chapter 12

Head and Neck

I. PHARYNGEAL APPARATUS (FIGURE 12.1; TABLE 12.1)

The pharyngeal apparatus consists of the **pharyngeal arches, pharyngeal pouches, pharyngeal grooves,** and **pharyngeal membranes,** all of which contribute greatly to the formation of the head and neck. The pharyngeal apparatus is first observed in week 4 of development and gives the embryo its distinctive appearance. There are five pharyngeal arches (1, 2, 3, 4, and 6), four pharyngeal pouches (1, 2, 3, and 4), four pharyngeal grooves (1, 2, 3, and 4), and four pharyngeal membranes (1, 2, 3, and 4). Pharyngeal arch 5 and pharyngeal pouch 5 completely regress in the human. Aortic arch 5 also completely regresses (see Chapter 5). The **Hox complex** and **retinoic acid** appear to be important factors in early head and neck formation. A lack or excess of retinoic acid causes striking facial anomalies.

A. **Pharyngeal arches (1, 2, 3, 4, 6)** contain **somitomeric mesoderm** and **neural crest cells.** In general, the mesoderm differentiates into **muscles** and **arteries** (i.e., aortic arches 1–6), whereas neural crest cells differentiate into **bone** and **connective tissue.** In addition, each pharyngeal arch has a **cranial nerve** associated with it.

B. **Pharyngeal pouches (1, 2, 3, 4)** are evaginations of endoderm that lines the foregut.

C. **Pharyngeal grooves (1, 2, 3, 4)** are invaginations of ectoderm located between each pharyngeal arch.

D. **Pharyngeal membranes (1, 2, 3, 4)** are structures consisting of ectoderm, intervening mesoderm and neural crest, and endoderm located between each pharyngeal arch.

II. DEVELOPMENT OF THE THYROID GLAND

In the midline of the floor of the pharynx, the endodermal lining of the foregut forms the **thyroid diverticulum.** The thyroid diverticulum migrates caudally, passing ventral to the hyoid bone and laryngeal cartilages. During this migration, the thyroid remains connected to the tongue by the **thyroglossal duct,** which later is obliterated. The site of the thyroglossal duct is indicated in the adult by the **foramen cecum.**

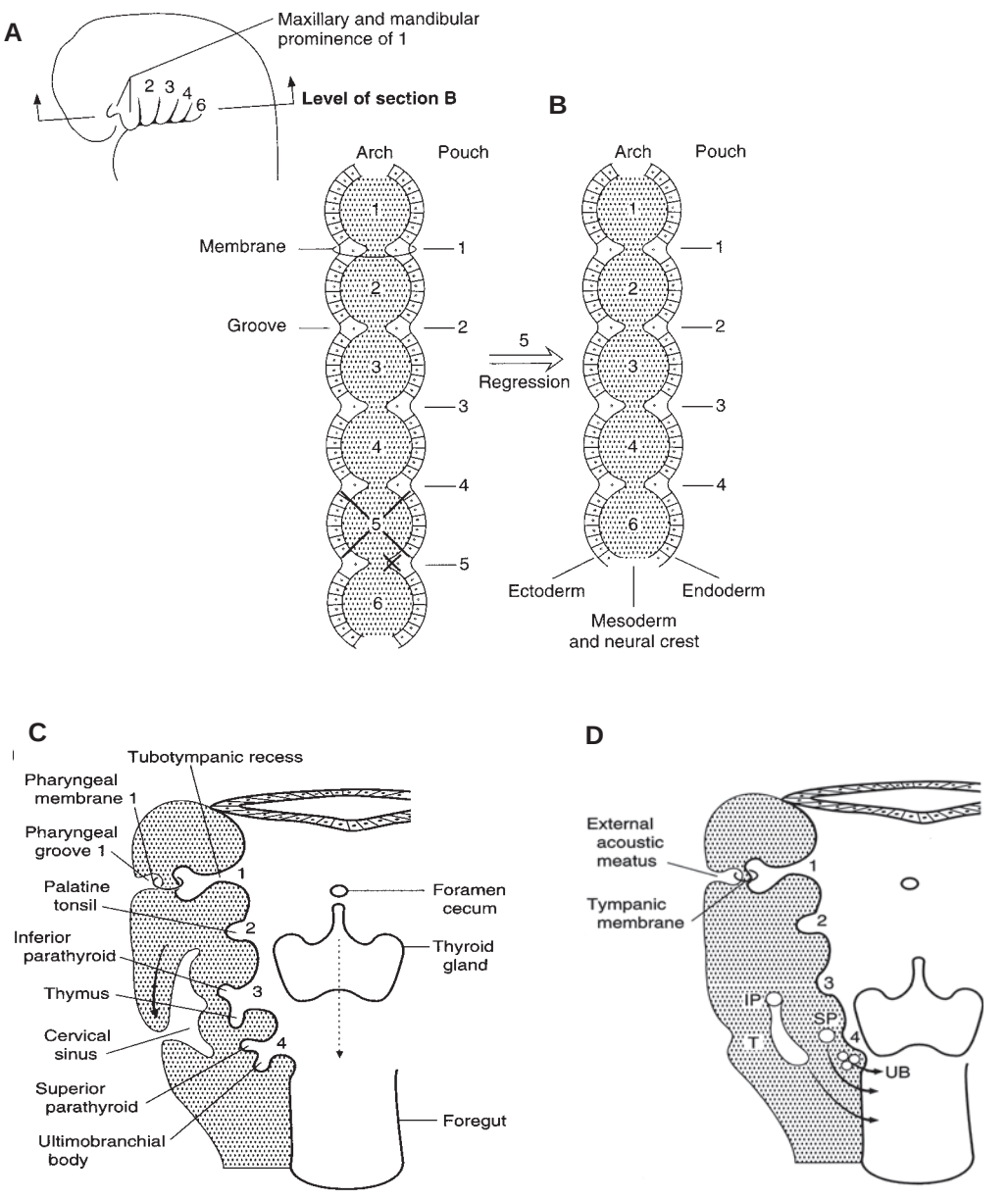


FIGURE 12.1. **(A)** Lateral view of an embryo in week 4 of development, showing the pharyngeal arches. Note that pharyngeal arch 1 consists of a maxillary prominence and a mandibular prominence, which can cause some confusion in numbering of the arches. **(B)** A schematic diagram indicating a convenient way to understand the numbering of the arches and pouches. The X's indicate regression of pharyngeal arch 5 and pouch 5. **(C, D)** Schematic diagrams of the fate of the pharyngeal pouches, grooves, and membranes. **(C)** *Solid arrow* indicates the downward growth of pharyngeal arch 2, thereby forming a smooth contour at the neck region. *Dotted arrow* indicates downward migration of the thyroid gland. **(D)** *Curved arrows* indicate the direction of migration of the inferior parathyroid (IP), thymus (T), superior parathyroid (SP), and ultimobranchial bodies (UB). Note that the parathyroid tissue derived from pharyngeal pouch 3 is carried farther caudally by the descent of the thymus than parathyroid tissue from pharyngeal pouch 4.

table 12.1 Adult Derivatives of Pharyngeal Arches, Pouches, Grooves, and Membranes

Arch	Nerve	Adult Derivatives
1	CN V	**Mesoderm:** Muscles of mastication, mylohyoid, anterior belly of digastric, tensor veli palatini, tensor tympani **Neural crest from R1 and R2:** Maxilla, mandible, incus, malleus, zygomatic bone, squamous temporal bone, palatine bone, vomer, sphenomandibular ligament, and Meckel's cartilage
2	CN VII	**Mesoderm:** Muscles of facial expression, posterior belly of digastric, stylohyoid, stapedius **Neural crest from R4:** Stapes, styloid process, stylohyoid ligament, lesser horn and upper body of hyoid bone, and Reichert's cartilage
3	CN IX	**Mesoderm:** Stylopharyngeus, common carotid arteries, internal carotid arteries **Neural crest from R6 and R7:** Greater horn and lower body of hyoid bone
4	CN X (superior laryngeal nerve)	**Mesoderm:** Muscles of soft palate (except tensor veli palatini), muscles of the pharynx (except stylopharyngeus) cricothyroid, cricopharyngeus, laryngeal cartilages, right subclavian artery, arch of aorta **Neural crest:** none
6	CN X (recurrent laryngeal nerve)	**Mesoderm:** Intrinsic muscles of larynx (except cricothyroid), upper muscles of the esophagus, laryngeal cartilages, pulmonary arteries, ductus arteriosus **Neural crest:** none
Pouch		
1		Epithelial lining of auditory tube and middle ear cavity, and mastoid air cells
2		Epithelial lining of palatine tonsil crypts
3		Inferior parathyroid gland Thymus
4		Superior parathyroid gland Ultimobranchial body[a]
Groove		
1		Epithelial lining of the external auditory meatus
2,3,4		Obliterated
Membrane		
1		Tympanic membrane
2,3,4		Obliterated

[a]Neural crest cells migrate into the ultimobranchial body to form parafollicular cells (C cells) of the thyroid, which secrete calcitonin.

III. DEVELOPMENT OF THE TONGUE (FIGURE 12.2)

A. Oral part (anterior two thirds) of the tongue

1. The oral part of the tongue forms from the **median tongue bud** and **two distal tongue buds** that develop in the floor of the pharynx associated with **pharyngeal arch 1.**
2. The distal tongue buds overgrow the median tongue bud and fuse in the midline, forming the **median sulcus.**
3. The oral part is characterized by **filiform papillae** (no taste buds), **fungiform papillae** (taste buds present), **foliate papillae** (taste buds present), and **circumvallate papillae** (taste buds present).
4. General sensation from the mucosa is carried by the **lingual branch of the trigeminal nerve (cranial nerve [CN] V).**
5. Taste sensation from the mucosa is carried by the **chorda tympani branch of the facial nerve (CN VII).** Special visceral afferent (SVA) neurons convey taste sensation from the anterior two thirds of the tongue to the central nervous system. The cell bodies for these neurons lie in the **geniculate ganglion.** The peripheral processes "hitch a ride" with the **lingual nerve** and **chorda tympani nerve.** The central processes enter the brain stem via the **intermediate nerve** and terminate in the rostral portion of the **solitary nucleus.**

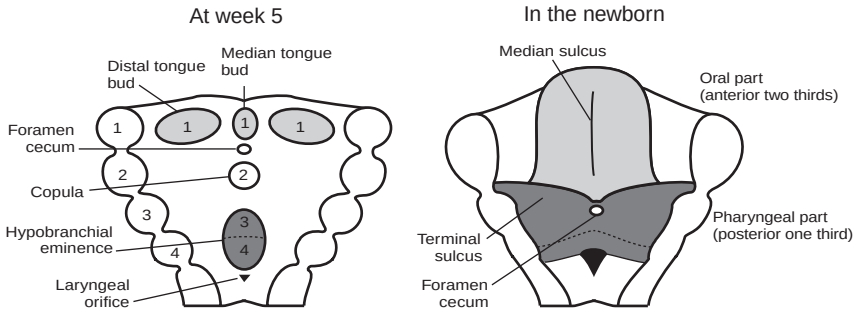


FIGURE 12.2. Development of the tongue at week 5 and in the newborn.

B. Pharyngeal part (posterior one third) of the tongue

1. The pharyngeal part of the tongue forms from the **copula** and **hypobranchial eminence** that develops in the floor of the pharynx associated with **pharyngeal arches 2, 3, and 4.**
2. The hypobranchial eminence overgrows the copula, thereby eliminating any contribution of pharyngeal arch 2 in the formation of the definitive adult tongue.
3. The line of fusion between the oral and pharyngeal parts of the tongue is indicated by the **terminal sulcus.**
4. The pharyngeal part is characterized by the **lingual tonsil,** which forms along with the palatine tonsil and pharyngeal tonsil (adenoids) **Waldeyer's ring.**
5. General sensation from the mucosa is carried primarily by the **glossopharyngeal nerve (CN IX).**
6. Taste sensation from the mucosa is carried predominantly by the **glossopharyngeal nerve (CN IX).**

C. Muscles of the tongue

1. The intrinsic muscles and extrinsic muscles (styloglossus, hyoglossus, genioglossus, and palatoglossus) are derived from myoblasts that migrate into the tongue region from **occipital somites.**
2. Motor innervation is supplied by the **hypoglossal nerve (CN XII),** except for palatoglossus muscle, which is innervated by CN X.

IV. DEVELOPMENT OF THE FACE (FIGURE 12.3)

A. The face is formed by three swellings: the **frontonasal prominence, maxillary prominence** (pharyngeal arch 1), and **mandibular prominence** (pharyngeal arch 1).

B. Bilateral ectodermal thickenings called **nasal placodes** develop on the ventrolateral aspects of the frontonasal prominence.

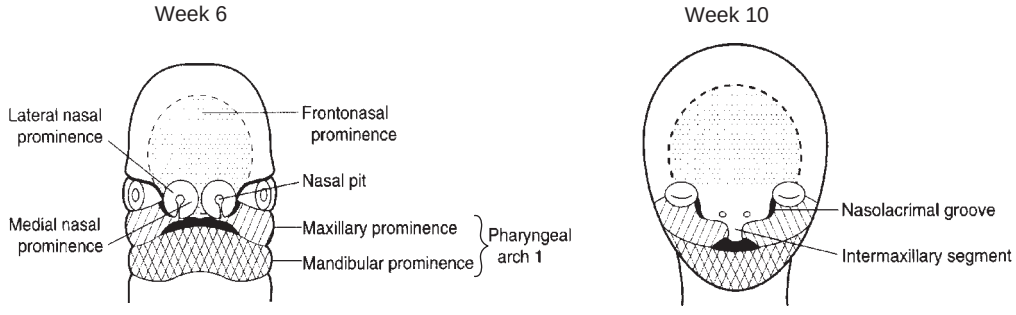


FIGURE 12.3. Development of the face at weeks 6 and 10.

C. The nasal placodes invaginate into the underlying mesoderm to form the **nasal pits,** thereby producing a ridge of tissue that forms the **medial nasal prominence** and **lateral nasal prominence.**

D. A deep groove called the **nasolacrimal groove** forms between the maxillary prominence and the lateral nasal prominence and eventually forms the **nasolacrimal duct** and **lacrimal sac.**

V. DEVELOPMENT OF THE PALATE (FIGURE 12.4)

A. Intermaxillary segment

1. The intermaxillary segment forms when the medial growth of the maxillary prominences causes the two medial nasal prominences to fuse together at the midline.
2. The intermaxillary segment forms the **philtrum of the lip, four incisor teeth,** and **primary palate.**

B. Secondary palate

1. The secondary palate forms from outgrowths of the maxillary prominences called the **palatine shelves.**
2. Initially the palatine shelves project downward on either side of the tongue but later attain a horizontal position and fuse along the **palatine raphe** to form the **secondary palate.**

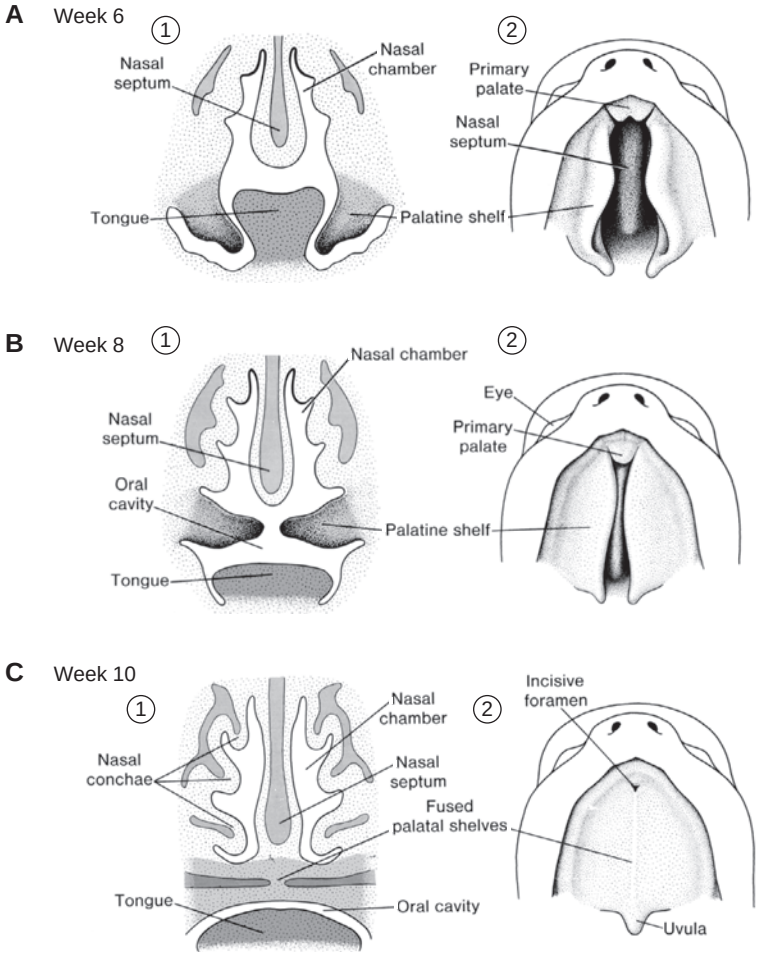


FIGURE 12.4. Development of the palate at weeks 6, 8, and 10. **(1)** Horizontal sections. **(2)** Roof of the mouth.

3. The primary and secondary palate fuse at the **incisive foramen** to form the **definitive palate.**
4. Bone develops in both the primary palate and anterior part of the secondary palate. Bone does not develop in the posterior part of the secondary palate, which eventually forms the **soft palate** and **uvula.**
5. The **nasal septum** develops from the medial nasal prominences and fuses with the definitive palate.

VI. DEVELOPMENT OF THE MOUTH

A. The mouth is formed from a surface depression called the **stomodeum,** which is lined by ectoderm, and the **cephalic end of the foregut,** which is lined by endoderm.

B. The stomodeum and foregut meet at the **oropharyngeal membrane.**

C. The epithelium of the **oral part of the tongue, hard palate, sides of the mouth, lips, parotid gland and ducts, Rathke's pouch,** and **enamel of the teeth** are derived from ectoderm.

D. The epithelium of the **pharyngeal part of the tongue, floor of the mouth, palatoglossal fold, palatopharyngeal fold, soft palate, sublingual gland and ducts,** and **submandibular gland and ducts** are derived from endoderm.

VII. DEVELOPMENT OF THE NASAL CAVITIES

A. The nasal placodes deepen considerably to form the nasal pits and finally the **nasal sacs.**

B. The nasal sacs remain separated from the oral cavity by the **oronasal membrane,** but it soon ruptures; the nasal cavities and oral cavity are then continuous via the **primitive choanae.**

C. Swellings in the lateral wall of each nasal cavity form the **superior, middle, and inferior conchae.**

D. In the roof of each nasal cavity, the ectoderm of the nasal placode forms a thickened patch—the **olfactory epithelium.**

E. Olfactory epithelium contains **sustentacular cells, basal cells,** and **ciliated cells.** These ciliated cells are bipolar neurons that give rise to the **olfactory nerve (CN I),** have a lifespan of 1–2 months, and are continuously regenerated.

VIII. CLINICAL CONSIDERATIONS

A. First arch syndrome (Figure 12.5) results from abnormal development of **pharyngeal arch 1** and produces various facial anomalies. It is caused by a lack of migration of neural crest cells into pharyngeal arch 1. Two well-described first arch syndromes are **Treacher Collins syndrome (mandibulofacial dysostosis)** and **Pierre Robin syndrome.** Treacher Collins syndrome is an autosomal dominant genetic disorder caused by a mutation in the ***TCOF1* gene** on **chromosome 5q32-q33.1** for the **treacle protein.** The treacle protein is a nucleolar protein that seems to be involved in microtubule dynamics. Clinical features include hypoplasia of the zygomatic bones and mandible, resulting in midface hypoplasia, micrognathia, and retrognathia; external ear abnormalities, including small, absent, malformed, or rotated ears; and lower eyelid abnormalities, including coloboma. The photograph in Figure 12.5 shows a young boy with Treacher Collins syndrome. Note the hearing aid cord.



FIGURE 12.5. Treacher Collins syndrome (mandibulofacial dysostosis).

B. Pharyngeal fistula (Figure 12.6) occurs when **pharyngeal pouch 2** and **pharyngeal groove 2** persist, thereby forming a patent opening from the internal tonsillar area to the external neck. It is generally found along the **anterior border of the sternocleidomastoid muscle.** In Figure 12.6 the radiograph after injection of a contrast medium demonstrates the course of the fistula through the neck (*arrow*). The fistula may begin inside the throat near the tonsils, travel through the neck, and open to the outside near the anterior border of the sternocleidomastoid muscle.

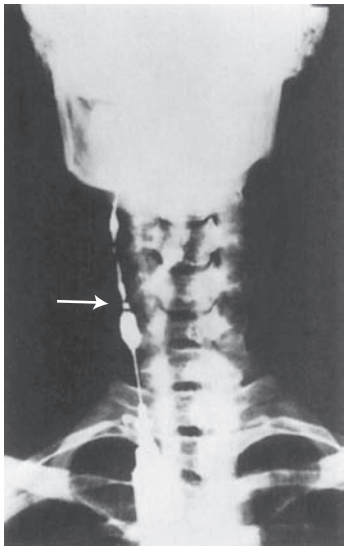


FIGURE 12.6. Pharyngeal fistula.

C. Pharyngeal cyst (Figure 12.7) occurs when parts of the **pharyngeal grooves 2, 3, and 4** that are normally obliterated persist, thereby forming a cyst. It is generally found near the **angle of the mandible.** The photograph in Figure 12.7 shows a fluid-filled cyst (*dotted circle*) near the angle of the mandible (*arrow*).

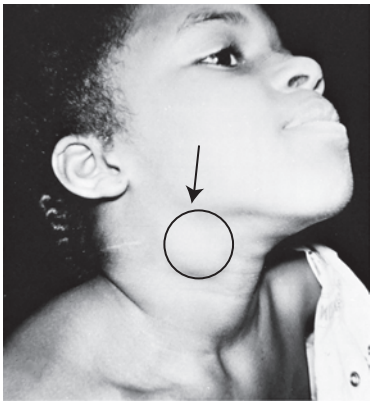


FIGURE 12.7. Pharyngeal cyst.

D. Ectopic thymus, parathyroid, or thyroid tissue (Figure 12.8) result from the abnormal migration of these glands from their embryonic position to their definitive adult location. Glandular tissue may be found anywhere along their migratory path. The photograph in Figure 12.8 shows a sublingual thyroid mass (*dotted circle*) in a 5-year old euthyroid girl. The [^{99M}Tc]pertechnetate scan localizes the position and the extent of the sublingual thyroid gland. There is no evidence of functioning thyroid tissue in the lower neck (i.e., in the normal anatomical position).

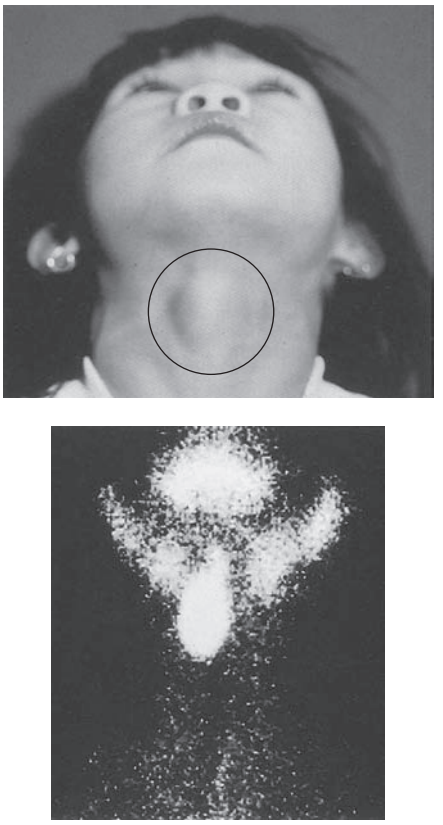


FIGURE 12.8. Ectopic thyroid tissue.

E. Thyroglossal duct cyst (Figure 12.9) occurs when parts of the thyroglossal duct persist and thereby form a cyst. It is most commonly located in the midline near the hyoid bone, but it may also be located at the base of the tongue, when it is then called a **lingual cyst.** The top photograph in Figure 12.9 shows a **thyroglossal duct cyst** (*arrow*), which is one of the most frequent congenital anomalies in the neck and is found along the midline most frequently below the hyoid bone. The MRI shows a **lingual cyst** consisting of a mass of thyroid tissue (*arrow*) at the base of the tongue.

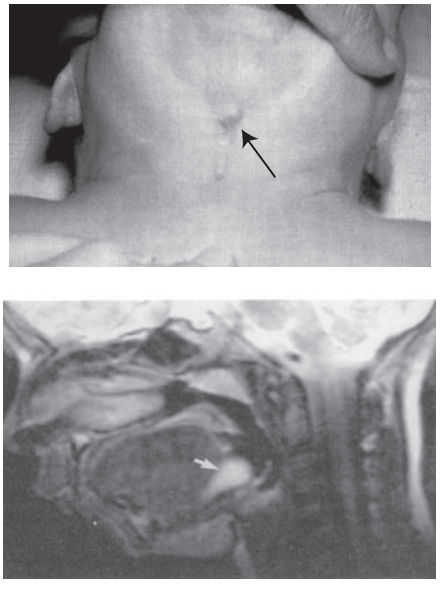


FIGURE 12.9. **(A)** Thyroglossal duct cyst. **(B)** Lingual cyst.

F. Congenital hypothyroidism (cretinism; Figure 12.10) occurs when a thyroid deficiency exists during the early fetal period due to a severe lack of dietary iodine, thyroid agenesis, or mutations involving the biosynthesis of thyroid hormone. This condition causes impaired skeletal growth and mental retardation. This condition is characterized by dry, rough skin, wide-set eyes, periorbital puffiness, a flat, broad nose, and large, protuberant tongue. The photograph in Figure 12.10 shows a child with impaired skeletal growth and mental retardation. Note the dry, rough skin (myxedema) and protuberant tongue.

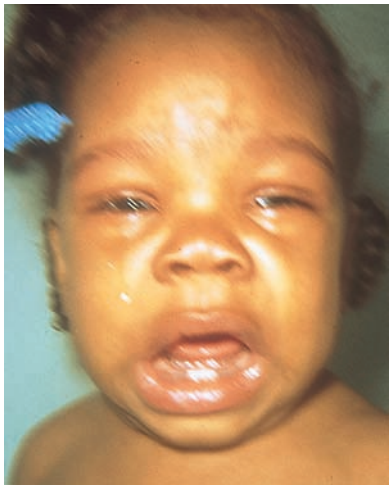


FIGURE 12.10. Congenital hypothyroidism (cretinism).

G. Cleft palate has multifactorial causes, including neural crest cell participation. It is classified as anterior or posterior. The anatomical landmark that separates anterior from posterior cleft palate defects is the incisive foramen.

1. **Anterior cleft palate** occurs when the palatine shelves fail to fuse with the primary palate.
2. **Posterior cleft palate** occurs when the palatine shelves fail to fuse with each other and with the nasal septum.
3. **Anteroposterior cleft palate** occurs when there is a combination of both defects.

H. Cleft lip (Figure 12.11) has multifactorial causes, including neural crest cells participation. Cleft lip and cleft palate are distinct malformations based on their embryological formation, even though they often occur together. They may occur unilaterally or bilaterally. Unilateral cleft lip is the most common congenital malformation of the head and neck. It results from the following:

1. The maxillary prominence fails to fuse with the medial nasal prominence.
2. The underlying somitomeric mesoderm and neural crest fail to expand, resulting in a **persistent labial groove**. The photograph in Figure 12.11 shows a child with a cleft palate and a unilateral cleft lip.



FIGURE 12.11. Unilateral cleft lip and cleft palate.

I. DiGeorge syndrome (DS; "catch 22"; 22q11 syndrome) is caused by a microdeletion of a region in chromosome 22q11.2 that is also called the *DiGeorge chromosomal region*. This results in the failure of **pharyngeal pouches 3 and 4** to differentiate into the thymus and parathyroid glands. DS is usually accompanied by facial anomalies resembling first arch syndrome (micrognathia, low-set ears) due to abnormal neural crest cell migration, cardiovascular anomalies due to abnormal neural crest cell migration during formation of the aorticopulmonary septum, immunodeficiency due to the absence of the thymus gland, and hypocalcemia due to the absence of parathyroid glands.

J. Ankyloglossia ("tongue-tie") occurs when the frenulum of the tongue extends to the tip of the tongue, thereby preventing protrusion.

Study Questions for Chapter 12

1. The most common site of a thyroglossal cyst is

(A) dorsal aspect of the neck
(B) anterior border of the sternocleidomastoid muscle
(C) superior mediastinum
(D) midline close to the hyoid bone
(E) base of the tongue

2. Taste sensation from the oral part (anterior two thirds) of the tongue is predominantly carried by

(A) trigeminal nerve (CN V)
(B) chorda tympani branch of the facial nerve (CN VII)
(C) glossopharyngeal nerve (CN IX)
(D) superior laryngeal branch of the vagus nerve (CN X)
(E) recurrent laryngeal branch of the vagus nerve (CN X)

3. The intermaxillary segment forms via the fusion of the

(A) maxillary prominences
(B) mandibular prominences
(C) palatine shelves
(D) lateral nasal prominences
(E) medial nasal prominences

4. The most common site of a pharyngeal fistula is the

(A) dorsal aspect of neck
(B) anterior border of sternocleidomastoid muscle
(C) superior mediastinum
(D) midline close to the hyoid bone
(E) base of the tongue

5. What is the most common congenital malformation of the head and neck region?

(A) Anterior cleft palate
(B) Posterior cleft palate
(C) Thyroglossal duct cyst
(D) Unilateral cleft lip
(E) Ankyloglossia

6. Which pharyngeal arch is associated with Treacher Collins syndrome?

(A) Pharyngeal arch 1
(B) Pharyngeal arch 2
(C) Pharyngeal arch 3
(D) Pharyngeal arch 4
(E) Pharyngeal arch 6

7. During surgery for the removal of a thyroid tumor, a number of small masses of glandular tissue are noted just lateral to the thyroid gland. Metastasis from the thyroid tumor is suspected, but histological analysis of a biopsy reveals parathyroid tissue and remnants of thymus. How can this finding be explained?

(A) Tumor tissue has differentiated into normal tissue
(B) A parathyroid gland tumor is also present
(C) Ectopic glandular tissue is commonly found in this region
(D) The patient has DiGeorge syndrome
(E) The glandular tissue is a result of a thyroglossal duct cyst

8. A newborn presents with midfacial and mandibular hypoplasia, defects of the first pharyngeal arch consistent with the diagnosis of Treacher Collins syndrome. What structure would most likely be involved with the syndrome?

(A) Hyoid bone
(B) Stapes
(C) Malleus
(D) Thyroid gland
(E) Inferior parathyroid gland

Answers and Explanations

1. **D.** The thyroid gland forms from a diverticulum in the midline of the floor of the pharynx. The thyroid migrates caudally and passes ventral to the hyoid bone. During this migration, the thyroid remains connected to the tongue by the thyroglossal duct. If a part of the thyroglossal duct persists, a cyst will develop, usually near the hyoid bone.
2. **B.** Taste sensation from the mucosa for the oral part of the tongue is carried by the chorda tympani branch of the facial nerve (CN VII). This part of the tongue forms from pharyngeal arch 1, so the trigeminal nerve (CN V) will carry sensory innervation from the mucosa.
3. **E.** The intermaxillary segment, which plays a critical role in the formation of the definitive adult palate, forms when the two medial nasal prominences fuse in the midline.
4. **B.** A pharyngeal fistula forms when pharyngeal pouch 2 and pharyngeal groove 2 persist. Therefore, these fistulas are found on the lateral aspect of the neck, usually along the anterior border of the sternocleidomastoid muscle.
5. **D.** Unilateral cleft lip is the most common congenital malformation of the head and neck. Cleft lip occurs when the maxillary prominences fail to fuse with the medial nasal prominences and when the underlying somitomeric mesoderm and neural crest fail to proliferate, resulting in a persistent labial groove. Cleft lip occurs in 1 of 900 births and may be unilateral or bilateral.
6. **A.** First arch syndrome results from abnormal development of pharyngeal arch 1 due to a lack of migration of neural crest cells. Treacher Collins syndrome is associated with underdevelopment of the zygomatic bone, down-slanting palpebral fissures, and deformed lower eyelids and external ears.
7. **C.** The parathyroid and thymus migrate in a caudal and medial direction during development; therefore, ectopic glandular tissue may be found anywhere along the migratory path.
8. **C.** The malleus is the only structure on this list derived from the neural crest of the first pharyngeal arch.