterine tube. The zygote undergoes a series of mitotic divisions as it moves along the uterine tube towards the uterus. The cells resulting from these divisions are called blastomeres which adhere to one another and form a ball of cells (morula). A fluid filled cavity is then formed in the center of morula to form a structure called blastocyst. The blastocyst is then reach the uterus and implanted in the uterine wall. The blastocyst in this time has two layers:

- The trophoblast which forms a single layer of cells covering the outside of the blastocyst
- Embryoblast forms the inner cell mass which is a cluster of cells located inside the trophoblast.

The inner cell mass develops into the embryo while the trophoblast forms the embryonic part of the placenta and other peripheral structures associated with the embryo.

The branchial (pharyngeal) arches:

The branchial arch system begins to form in the fourth week and consists of six paired arches that decrease in size from cranial to caudal. Each arch is covered externally by ectoderm and internally by endoderm. While a core of mesoderm exists within. The arches are separated by four pharyngeal grooves on the ectodermal aspect and five pharyngeal pouches from the endodermal aspect. Within Each branchial arch there is a core of mesoderm which becomes progressively infiltrated with migrating neural crest cells. In addition there is (cartilage, aortic arch artery, and nerve) which situated in each arch. Because the term *branchial arch* is traditionally used to describe the embryonic arch system of fish and amphibians, some authors prefer the term *pharyngeal arch.*

Pharyngeal arches give rise to a number of structures in the head and neck:

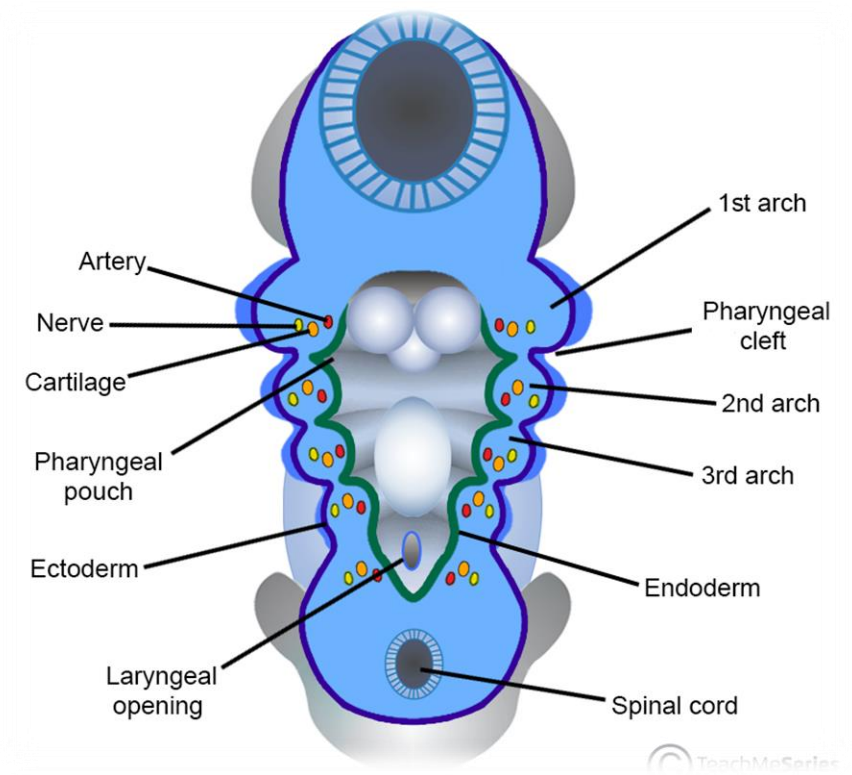
- First Pharyngeal arch (mandibular arch) give rise to maxilla, mandible and dentition.
- Second Pharyngeal arch (hyoid arch) make the suprahyoid apparatus of the neck.
- Third Pharyngeal arch makes infrahyoid region.
- Fourth and sixth Pharyngeal arches make laryngeal structures
- Fifth Pharyngeal arch rapidly degenerated after formation without any contribution in permanent structures.

Ectoderm produces the skin and sensory neurons of the lower face and neck

Endoderm forms the mucosal lining of the pharynx and associated endocrine organs in the neck (thyroid, parathyroid and thymus)

Neural crest cells produce most of the skeletal and connective tissues in the head and neck region.

Mesoderm produces the associated craniofacial musculature and cardiac outflow.



Development of the face:

In the region of the developing face, the migrating neural crest cells are divided in to anterior and posterior streams. Anterior stream develops into an elevation called the frontonasal process. Posterior stream develops into the branchial arches. In this stage of embryonic development, the craniofacial development presents with several elevations or processes. Five of these processes bound a depression called stomodeum which is the future site for the mouth. The processes are one centrally located frontonasal process, bilateral maxillary processes at the sides and bilateral mandibular processes below. The cranially located frontonasal process forms the forehead and nose; maxillary processes form the maxilla, lateral part of the face, zygomatic bone, etc. mandibular processes give rise to the mandible.

By five weeks of development, medial and lateral nasal processes form within the enlarged frontonasal process to surround an early ectodermal thickening, the nasal placode. The rapid development of these two processes sink the nasal placodes to form the nasal pits that is the future nostrils. The two medial processes grow toward each other and fuse at the midline to form tip of the nose, philtrum, primary palate and 4 maxillary incisors.

The maxillary process grow ventromedially to fuse with the medial nasal process and forms the rest of the upper lip. The maxillary process contributes to the lateral aspect of the upper lip, cheek, maxilla, rest of the maxillary teeth and secondary palate.

Thus the upper lip is formed from the maxillary process laterally and medial nasal process in the midline. The fusion of the medial nasal process and maxillary process completes during the 7^{th} week. Cleft lip develops if failure of fusion of these two processes takes place. This cleft may be unilateral or bilateral, it is also can be complete or incomplete one.

Posteriorly, from the medial sides of the maxillary process, the secondary palate is formed via growth, elevation and subsequent fusion between the paired palatine processes. These

processes also fuse with the nasal septum superiorly and the primary palate anteriorly, ultimately separating the oral and nasal cavities.

Development of the palate

The palate begins to develop early in the 6th week but the process is not completed until 12th week. The most critical period during palatal development is the end of the week to the beginning of the 9th week.

The entire palate develops from:

1. Primary palate (premaxilla): is the triangular shaped part of the palate anterior to the incisive foramen. Its origin is the deep portion of the intermaxillary segment which arise from the fusion of the two medial nasal processes.
2. The secondary palate: the hard and soft palate posterior to the incisive foramen.it arises from the fusion of the lateral palatal shelves of the maxilla. Later on, these lateral palatal shelves fuse with the primary palate in front and with nasal septum above.

Cleft palate results if the lateral palatal shelves failed to fuse with nasal septum, with the primary palate or together.

The fusion of the palatal shelves does not start from the anterior terminus rather it begins about 1l3rd the distance from the anterior margin at the future site of incisive papilla. Fusion proceeds both anteriorly and posteriorly from that region. Nasal septum fuses with palate only anteriorly, in the posterior region, the soft palate and uvula remains free. The site of fusion is the future mid-palatal suture.

Fusion at first is only epithelial, the epithelial layers are thickened and they approximate and fuse to form a single layer of epithelium. Ossification starts by 8th week of IUL. Posterior most part remain unossified as soft palate and uvula.

Development of tongue

Development of the tongue begins about the 6th week of development.

- Anterior 2l3 of the tongue (body) is derived from mesoderm of the 1st pharyngeal arch.
- Posterior third of the tongue (base) has contribution from 2nd, 3rd, and 4th pharyngeal arches mesoderm
- The epiglottis is derived from the 4th pharyngeal arch. And form the most posterior boundaries of the tongue.
- The line of demarcation between the body and the base is called terminal sulcus and the foramen cecum is found in the midline of this structure.

Development of skull

The development of the skull is considered in:

1st development of the neurocranium which is the cranial vault and the cranial base.

2nd development of the viscerocranium which includes the skeleton of the face and associated structure

Each component has some structures that form by endochondral ossification (cartilaginous component) and other structures that form by intramembranous ossification (membranous ossification).

The endochondral ossification occurs where the primary cartilage is converted into bone.

The intramembranous ossification occurs where bone is directly formed from the undifferentiated mesenchymal tissue with no cartilage precursor.

Neurocranium (cranial vault and base of the skull)

The cartilaginous neurocranium (chondocranium) consist of several cartilages that fuse and undergo endochondral ossification to give rise to the base of the skull. The cartilage junctions between two bones are called synchondroses.

The membranous neurocranium give rise to flat bones of the cranial vault.

Viscerocranium (the skeleton of the face and associated structures)

The cartilaginous Viscerocranium includes the middle ear ossicles, styloid process of the temporal bone, the hyoid bone and the laryngeal cartilage.

The membranous Viscerocranium includes maxilla, zygomatic bones, squamous part of temporal bone and the mandible. These bones develop by intramembranous ossification except for the mandibular condyle, coronoid process and midline of the chin.

Development of the mandible

Mandible arises as bilateral processes that grow ventromedial and fuse in the midline. In about the 6th week IUL, bilateral rod like cartilaginous condensation (Meckel's cartilage) develop and extend from the site of the future ear to the midline but this does not imply that the mandible ossifies endochondrally. Actually, mesenchymal condensations develop lateral to Meckel's cartilage at 36-38 days IUL and ossification starts from the same location of the future mental foremen the angel formed by the division of the inferior alveolar nerve into incisive and mental branches at 7th week of IUL. From this center of ossification, bone formation spread rapidly anteriorly to the midline and backward to a point where the mandibular nerve divides in to lingual and inferior alveolar branches. As the ossification proceeds medially towards the midline, Meckel's cartilage largely disappears.

Meckel's cartilage only has a close positional relationship to the developing mandible but makes no actual contribution to it. It merely provides a framework around which the bone of mandible forms. Though the mandible initially develops intramembranously but its subsequent growth is related to the appearance of the secondary cartilage the condylar cartilage.

At the 10th week of IUL, condylar cartilaginous condensation appears as cone shaped projections. The cartilage cells of the condylar process differentiate and increase in number, thus increasing the size of the condyle. Ossification start at 14th week IUL. The superior end of the condyle persists as cartilage. The presence of cartilage in the superior end may be responsible for the growth of the mandible in the postnatal life. The activity of the condylar

cartilage does not appear until the 4^{th} or 5^{th} month of postnatal life and continues until the age of 20 years so it has no role in the prenatal life.

The mandible develops largely from intramembranous ossification, except in three areas where endochondral ossification occurs and these are condylar process, coronoid process and mental region.

The right and left sides of the mandible are separate at birth. The ramus of the mandible is relatively short and low. The coronoid and condylar process of fetal mandible are at the level of the occlusal plane. In the postnatal life, height is gained by alveolar and ramus growth.