Development of the Face

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ABSTRACT

The human face develops between the fourth and eighth week after conception. Its development can be traced to five facial primordia appearing around the stomodeum in the fourth week. They are, namely, one frontonasal prominence, two maxillary and two mandibular prominences. Two nasal placodes develop on each side of the lower part of the frontonasal prominence at the end of the fourth week and further develop into the medial and lateral nasal prominences. The early development of the human face is similar to that of other mammals, such as pigs, rats and rabbits; all of which acquire branchial arches in the early stage of development. The rabbit branchial arches develop at the 4-5 mm stage and nearly disappear at the 12-14 mm stage, as the second one grows dorsally and obliterates the cervical sinus. The medial and lateral nasal prominences appear at the 4-5 mm stage. At the 12-14 mm stage the nasal cavities are more extensive than those of a 10 mm pig embryo and are of the same stage of development as a 15 mm pig embryo. Currently, we use 10 and 15 mm pig embryos as models in this study of human facial development. However, in the future, it will be more suitable to use 4-12 mm rabbit embryos because they are obtained more easily.

Keywords: Frontonasal prominence; Maxillary prominence; Mandibular prominence; Primordia

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The human face develops between the fourth and eighth week following conception. It begins with five facial primordia: one frontonasal, two maxillary and two mandibular prominences. The lower jaw is the first part of the face to form by the fusion of both mandibular prominences at the end of the fourth week. By this time, two nasal placodes develop at the ventrolateral aspect of the frontonasal prominence. Mesenchyme proliferation at the margin of the nasal placodes, results in horseshoe-shaped elevations, that is, the medial and lateral nasal prominences surrounding the nasal pits. The maxillary prominences enlarge and grow medially toward each other and the medial nasal prominences. The medial migration of the maxillary prominences moves the medial nasal prominences toward each other and the median plane. Each maxillary prominence is separated from the lateral nasal prominence by a cleft, the nasolacrimal groove.

During the sixth week, the medial nasal prominences fuse with each other at the median plane, and together with the maxillary prominences lateral and inferior to it. The median fusion forms the intermaxillary segment which gives rise to the philtrum of the lip, the premaxillary part of the maxilla and the primary palate. The lateral part of the upper lip and the secondary palate originate from the maxillary prominences. The lips and cheeks are invaded by the mesenchyme of the second branchial arch which differentiates into the muscles for facial expression, whereas the mesenchyme of the first branchial arch differentiates into the muscles of mastication. The frontonasal prominence forms the forehead and dorsum of the nose. The sides of the nose are derived from the lateral nasal prominences. The nasal septum is formed by the medial nasal prominences. The maxillary prominences form the cheeks and lateral part of the upper lip while the mandibular prominences form the lower lip and the chin.

The nasal cavity is initially indicated by the nasal placodes which later become depressed forming the nasal pits which are surrounded by the medial and lateral nasal prominences. The nasal pits depress gradually to form the nasal sacs which are separated from the oral cavity by the oronasal membrane which, when ruptured, will bring about the communication between the oral and nasal cavities. The communication, the choana, shifts posteriorly when the secondary palates are formed.

The final development of the face occurs slowly and results mainly from changes in the proportion and relative positions of the facial components. During the early fetal period, the nose is flat and the mandible is underdeveloped. They obtain their characteristics when the brain enlarges, creating a prominent forehead; the eyes move medially and the auricles rise upward by the mandibular growth.

The face and nasal cavities of humans and pigs originate from the same primordials. Also, similar are the pathway and sequences in which all the primordials move and fuse. For this reason, the development of the human face can be illustrated by a serial sections of pig embryos, which we employed as laboratory models to get a better understanding of how a normal face develops and how abnormalities, such as cleft lip and cleft palate occur. Failure of fusion of the facial primordials causes a greater

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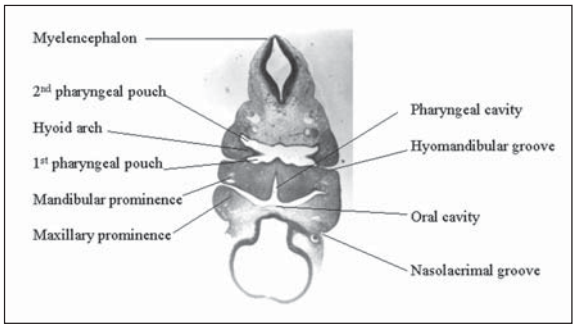

Fig 1. Transverse section of 4-5 mm. rabbit embryo through the nasal pit.

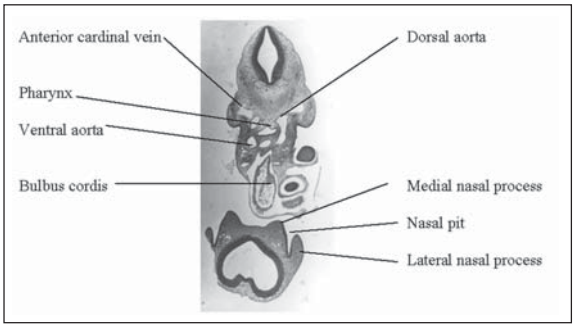

Fig 3. Transverse section of 4-5 mm. rabbit embryo through the nasal pit.

or lesser degree of facial cleft. Currently, pig embryos are not availble, while the present stock of slides turn older and some of them are no longer suitable. For this reason, we should study facial development of other mammals to find suitable substitutes for pig embryos.[1-3] Rabbit embryos are easily obtained and they were used in this study to compare suitable stages with the 10 mm and 15 mm pig embryos.

MATERIALS AND METHODS

Maternal rabbits (*Oryctolagus cuniculus*) with their embryos were obtained from the Department of Animal Laboratory, AFRIMS. They were bred, and later fed until their conceptions were 12 and 15 days. At each proper stage, a maternal rabbit was injected with an overdose of an anesthetic drug. A low midline incision was made. The uterus, at the proper embryonic stage, was dissected from the abdominal cavity. Each embryonic mass was separated from the other and placed in Bouin's solution for fixation for at least 24 hours. The process of removing the excess fixative was performed by placing it in 70% ethyl alcohol. The solution was changed daily until the fixative was entirely removed by observing the color of the specimen which gradually changed from yellow to white. The embryos were dissected from the uteri and placed in 70% ethyl alcohol. They were dehydrated, cleared, embedded, and serially sectioned. Then the mounted sections were stained with hematoxylin. The developing branchial arch regions were observed under a light microscope. The face development of a 4-14 mm rabbit embryo was compared with that of a 10 mm pig embryo.

RESULTS

1. 4-5 mm rabbit embryos. (Fig 1- 3)

At this stage, facial development can be illustrated in the transverse section of the branchial arch region. The centre of the facial primordial is the stomodeum or oral cavity. The stomodeum is cephalolaterally surrounded by the maxillary prominences and the mandibular prominences caudally. The frontonasal prominence cannot be illustrated in this section. The mandibular prominences are partially approaching, but a cleft between them still remains. On the lateral sides of the stomodeum, the maxillary and mandibular prominences are fused. Rostrally to the maxillary prominence are the developing eyes, which appear as optic stalks that grow laterally. The mesenchyme surrounding the brain vesicle is loosely arranged while the mesenchyme of the maxillary and mandibular prominences is dense as that of the other branchial arches. Caudally to the mandibular prominences are the hyoid arches which are separated by the external cleft, the hyomandibular cleft.

The more caudal sections of a 4-5 mm rabbit embryo reveal an early developing nose and the appearance of the medial and lateral nasal prominences surrounding the anterior nare or nasal pits. The epithelium of the nasal pit is a distinctively tall columnar epithelium. The cleft between the lateral nasal and the maxillary prominences is indicated, namely, the nasolacrimal groove The hyomandibular cleft separates the mandibular prominence and the hyoid arch. The middle between the hyoid arches is the cross section of the thyroid diverticulum.

2. A 12-14 mm rabbit embryo (Fig 4 - 6)

The branchial arches appear in rabbit embryos for a very short period. At the 12-14 mm stage, they nearly disappear by the fusion of the second arch and the epicardial ridge, bringing about a smooth contour on the side of the neck. The centre of the facial development is still indicated by the stomodeum which is surrounded by the fused mandibular prominence caudally and the maxillary prominences cephalolaterally. The cephalomedian boundary of the stomodeum is indicated by the fused medial nasal prominences and is illustrated in the figure as the

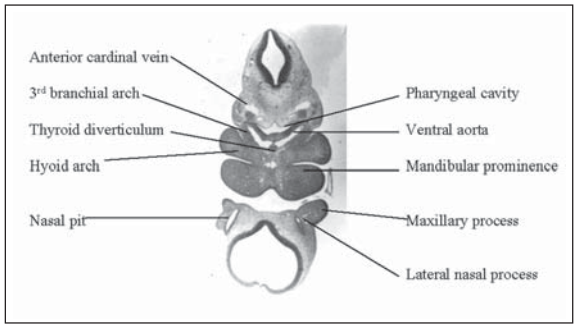

Fig 2. Transverse section of 4-5 mm. rabbit embryo through the nasal pit.

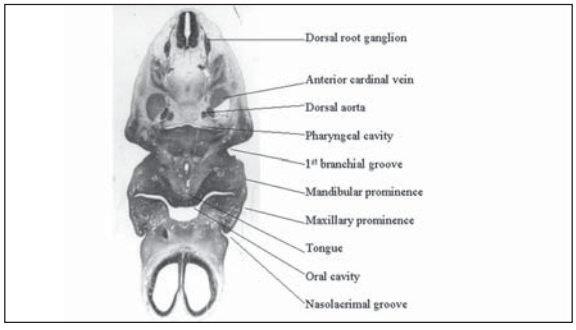

Fig 4. Transverse section of 12-14 mm. rabbit embryo through the oral cavity.

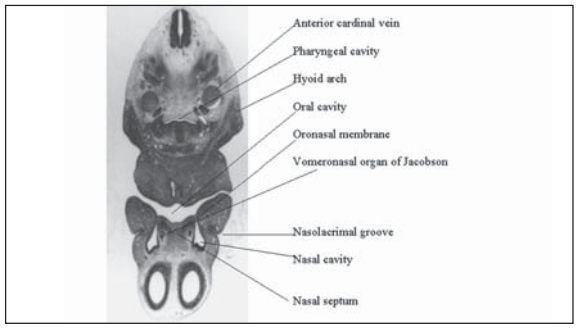

Fig 5. Transverse section of 12-14 mm. rabbit embryo through the oral cavity.

nasal septum. The oral end of the medial nasal prominence gradually grows to approach the maxillary prominences and gives rise to the premaxillar and the philtrum of the upper lip. At the floor of the stomodeum, the tongue appears as a median swelling caused by the fusion of both sides of the tongue primordia, the lateral lingual swellings. The maxillary and mandibular prominences fuse laterally. The nasal cavity, originating from the growth of the primitive nasal sac, is relatively large. The cavity is surrounded by the nasal septum medially and the lateral nasal prominence laterally, and is separated from the oral cavity by a thin membrane, the oronasal membrane. This membrane soon ruptures, bringing about a communication between the oral and nasal cavities, the primitive choana. The nasal septum is a densely thick mesenchymal mass covered by tall columnar epithelium. The vomeronasal organs, which develop on both sides of the nasal septum, are transient and originate from the epithelium invaginates on each side of the nasal septum.

3. A 10 mm pig embryo (Fig 7)

A study on the facial development of a pig embryo can be done by tracing the slide along the branchial arch level. The centre of the facial development is the stomodeum which is cephalolaterally surrounded by the maxillary prominence and caudally by the mandibular prominence. More dorsal in this section is the pharyngeal region characterized by bar-like thickenings of the second to fourth branchial arches. The mandibular prominences do not completely approach. Rostrally to the stomodeum, the eyes are developing. The cleft between the developing eye and the maxillary prominence is the nasolacrimal groove.

4. A 15 mm pig embryo. (Fig 8)

A 15 mm pig embryo is slightly more advanced in development of the nasal cavity. The nasal sac invaginates from the anterior and deeper inside to form the

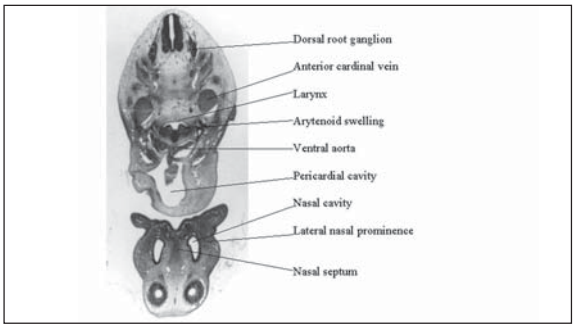

Fig 6. Transverse section of 12-14 mm. rabbit embryo through nasal cavity.

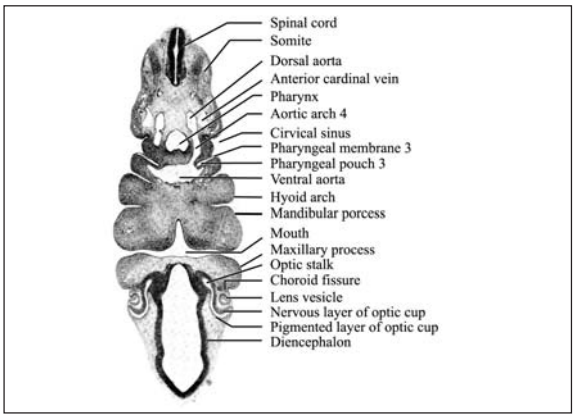

Fig 7. Transverse section of the 10 mm embryo through the branchial arch

nasal cavity which is surrounded by the medial and lateral nasal prominences. The medial nasal prominences fuse to form the nasal septum. The lateral nasal prominence is divided from the maxillary prominence by a groove called the nasolcrimal groove. The lateral wall of the nasal cavity starts to develop the concha.

DISCUSSION

A 4-14 mm rabbit embryo can illustrate the primordia of facial and nasal development. A 4-5 mm rabbit embryo acquires branchial arches; the first one divides into two prominences, the maxillary and the mandibular prominences, surrounding the oral cavity. The nasal placode develops earlier as in the 4-5 mm stage; the nasal pit is surrounded by the medial and lateral nasal prominences. A 4-5 mm rabbit embryo is similar to a 10 mm pig embryo, both of them can be compared to a human embryo at the beginning of the fifth week. 12-14 mm rabbit embryos no longer exhibit the branchial arch, since the second one moves dorsally and obliterates the cervical sinus. With regard to the external appearance of the face and neck, this is at the same stage of a 15 mm pig embryo, which can also be compared to a human embryo in the seventh week. As observed in the cross section, the nasal sac deepens to form the primitive nasal cavity. The cavity is bound laterally by the lateral nasal prominence and medially by the fused medial nasal prominences. The nasal and oral cavities are separated by the oronasal membrane. This membrane is transient and will soon rupture, bringing the oral and nasal cavities into communication. The vomeronasal organs develop in the nasal septum while the lateral wall exhibits several elevations, the conchae.

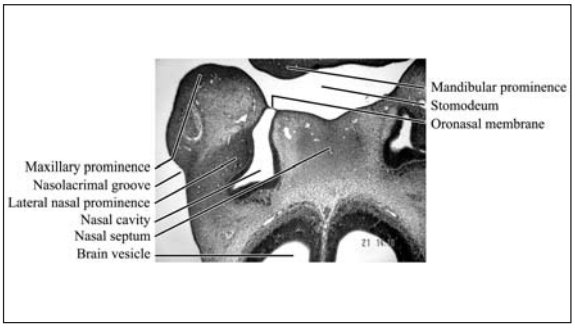

Fig 8. Transverse section of 15 mm pig embryo through the nasal cavity

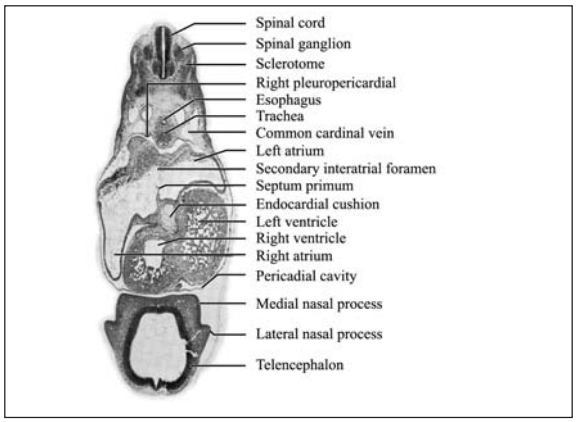

Fig 10. Transverse of 10 mm pig embryo at the level of foramen

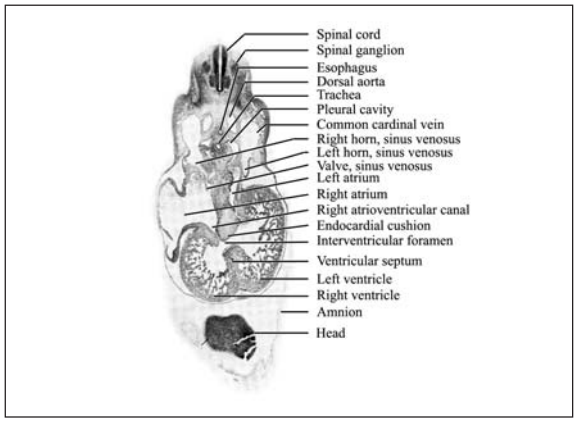

Fig 11. Transverse section of 10 mm pig embryo at the level of interventricular foramen

The early development of the human face is similar to that of other mammals, such as pigs, rats and rabbits[4-11], all of which exhibit branchial arches in the early developmental stage. Thus, it is not only that a rabbit embryo can be used instead of that of a pig, but also those of other mammals. The problem is that there is no standard textbook available for reference on these matters. This is also an interesting point for embryologists to investigate more deeply in order to find the most suitable animal to use as a laboratory model instead of pigs, and to prepare a standard textbook describing the embryology of such an animal.

CONCLUSION

The development of the face and nasal cavities in 4-14 mm rabbit embryos was studied. The facial primordia exhibited by a 4-5 mm rabbit embryo are the maxillary, mandibular, medial and lateral nasal prominences. These primordia surround the oral cavity. A 12-14 mm rabbit embryo shows more advancement in the nasal development. The nasal cavity is surrounded by the lateral nasal and fused medial nasal prominences, the nasal septum. The nasal cavity is still separated from the oral cavity by the oronasal membrane. A 4-14 mm rabbit embryo can be used as another laboratory model for studying human face development. This is another way to solve the problem of increasing numbers of medical students since the pig embryo is no longer available.

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บทคัดย่อ

การเจริญพัฒนาการของใบหน้า

จันทิมา รุ่งเรืองชัย, ปร.ด., ชจี ปิลกศิริ ปร.ด., สมพิศ อิ่มใจ วท.ม.
ภาควิชากายวิภาคศาสตร์, คณะแพทยศาสตร์ศิริราชพยาบาล, มหาวิทยาลัยมหิดล, กทม 10700, ประเทศไทย

ใบหน้ามนุษย์มีการพัฒนาการขึ้นตั้งแต่สัปดาห์ที่ 4 ถึงสัปดาห์ที่ 8 ในครรภ์ เริ่มด้วยการเกิดรอยนูนรอบช่องปาก 5 อันคือ ฟรอนโตนาสัล 1 แมซิลลาร์ 2 และแมนดิบูลาร์ 2 ซึ่งปรากฏขึ้นในสัปดาห์ที่ 4 และในปลายสัปดาห์นี้เอง รอยนูน นาสัล เริ่มปรากฏขึ้นที่ปลายล่างของรอยนูนฟรอนโตนาสัล การพัฒนาการของใบหน้ามนุษย์นั้นมีความคล้ายคลึงกับสัตว์เลี้ยงลูกด้วยนมหลายชนิด เช่น หมู, หนู และกระต่าย ซึ่งสัตว์เหล่านี้ล้วนมีการกำเนิดของแบรงเชียล อาร์ช ขึ้นมาก่อนทั้งสิ้น ดังนั้นในการศึกษาการพัฒนาการของใบหน้ามนุษย์ในวิชาวิทยาเอมบริย์โอของภาควิชากายวิภาคศาสตร์ คณะแพทยศาสตร์ศิริราชพยาบาล จึงใช้ตัวอ่อนหมูในการศึกษาเปรียบเทียบ แต่ปัจจุบันไม่สามารถหาตัวอ่อนหมูได้อีก จึงได้ศึกษาตัวอ่อนของสัตว์เลี้ยงลูกด้วยนมอื่นที่หาได้ง่ายกว่าคือกระต่าย เพื่อหาระยะการเจริญที่พอเหมาะในการศึกษาพัฒนาการของใบหน้าที่เทียบกับมนุษย์ได้เช่นกัน พบว่าตัวอ่อนกระต่ายขนาด 4 มม. ใช้แทนตัวอ่อนหมูขนาด 10 มม. ได้ในระยะที่มี แบรงเชียล อาร์ช ส่วนตัวอ่อนกระต่ายขนาด 12 มม. ใช้แทนตัวอ่อนหมูขนาด 15 มม. ได้ในการศึกษาพัฒนาการของช่องโพรงจมูก ในอนาคตแม้นักศึกษาจะเพิ่มขึ้นและหาตัวอ่อนหมูไม่ได้ ก็อาจใช้ตัวอ่อนกระต่ายมาเทียบแทนกันได้