Embryology; Development of the skull and bones

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Development of somite
Paraxial mesoderm forms a segmented series of tissue blocks on each side of the neural tube, known as somitomeres in the head region, and somites from the occipital region caudally.
Following segmentation, somites and somitomeres form a ball of epithelial cells arranged around a small cavity in the centre.

As a result of further differentiation, cells in the ventromedial wall of the somites and somitomeres, lose their epithelial arrangement and become mesenchymal, called the Sclerotome. Cells in the upper region of somite give rise to the dermatome as well as two muscle-forming areas at the ventrolateral (VLL) and dorsomedial lips (DML). Cells from these lips proliferate and migrate beneath the dermatome, forming the myotome.
Parts of the mesoderm

- Somatic (parietal) mesoderm
- Splanchnopleuric Mesoderm (visceral)
- Parietal Mesoderm
- Transverse Section
- Dorsal
- Lateral plate
- Paraxial mesoderm
- Extraembryonic aorta
- Secondary yolk sac
- Maternal sinusoid

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Somites and somitomeres
Differentiation of somite

- Neural groove
- Ventral somite wall
- Notochord

- Dorsomedial muscle cells
- Ventrolateral muscle cells
- Intraembryonic coelom
- Notochord
- Dorsal aorta

- Dermomyotome
- Sclerotome
- Myotome
- Sclerotome
- Dermatome
- Dorsal aorta

- Neural tube
The human skeleton develops from
1-Somitomeres and somites (Paraxial mesoderm)
2-Lateral plate (parietal layer) of mesoderm
3-Neural crest

At the end of the forth week the sclerotome cells differentiate into mesenchymal tissue (embryonic loose connective tissue); cells of this tissue can migrate and differentiate into fibroblasts, chondroblasts or osteoblasts
Development of Neural tube
1-Parietal layer of the lateral plate of mesoderm of the body wall can differentiate into osteoblasts giving rise to the bones of pelvic girdle, shoulder girdles, limbs and sternum

2-Neural crest cells in the head region can also differentiate into mesenchymal cells and give rise to bones of the skull and face

3-Somitomeres and occipital somites (paraxial mesoderm) gives rise to cranial vault and base of the skull

4-Mesenchyme of the dermis can also differentiates into flat bones of the skull (the process is known as intramembranous ossification)

In most bones Mesenchymal cells first giving rise to hyaline cartilage models which later on become ossified by endochondral ossification
The skull is formed of two parts

1- **Neurocranium** that forms a protective case, which surrounds the brain and special sensory organs (optic, auditory, and olfactory)

2- **Viscerocranium** that includes the facial skeleton, the ear ossicles, hyoid bone, laryngeal and tracheal cartilages, and certain processes of the skull.

**Neurocranium** develops from two sources

1- **Membranous neurocranium** which forms the flat bones of the vault of skull

2- **Cartilaginous neurocranium (Chondrocranium)** which forms the bones of the base of skull
1- Membranous neurocranium: (flat bones of the vault of skull) are derived from the neural crest cells, somites and somitomeres. Mesenchyme from these sources cover the brain and undergoes membranous ossification, this leads to the formation of flat membranous bones. During fetal and postnatal life Membranous bones enlarge By deposition of new bone Layers on the outer surface and by simultaneous osteoclastic bone resorption from the inside

Blue mesenchyme is derived from neural crest. Brown mesenchyme is derived from paraxial mesoderm (somites and somitomeres). Yellow mesenchyme is derived from lateral plate mesoderm.
Skull of the newborn

Bones of the newborn are separated from each other by strips of connective tissue, they are called **Sutures.** **Sagittal suture** is derived from the mesenchyme of the **neural crest**

**Coronal suture** is derived from mesenchyme of **paraxial mesoderm** (somites and somitomeres).

Meeting of more than two skull bones, gives rise to a wide sutures called **Fontanelles.** There are **Anterior, Posterior, Posterolateral (mastoid) and Anterolateral (Sphenoid) fontanelles**

Suters and fontanelles allow overlapping (molding) of the skull bones during birth. Shortly after birth, the skull bones return back to their original positions and the skull looks rounded. Bones of the vault continue to grow after birth due to the brain growth.
The anterior fontanelle is closed by the age of 18 months. The posterior fontanelle closes at 1-2 months after birth.

Several sutures remain membranous for a considerable time after birth, some of them remain open until adulthood when they ossify.
2- Cartilaginous neurocranium (Chondrocranium)
It gives rise to the bones of the base of skull.
It consists of several separate cartilages. The base of the skull is formed when these cartilages fuse and ossify by endochondral ossification.

Cartilages that lie in front of the rostral end of notochord (prechordal chondrocranium) are derived from neural crest; these cartilages end at the level of the pituitary gland in the center of the sella turcica.

Cartilages that lie posterior to the pituitary gland (chordal chondrocranium) arise from occipital somites
Dorsal view of the chondrocranium, or base of the skull, in the adult showing bones formed by endochondral ossification.

Bones that form rostral to the rostral half of the sella turcica arise from neural crest and constitute the prechordal (in front of the notochord) chondrocranium (blue).

Those forming posterior to this landmark arise from paraxial mesoderm (chordal chondrocranium) (red).
2- Viscerocranium

These are the bones of the face. Bones of the face are formed mainly from the 1\textsuperscript{st} and 2\textsuperscript{nd} Pharyngeal arches and from mesenchyme derived from the Neural crest cells.

a- The dorsal portion of the first pharyngeal arch (maxillary process) gives rise to the maxilla, zygomatic bone, and part of the temporal bone.

b- The ventral portion of the first pharyngeal arch (mandibular process) contains the Meckel cartilage. Mesenchyme around the Meckel cartilage gives rise to the mandible through membrane ossification. Meckel cartilage gives rise to shenomandibular ligament and disappears.
2-The dorsal tip of mandibular process with the 2\textsuperscript{nd} pharyngeal arch give rise to the ear ossicles, the Incus, Malleus and stapes. These are the first bones to become fully ossified.

\textbf{Mesenchyme derived from Neural crest} cells gives rise to the Nasal and Lacrimal bones.

At the beginning of neonatal life the face is small in comparison with that of the neurocranium. This is caused by the absence of the paranasal air sinuses and the small size of the bones.  
\textbf{With the appearance of teeth and development of paranasal air sinuses, the baby's face loses its characteristics.}
Development of Viscerocranium from the Neural crest and 1\textsuperscript{st} and 2\textsuperscript{nd} pharyngeal arches

Neural crest cells gives rise to the Nasal and Lacrimal bones

The dorsal tip of mandibular process with the 2\textsuperscript{nd} pharyngeal arch give rise to the ear ossicles
The dorsal tip of mandibular process with the 2\textsuperscript{nd} pharyngeal arch give rise to the ear ossicles, the Incus, Malleus and stapes.
Congenital anomalies of the skull
Development of vertebrae
Normal vertebrae
Development of vertebra

Somites in the early embryo develop into sclerotomes. The sclerotomes form the vertebrae as well as the rib cartilage. During the 4th week, cells of sclerotomes migrate in 3 directions (retaining their segmental arrangement), as follows:

1. Cells passing ventro-medially around the notochord to form the bodies of vertebrae. These cells meet the sclerotome cells from the other side.
Formation of vertebral body

Body of each vertebra develops from the adjacent halves (caudal and cranial) of each two sclerotomes, i.e. the caudal dense part joins the cranial less dense part of the sclerotome below. This process is called resegmentation.

Mesenchymal cells between cephalic and caudal parts of each sclerotome segment do not proliferate but fill the space between two precartilagenous vertebral bodies and form the Intervertebral disc.

The notochord degenerate in the region of the vertebral bodies and persist and enlarges in the region of the intervertebral disc and form the nucleus pulposus of the disc; that later is surrounded by circular fibres of the annulus fibrosus forming the intervertebral disc.
Development of vertebral column at various stages
Resegmentation of sclerotomes into vertebrae cause the myotomes to bridge the intervertebral discs; this alteration gives them the capacity to move the spine.

For the same reason, intersegmental arteries, which were lying between the sclerotomes, now pass midway over the vertebral bodies.

Spinal nerves, come to lie near the intervertebral discs and leave the vertebral column through the intervertebral foramina.
Development of vertebral column at various stages
2-Cells of the sclerotome passing dorsally behind the neural tube, surround the developing spinal cord to form the vertebral arch.

3- Cells passing ventro-laterally to form the costal elements of vertebrae, which develop into ribs in the thoracic region.

The sternum develops in the parietal layer of lateral plate mesoderm in the ventral body wall.
Hi Prof, It is great to hear from you, I really enjoyed your teaching last year. You taught me the hardest subject I have encountered so far in a manner that I understood and could remember. I hope you are enjoying your new job in Jordan. Are you still teaching anatomy? Many thanks for your teaching and best of luck in Jordan
Sam Allison
Thank You