

11. Development of head and face. Palate. Skull.

Please note that the development of the brain, sensory organs, pharyngeal arches, stomodeum, teeth, tongue, thyroid gland have already been discussed in Chapters on development of the nerve system and digestive system.

In general, bone tissue originates from:

- the of the somitic paraxial mesoderm, namely from the ventromedial part, the sclerotome
- the head non-segmented mesoderm
- the somatopleuric lateral plate mesoderm → skeleton of limbs
- the neural crest, which differentiates into the head ectomesenchyme
- mesenchyme
  - its cells migrate and differentiate into fibroblasts, the source of the desmogenous (intramembranous) ossification
  - its cells imgrate and differentiate into chondroblasts, the source of the chondrogenous ossification of the hyaline cartilage models

The skull

- neurocranium forms a protective case surrounding the brain
  - desmocranium is the membranous part consisting of flat bones
    - it is derived from the mesenchyme originating from the paraxial mesoderm and neural crest cells
    - flat, membranous bones are formed around the brain via the intramembranous ossification
    - bone spicules radiate from primary ossification centers toward the periphery
    - membranous bones enlarge by apposition of new layers on the outer surface
  - chondrocranium is the cartilaginous part
    - the base of the skull and the capsules of sensory organs
    - originaly consists of number of separate cartilages, some of which are paired
      - parachordali cartilages
      - hypophyseal cartilages
      - prechordal trabecular cartilages
    - the prechordal chondrocranium is anterior to the sella turcica
      - it develops from the neural crest
      - ethmoidal bone, minor and major wings of the sphenoidal bone
    - the chordal chondrocranium (posterior to the sella turcica)
      - it develops from the occipital sclerotomes
      - the body of the sphenoidal bone, the base of the occipital bone, the petrous part of the temporal bone
    - small regions of hyaline cartilage persist as the spheno-petrous and petro-occipital synchondroses
- viscerocranium (splanchnocranium) form the skeleton of the face
  - it is formed mainly from the first two pharyngeal arches, which receive an important contribution of the ectomesenchyme cells of the neural crest

- the 1st pharyngeal arch gives rise to:
  - the maxillary process: the premaxilla (incisive bone), maxilla, palatal bone, zygomatic bone, incus and part of the temporal bone
  - the mandibular process: the Meckel cartilage, mandible, malleus, sphenomandibular ligament
- the 2nd pharyngeal arch gives rise to the: stapes, styloid process, stylohyoid ligament, the lesser horns and the upper part of the body of the hyoid bone
- the 3rd pharyngeal arch gives rise to the: lower part of the body and the greater horns of the hyoid bone
- the 4th pharyngeal arch gives rise to the thyroid cartilage and the epiglottis
- the 6th pharyngeal arch gives rise to the cricoid, arytenoid, and corniculate cartilages

o the development of the paranasal sinuses involves the pneumatization of bones, which occurs mainly postnatally in infants and children

o the development of the maxilla and the mandible involves also development of the dentition

The development of face

– the neural crest-derived mesenchyme from the 1st pharyngeal arch proliferates and forms several facial prominences during the week 4

o the maxillary prominences are lateral to the stomodeum; these will form the upper lip, the cheeks, and the maxilla

o the mandibular prominences are caudal to the stomodeum; it will form the lower lip and the chin

o the frontonasal prominence is cranially to the stomodeum

- on its both sides, the nasal olfactory placodes differentiate from the surface ectoderm under inductive influence of the ventral portion of the prosencephalon → in week 5, the nasal placodes invaginate to form nasal pits
- the nasal pits are surrounded by the lateral and medial nasal prominences

o the maxillary prominences increase, grow medially and press the medial nasal prominences toward the midline, where they form the philtrum → the maxillary and the medial nasal prominences fuse together and form the upper lip

o the nasolacrimal groove separates the maxillary and the lateral nasal prominences; it invaginates into an epithelial cord, which moves deeper below the surface ectoderm and becomes the nasolacrimal duct; its upper portion widens to form the lacrimal sac

o the nose is formed as follows:

- the bridge of the nose originates from the frontal prominence
- the tip and the crest of the nose originates from the left and right medial nasal prominences
- the alae of nose originate from the lateral nasal prominences

The palate

– the primary palate: the two medial nasal prominences fuse into the intermaxillary segment, which has two components

o the labial component, which forms the philtrum of the upper lip

o the upper jaw component, which becomes the incisive bone (intermaxilla, premaxilla), forming the triangular primary palate

- the secondary palate: forms the main part of the definitive palate
  - from the maxilla, two shelf-like outgrowths appear in week 6 and are directed obliquely downward on each side of the tongue
  - in week 7, the palatine plates ascend into horizontal position above the tongue and fuse together in the midline, thus forming the secondary palate
- the primary palate fuses with the secondary palate in the right and left incisive sutures; these sutures intersect in the incisive foramen, through which the incisive canal communicates with the oral cavity (it contains the nasopalatine nerve from the maxillary nerve and the sphenopalatine artery)

Nasal cavities

- the nasal pits invaginate and become surrounded by the proliferating nasal primonences in week 6
- the nasal pits are separated from the primitive oral cavity by the oronasal membrane
- the oronasal membrane breaks down and thus the primitive choanae originate as the communications between the nasal chambers and the oral cavity
- the inner part of the frontonasal prominences develops into the nasal septum
- the formation of the secondary palate separates the definitive nasal and oral cavities; the definitive choanae are at the junction of the nasopharynx with the oropharynx
- the lateral walls of the nasal cavities elevate to form the conchae superior, middle, and inferior conchae (turbinates)
- the mucosa of the lateral nasal walls forms diverticula that extend into the maxilla, ethmoid, frontal, and sphenoid bones, thus forming the primordia of the paranasal sinuses; the sinuses develop later on in infants and in children
  - before birth, only the primordium of the maxillary sinus is present; it grows substantially after eruption of the secondary teeth
  - the primordia of the other paranasal sinuses grow by pneumatization of the bones in children

Skull of a newborn

- bitemporal diameter: 8 cm (the distance between the most distant points of the coronal suture)
- biparietal diameter: 9.5 cm (the distance between the parietal tuberosities)
- frontooccipital diameter: 11-12 cm (the distance between the middle point of the forehead and the most distant occipital point)
- mento-occipital diameter: 13.5 cm (between the chin and the occiput)
- fronto-occipital circumference: 34 cm
- the dimensions of the head equal to the dimensions of the skull plus the thickness of the soft wissues (+0.4 cm)
- the sutures separating the skull bones are filled with connective tissue membranes named fontanelles; the fontanelles allow the bones to overlap (molding) during birth
  - the anterior (major) fontanelle: at the intersection between the coronal × frontal × sagittal sutures; it closes until the second year
  - the posterior (minor) fontanelle: the intersection between the sagittal × lambdoid sutures; it closes about 3 months after the birth (until the end of the 1st year)
  - the sphenoidal (anterolateral) fontanelle: intersection between the coronal suture and the sphenoidal bone

- the mastoid (posterolateral) fontanelle: intersection between the lambdoid suture and the petrous part of the temporal bone and the occipital bone

Developmental disorders in the facial region

- "facial clefts" are actually due to a partial or complete lack of fusion of parts contributing to the development of embryonic face
  - anterior clefts (anterior to the incisive foramen)
    - lack of fusion between the maxillary prominence with the medial nasal prominence on one side or on both sides
    - lateral cleft lip (cheiloschisis); cleft upper jaw (gnathoschisis); cleft between the primary and secondary palates (in the incisive suture)
  - posterior clefts (posterior to the incisive foramen)
    - cleft secondary palate (palatoschisis) – lack of fusion of the palatine shelves, which are either short or they fail to elevate due to the upper position of the tongue (normally, the tongue moves caudally, being pulled by the mandible)
    - cleft uvula
  - combined anterior and posterior clefts (cheilo-gnatho-palatoschisis)
  - oblique facial clefts: persisting nasolacrimal groove between the maxillary prominence and the lateral nasal prominence
  - the midline cleft lip due to lack of fusion between the medial nasal prominences

Developmental disorders of the skull

- cranioschisis: the cranial neuropore fails to close; the cranial vault fails to form and brain exposed to amniotic fluid degenerates, which results in anencephaly
- meningocele is herniation of meninges through the skull defects
- meningoencephalocele is herniation of meninges and brain tissue through the skull defects
- craniosynostosis: abnormal and premature closure of one or more sutures resulting from loss and abnormal migration of head mesenchyme of from abnormal molecular signaling between cells of head mesenchyme; it occurs as a part of many genetic sydromes
  - closure of the sagittal suture → scaphocephaly (long and narrow skull is bulging frontally and occipitally)
  - closure of the coronal suture → acrocephaly, turricephaly (short, tower-like skull)
  - closure of the coronal and lambdoid sutures → brachycephaly (short skull)
- microcephaly: the brain fails to grow, and, therefore, the skull fails to expand; it often results in severe intellectual disablement
- achondroplasia: usually inherited as autosomal dominant skeletal dysplasia; failure of chondrogenous ossification; it results in dwarfism affecting the growth of the long bones and the base of the skull; the bones originating via the desmogenous ossification (such as the maxilla and the mandible) grow normally